

THE 1970 AEROSPACE YEAR BOOK

FORTY-EIGHTH EDITION



Official Publication of the
AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.

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Publisher
Leonard Klingsberg

Editor
James J. Haggerty

Managing Editor
Margaret Irminger

Advertising Manager
Norman Understein

Production Manager
John J. O'Malley

Artist
Ivan X. Spear

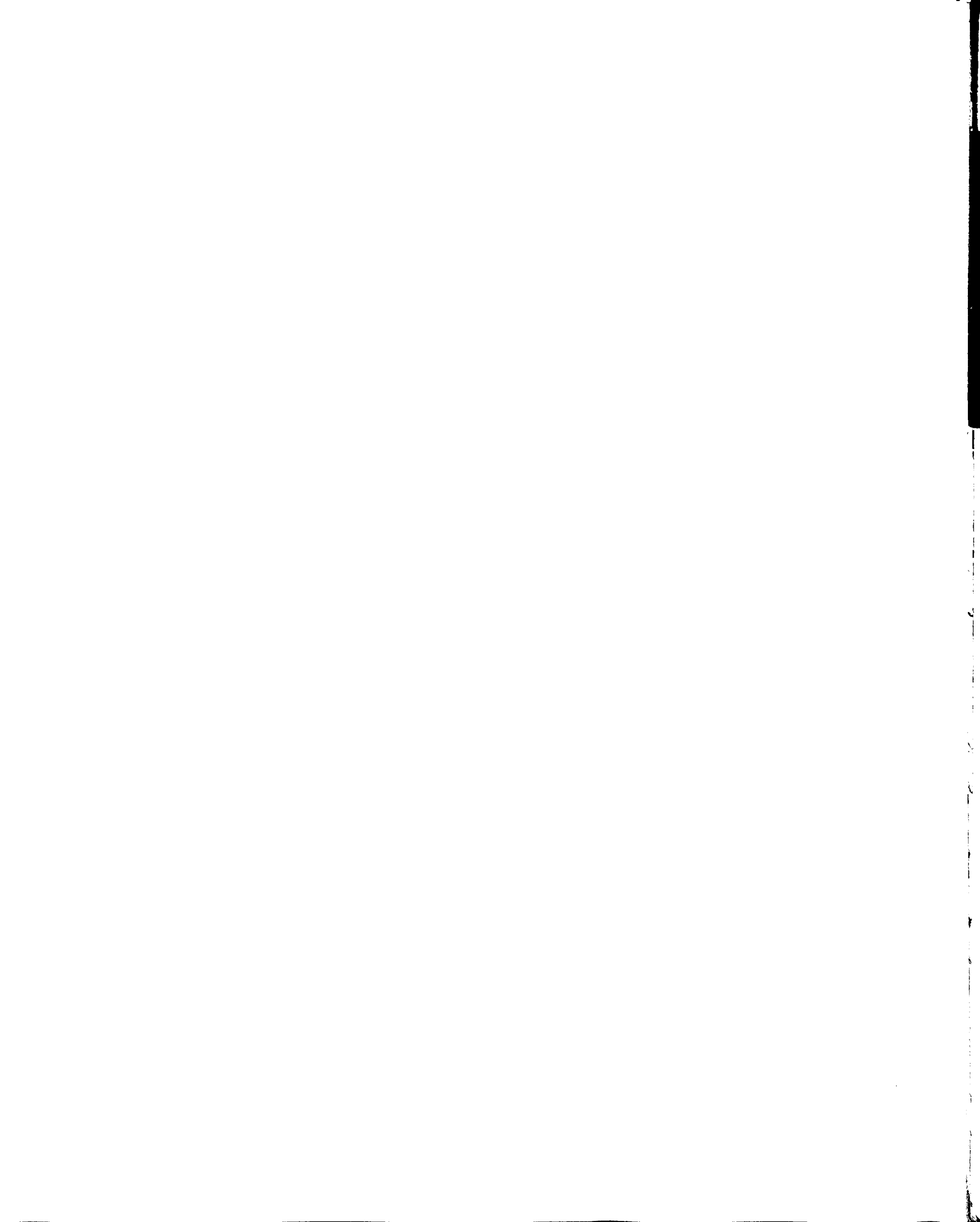
AIA Coordinator
Gerald J. McAllister



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FOREWORD

by Karl G. Harr, Jr.

*President,
Aerospace Industries Association*

In 1969 the accelerating momentum which was the hallmark of the aerospace industry during the decade of the sixties was solidly underscored by landing astronauts on the moon and returning them to earth—unquestionably man's greatest technological and managerial feat.

When astronaut Neil A. Armstrong stepped from the Lunar Module *Eagle* and became the first man to set foot on the moon, a bold national commitment was fulfilled. Four months later, Apollo 12 duplicated this incredible achievement.

These 2 1969 lunar missions fittingly capped a decade of constantly rising technical and managerial capabilities. Less dramatic but equally significant evidence of these increased capabilities was also demonstrated during the year. For example:

- The cumulative effect of the large-scale introduction of turbine-powered transports into the world's airline fleets produced astonishing statistics on the use of air transportation. U.S. scheduled airlines alone, which in 1959 carried 56,000,000 passengers and flew 847,000,000 cargo ton-miles, carried 162,000,000 passengers and flew 4.4 billion cargo ton-miles in the final year of the 1960s.

- At the same time, at year-end industry was on the threshold of delivering to the world's air carriers the first models of the wide-bodied, high-capacity transports, representing the third generation of turbine-powered commercial airliners. Such aircraft promise to add a further dramatic stimulus to air transportation growth.

- The supersonic transport (SST), the next major step in commercial air transportation, moved several significant steps from the mock-up stage toward the world's runways.

- General aviation demonstrated a period of solid growth. In 1959, U.S. manufacturers produced 7,689 general aircraft with a retail value of \$170,000,000.

In 1969, they produced 12,456 units with a retail value of almost \$780,000,000. Commercial helicopter production grew from 266 units in 1960 to 550 units in 1969 of much higher performance capability.

- In military aviation, 2 new high-performance air superiority fighters were contracted for and competitive designs were being prepared for an advanced bomber system.

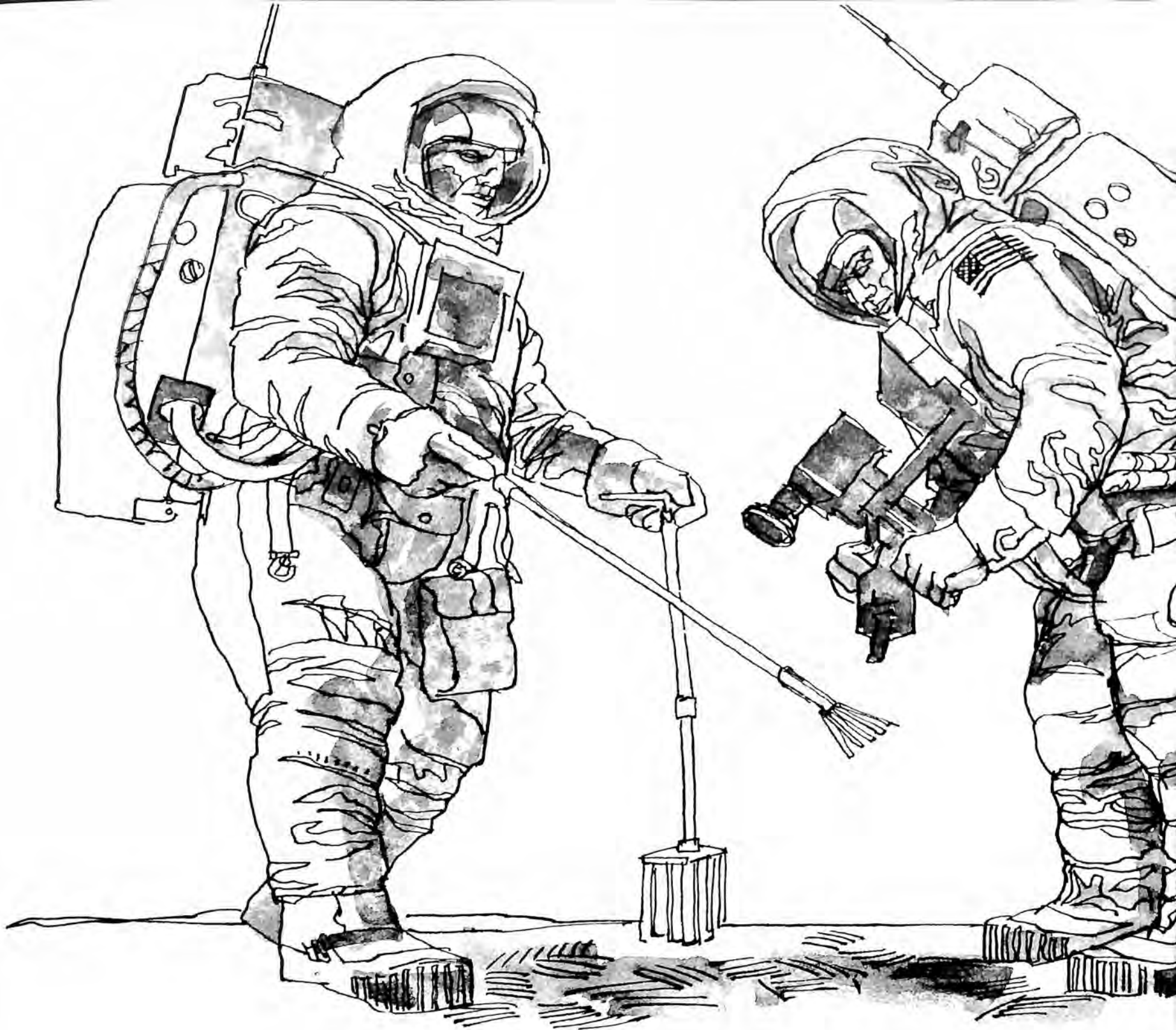
- In space exploration, development of a space shuttle, a fully recoverable aircraft-type vehicle capable of orbital flight, was awarded high priority. The shuttle is basic to the goal of low-cost, large-scale space missions.

- Finally, sales of non-aerospace products and services—activities by the industry utilizing aerospace technology in such areas as pollution control, marine sciences, urban transportation, and medical applications—increased in 1969, even while sales in most of the other major categories of effort showed a slight decline.

In summary, the aerospace industry matured in many areas and, as it did so, engendered an increase in public demand and expectation corresponding to the industry's demonstrated capability for even greater problem-solving performance in the decade of the seventies.

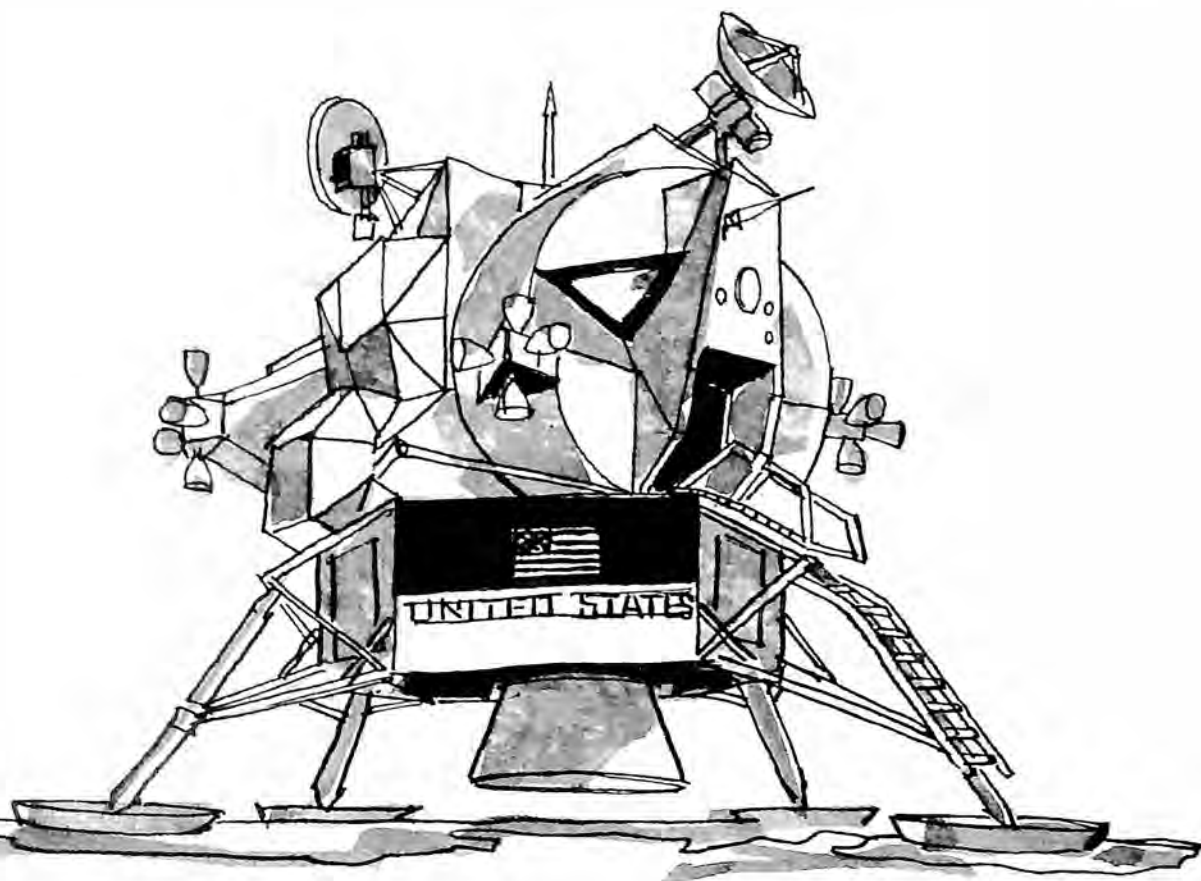
The industry continues to move further into the forefront of creative responsiveness to national needs over and above its responsibilities in space exploration, national defense, and civil aviation. Aerospace companies have already made significant efforts in socioeconomic areas, backing them with their financial and technical resources.

As we look to the future, it seems certain that the seventies will see the industry increasingly involved in solving a wide variety of pressing domestic problems.



1969 Aerospace Events

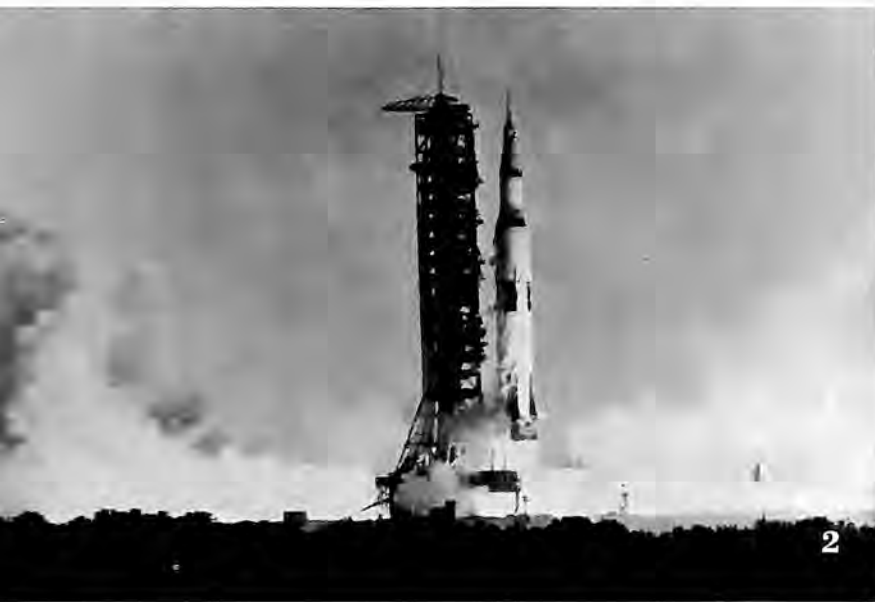
The highlights of the aerospace year, including major developments involving aerospace people and equipment and the aircraft, missiles, launch vehicles, spacecraft, engines, and systems which passed notable milestones in 1969.



MEN ON THE MOON

The greatest technological undertaking in history culminated in 1969 with the first landings of men on the moon. The United States fulfilled its memorable "within the decade" commitment, made by President John F. Kennedy in 1961, with the flight of Apollo 11 just 98 months after the go-ahead was signaled. Only 4 months later, another Apollo team made a second lunar landing. For NASA and the

aerospace industry, the year's Apollo feats represented a magnificent effort of program management and hardware fabrication. They also brought to the whole world a new capability for exploring and understanding the awesome workings of the universe. The lunar landings were, to use the words of the man who first set foot on the moon, a "giant leap for mankind."

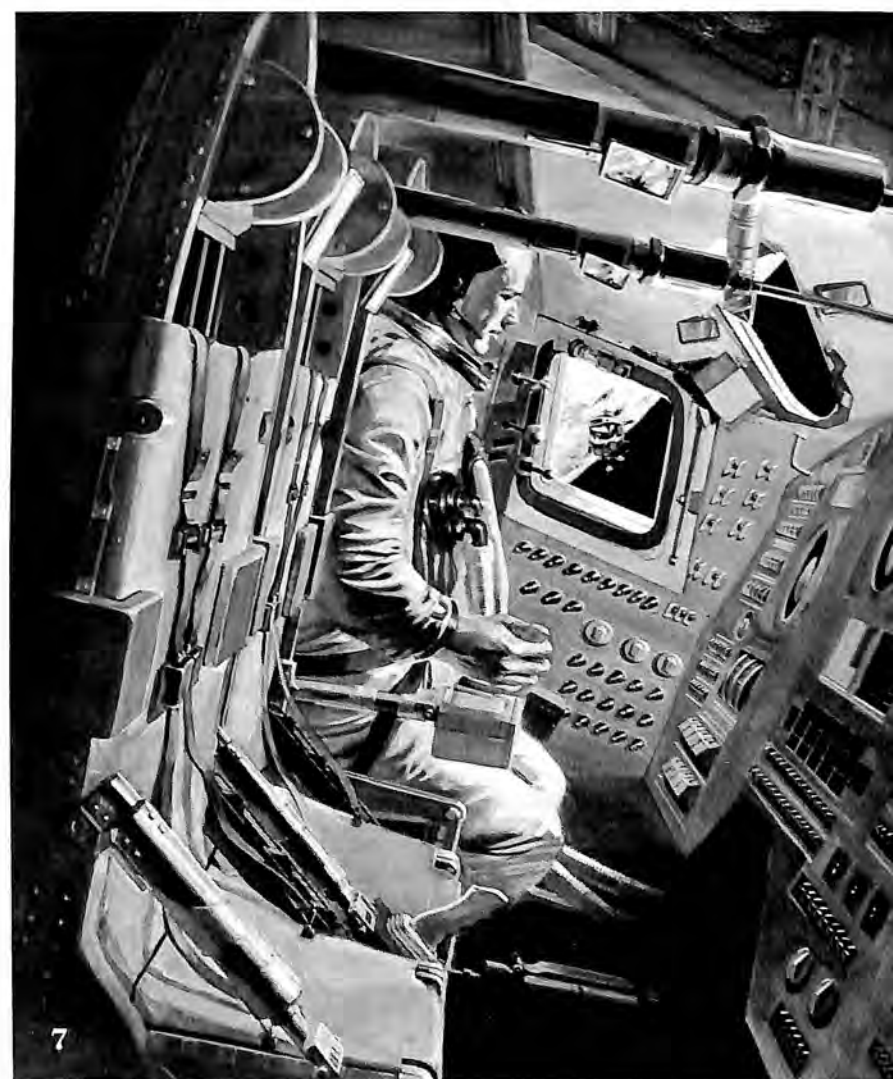


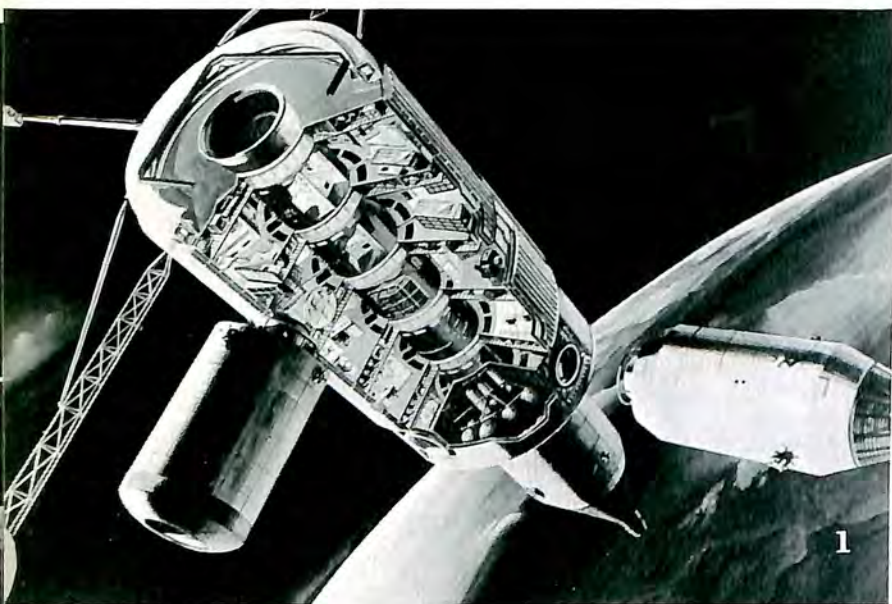
APOLLO

The lunar landings were preceded by 2 other Apollo missions in 1969, the first of which was launched on February 28. Apollo 9 was crewed by commander James A. McDivitt, Command Module pilot David R. Scott, and Lunar Module pilot Russell Schweickart, shown in Photo 1 during the first Apollo space walk. Apollo 9 was the final qualification test of the Lunar Module, which was thoroughly checked out in a 10-day earth-orbital flight. Apollo 10, launched May 18 and manned by Thomas P. Stafford, Eugene A. Cernan, and John W. Young, was an 8-day dress rehearsal for the first landing; it was a lunar mission in which Stafford and Cernan descended in the Lunar Module to within 9.4 miles of the moon's surface. Man's first visit to the moon began on July 16 with the launch from Cape Kennedy of Apollo 11, boosted by the Saturn V vehicle (Photo 2). Aboard were spacecraft commander Neil Armstrong, Command Module pilot Michael Collins, and Lunar Module pilot Edwin Aldrin (left to right in Photo 3). While Collins orbited, Armstrong and Aldrin descended in the Lunar Module and touched down on the moon on July 20. Armstrong took man's first steps on the moon 109 hours 24 minutes after launch; Aldrin followed 18 minutes later. Among their first acts was the planting of the American flag on the moon (Photo 4). Later, they de-

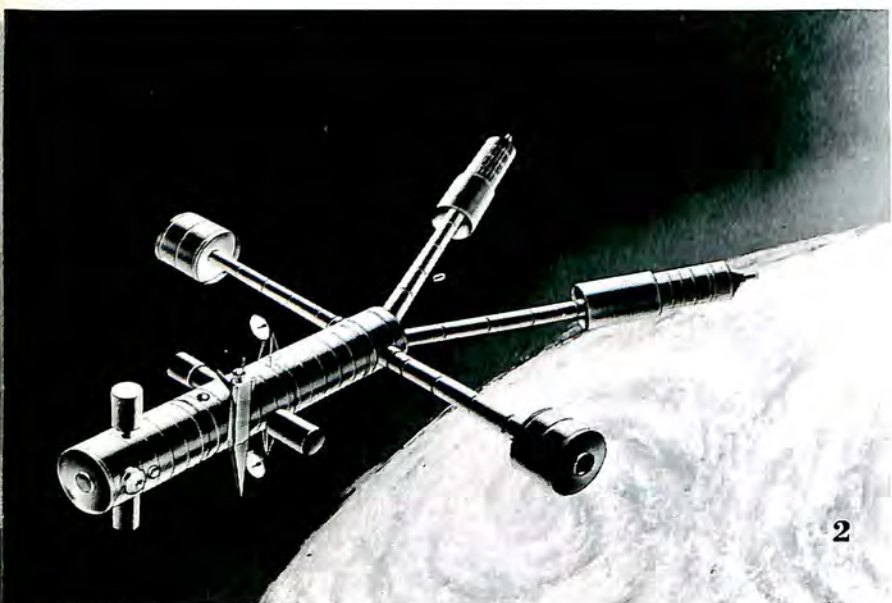


ployed a number of scientific experiments (Photo 5) and left the moon. Following a 60-hour return flight, Apollo 11 splashed down in the Pacific and the astronauts were picked up by the recovery carrier USS *Hornet*. Apollo 12 was launched November 14, carrying commander Charles Conrad, Command Module pilot Richard F. Gordon, and Lunar Module pilot Alan L. Bean (left to right in Photo 6). Conrad and Bean spent almost 8 hours walking the moon's surface on November 19 and blasted off on November 20. (In Photo 7, artist's conception shows Gordon maneuvering the Command and Service Modules to a docking with the returning Lunar Module, visible through the window.) Major contractors for Apollo include The Boeing Company, Saturn V integration and construction of basic stage; North American Rockwell Corporation, second stage; McDonnell Douglas Corporation, third stage; International Business Machines Corporation, Instrument Unit; North American Rockwell (Rocketdyne), propulsion, all Saturn V stages; North American Rockwell (Space Division), Command and Service Modules; Grumman Aerospace Corporation, Lunar Module; Aerojet-General Corporation, Service Module propulsion system; TRW Inc., Lunar Module descent engine; Rocketdyne and Bell Aerospace, Lunar Module ascent engine.





1



2



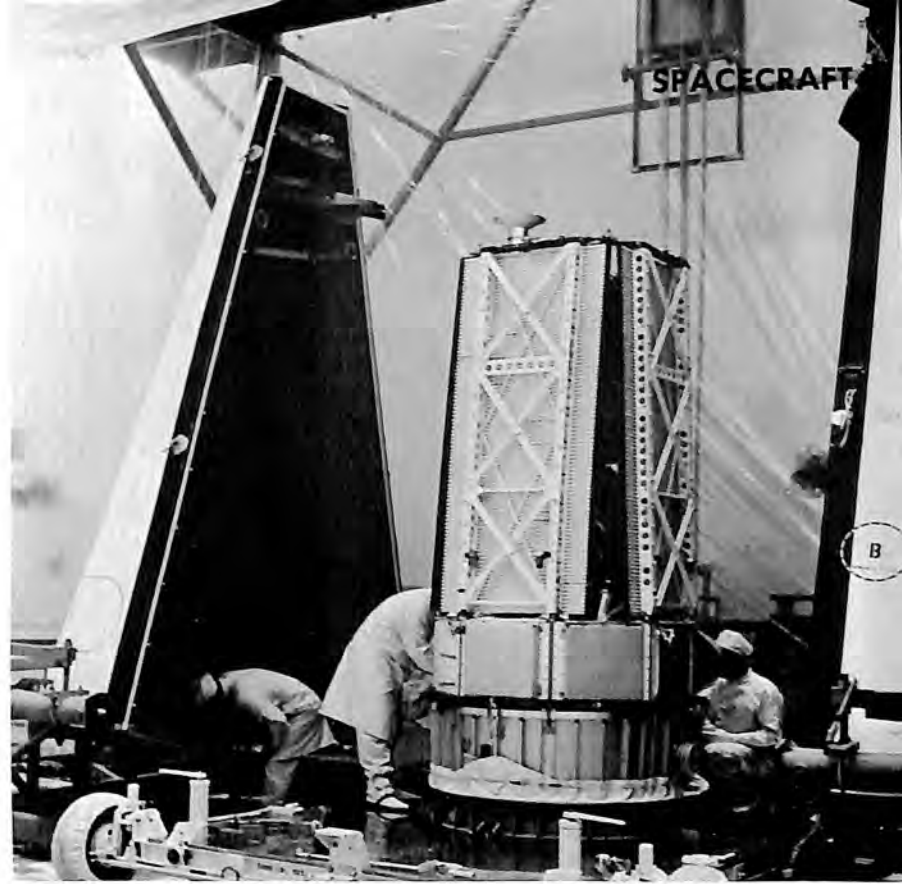
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SPACE STATION/SHUTTLE

NASA's advanced mission effort in 1969 focused on a space station and its associated logistics shuttle, both to be operational in the latter half of the decade. NASA's basic concept envisions a 12-man station, capable of growth to accommodate 50, with a lifetime of at least 10 years. In 1969, NASA awarded design and planning studies to McDonnell Douglas Corporation and North American Rockwell Corporation. Photo 1 shows one McDonnell Douglas concept of the 12-man station, with a resupply vehicle docked at one end while another maneuvers into docking position. The basic platform would be the nucleus for later growth to the 50-man station (Photo 2). A North American version of the basic station is shown in Photo 3. The vehicle at lower left is an experiment module placed in similar orbit. In left background, a logistics shuttle approaches.

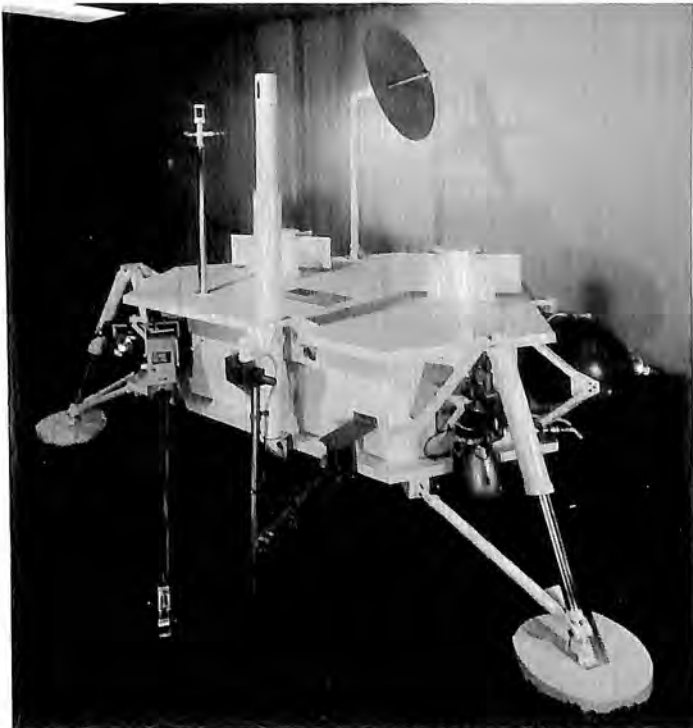
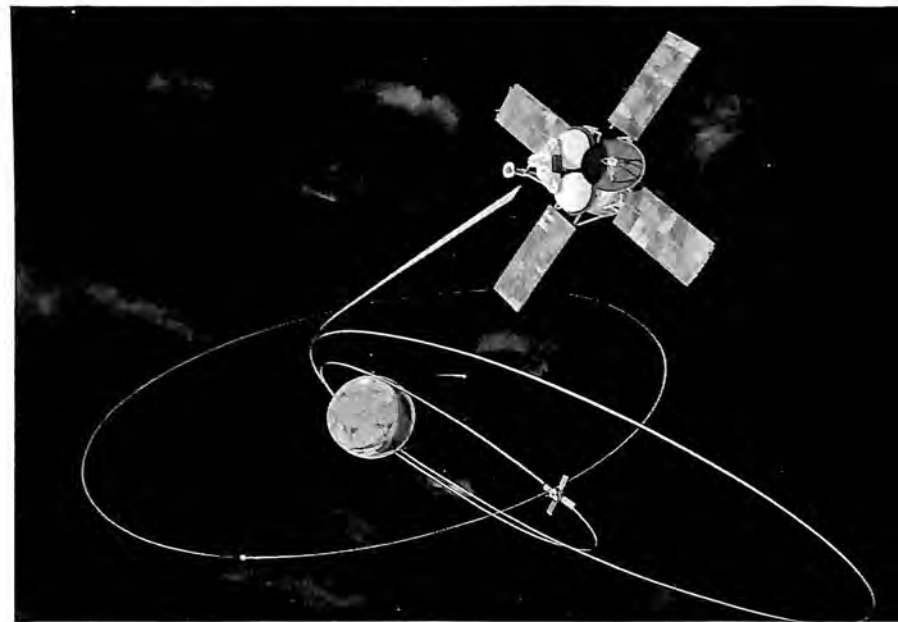
MARINER MARS '69

Mariner 6 (February 24) and Mariner 7 (March 27) were launched on Mars flyby missions, reaching the vicinity of the planet on July 31 and August 5, respectively. From approach points as close as 2,000 miles, the 2 spacecraft sent back data on the chemical composition of the Martian atmosphere and surface, together with nearly 200 high-resolution photos. Jet Propulsion Laboratory was prime contractor.



MARINER MARS '71

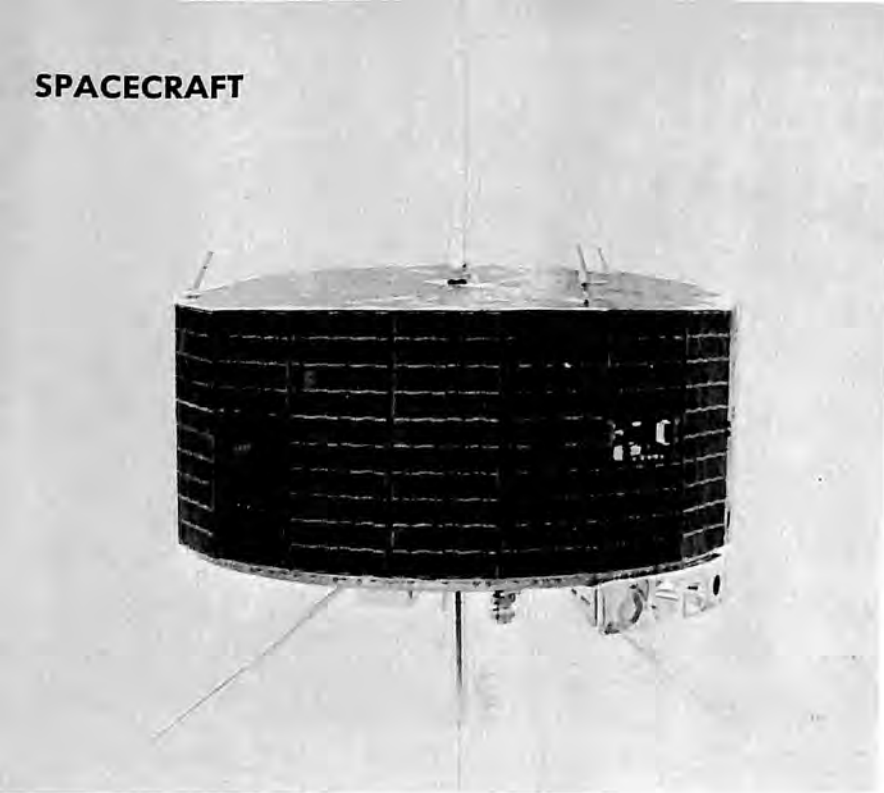
In hardware status were 2 advanced Mariners designed to orbit Mars at 1,500 miles for as long as 90 days. They will be launched in early spring of 1971 and go into Mars orbit in the fall. Prime contractor is Jet Propulsion Laboratory.



VIKING

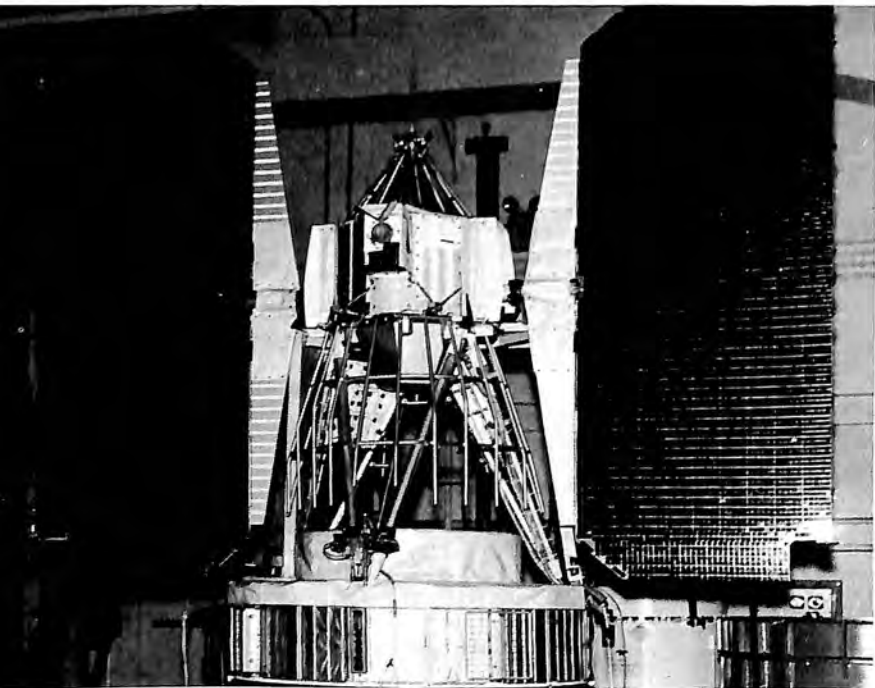
NASA assigned Martin Marietta Corporation as prime contractor for Project Viking, in which 2 spacecraft will be launched on a Mars life quest in 1975. The complete spacecraft will include both orbiters and landers. Jet Propulsion Laboratory was teamed with Martin Marietta. In photo, the 1,100-pound landing capsule, which will carry about 70 pounds of experiments and life-detection equipment.

SPACECRAFT



ESSA 9

NASA launched, for the Environmental Science Services Administration, the ESSA 9 weather satellite on February 26. It was a replacement in the U.S. satellite network for ESSA 7, no longer functioning. RCA built the spacecraft.



NIMBUS 3

Nimbus 3, launched April 14, marked a milestone in metsat technology by taking the first "vertical soundings," readings of atmospheric conditions from the ground up. The Nimbus spacecraft are built by General Electric Company.



TIROS M

The latest in RCA's series of Tiros weather satellites, Tiros M, was being readied at year-end for early 1970 launch. In addition to its normal cameras, Tiros M carries infrared radiometers for nighttime cloud coverage and secondary sensors for vertical soundings. Tiros M is the forerunner of an advanced series of metsats, space buses that can carry a variety of sensors.

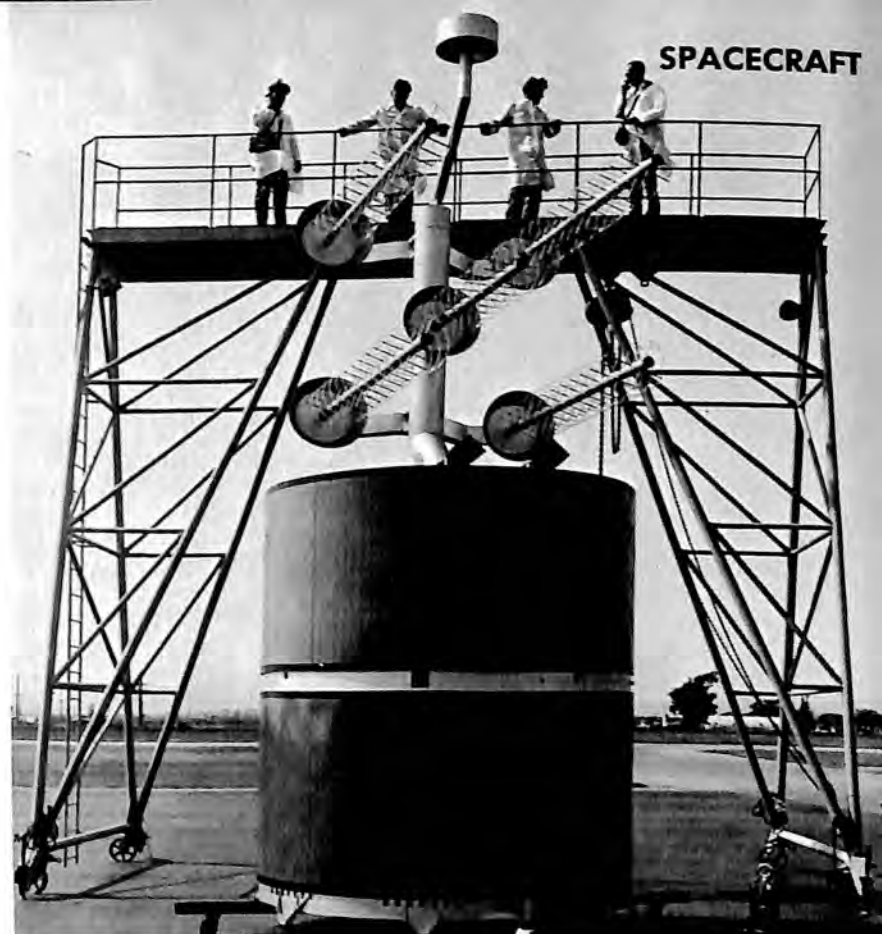
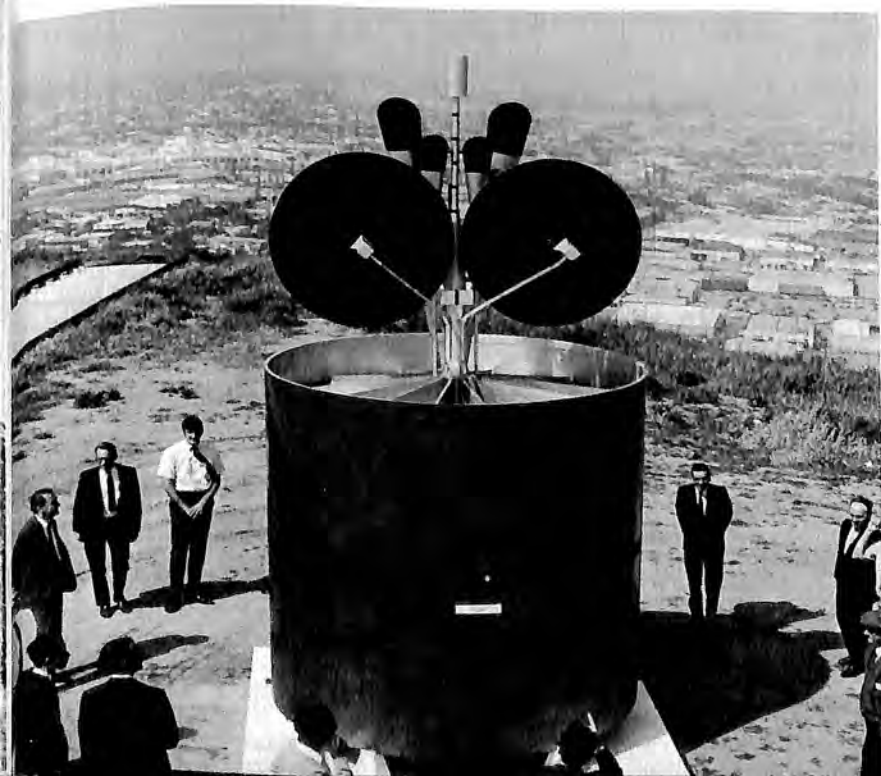


INTELSAT 3

Communications Satellite Corporation launched 2 additional Intelsat 3 comsats, bringing to 4 the number in service. Intelsat 3 F-3 was launched February 5 and F-4 was orbited May 21. A third satellite, designated F-5, failed to achieve orbit after a July 25 launch and Comsat scheduled a replacement launch for early 1970. TRW Inc. builds the Intelsat 3s.

INTELSAT 4

In fabrication status was Intelsat 4, being built by Hughes Aircraft Company for Communications Satellite Corporation. The world's largest commercial comsat, Intelsat 4 will be 17½ feet high and almost 8 feet in diameter and will have a capacity 25 times that of any in-service comsat. It is slated for 1971 launch.

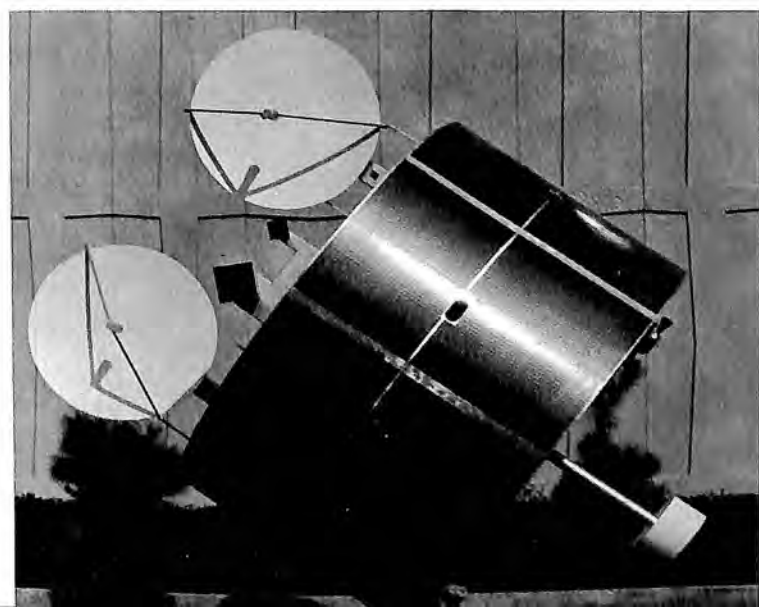


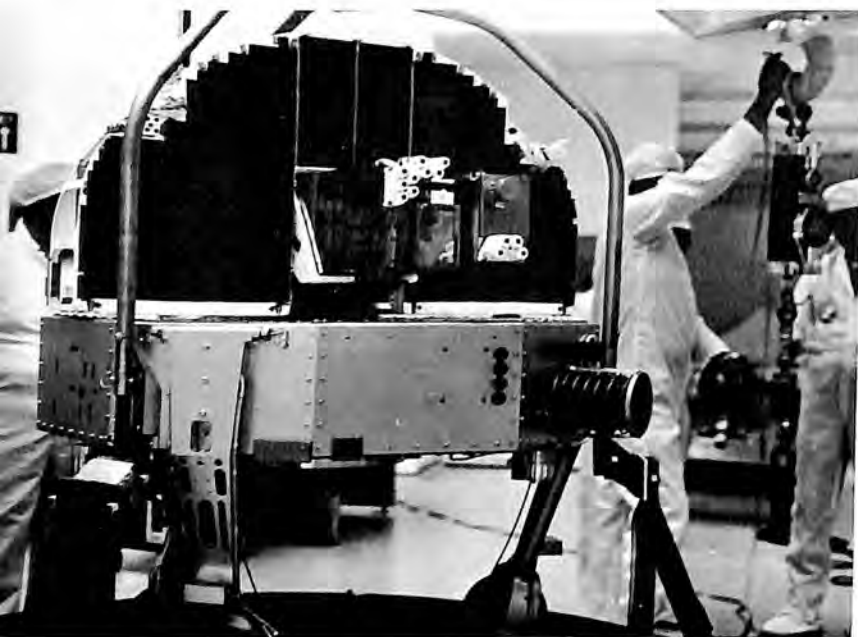
TACSAT

Launched February 9 into synchronous orbit was the largest communications satellite ever orbited, the Air Force's TACSAT, built by Hughes Aircraft Company. Weighing 1,600 pounds, TACSAT is designed for message relay between stations equipped with very small antennas.

DEFENSE SATELLITE COMMUNICATIONS SYSTEM PHASE II

The Air Force contracted with TRW Inc. for development of a new series of comsats for Phase II of the Defense Satellite Communications System. The satellites will be synchronous-orbiting and they will eventually replace the 26 comsats in the Initial Defense Satellite Communications System. They will make possible large volume communications between small transportable terminals.



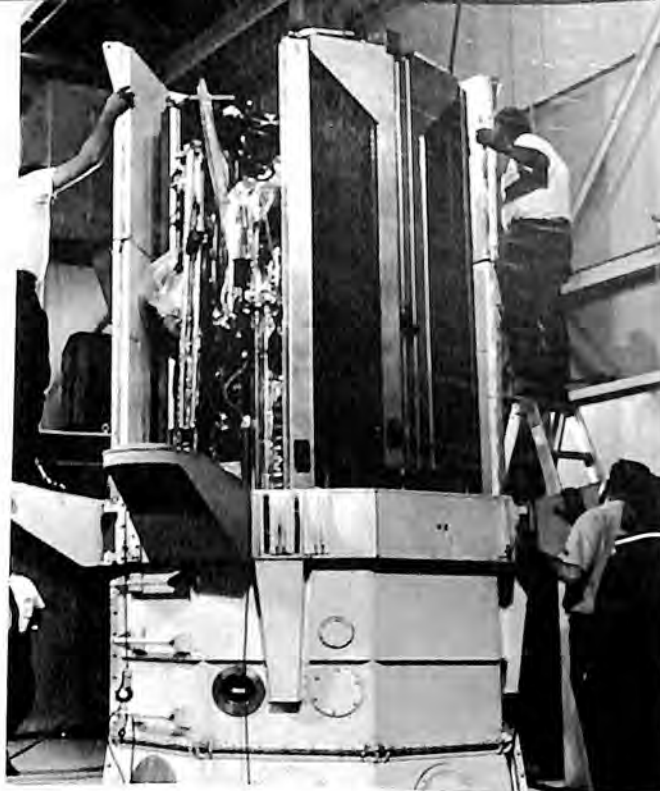


ORBITING SOLAR OBSERVATORIES 5 AND 6

NASA launched 2 more Orbiting Solar Observatories in its continuing study of solar phenomena and radiation. OSO 5 was successfully orbited on January 22; OSO 6 went into space on August 9. The OSOs were built by Ball Brothers Research Corporation.

EXPLORER 41

On June 21, NASA launched Explorer 41, also known as Interplanetary Monitoring Platform G. The satellite, built by Goddard Space Flight Center, carried 12 experiments to study particles and fields near earth and as far out as 100,000 miles.

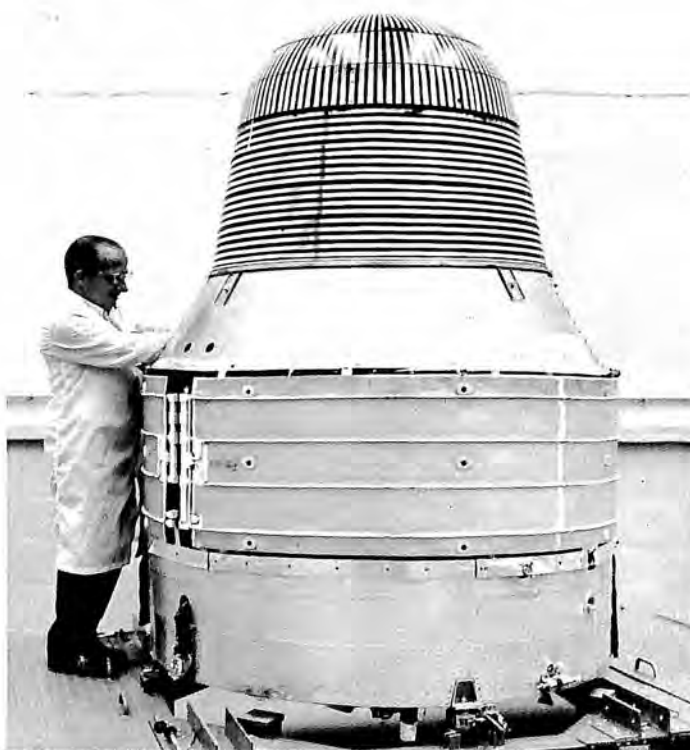


ORBITING GEOPHYSICAL OBSERVATORY 6

The last of the Orbiting Geophysical Observatory spacecraft, OGO 6, was successfully launched June 5. Built by TRW Inc., it carried 25 experiments investigating earth-sun relationship.

BIOSATELLITE 3

Intended primarily as an experiment in the effects of long-term weightlessness, Biosatellite 3, launched June 28, was only partially successful. Its encapsulated monkey subject, recovered by midair snatch, died after only 9 days in orbit. However, the basic spacecraft remained in orbit for 38 days and provided long-duration data on such functions as fuel cell power, attitude control, telemetry, and tracking. General Electric was prime contractor.



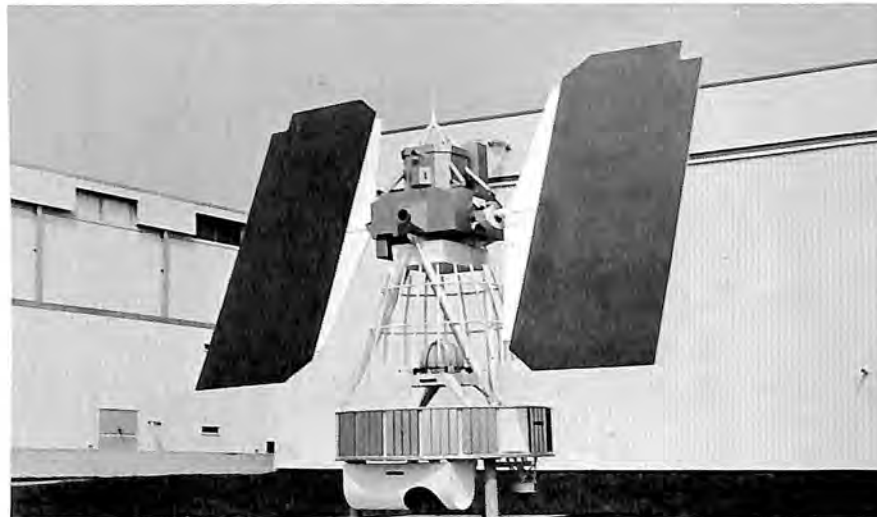
APPLICATIONS TECHNOLOGY SATELLITES

On August 12, NASA launched the Hughes-built Applications Technology Satellite 5, last of a first-generation series of spacecraft designed to test advanced equipment for applications satellites. At year-end, NASA was preparing to select a contractor for development of 2 advanced members of the family, ATS-F and -G. In photo, a NASA model of the planned new satellite; the basic spacecraft in foreground is dwarfed by the 30-foot-diameter parabolic antenna, folded during launch and deployed in space.



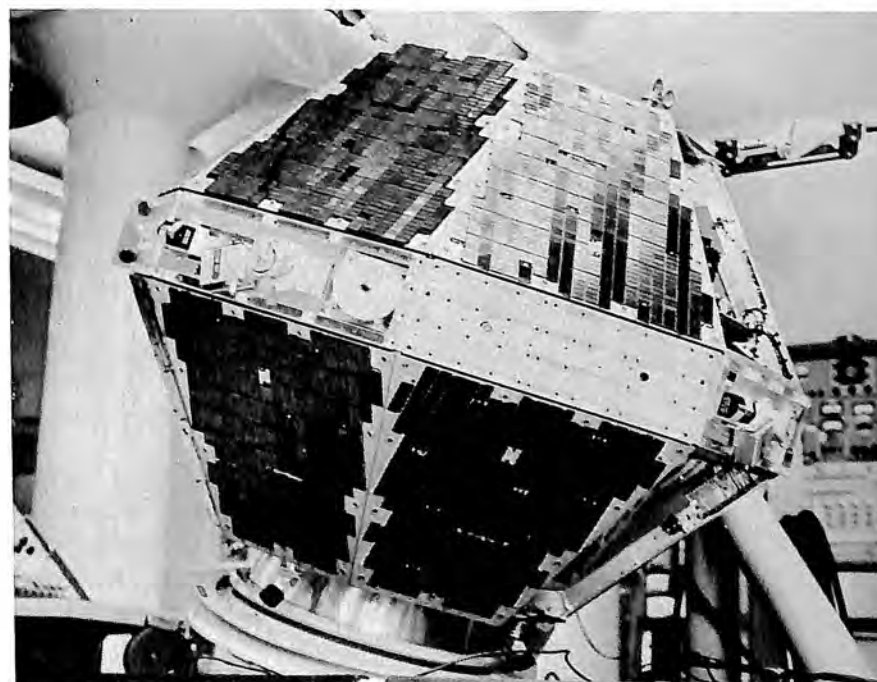
EARTH RESOURCES TECHNOLOGY SATELLITE

In design competition status at year-end was the Earth Resources Technology Satellite, forerunner of a late-1970s operational system for monitoring earth's resources. The ERTS program includes 2 satellites carrying sensor and data collection experiments. First launch was planned for 1972. In photo, General Electric's design.

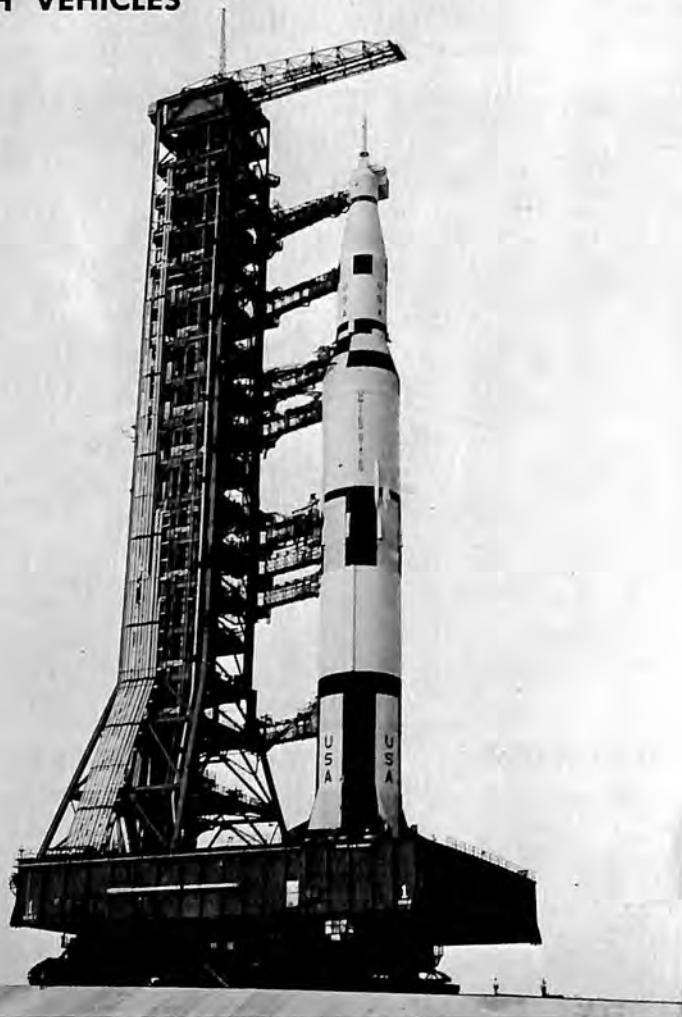


INTERNATIONAL PROGRAMS

Continuing its program of international space cooperation, NASA provided launch and advisory services for a number of foreign projects during 1969. Among them were ISIS 1 (photo), a Canadian ionosphere sounding satellite, launched January 30; ESRO 1B, a polar ionosphere investigator, launched October 1 for the European Space Research Organization; Azur 1, Germany's first satellite, launched November 7 to study radiation belts; and Skynet A, a comsat project of the British Ministry of Defense, launched November 21.



LAUNCH VEHICLES



SATURN V

The world's most powerful launch vehicle, Saturn V, performed flawlessly on 4 Apollo missions in 1969 for a total record of 7 successes in 7 flights. Major contractors include Boeing, North American Rockwell, McDonnell Douglas, and International Business Machines Corporation.

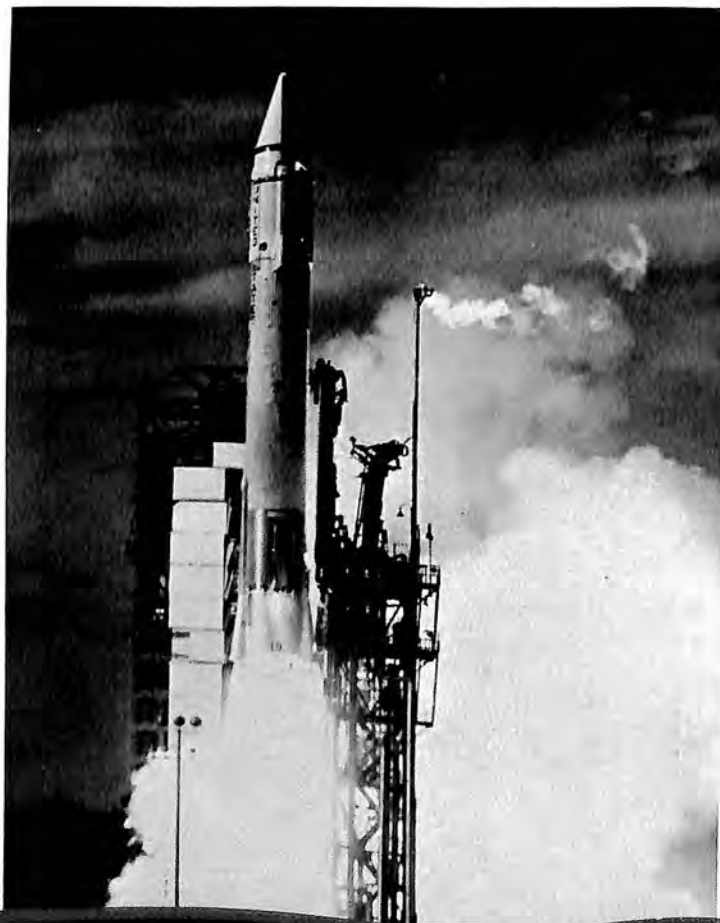
ATLAS/CENTAUR

Scoring its eighth and ninth straight successes, Atlas/Centaur launched 2 Mariners toward Mars on February 24 and March 27. Later in the year, it lofted ATS 5 into orbit. The launch vehicle is built by Convair Division of General Dynamics Corporation.



TITAN III

On May 23, the Air Force launched the final Titan IIIC in the research and development phase of the program, sending 5 satellites into various orbits. With the flight, The Aerospace Corporation concluded its technical direction activities. Martin Marietta Corporation continued to build operational Titan IIIs in 4 versions.



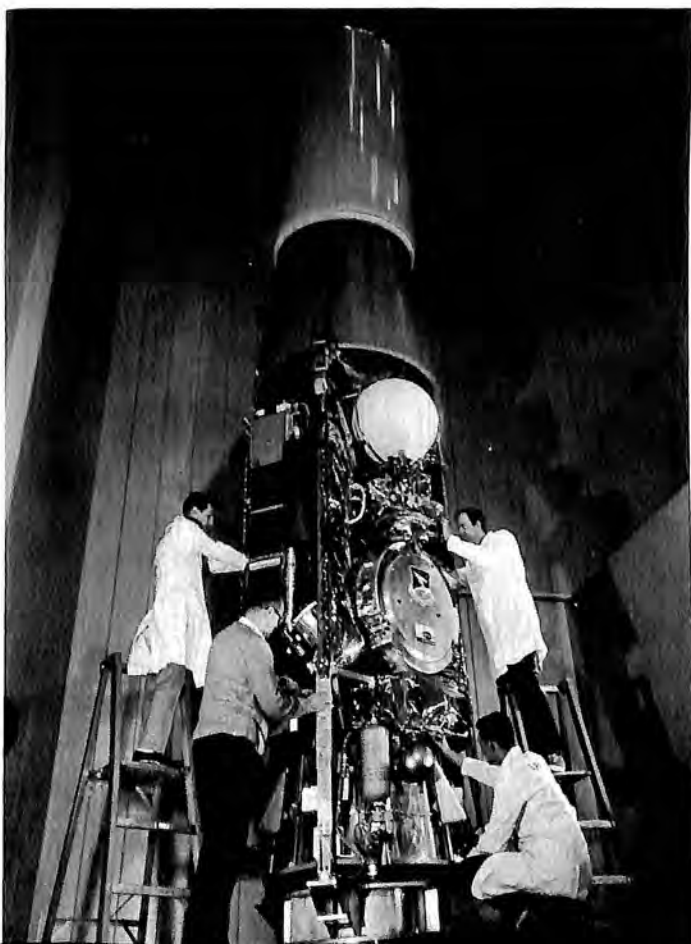
DELTA SUPER SIX

McDonnell Douglas unveiled the newest member of the versatile Delta family of launch vehicles, Delta Super Six. The new booster has 6 jettisonable solid motors clustered around the base of the first stage; earlier Deltas have 3. The change boosts basic thrust by 150,000 pounds, to a total of 483,000 pounds.



KANGAROO

United Technology Center was developing a new type of sounding rocket, Kangaroo, capable of reaching altitudes of over 400,000 feet. It is intended to serve primarily as a "space scout," to be sent aloft prior to manned spacecraft launches and reentries to scout the spacecraft's trajectory for possible radiation and other hazards. It will also be used as a meteorological rocket and explorer of the radiation belts.



BURNER IIA

The Boeing Company initiated development of Burner IIA, an advanced version of the Air Force's solid-fuel upper stage. Burner IIA is a 2-stage version capable of orbiting a greater variety of payloads into more precise trajectories.



MISSILES

POSEIDON

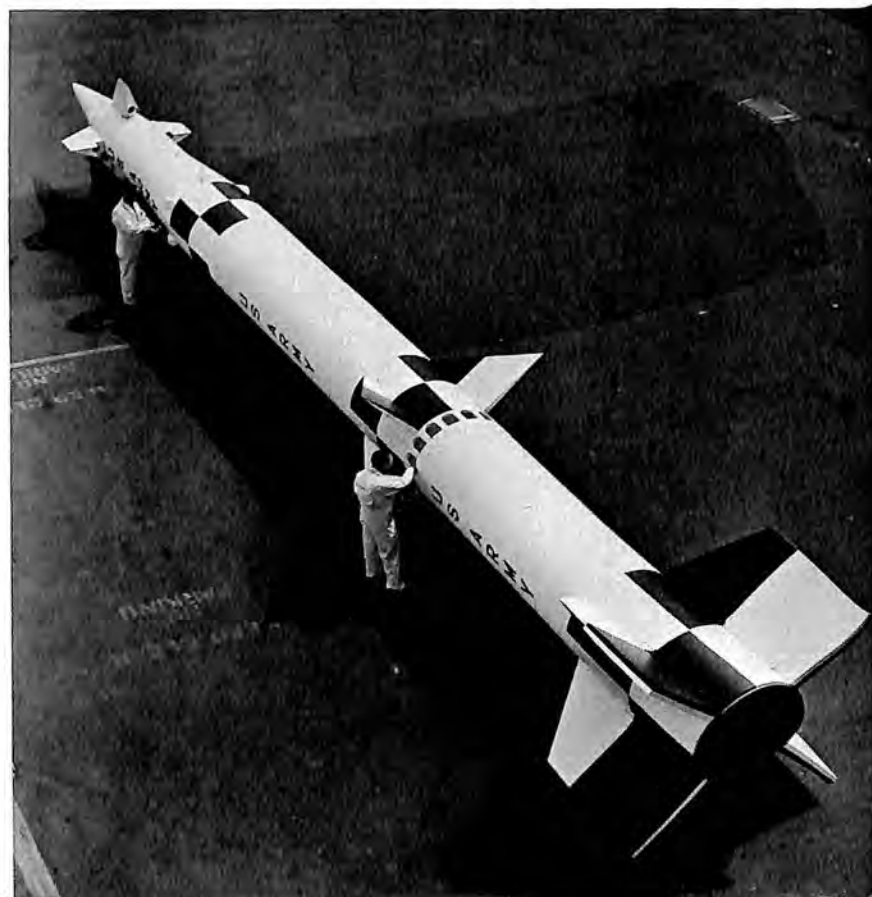
Poseidon, the Navy's newest sub-launched ballistic missile, cleared another test hurdle on December 17 when it was successfully sea-launched for the first time. The missile was fired from the USS *Observation Island* toward a target 1,000 miles down the Eastern Test Range. Being considered for hardware development at year-end was a Poseidon follow-on known tentatively as the ULMS (Undersea Long-Range Missile System). Lockheed Missiles & Space Company is Poseidon prime contractor.

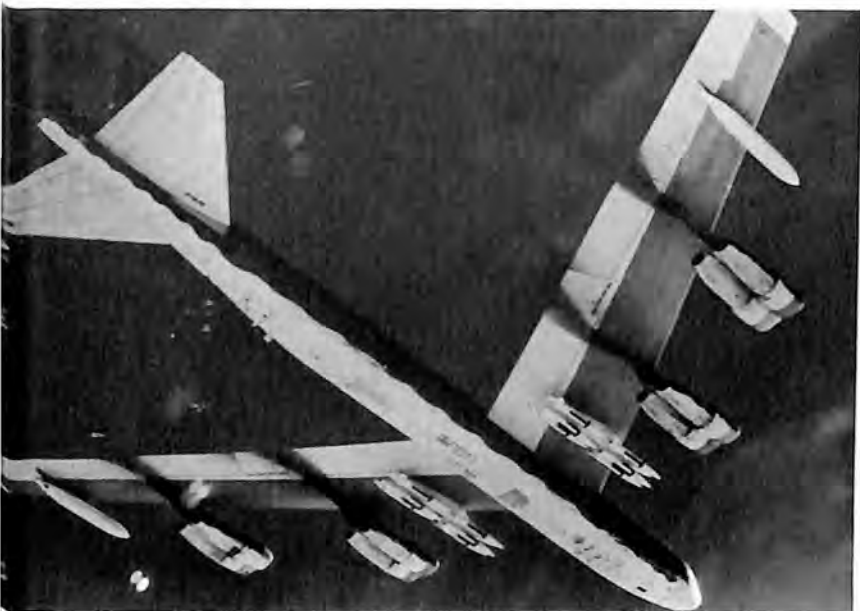
AEGIS (No Photo)

The Navy signaled go-ahead on a major new missile system called Aegis and awarded RCA an engineering development contract. Aegis, also known as the Advanced Surface Missile System, is to be a fleet defensive system against aircraft and missile attack in the mid-1970s and beyond. The missile component of the system will be a modified version of the Standard missile, built by General Dynamics Corporation. The total system will include, in addition to the missile, an advanced scanning radar, missile-guiding illuminator radars, a computer, and a versatile launcher capable of firing either air defense or antisubmarine missiles.

SAFEGUARD

Sprint and Spartan (photo), the low-altitude and long-range interceptors, respectively, of the Army's Safeguard missile defense system, continued in advanced test status during 1969, and the antiballistic missile program moved into a new developmental stage. The Advanced Research Projects Agency of the Department of Defense awarded McDonnell Douglas Astronautics Company, Spartan producer, a contract to develop and test a new ABM configuration called Upstage. McDonnell Douglas and Martin Marietta-Orlando (Sprint manufacturer) serve as principal subcontractors to Western Electric Company, Safeguard prime contractor, and Bell Telephone Laboratories, responsible for system design and development.





SRAM

The Air Force's SRAM (Short-Range Attack Missile), being developed by The Boeing Company, entered flight-test status and several successful powered launches were conducted. SRAM is an air-to-ground weapon with nuclear capability, planned for deployment on late model B-52s and on FB-111 bombers.

ZAP (No Photo)

Test firings from a Navy A-4 aircraft of the ZAP flak-suppression missile got under way in November. ZAP (Zero Antiaircraft Potential) is a non-nuclear rocket fired from underwing pods. Martin Marietta-Orlando, Thiokol, and Avco team to produce the missile.



SAM-D

The first "launch environmental" tests of SAM-D, the Army's multiple-launch air defense system for field use, were conducted at Martin Marietta-Orlando late in the year. Full-scale, flightweight missile models were fired from test canisters similar to those to be employed in the operational system. First 2 tests of the "bazooka-launch" technique were successful. Martin Marietta builds the missile and canister as principal subcontractor to Raytheon Company.



MINUTEMAN

The Air Force's Minuteman III 3-stage solid-fueled ICBM continued in flight-test status. The third version of the ICBM has a new reentry system and a third-stage engine of increased diameter to provide greater flexibility in delivering heavier payloads than Minuteman I and II. Late in 1969, the USAF initiated a study of the feasibility of developing a mobile version of Minuteman. The Boeing Company is Minuteman prime contractor.

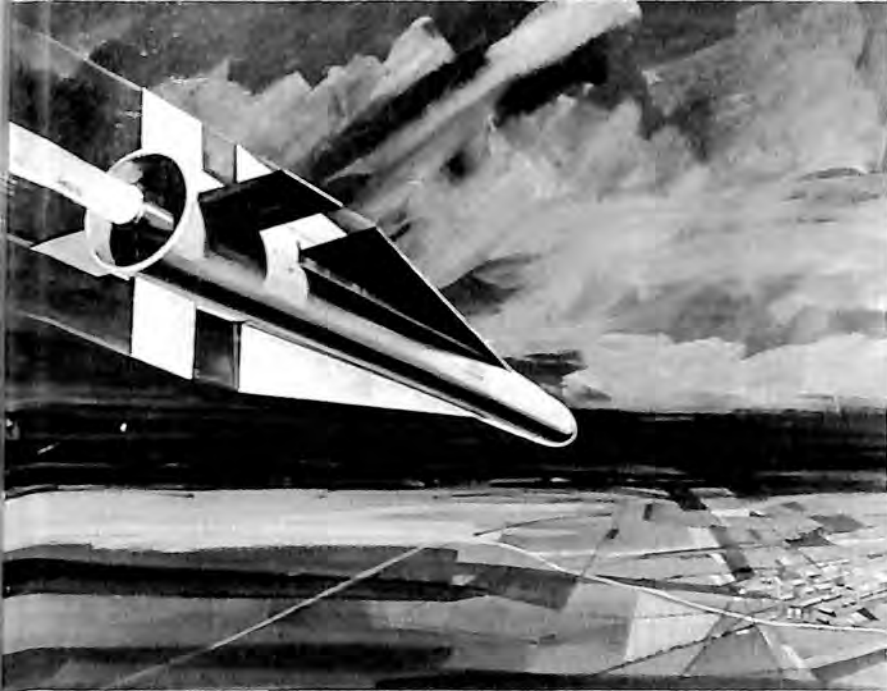
LANCE

The Army's Lance mobile surface-to-surface missile moved closer to production with successful completion of temperature-extreme environmental tests and first firings of the extended-range version of the system. Lance is being developed by LTV Aerospace Corporation.

PERSHING 1-A

In the latter part of the year, the Army started converting some of its Pershing missile units to the new Pershing 1-A system. The new system features major improvements in ground-support equipment, among them wheeled (instead of tracked) vehicles for transporting firing units and a fast-reacting erector-launcher. Martin Marietta-Orlando is prime contractor for Pershing 1-A.





MAVERICK

The Air Force's Maverick, a Hughes Aircraft-built TV-guided air-to-ground missile, began unguided flight tests in September and first guided tests in December. Maverick will be carried by USAF F-4s, F-111s, and A-7Ds.



CONDOR

Development of the Navy's Condor missile progressed during the year with several unpowered flights and a series of ground tests of the weapon's solid rocket motor. Built by Columbus Division of North American Rockwell, Condor is a TV-guided missile designed to give Navy attack aircraft stand-off capability.

HARPOON (No Photo)

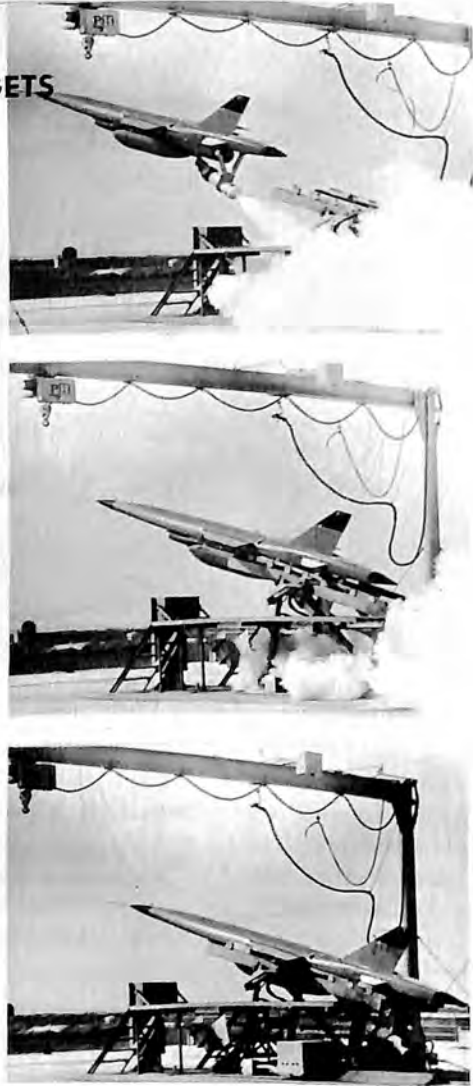
At year-end, the Navy was preparing to initiate development of a new anti-shipping missile called Harpoon. The weapon would be built in 2 versions, one for air-launch and the other for firing from surface vessels.

PHOENIX

A highlight of the Phoenix air-to-air missile development program came in March when, for the first time, 2 missiles simultaneously launched from a single aircraft scored direct hits on 2 different airborne targets. The firing was a test of the multiple-launch capability of the AWG-9 missile control system. Phoenix and AWG-9, both built by Hughes Aircraft, will be used on the Navy's F-14 fighter.



DRONES AND TARGETS



FIREBEE II

Naval Air Systems Command awarded a production contract to Teledyne Ryan Aeronautical for the Firebee II 1,000-mile-per-hour jet target drone. At year-end, Firebee II was undergoing Navy mission evaluation flights prior to fleet deployment, slated for early 1971.

LOCAT

Aeronutronic Division of Philco-Ford Corporation received an order from the Army for a test and evaluation quantity of its LOCAT (Low-Cost Aerial Target). Made of plastic and rolled paper tubing, LOCAT is a ballistic aerial target system used by the Army to train missile crews in defense against low-altitude aircraft.



GUNRUNNER

A new low-cost aerial target system, developed by Atlantic Research Corporation for both Army and Navy use, is Gunrunner, built by a unique molded foam fabrication process. Gunrunner was in flight status in 1969, being used primarily for training Army troops in the use of the Redeye missile.



BOEING 747

Heralding the start of a new era of commercial air transportation, the Boeing 747 successfully accomplished its maiden flight on February 9. Over the following 10 months, 5 production aircraft accumulated well over 1,000 test hours; first delivery was made to Pan American World Airways on December 13. By year-end, Boeing was turning out one of the advanced-technology jetliners every 4½ working days.



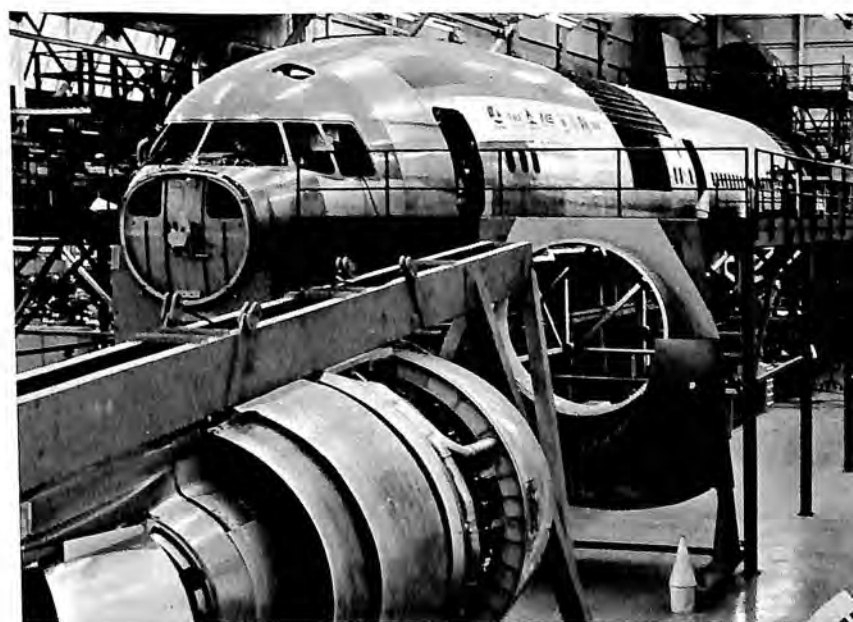
McDONNELL DOUGLAS DC-10

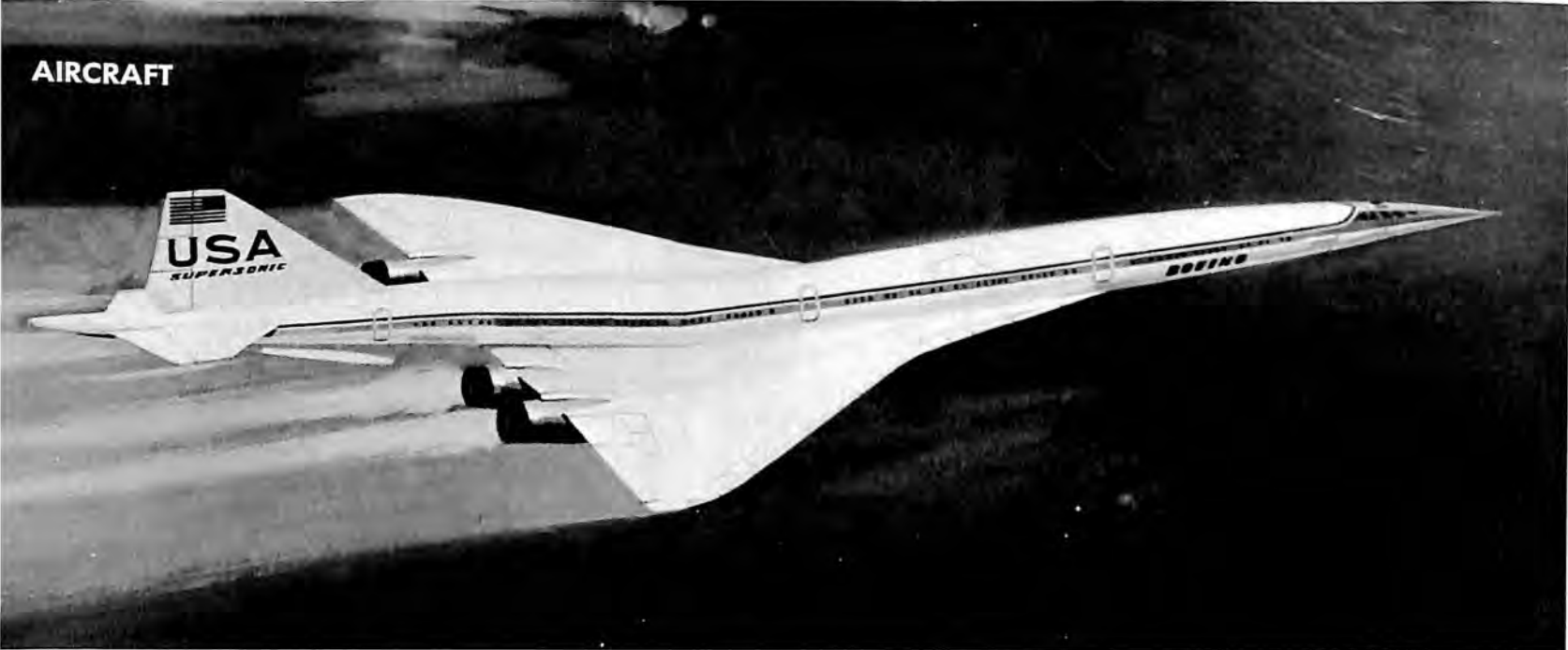
The McDonnell Douglas DC-10, another of the "wide-body" advanced-technology jetliners, moved into hardware status in 1969. First manufacturing operations began January 9 and initial assembly operations started June 23 at the company's Santa Monica facility. The upper and lower halves of the first DC-10 production nose section were joined October 17 at Santa Monica and the unit was transferred to the Long Beach plant, where final assembly was under way at year-end.



LOCKHEED L-1011

At Lockheed's Burbank and Palmdale facilities, major assembly work began on the third of the "wide-bodies," the L-1011 TriStar. By year-end, all major fabrication work was in production. Schedules called for first mating of fuselage sections in January 1970, complete fuselage mating in February, and first flight late in 1970.





BOEING SUPERSONIC TRANSPORT

In September, President Nixon recommended government funding of 2 prototypes of the Boeing-designed U.S. supersonic transport. Work started on long-lead-time equipment, on tooling, and on engineering mock-ups, including a metal mock-up of the entire fuselage and one wing. Target date for SST commercial service is 1978.

LOCKHEED C-5 GALAXY

During the year, Lockheed-Georgia Company amassed over 1,700 test hours on 9 C-5 Galaxy Air Force jet transports, the largest aircraft in the world. First delivery to the USAF was made December 17 in formal ceremonies at Marietta, Georgia.



USAF B-1 (No Photo)

The long-projected Advanced Manned Strategic Aircraft, newly designated B-1, went into design competition status in 1969. Design guidelines called for a Mach 2.5 nuclear bomber capable of B-52 range and weighing less than 450,000 pounds. Competitors included Boeing, North American Rockwell, and General Dynamics. Selection of a contractor for hardware development was expected before July 1, 1970.

SWEARINGEN METRO

The Swearingen SA-226TC Metro, a cooperative venture of Swearingen Aircraft and Fairchild Hiller Corporation, made its initial flight on August 26. The Metro is a 22-place turboprop commuter airliner. Certification and first deliveries were expected early in 1970.



CESSNA CITATION

The Cessna Citation, a 6- or 7-place fanjet-powered corporate aircraft, made its first flight on September 15. Initial deliveries were scheduled for late 1971. Cessna announced that the Citation is the first of a new family of business jets.



BEECH KING AIR 100

New flagship of the Beechcraft corporate aircraft fleet is the King Air 100, introduced in May. Beech was building the King Air 100 in a variety of configurations, including a 15-place commuter version. It is powered by twin turbines and is pressurized.



McDONNELL DOUGLAS MODEL 188

McDonnell Douglas and American Airlines teamed to conduct a 3-month evaluation of the operating characteristics of STOL aircraft in intermetropolitan service, using the Model 188 STOL, for which McDonnell Douglas has a licensing agreement with Breguet Aviation of France. In photo, Model 188, which can land in less than 400 feet, prepares to touch down at Meigs Field on the lakefront in downtown Chicago.





McDONNELL DOUGLAS F-15

A competition for the Air Force's highest priority development program was resolved December 23 with an award to McDonnell Douglas Corporation for the F-15 air superiority fighter, planned as the U.S. fighter mainstay until the mid-1980s. Designed for both air-to-air and air-to-ground capability, the F-15 will be a single-place, fixed-wing, Mach 2-plus, twin-turbofan aircraft in the 40,000-pound class; it will carry a mix of medium- and short-range missiles together with an internal rapid-firing gun. Long-range plans envision as many as 700 airplanes. Initial contract called for engineering and fabrication of 20 developmental-test aircraft at a cost of \$1.146 billion.



GRUMMAN F-14

In January, Grumman Aerospace Corporation was awarded the development and production contract for the Navy's F-14 air superiority fighter, a 2-place tandem aircraft featuring a variable-geometry wing and powered by twin turbofans. Initial contract authorized 6 prototypes and targeted first flight for early 1971.



GENERAL DYNAMICS FB-111A

Fort Worth Division of General Dynamics made first delivery of the FB-111A Air Force bomber to Strategic Air Command on October 8. The variable-wing bomber has the same fuselage as the F-111 fighter but a wingspan 7 feet longer. Initial SAC employment was to be for training flight crews at Carswell AFB, Texas.

LTV AEROSPACE A-7

Vought Aeronautics Corporation, a subsidiary of LTV Aerospace, started deliveries of the A-7D tactical fighter (photo) to the Air Force on September 1. The company also completed production of the Navy's A-7B and introduced a new Navy version, the A-7E, which successfully completed carrier-suitability trials aboard the USS *Independence* in October.



LOCKHEED P-3C ORION

Lockheed-California Company made initial deliveries of the P-3C Orion to the Navy in September. An advanced version of the patrol craft that has been in Navy service since 1962, the P-3C is equipped with the computerized A-NEW antisubmarine detection system. The program called for about 100 P-3Cs.



LOCKHEED S-3A

In August, the Navy awarded a contract for development and production of a new antisubmarine patrol aircraft, the S-3A, which will have a computer-controlled avionics package, an extension of that in the P-3C. The contract was awarded to a 3-company team; Lockheed-California, prime contractor, will be assisted by Vought Aeronautics and Sperry Rand.



GRUMMAN E-2B HAWKEYE

The Grumman E-2B, a new, computer-equipped version of the 10-year-old Navy Hawkeye early-warning aircraft, made its first flight on February 20. Grumman initiated development of a more advanced model, the E-2C, with improved avionic systems.





LOCKHEED YO-3A

Lockheed Missiles & Space Company unveiled its YO-3A quiet observation aircraft, developed for the Army Aviation Systems Command. Powered by a 6-cylinder engine turning a 6-bladed propeller, YO-3A is a 2-place craft adapted from a Schweizer sail-plane; it is capable of remaining aloft for long durations with little power expenditure. It was in limited production.



McDONNELL DOUGLAS A-4M

McDonnell Douglas initiated development of still another model of the ageless A-4 Skyhawk attack bomber. The new version is the A-4M, featuring a higher-thrust engine and increased firepower. For Marine Corps use, it was slated for service introduction in 1971.



McDONNELL DOUGLAS TA-4J

In June, McDonnell Douglas delivered the first 7 TA-4J Skyhawks to the Navy. The TA-4J is an advanced jet trainer version of the Skyhawk series.



NORTH AMERICAN ROCKWELL T-2C

In January, Columbus Division of North American Rockwell incorporated into its production line the T-2C, an improved and more economical model of the basic trainer used by the Navy and the Marine Corps.

SIKORSKY SKYCRANE

In August, the Sikorsky S-64E Skycrane became the largest helicopter ever certificated for commercial use by the Federal Aviation Administration. It saw initial duty in Alaska's North Slope oil exploration project. Sikorsky also delivered to the Army the first CH-54Bs, improved versions of the military heavy-lift Skycrane.



SIKORSKY CH-53D/G

On September 25, Sikorsky delivered 2 CH-53D/G transport helicopters to the Federal Republic of Germany. They were the first of 135 to be built for Germany in a co-production program involving Sikorsky and German industry.



BELL AH-1J SEACOBRA

Bell Helicopter's AH-1J SeaCobra started its flight-test program in October. A twin-engine version of the HueyCobra, the high-speed weapons platform was being produced for the Marine Corps.



KAMAN HH-2C

Kaman Corporation made first deliveries to the Navy of the HH-2C armed search and rescue helicopter. The HH-2C is equipped with a chin-mounted minigun turret and waist-mounted machine guns.



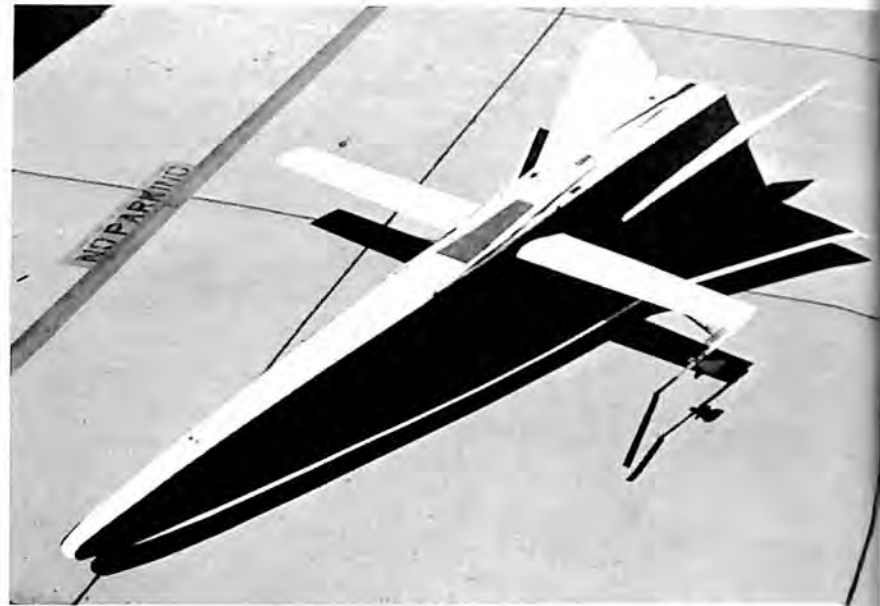


HUGHES 500

Hughes Tool Company's Aircraft Division initiated deliveries of its commercial Model 500 helicopter in May and by year-end the 500, a derivative of the Army OH-6A, was serving in 14 countries. The division was also producing the 500M, an international military version.

BELL OH-58 KIOWA

Bell Helicopter's OH-58A Kiowa joined the Army inventory in May in a light observation role and was introduced to Vietnam action in the fall. Bell had Army orders for 1,200 OH-58s and the total was expected to reach 2,200.

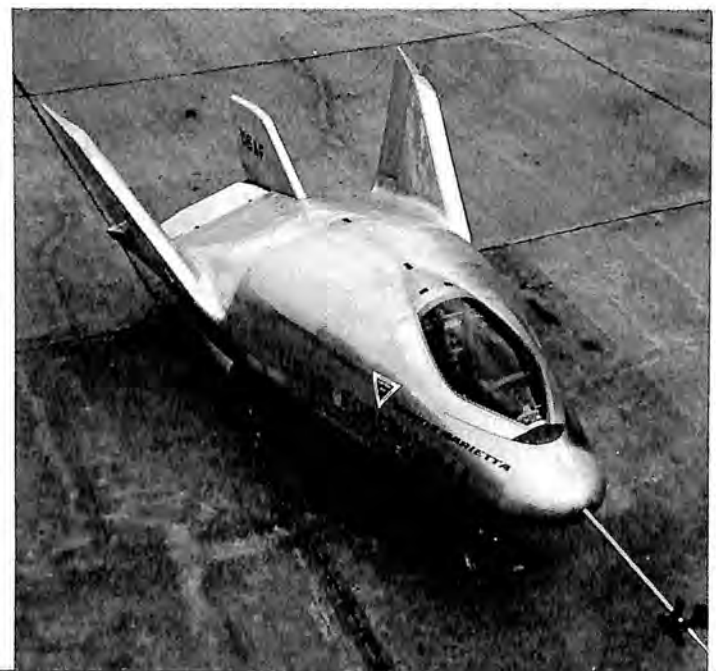


NASA HYPER 3

A new lifting-body research craft, Hyper 3, made its first glide flight on December 12. Helicopter-dropped from 10,000 feet, the craft was unmanned and guided to a landing by remote control. Hyper 3 was developed in-house by NASA's Flight Research Center.

MARTIN MARIETTA X-24A PILOT

A hybrid aircraft/spacecraft, the X-24A PILOT lifting-body research craft entered flight-test status in 1969; first glide flight was on May 5. Built by Martin Marietta-Baltimore, the rocket-powered X-24A is designed to explore lifting-body characteristics at velocities from Mach 2 down to landing speed.

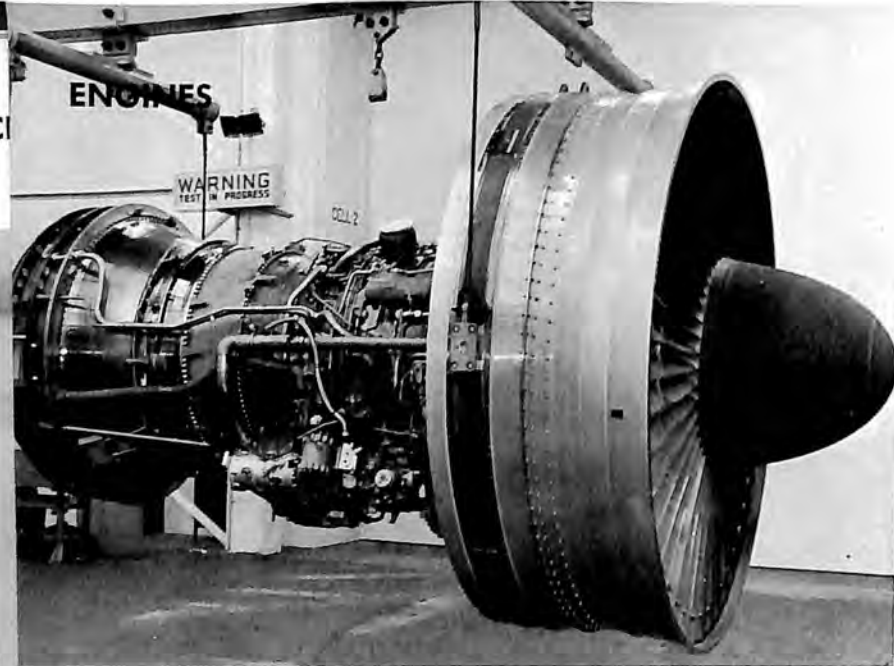




APOLLO ENGINES

Five types of rocket engines provided propulsion for the various phases of the historic 1969 Apollo moon missions. Launch of the Saturn V/Apollo stack from earth was the assignment of the F-1 (Photo 1), the world's most powerful rocket engine, built by Rocketdyne Division of North American Rockwell Corporation; 5 F-1s in the basic stage of Saturn V provided 7,600,000 pounds of launch thrust. The J-2 engine (Photo 2), also built by Rocketdyne, powered the upper stages of the launch vehicle; 5 J-2s, developing over 1,100,000 pounds of thrust, provided second stage propulsion, and a single J-2 in the third stage sent the moonbound Apollos into lunar trajectory. En route course corrections and the maneuvers that sent Apollo into and out of lunar orbit were handled by Aerojet-General's Service Propulsion System (Photo 3), a 20,500-pound-thrust rocket engine. Astronaut descent to the moon in the Lunar Module was accomplished by means of the Lunar Module Descent Engine (Photo 4); built by TRW Inc., the throttleable rocket provided variable thrust as needed, with power output ranging from 1,000 to 10,000 pounds. For escape from the moon and rendezvous with the waiting Command/Service Modules, astronauts used the 3,500-pound-thrust Lunar Module Ascent Engine (Photo 5), built by Rocketdyne. Also vital to mission successes were the attitude control thrusters of all 3 spacecraft modules; Marquardt built the 100-pound-thrust units for the Service Module and the Lunar Module, and Rocketdyne provided the 93-pound-thrust systems for the Command Module.





PRATT & WHITNEY AIRCRAFT JT9D

Pratt & Whitney Aircraft began deliveries of production models of the JT9D engine, power plant for the Boeing 747, in April. The JT9D, a 43,500-pound-thrust smokeless turbofan, was certificated for commercial operation in May.

PRATT & WHITNEY AIRCRAFT JT8D

Pratt & Whitney Aircraft developed a smoke-reducing combustion chamber for the JT8D, power plant for several jetliners, and participated with 8 airlines and the Federal Aviation Administration in an evaluation program which started in August. In photo of 2 Boeing 727 takeoffs, the lower plane is equipped with the redesigned chambers.

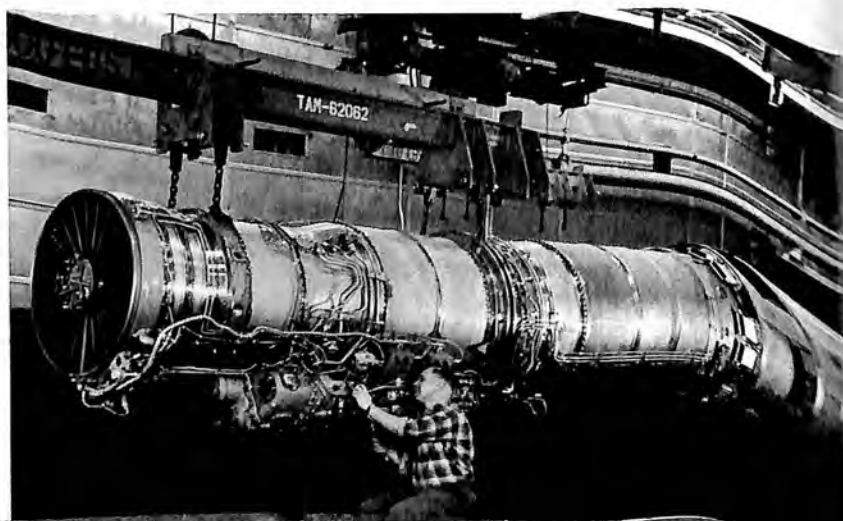


GENERAL ELECTRIC TF34

General Electric Company's TF34 high bypass turbofan, selected by the Navy to power the new Lockheed S-3A antisubmarine warfare aircraft, entered test status in April.

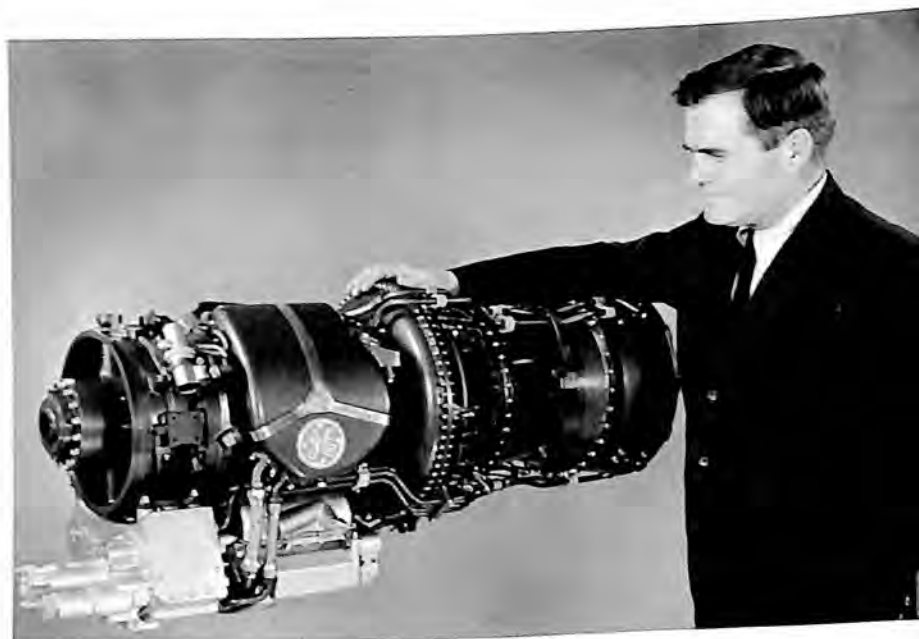
PRATT & WHITNEY AIRCRAFT TF30

The world's first afterburning turbofan, the TF30, was selected as the power plant for the Navy's Grumman F-14A fighter. Built by Pratt & Whitney Aircraft, the TF30 is in the 20,000-pound-thrust class.



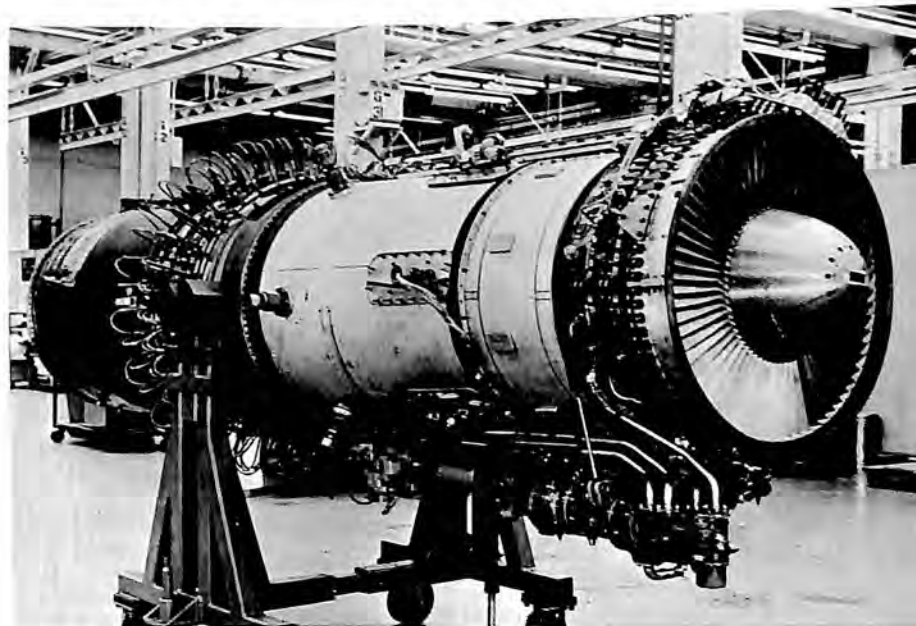
GENERAL ELECTRIC GE12

General Electric introduced the GE12, an advanced-technology demonstrator engine being developed under Army contract. The GE12 is a 1,500-shaft-horsepower turboshaft engine which features low weight, low fuel consumption, high reliability with low vulnerability, and simplified maintenance.



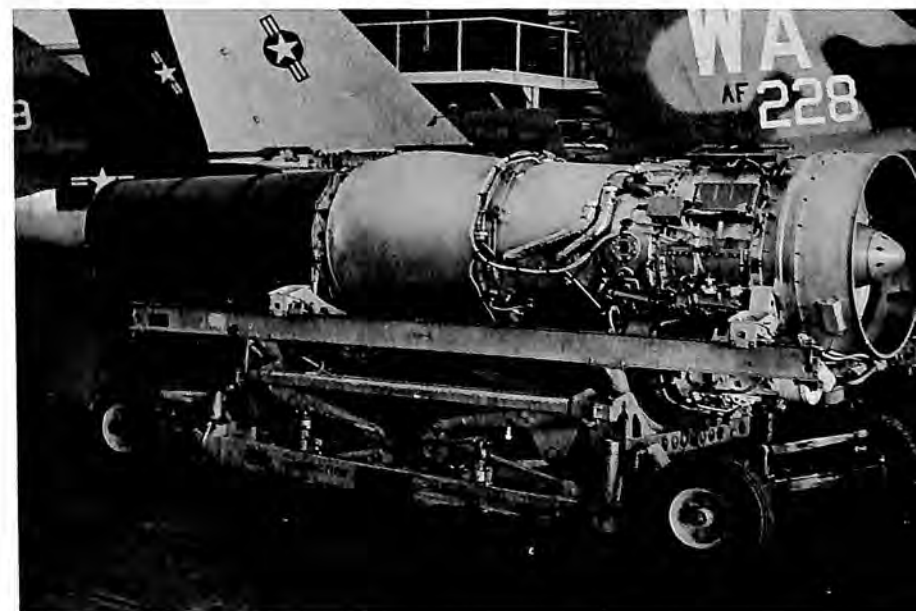
GENERAL ELECTRIC GE1/10

General Electric started testing an augmented turbofan demonstrator designated GE1/10. The engine provides the technological basis for the GE-proposed power plants for the USAF F-15 and the Navy F-14B air superiority fighters.



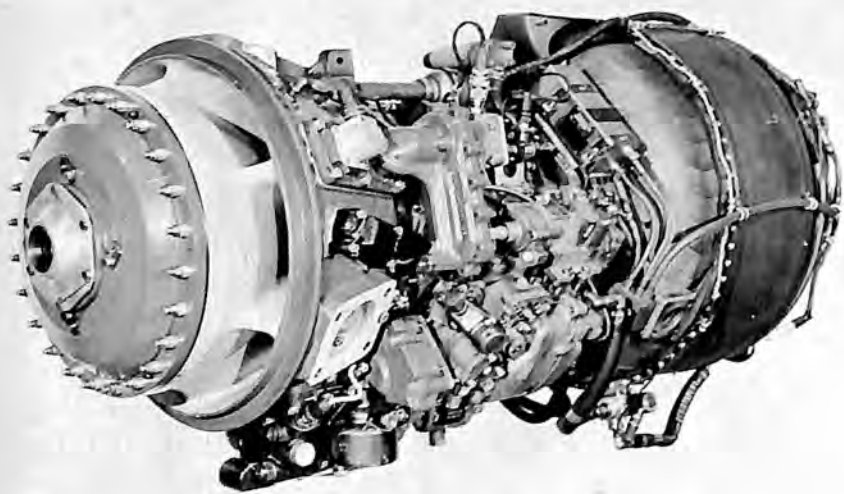
ALLISON TF41

Allison Division of General Motors Corporation made first deliveries to the Navy of the TF41-A-2, the 15,000-pound-thrust turbofan that powers the A-7E carrier-based attack aircraft. Also in production was the TF41-A-1, rated at 14,250 pounds thrust, power plant for the Air Force's A-7D.



ALLISON XJ99 (No Photo)

The XJ99 advanced lift-jet successfully completed its first test runs during 1969. The engine is being jointly developed by Allison and the Aero Engine Division of Rolls-Royce.

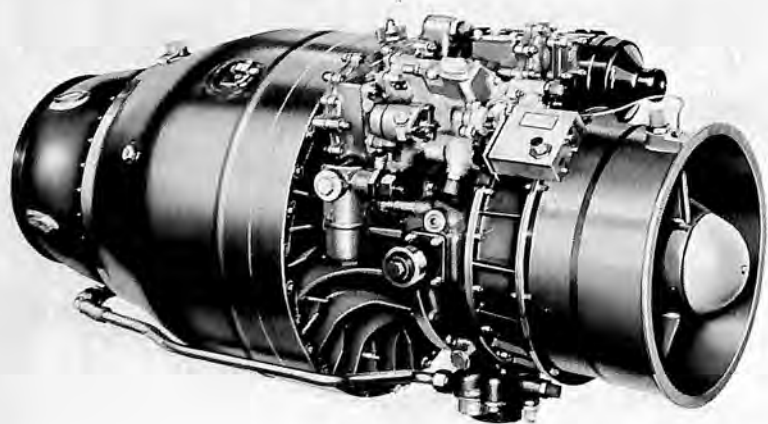


AVCO LYCOMING T53, T55

Avco Lycoming Division of Avco Corporation completed Federal Aviation Administration qualification tests on its new T53-19A helicopter engine. The division's research and development activities focused on an advanced model of the T55 series aimed at a USAF requirement for a new close-support aircraft.

CONTINENTAL J69

Teledyne Continental Aviation and Engineering successfully completed the flight-test program of its YJ69-T-406 engine, power plant for the supersonic Firebee II drone. The company received production orders for the -406 and for other J69 models used to power subsonic drones.

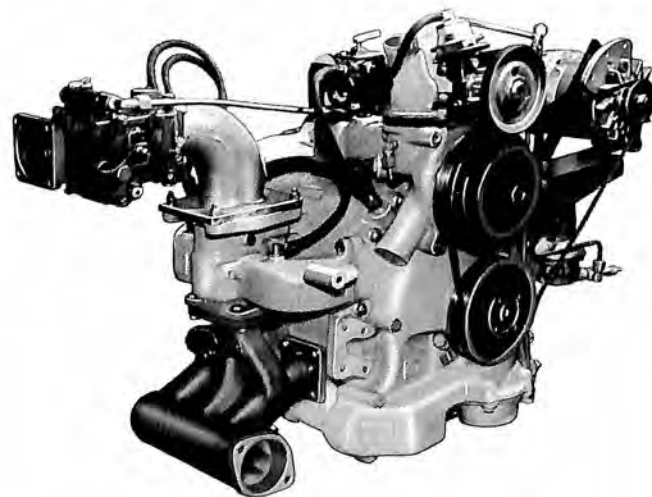


GARRETT-AIRESEARCH ATF 3

Garrett-AiResearch (Los Angeles) introduced the ATF 3, a 4,050-pound-thrust advanced-technology fanjet for corporate aircraft. A prototype engine attained full thrust in ground tests and the company was readying the ATF 3 for flight testing, scheduled to get under way early in 1970.

CURTISS-WRIGHT RC2-60

Curtiss-Wright's RC2-60 rotating combustion engine flew for the first time late in 1969. The test engine was installed in the Lockheed Q-Star quiet observation aircraft.





UNITED TECHNOLOGY 120-INCH MOTOR

United Technology Center ground-tested the most powerful flightweight, segmented solid-propellant motor ever fired, a 101-foot-tall system assembled from 7 40-ton 120-inch-diameter segments. The motor, a 7-segment version of the 5-segment rockets that power the lift-off stage of the Titan IIC, developed 1,400,000 pounds thrust.

MAVERICK, SAM-D MOTORS (No Photo)

On September 19, the Thiokol solid motor in the USAF's Maverick air-to-ground missile made its air debut on the first unguided flight of Maverick. Thiokol's SAM-D motor was ground-tested and also used in "launch environmental" tests of flightweight models. The company's Huntsville Division produces both Maverick and SAM-D motors.

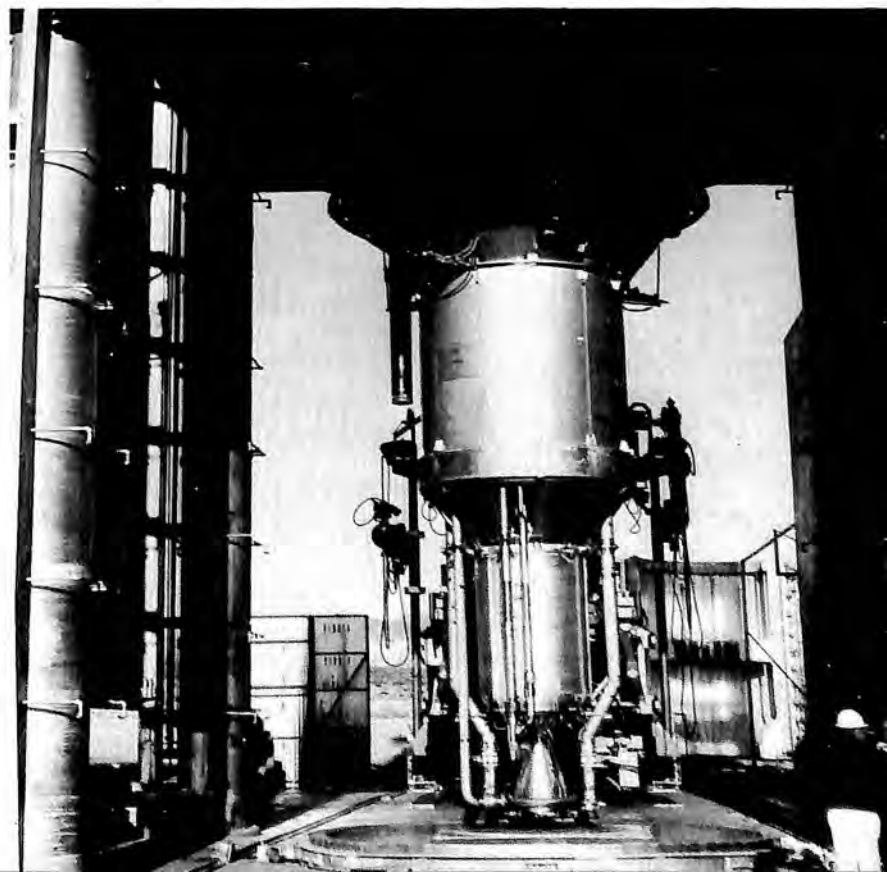
AEROJET-GENERAL/WESTINGHOUSE NERVA

A major milestone in space nuclear propulsion was passed in 1969 with the completion of testing of the XE, an experimental nuclear rocket and forerunner of NERVA, a 75,000-pound-thrust flight-rated engine being developed by NASA and the Atomic Energy Commission. The XE, which accomplished 28 test runs from March through August, was built by Aerojet-General and Westinghouse Electric, the same team responsible for NERVA. First static tests of NERVA (photo)—almost 4 test hours—were conducted in 1969.



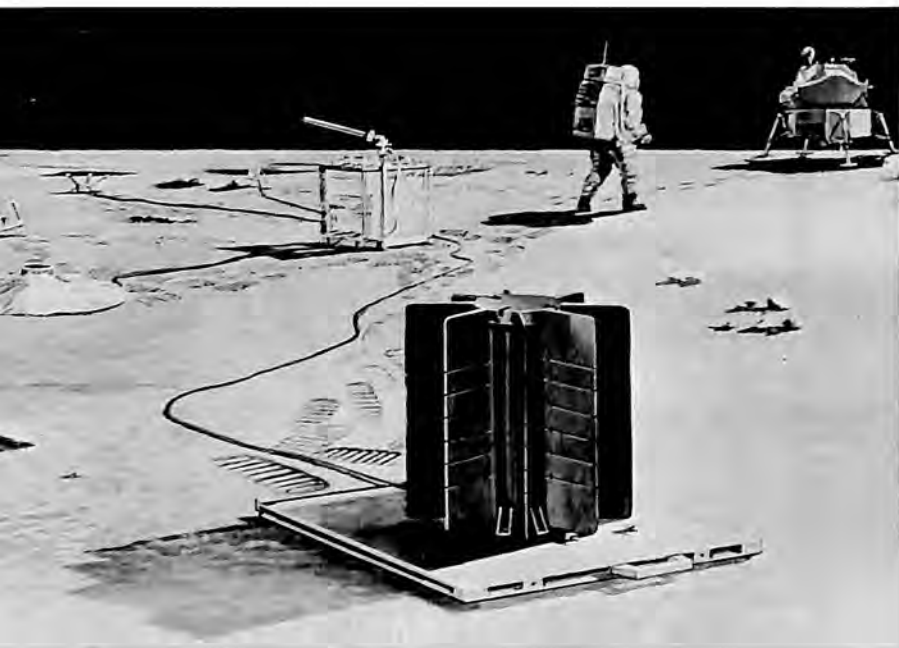
SRAM MOTOR

Shown here in ground run at Lockheed Propulsion Company's Potrero, California, test facility, the Lockheed-built solid-propellant pulse motor for the Boeing SRAM (Short-Range Attack Missile) completed its preflight readiness program and successfully powered the initial flights of the new missile.



SYSTEMS

The term "systems" covers the wide range of equipment built by the aerospace industry other than primary products such as aircraft, missiles, and spacecraft. The systems shown here are random selections representative of the extremely broad industry product line.



BENDIX ALSEP/GENERAL ELECTRIC SNAP-27

Bendix/Aerospace Systems developed the Apollo Lunar Surface Experiments Package (ALSEP), first array of which was set up on the moon by the Apollo 12 lunar explorers. ALSEP, to be deployed on Apollos 13 through 15, consists of 2 seismic experiments to study "moonquakes," a heat-flow experiment to measure the moon's thermal properties, a magnetometer to measure magnetic fields, a lunar atmosphere detector, and 3 experiments to study the properties of charged particles near the lunar surface. The instruments are powered, for at least a year, by the General Electric SNAP-27 (foreground in photo), a plutonium-fueled, radioisotope thermoelectric generator.

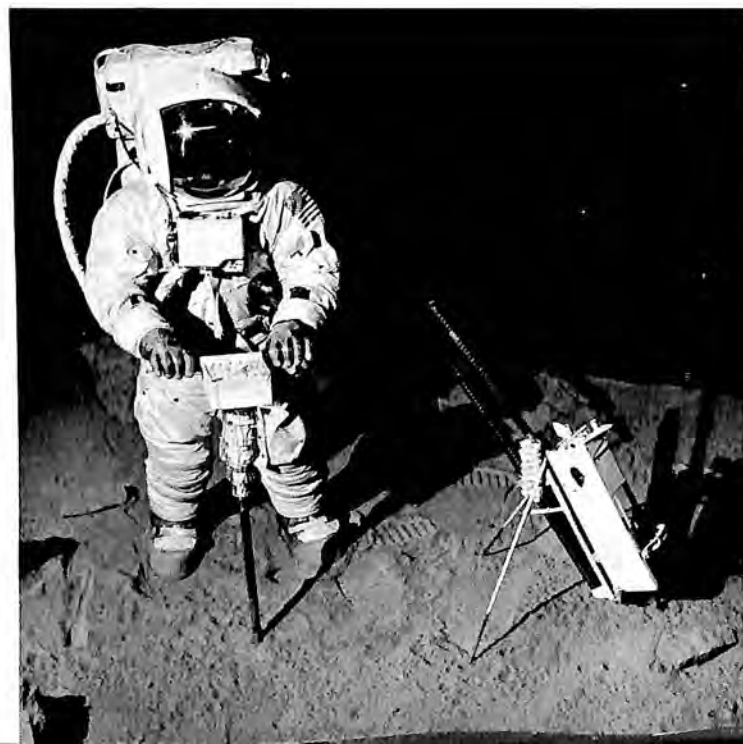


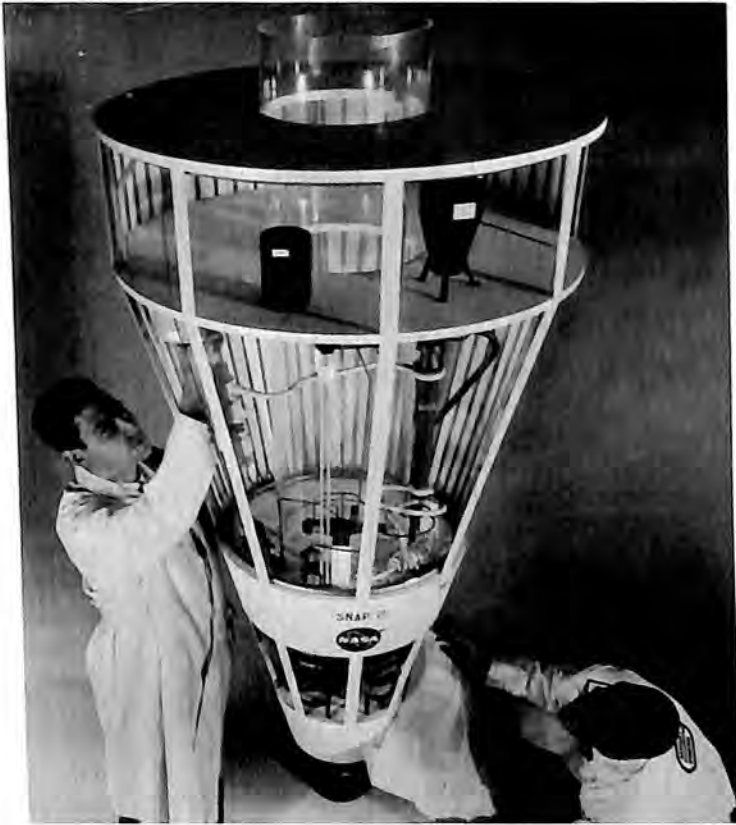
WESTINGHOUSE CAMERAS

Westinghouse Electric developed the 2 cameras that allowed home viewers to follow the historic Apollo 11 flight. At left is the black and white camera used by astronauts Armstrong and Aldrin to televise their activities on the moon. The color camera (right) was used in the Command Module for progress reports en route to and from the moon.

MARTIN MARIETTA DRILL

For Apollo 13 and later missions, Martin Marietta developed a lunar drill to obtain subsurface cores and to emplace heat-flow probes which relay soil thermal data to earth.



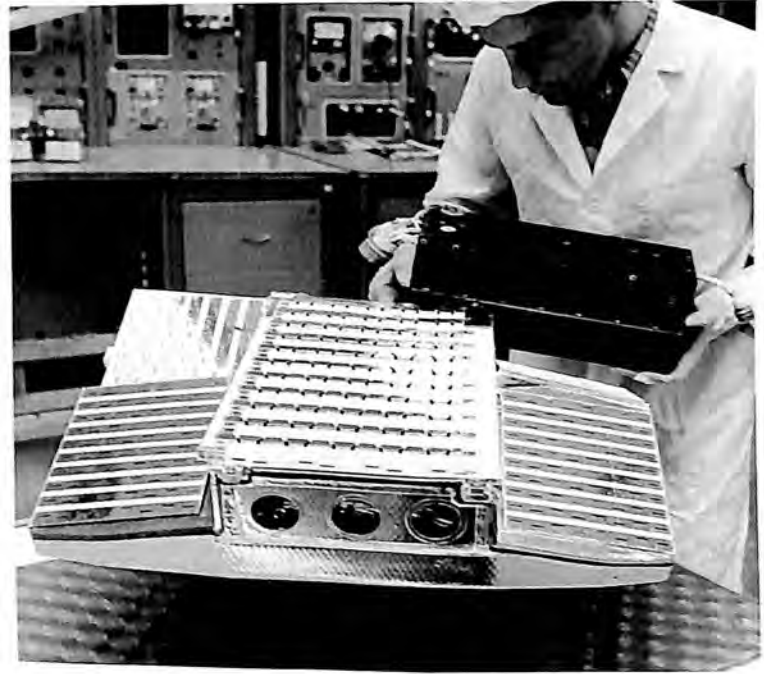


AEROJET-GENERAL SNAP-8

Aerjet-General conducted the first full-system test of the SNAP-8 nuclear power source, the most powerful in development. Designed as a power plant for moon or space stations and a variety of other applications, SNAP-8 can produce 35 kilowatts of electrical power.

RCA BACKPACK RADIO

RCA developed the Extravehicular Backpack Radio which permitted astronauts of Apollos 11 and 12 to converse with each other and to maintain contact with earth stations and the orbiting Command Module.



RYAN LANDING RADAR

Teledyne Ryan's Electronic and Space Systems division developed the landing radar that guided the Lunar Module to moon landings on Apollos 11 and 12. The radar was first space-tested on Apollo 9 and first checked out in the lunar environment on Apollo 10.

HUGHES LASER RANGE FINDER

A laser range finder that beams a high-powered laser pulse to the moon was developed by Hughes Aircraft. A portion of the pulse is returned to earth by a reflector left on the moon by Apollo 11 astronauts; scientists can compute earth-moon distance with great accuracy by measuring the round-trip travel time of the pulse.





BELL AEROSPACE LANDING AID

In July, the USS *Saratoga* became the first Navy carrier with a fully operational and completely automatic aircraft landing capability when the Bell Aerospace AN/SPN-42 all-weather carrier landing system was declared ready for regular service. In foreground is the AN/SPN-42 radar dish.



HONEYWELL WARNING SYSTEM

Honeywell's Aerospace Division developed a collision avoidance system for use in helicopters and fixed-wing aircraft. A pilot is warned by a cockpit flashing light and an audio signal in his headset when another airplane equipped with the system comes within a programmed distance. The Army is using the system in its TH-13T training helicopters. In photo, TH-13T panel display.

ITT GILFILLAN RADAR

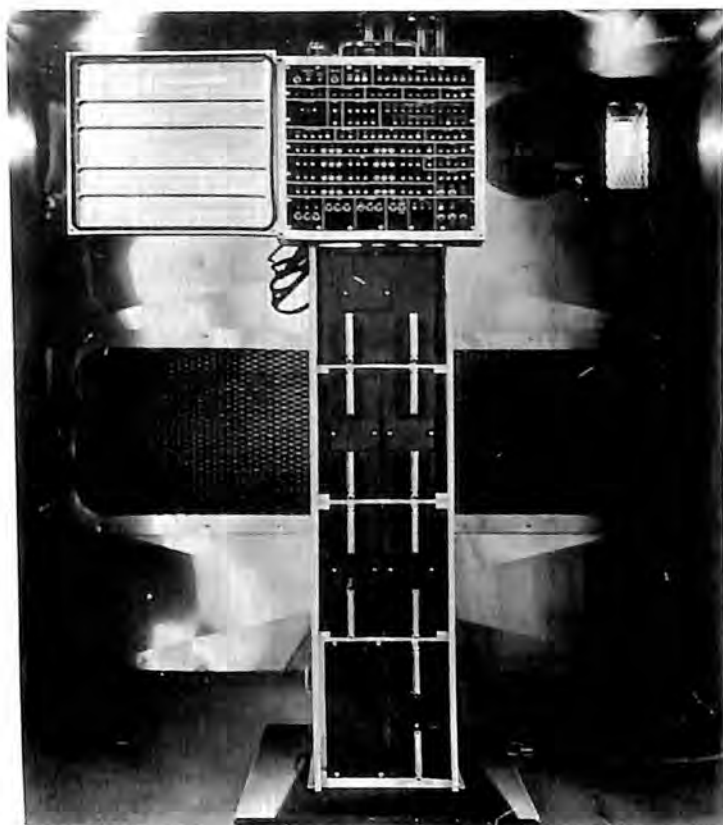
ITT Gilfillan, Inc., built for the Marine Corps the AN/TPS-32 long-range tactical surveillance radar. The system, which can handle a large number of targets simultaneously and provide range, azimuth, and altitude information on them, offers 3-dimensional accuracy and extensive coverage in a transportable package.



NORTHROP NAVIGATION SET

Northrop Corporation produced the AN/ARN-(99) Omega navigation set, a developmental and service test model, under contract to Naval Air Systems Command. Heart of the system is a compact airborne digital computer (photo) which has the computational capacity of some room-sized machines.





SPERRY RAND/UNIVAC COMPUTER

For the Navy's new P-3C Orion, Sperry Rand/Univac provided the CP-901/ASQ-114 microelectronic avionics computer, the primary data processor for the antisubmarine warfare aircraft.

GOODYEAR SHELTER

Under USAF contract, Goodyear Aerospace Corporation developed the "bare base shelter," designed to enable the Air Force to establish air bases rapidly where only minimal facilities exist. The personnel shelter is air-transported in a package only 13 feet long and 3 feet thick; it unfolds like an accordion into a building 39 feet long, 13 feet wide, and 8 feet high.

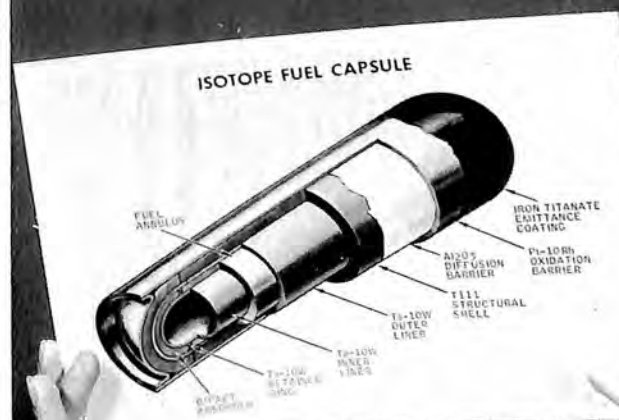


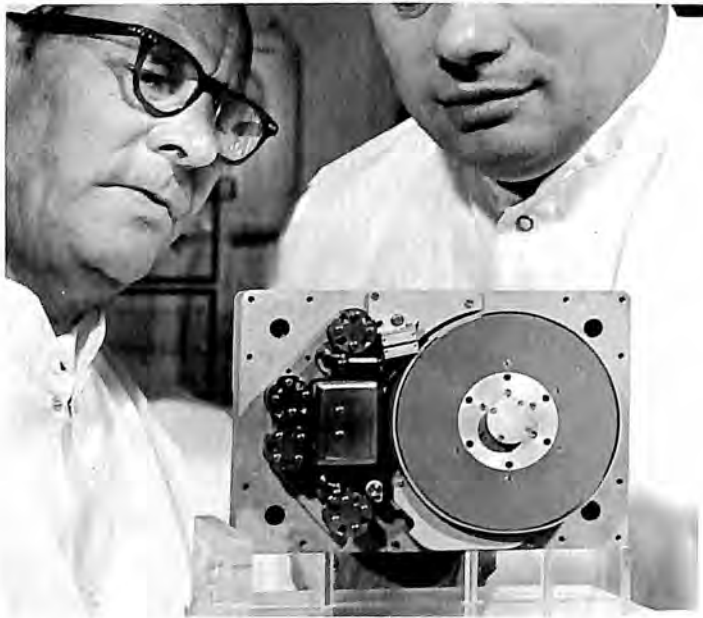
RCA GROUND TERMINALS

In experimental use were small, portable ground terminals that permit a soldier in the field to maintain contact via satellite with command headquarters. The RCA-built terminals were being evaluated in tests with the TACSAT 1 tactical communications satellite.

ATOMICS INTERNATIONAL CAPSULE

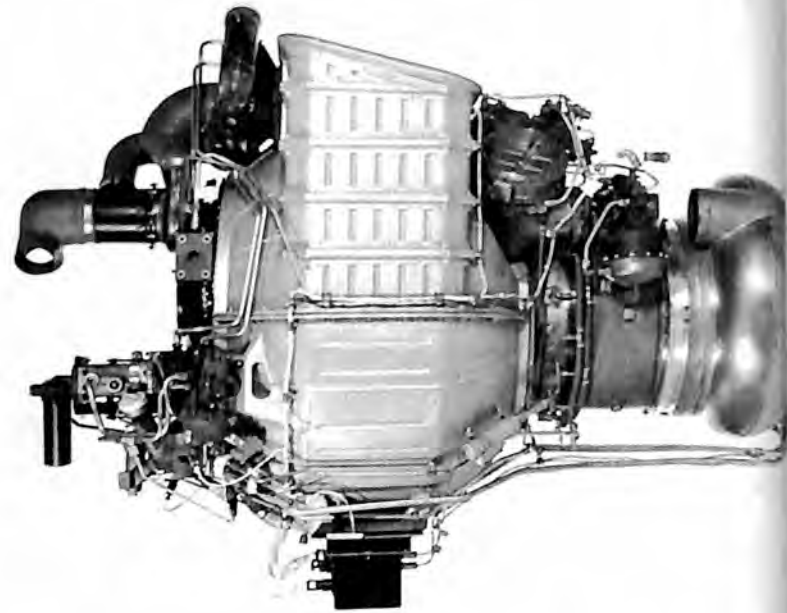
North American Rockwell's Atomics International Division developed a radioisotope capsule (cutaway shown) to furnish heat energy for electric power systems in space stations, lunar bases, undersea laboratories, and remote land areas. The capsule is only 7 inches long and weighs 5 pounds.





LOCKHEED RECORDERS

The spectacular photographs of Mars taken by Mariners 6 and 7 were stored and played back to earth by single-reel tape recorders developed by Lockheed Electronics Company. Each spacecraft carried 2 recorders, a digital and an analog system, to increase quality and quantity of data.

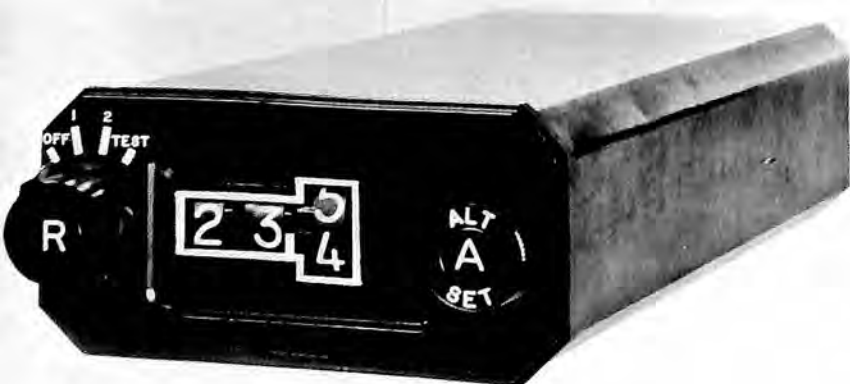


GARRETT-AIRESEARCH POWER UNIT

The latest development in large airborne auxiliary power units and the largest of its kind is the GTCP 660, produced by Garrett-AiResearch (Arizona). The 660 develops 300 shaft horsepower, 825 pounds of bleed air per minute, or combinations of both at the same time.

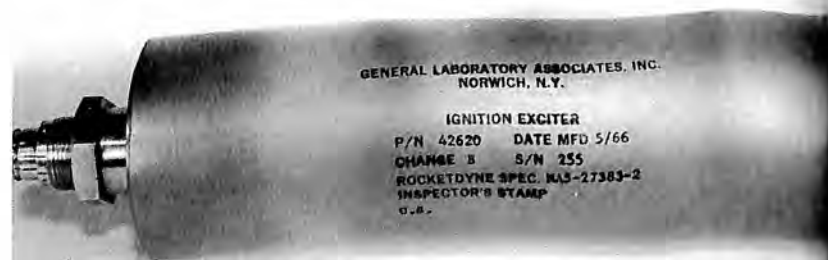
KOLLSMAN ALERT DEVICES

In photo is one of a family of altitude-alert devices developed by Kollsman Instrument Corporation. The devices alert pilots by both sight and sound that they are approaching preselected altitudes, in sufficient time to level off the plane.



GENERAL LABORATORY IGNITER

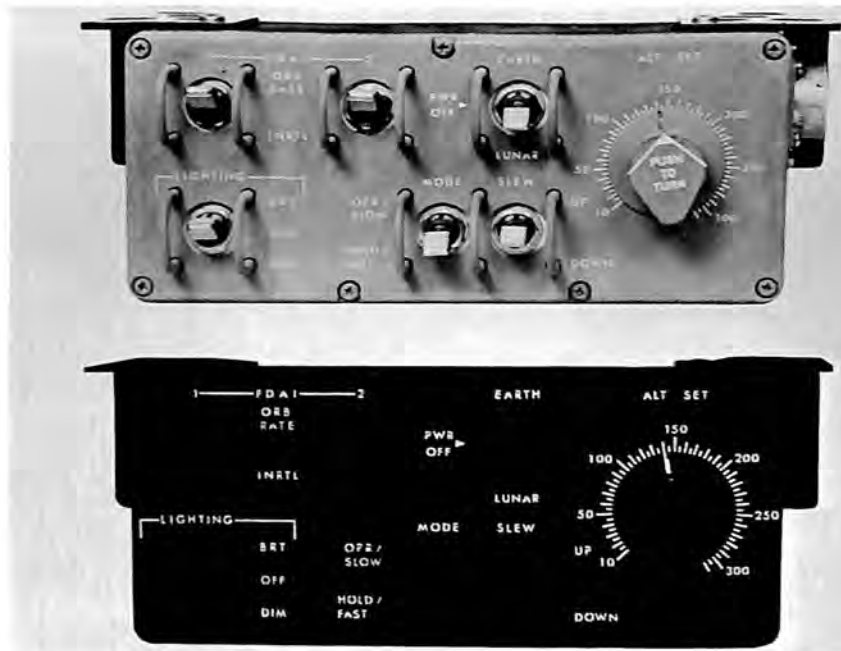
General Laboratory Associates produced the ignition unit that kicked the S-IVB stage into action and sent the Apollo 10, 11, and 12 spacecraft into lunar trajectory. The same unit is used to ignite the 5 J-2 engines in the second stage of the Saturn V moonbooster.





HONEYWELL SUN SENSOR

Honeywell Radiation Center developed a fine sun sensor, part of the pointing and control system of the Apollo Telescope Mount, which is a modified Apollo to be used as a space astronomical observatory. The electrooptical instrument provides exceptionally precise attitude information for pointing telescopes.



SINGER-GENERAL PRECISION ORDEAL

For both the Command and Lunar Modules of the Apollo spacecraft, Kearfott Division of Singer-General Precision provided the ORDEAL (Orbital Rate Drive Electronics for Apollo) system, essentially a small computer with panel instrumentation that establishes the desired pitch attitude for spacecraft docking.

HUGHES DATA SYSTEM

Installed on the Navy cruiser USS *Long Beach* was the Naval Tactical Data System. In photo, the display subsystem of the NTDS, built by Hughes Aircraft, uses input from Hughes-built Scanfar radar computers to enable the *Long Beach* to detect and track automatically hundreds of targets at the same time.



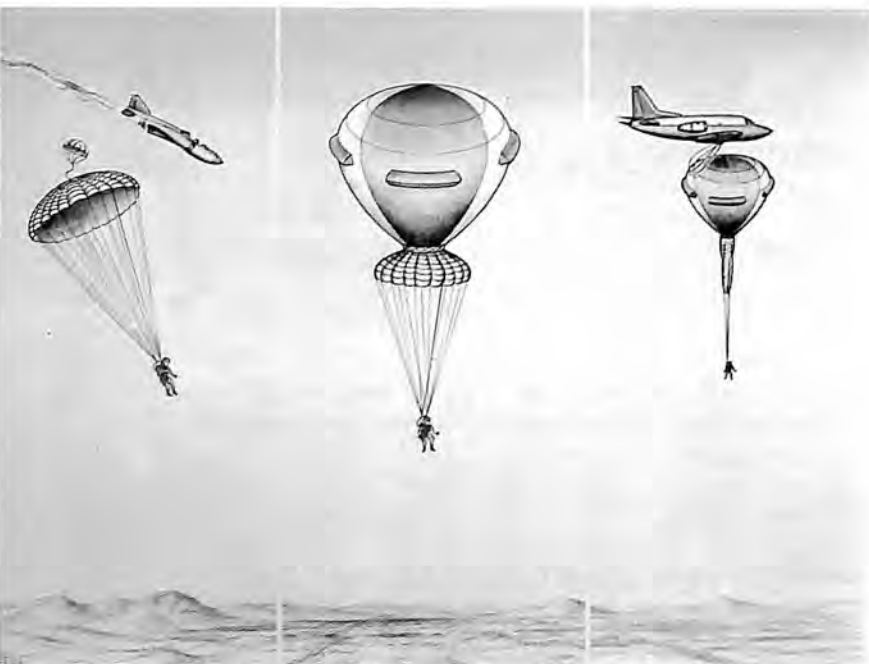
TRW PUMP

TRW's Equipment Group developed a main-engine fuel pump capable of delivering the flows and pressures required by the world's largest gas turbine engines. The single-stage pump operates at 6,000 revolutions per minute, and its gears and bearings make use of a new development in surface coatings for extreme durability and long service life.



BELL AEROSPACE FLYING BELT

An advancement of earlier rocket-powered flying belts, a jet-powered backpack mobility system made its first flight in April. The individual lift system, being developed for the Army by Bell Aerospace Company Division of Textron Inc., is powered by the world's smallest turbofan engine.



GOODYEAR RECOVERY DEVICE

In development for the USAF by Goodyear Aerospace was the Pilot Airborne Recovery Device (PARC), which permits ejected pilots to remain aloft by hot-air balloon over enemy territory until rescue planes can retrieve them in midair (photo). A ballute (balloon/parachute) attached to the top of the chute, inflated from a tank of propane gas strapped to the pilot's back, offers 30 minutes' hovering time out of range of enemy small arms fire.



SPERRY RAND/UNIVAC PROCESSOR

An important step toward computerized control of air traffic went into operation at Kennedy International Airport, New York, in the Common IFR Room. Composite picture illustrates the new unified display of instrument traffic, in which 2 Sperry Rand/Univac 1219 computers (in background) process radar signals and provide a continuous picture of each aircraft's identity and position.



AIA LEADERSHIP

In November, Karl G. Harr, Jr. (top), was reelected president of Aerospace Industries Association. Harvey Gaylord (lower left), executive vice president of Textron Inc., was elected chairman of the AIA board for 1970. He succeeded James R. Kerr (lower right), president and chief operating officer of Avco Corporation. **Editor's Note:** Mr. Gaylord resigned as chairman of the board on March 1, 1970. The current vice chairman, Roger Lewis, president, General Dynamics Corporation, served as acting chairman pending the election of Mr. Gaylord's successor.

RECORDS

WORLD RECORDS

The National Aeronautic Association, which represents the United States in the Federation Aeronautique Internationale, sanctions, certifies, and registers all record attempts within the United States in order that they may be recognized by other nations. NAA's Contest Board compiled this list of records completed during 1969 by U.S. participants.

CLASS	DATE	AIRCRAFT	PILOT	RECORD DESCRIPTION	RECORD
ABSOLUTE WORLD RECORDS					
MANNED SPACECRAFT					
World	3/3-13/69	Apollo 9	Russell Schweickart	Duration of stay outside spacecraft	47 minutes, 1 second
World	7/16-24/69	Apollo 11	Neil Armstrong	Duration of stay outside spacecraft	2 hours, 31 minutes, 40 seconds
World	11/19-20/69	Apollo 12	Charles Conrad	Duration of stay outside spacecraft	7 hours, 38 minutes, 7 seconds
WORLD CLASS RECORDS					
MANNED SPACECRAFT					
K-2	3/3-13/69	Apollo 9	James McDivitt David Scott Russell Schweickart	Duration in group flight	26 hours, 32 minutes, 59 seconds
K-2	3/3-13/69	Apollo 9	James McDivitt David Scott Russell Schweickart	Greatest mass of spacecraft in group flight	62,675 pounds
K-2	3/3-13/69	Apollo 9	James McDivitt David Scott Russell Schweickart	Duration in group flight with spacecraft linked	21 hours, 36 minutes, 31 seconds
K-2	3/3-13/69	Apollo 9	James McDivitt David Scott Russell Schweickart	Distance in group flight with spacecraft linked	325,318 miles
K-2	3/3-13/69	Apollo 9	James McDivitt David Scott Russell Schweickart	Greatest mass of spacecraft while linked	62,675 pounds
K-3	5/18-26/69	Apollo 10	Thomas P. Stafford John W. Young Eugene A. Cernan	Duration of lunar mission	192 hours, 3 minutes, 23 seconds
K-3	5/18-26/69	Apollo 10	Thomas P. Stafford John W. Young Eugene A. Cernan	Duration in lunar orbit	61 hours, 34 minutes, 39 seconds
K-3*	5/18-26/69	Apollo 10	Thomas P. Stafford John W. Young Eugene A. Cernan	Greatest mass lifted into lunar orbit	62,429 pounds
K-3	7/16-24/69	Apollo 11	Michael Collins	Duration in lunar orbit	59 hours, 27 minutes, 50 seconds
K-3	7/16-24/69	Apollo 11	Neil Armstrong Edwin E. Aldrin	Duration of stay on lunar surface	21 hours, 36 minutes, 21 seconds
K-3	7/16-24/69	Apollo 11	Edwin E. Aldrin	Duration of stay on lunar surface inside spacecraft	19 hours, 49 minutes, 28 seconds
K-3	7/16-24/69	Apollo 11	Neil Armstrong	Duration of stay on lunar surface outside spacecraft	2 hours, 31 minutes, 40 seconds
K-3	7/16-24/69	Apollo 11	Neil Armstrong Edwin E. Aldrin	Greatest mass landed on moon	16,153 pounds
K-3	7/16-24/69	Apollo 11	Neil Armstrong Edwin E. Aldrin	Greatest mass lifted into lunar orbit from lunar surface	5,928.6 pounds
K-3*	7/16-24/69	Apollo 11	Neil Armstrong Edwin E. Aldrin	Greatest mass lifted from lunar surface	10,776.6 pounds
K-3†	11/14-24/69	Apollo 12	Charles Conrad Richard Gordon Alan Bean	Duration of lunar mission	244 hours, 36 minutes, 23 seconds
K-3†	11/14-24/69	Apollo 12	Richard Gordon	Duration in lunar orbit	88 hours, 56 minutes, 1 second

*Tentative

†Final certification pending

CLASS	DATE	AIRCRAFT	PILOT	RECORD DESCRIPTION	RECORD
K-3†	11/14-24/69	Apollo 12	Charles Conrad Alan Bean	Duration of stay on lunar surface	31 hours, 31 minutes, 9 seconds
K-3†	11/14-24/69	Apollo 12	Alan Bean	Duration of stay on lunar surface inside spacecraft	25 hours, 6 minutes, 22 seconds
K-3†	11/14-24/69	Apollo 12	Charles Conrad	Duration of stay on lunar surface outside spacecraft	7 hours, 38 minutes, 7 seconds
PISTON-ENGINE AIRPLANES					
Class C-1 (unrestricted weight)					
C-1	8/16/69	Grumman F-8F-2	Darryl Greenamyer	Speed over 3-kilometer course	482.462 mph
C-1	11/7-10/69	Bede BD-2	James R. Bede	Distance in closed circuit	8,974 miles
Class C-1.b (1,102-2,204 pounds)					
C-1.b	3/30/69	Waco Meteor	Barry Schiff	Speed in 100-kilometer closed circuit	229.55 mph
C-1.b	3/25/69	Waco Meteor	Harold Fishman	Speed in 1,000-kilometer closed circuit	200.4 mph
Class C-1.c (2,204-3,858 pounds)					
C-1.c	4/3-16/69	Cessna 210	Alvin Marks	Speed around the world	73.45 mph
Class C-1.d (3,858-6,614 pounds)					
C-1.d	11/7-10/69	Bede BD-2	James R. Bede	Distance in closed circuit	8,974 miles
TURBOPROP AIRPLANES					
Class C-1.f (13,227-17,636 pounds)					
C-1.f	6/1/69	North American Rockwell OV-10A	Lieutenant Colonel R. W. Lewis, USMC	Distance in straight line	2,539.78 miles
SPEED OVER RECOGNIZED COURSES					
Class C-1.c (2,204-3,858 pounds)					
C-1.c	4/3/69	Cessna 210	Alvin Marks	Sacramento/Wichita	185.32 mph
C-1.c	4/3-4/69	Cessna 210	Alvin Marks	Sacramento/Hamilton, Bermuda	98.06 mph
C-1.c	4/3-5/69	Cessna 210	Alvin Marks	Sacramento/Santa Maria	87.89 mph
C-1.c	4/3-6/69	Cessna 210	Alvin Marks	Sacramento/Madrid	79.2 mph
C-1.c	4/3-7/69	Cessna 210	Alvin Marks	Sacramento/Athens	69.31 mph
C-1.c	4/3-8/69	Cessna 210	Alvin Marks	Sacramento/Teheran	61.61 mph
C-1.c	4/3-9/69	Cessna 210	Alvin Marks	Sacramento/Karachi	57.6 mph
C-1.c	4/9-16/69	Cessna 210	Alvin Marks	Karachi/Sacramento	44.63 mph
C-1.c	4/10-16/69	Cessna 210	Alvin Marks	New Delhi/Sacramento	45.93 mph
C-1.c	4/10-16/69	Cessna 210	Alvin Marks	Bangkok/Sacramento	55.44 mph
C-1.c	4/12-16/69	Cessna 210	Alvin Marks	Manila/Sacramento	71.73 mph
C-1.c	4/11-16/69	Cessna 210	Alvin Marks	Singapore/Sacramento	70.26 mph
C-1.c	4/13-16/69	Cessna 210	Alvin Marks	Agana, Guam/Sacramento	77.96 mph
C-1.c	4/14-16/69	Cessna 210	Alvin Marks	Wake Island/Sacramento	81.19 mph
C-1.c	4/16/69	Cessna 210	Alvin Marks	Honolulu/Sacramento	187.39 mph
C-1.c	5/2/69	Beechcraft Bonanza	Hypolite T. Landry, Jr.	Baton Rouge/Hamilton, Bermuda	161.61 mph
C-1.c	5/2-5/69	Beechcraft Bonanza	Hypolite T. Landry, Jr.	Baton Rouge/Santa Maria	43.46 mph
C-1.c	5/2-6/69	Beechcraft Bonanza	Hypolite T. Landry, Jr.	Baton Rouge/Madrid	45.79 mph
C-1.c	5/2-7/69	Beechcraft Bonanza	Hypolite T. Landry, Jr.	Baton Rouge/Athens	37.04 mph
C-1.c	5/2-10/69	Beechcraft Bonanza	Hypolite T. Landry, Jr.	Baton Rouge/Teheran	36.73 mph
C-1.c	5/2-12/69	Beechcraft Bonanza	Hypolite T. Landry, Jr.	Baton Rouge/Karachi	34.77 mph
C-1.c	5/2-12/69	Beechcraft Bonanza	Hypolite T. Landry, Jr.	Baton Rouge/New Delhi	33.67 mph
C-1.c	5/2-15/69	Beechcraft Bonanza	Hypolite T. Landry, Jr.	Baton Rouge/Bangkok	29.19 mph
C-1.c	5/16-25/69	Beechcraft Bonanza	Hypolite T. Landry, Jr.	Bangkok/Baton Rouge	43.34 mph

†Final certification pending

RECORDS

CLASS	DATE	AIRCRAFT	PILOT	RECORD DESCRIPTION	RECORD
C-1.c	5/17-25/69	Beechcraft Bonanza	Hypolite T. Landry, Jr.	Manila/Baton Rouge	45.57 mph
C-1.c	5/18-25/69	Beechcraft Bonanza	Hypolite T. Landry, Jr.	Agana, Guam/Baton Rouge	44.93 mph
C-1.c	5/23-25/69	Beechcraft Bonanza	Hypolite T. Landry, Jr.	Honolulu/Baton Rouge	82.54 mph
C-1.c	6/19-25/69	Beechcraft Bonanza	Hypolite T. Landry, Jr.	Wake Island/Baton Rouge	42.11 mph
C-1.c	6/25/69	Beechcraft Bonanza	Hypolite T. Landry, Jr.	San Francisco/Baton Rouge	152.52 mph
C-1.c†	10/28-29/69	Cessna P206	Geraldine Mock	Tarawa/Guadalcanal	155.75 mph
C-1.c†	10/29-30/69	Cessna P206	Geraldine Mock	Guadalcanal/Rabaul	144.36 mph
C-1.c	5/3-5/69	Cessna 210	Samuel Marshall, Jr.	Dallas/Gander	62.61 mph
C-1.c	5/6-8/69	Cessna 210	Samuel Marshall, Jr.	Gander/Dallas	56.22 mph
Class C-1.d (3,858-6,614 pounds)					
C-1.d†	10/20/69	Cessna P206	Geraldine Mock	Oakland/Honolulu	153.28 mph
C-1.d†	10/26/69	Cessna P206	Geraldine Mock	Honolulu/Tarawa	141.71 mph
C-1.d	5/30/69	Piper Twin Comanche	Jeremie J. Kaelin	Louisville/Gander	121.65 mph
C-1.d	6/1/69	Piper Twin Comanche	Jeremie J. Kaelin	St. Johns/Santa Maria	173.86 mph
C-1.d	6/1-2/69	Piper Twin Comanche	Jeremie J. Kaelin	St. Johns/Zurich	114.62 mph
C-1.d	6/1-2/69	Piper Twin Comanche	Jeremie J. Kaelin	Santa Maria/Zurich	139.54 mph
C-1.d	6/13/69	Piper Twin Comanche	Jeremie J. Kaelin	Zurich/Athens	166.12 mph
Class C-1.e (6,614-13,227 pounds)					
C-1.e	2/3/69	Beechcraft King Air	Leonard M. Greene	Seattle/Pittsburgh	257.98 mph
Feminine Records					
Feminine†	10/20/69	Cessna P206	Geraldine Mock	Oakland/Honolulu	153.28 mph
Feminine†	10/20-30/69	Cessna P206	Geraldine Mock	Oakland/Rabaul	24.26 mph
Feminine†	10/26/69	Cessna P206	Geraldine Mock	Honolulu/Tarawa	141.71 mph
Feminine†	10/28-29/69	Cessna P206	Geraldine Mock	Tarawa/Guadalcanal	155.75 mph
Feminine†	10/29-30/69	Cessna P206	Geraldine Mock	Guadalcanal/Rabaul	144.36 mph
HOT AIR BALLOONS					
AX-3 (400-600 cubic meters)					
AX-3†	9/18/69	Semco Balloon	George A. Stokes	Duration	51 minutes
AX-3†	9/18/69	Semco Balloon	George A. Stokes	Distance	9.6 miles
SAILPLANES					
Class D-1 (single-place)					
D-1	8/8/69*	SISU 1A	Alvin H. Parker	Distance to a goal	573.27 miles
D-1	8/22/69	Schleicher AS-W12	Wallace Scott	Distance to a goal	605.23 miles
Class D-2 (multi-place)					
D-2	7/31/69	Schweizer 2-32	Ross Briegleb	Speed-over 100-kilometer triangular course	69.16 mph
U.S. NATIONAL RECORDS					
COMMERCIAL AIRLINES					
Commercial	10/1/69	Douglas DC-8-63	Captain T. Outland, Delta Air Lines	Speed on commercial air route, Miami/Houston	477.82 mph
Commercial	10/6/69	Boeing 727-100	Captain Clark Willard, Northeast Airlines	Speed on commercial air route, Miami/Los Angeles	525.96 mph

†Final certification pending



WRIGHT BROTHERS MEMORIAL TROPHY

The Wright Brothers Memorial Trophy was awarded to William M. Allen, chairman, The Boeing Company, for "significant public service in the development of commercial airliners, civil and military aircraft and for outstanding leadership and foresight." Trophy presentation was made December 17 at the Wright Memorial Dinner in Washington, D.C. In photo, left to right, Howard Maginniss, dinner chairman; Clifton F. von Kann, president, Aero Club of Washington, sponsor of the Wright Memorial Dinner; Vice President Spiro T. Agnew; trophy recipient Allen; and Frederick B. Lee, president of the National Aeronautic Association, which administers the trophy.

COLLIER TROPHY

The Robert J. Collier Trophy, also administered by the National Aeronautic Association, went to the first men to orbit the moon, the crew of Apollo 8 (the trophy was awarded for the most significant achievement in aeronautics or astronautics during the preceding calendar year, 1968). Presentation was made at a luncheon in Washington on May 7 by NASA Administrator Thomas O. Paine. In photo are the recipients, left to right, Apollo 8 commander Frank Borman, Command Module pilot James A. Lovell, Jr., and Lunar Module pilot William A. Anders.





BREWER TROPHY

Joseph T. Geuting, Jr. (left), president of the General Aviation Manufacturers Association, received the Frank G. Brewer Trophy for outstanding contributions to aerospace education. The trophy was presented by A. Paul Vance, vice president of the National Aeronautic Association, trophy-administering organization.

HARMON TROPHIES

The 1969 Harmon International Aviation Trophies, awarded for outstanding feats of piloting skill during the preceding calendar year (1968), went to the Apollo 8 crew and to an Air Force test pilot. James A. Lovell, Jr., William A. Anders, and Frank Borman (left to right in photo) won the Astronaut's Trophy for their December 21-27, 1968, lunar orbit mission. The Aviator's Trophy was awarded to Major Jerauld R. Gentry, USAF, for his work as test pilot of the NASA HL-10 lifting-body research craft during 1968.





AIAA AWARDS

Two leading aircraft engine developers shared the Goddard Award of the American Institute of Aeronautics and Astronautics. The award, made for separate contributions, went jointly to Perry W. Pratt, vice president, United Aircraft Corporation (left in photo), and Dr. Stanley G. Hooker, technical director, Bristol Engine Division of Rolls-Royce (at podium). AIAA's Hill Transportation Award was presented to George Low, NASA, for his leadership role in the Apollo program. Other AIAA award winners: Edgar C. Lineberry, Jr., Lawrence Sperry Award; Gifford Bull, DeFlorez Training Award; Otto E. Bartoe, Jr., Spacecraft Design Award; Dr. Eberhardt Rechtin, Aerospace Communications Award; Professor Rene H. Miller, Sylvanus Albert Reed Award; Dr. Robert Fletcher, Robert M. Losey Award; Dr. Charles P. Sonett, Space Science Award; Harold Kaufman, Wyld Propulsion Award; Dr. Holt Ashley, Structures Award; William G. Park, Octave Chanute Award; and the Apollo 7 crew—Walter M. Schirra, Donn F. Eisele, and R. Walter Cunningham—the Haley Astronautics Award.

AMERICAN HELICOPTER SOCIETY AWARDS

The Dr. Alexander Klemin Award, highest honor of the American Helicopter Society, went to General William B. Bunker, USA, then Deputy Commanding General, U.S. Army Materiel Command, "for foresight in establishing standards of performance and utility for Army helicopters and for ceaseless insistence upon excellence in all phases of helicopter development." In photo, AHS awards chairman Robert A. Wagner (right) presents the award to General Bunker, who died less than 3 weeks after the presentation. Other AHS awards presented at the May 16 AHS Honors Night Dinner in Washington, D.C.: Paul E. Haueter Memorial Award, to Peter G. Kappus, General Electric Company; Frederick L. Feinberg Award, to Ronald L. Diggins, Petroleum Helicopters, Inc.; Grover E. Bell Award, to Sikorsky Aircraft; Captain William J. Kossler Award, to the petroleum industry for exploiting the helicopter's unique capabilities.





AFA AWARDS

The Air Force Association's highest award, the H. H. Arnold Trophy honoring the Aerospace Man of the Year (presented in 1969 for preceding year accomplishments), went to the Apollo 8 crew (in Photo 1, Frank Borman at podium, James A. Lovell, Jr., and William A. Anders to the right; presentation made by former AFA president Robert W. Smart, next to Borman on the left). In Photo 2, Captain Albert P. Kaiser, USAF, receives the David C. Schilling Trophy for Flight from Smart; Kaiser was cited for "superb airmanship in the aerial recovery of capsules ejected from satellite systems." The Gill Robb Wilson Trophy was presented by AFA board chairman Jess Larson to the former executive director of the National Aeronautics and Space Council, Dr. Edward Welsh; Larson and Welsh are left and right at podium in Photo 3. The association's Theodore von Karman Trophy went to Lieutenant Colonel Harry F. Rizzo, USAF, of the Air Force Weapons Laboratory, for his work in directing research on nuclear weapons effects. Major General Frederick E. Morris, USAF, won the Thomas P. Gerrity Trophy for Systems and Logistics.





AAAA AWARDS

The Army Aviation Association of America presented its Army Aviator of the Year award to Major Patrick H. Brady, USA. In Photo 1, Brady is presented the award by Thaddeus R. Beal, Under Secretary of the Army. Named Aviation Soldier of the Year was Sergeant First Class William R. Baum, who is shown in Photo 2 receiving the award from Army Secretary Stanley R. Resor. The James H. McClellan Aviation Safety Award went to Colonel Russell P. Bonasso. In Photo 3, award presentation is made by Howard E. Haugerud, president of the McClellan Foundation. In another presentation at the 11th Annual AAAA Honors Luncheon, held October 17 in Washington, D.C., the Outstanding Aviation Unit Award went to the 25th Aviation Battalion, 25th Infantry Division in Vietnam.



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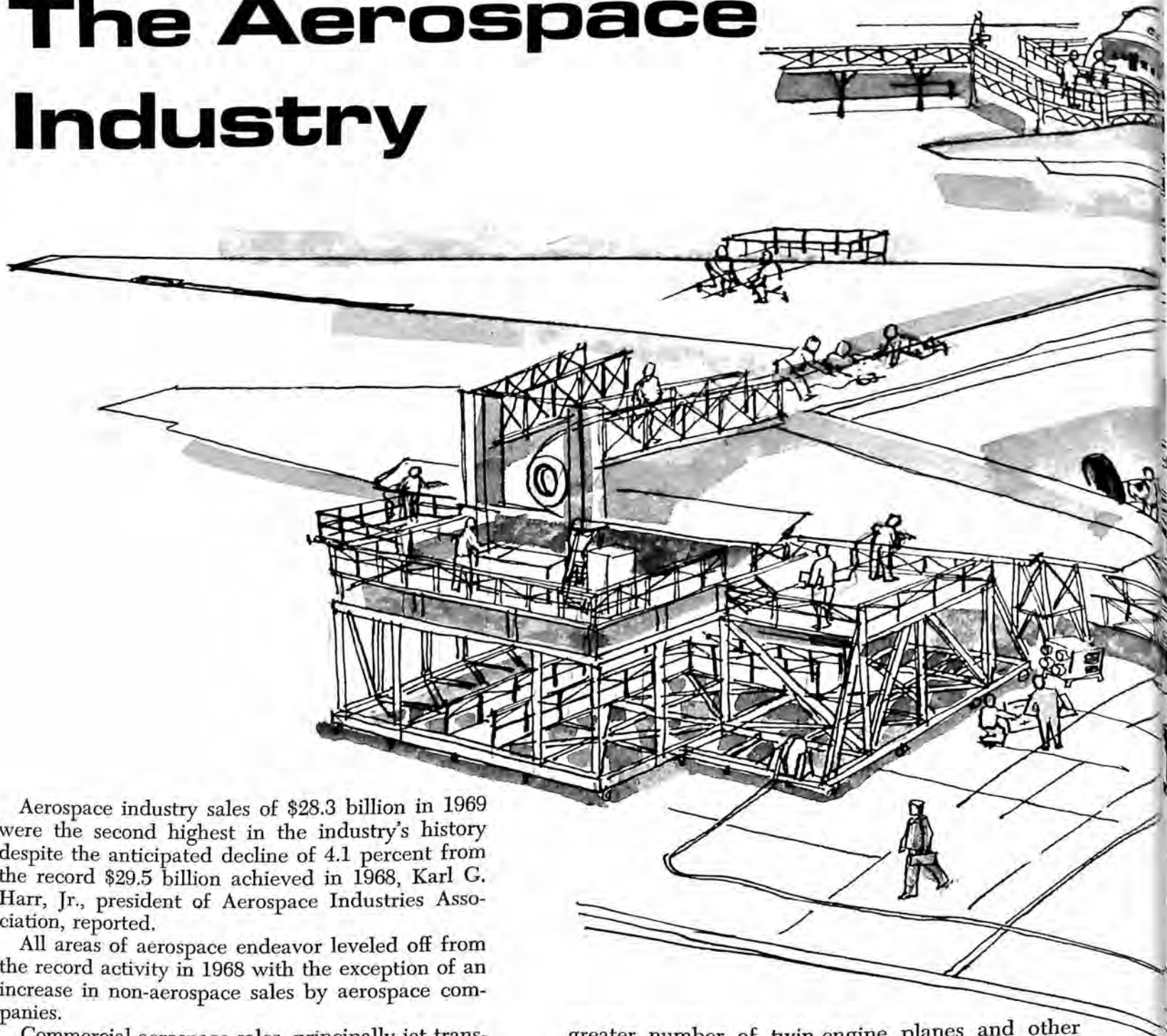
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The Aerospace Industry



Aerospace industry sales of \$28.3 billion in 1969 were the second highest in the industry's history despite the anticipated decline of 4.1 percent from the record \$29.5 billion achieved in 1968, Karl G. Harr, Jr., president of Aerospace Industries Association, reported.

All areas of aerospace endeavor leveled off from the record activity in 1968 with the exception of an increase in non-aerospace sales by aerospace companies.

Commercial aerospace sales, principally jet transports, amounted to \$6.8 billion in 1969, as compared with \$6.43 billion in 1968. The trend was expected to be temporary; it was the result of phasing out one series of transport models while production of the new wide-bodied jet transports was just getting under way. Other areas of commercial aerospace sales—executive and utility fixed-wing aircraft and helicopters—showed sales increases.

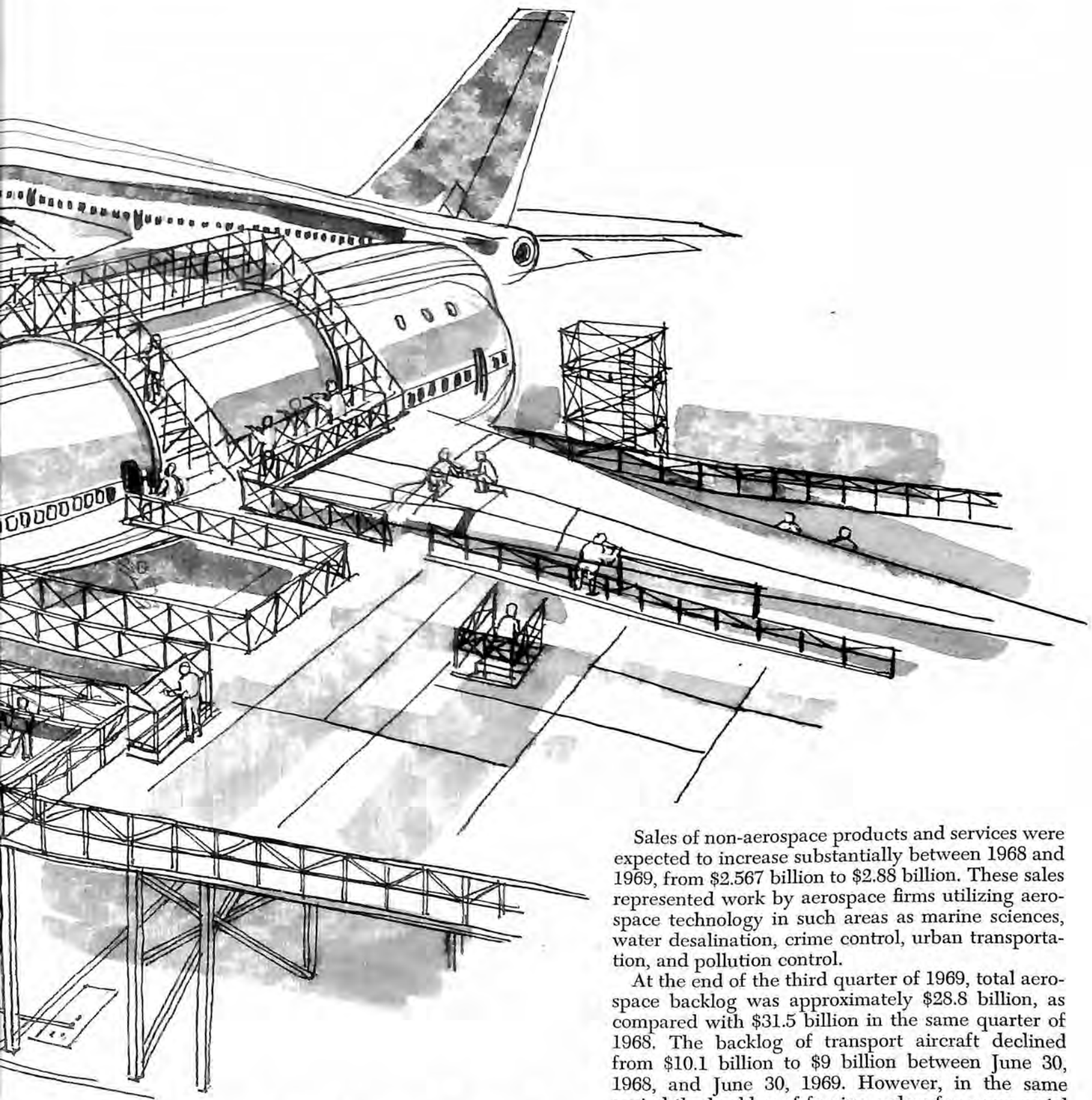
Dollar value of utility and executive aircraft shipped increased from \$421,000,000 in 1968 to \$478,000,000 in 1969, although units delivered declined from 13,698 in 1968 to 12,948 in 1969. The increase in dollar value was due to the production of a

greater number of twin-engine planes and other larger utility and executive aircraft.

Civilian helicopter production increased from 522 units to 550 units between 1968 and 1969, and dollar value of this production rose from \$57,000,000 to \$66,000,000. Civil helicopters were being used primarily for business purposes although increasing numbers were being used for traffic and crime control and as air ambulances.

Other major sales highlights between 1968 and 1969 included—

- Sales by the aerospace industry to the Department of Defense of \$16.2 billion in 1969, as compared with \$16.6 billion in 1968.



- Military aircraft sales of \$10 billion in 1969, as compared with \$10.7 billion in 1968.
- Missile sales of \$5.034 billion in 1969, as compared with \$4.719 billion in 1968, an increase of 6.7 percent.
- A drop in space sales to \$4.499 billion in 1969 from \$5.108 billion in 1968, a result of the approaching completion of the hardware phase of the Apollo program as well as of the cancellation of the Manned Orbiting Laboratory.

Sales of non-aerospace products and services were expected to increase substantially between 1968 and 1969, from \$2.567 billion to \$2.88 billion. These sales represented work by aerospace firms utilizing aerospace technology in such areas as marine sciences, water desalination, crime control, urban transportation, and pollution control.

At the end of the third quarter of 1969, total aerospace backlog was approximately \$28.8 billion, as compared with \$31.5 billion in the same quarter of 1968. The backlog of transport aircraft declined from \$10.1 billion to \$9 billion between June 30, 1968, and June 30, 1969. However, in the same period the backlog of foreign orders for commercial transports rose from \$2.8 billion to \$2.9 billion.

Aerospace shipments abroad continued to increase, as they have since 1964. Between 1968 and 1969, they rose from \$2.994 billion to \$3.296 billion, or 10.1 percent. Principally responsible for the increase were military shipments, which rose from \$820,000,000 to \$1.293 billion, up almost 58 percent. The major portion of the increase was for fighter-bombers.

Civilian exports declined slightly from records set

in 1968. These shipments fell from \$2.174 billion to \$2.003 billion, or 7.9 percent.

The aerospace industry remained the nation's largest manufacturing employer with over 1,300,000 workers, although employment declined from 1,430,000 to 1,311,000 between December 1968 and December 1969. Declining aerospace program levels for aircraft, missiles, and space caused lower levels of employment. However, employment still remained higher than for any previous year with the exception of 1967 and 1968.

Production workers in the industry dropped in the period from 774,000 to 665,000, or 14 percent. The major drop was in work on aircraft programs. In 1969, production workers made up 50 percent of total employment; scientists and engineers, about 16 percent; technicians, 6 percent. The remainder were in white collar categories. It was anticipated that aerospace employment would further decline by 2 percent between 1969 and 1970, from 1,311,000 to 1,285,000 workers.

Profits in the aerospace industry were expected to decline from 3.2 percent in 1968 to 2.8 percent in 1969. This decline resulted from rising financing, labor, and material costs which in turn adversely affected the levels of net income. Declining sales levels were also a factor.

Approximately 3 percent of total annual sales was being invested by aerospace firms for the expansion, replacement, and modernization of plant and equipment, and between 1968 and 1969 company expenditures on plant and equipment were expected to rise by 12.3 percent, from \$730,000,000 to \$820,000,000. Between 1969 and 1970, these expenditures were expected to level off at \$820,000,000.

Between 1968 and 1969, average weekly hours in the aerospace industry declined slightly, from 41.8 to 41.7. Overtime dropped substantially, from 3.6 to 2.7 hours in the period, coinciding with a decline in total employment.

Between 1968 and 1969, average production worker weekly earnings in the aerospace industry rose from \$153.53 to \$161.18. The industry payroll rose from \$13.7 billion to \$14 billion.

Looking ahead, AIA predicted 1970 industry sales of \$27.7 billion, a decline of \$600,000,000 resulting primarily from a lower sales level for military aircraft.

Commercial aerospace sales were expected to increase during the 1969-70 period from \$5.8 billion to \$6.1 billion, or 5.2 percent. This would result from an increase in the dollar value of civil transports from \$2.895 billion to \$3.162 billion, or 9.2 percent, due largely to deliveries of the first production units of a wide-bodied jet transport model.

Utility and executive aircraft production was expected to increase from 12,948 units in 1969 to 13,781 in 1970. The dollar value of these aircraft will climb from \$478,000,000 to \$532,000,000.

Helicopter production was expected to decrease

from 550 units to 500 units, with a corresponding lower dollar value of \$61,000,000 in 1970.

Department of Defense sales were estimated at \$15.4 billion in 1970, with the decrease due primarily to lower aircraft sales; missile and military space programs were expected to remain approximately the same between 1969 and 1970.

Non-aerospace sales were expected to increase slightly over 1969 levels, to \$2.9 billion.

ABEX CORPORATION

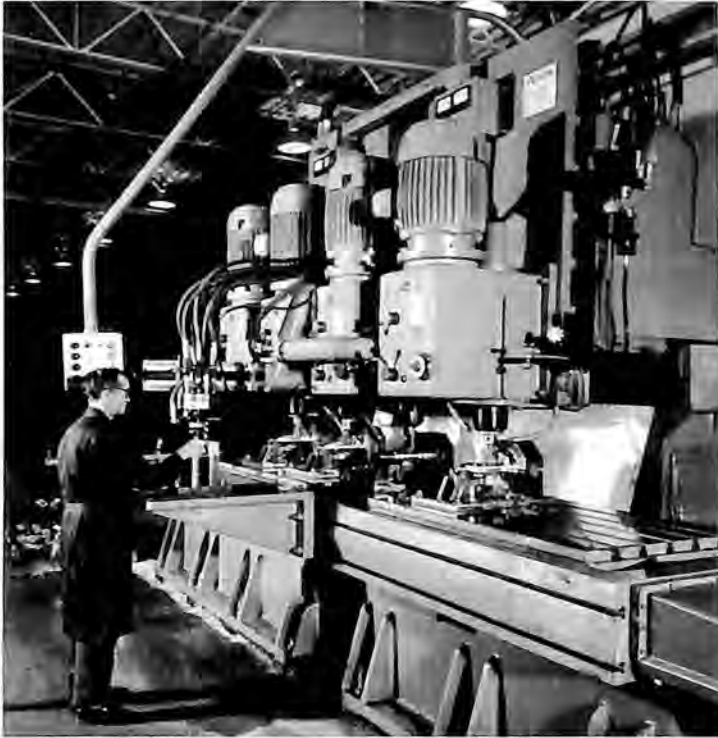
In 1969, the Abex commercial airlines servovalve was specified sole source for all flight controls on the McDonnell Douglas DC-10, the Lockheed L-1011, and the Boeing 747. With over 25,000,000 airline miles on its record, the jet-pipe servovalve demonstrated an amazingly low removal rate. The Aerospace Division facility in Los Angeles also had its engine-driven hydraulic pumps and hydraulic transfer packages specified on the Grumman F-14, the DC-10, and the 747, plus main landing gear steering controls for the latter.

Aerospace equipment participated in the Apollo 11 flight and was serving on about a dozen of the deep-submergence sea vessels which are exploring down instead of up. Contracts were received from the Navy for development of a 10,000-pound-per-square-inch pump and from Boeing for development of an engine-drive pump for the supersonic transport. The plant continued to ship equipment for the 727, 737, F-111, A-6A, CH-53A, C-5A, and a number of other significant programs of both commercial and military nature.

The Canadian facility continued to ship main landing gear for the Boeing 737 and was preparing to make shipment of the first nose gear for the McDonnell Douglas DC-10. Additional contracts were received for the General Dynamics F-111 wing-sweep actuation systems, the Boeing-Vertol CH-47 landing gear, and the Fokker F-28 primary and secondary flight controls. The plant also produced landing gear for the de Havilland DHC-4 Caribou and DH-5 Buffalo, the Northrop F-5, the Canadair CF-5, and the LTV A-7D. Production facilities were consolidated in the new plant in Montreal; at year-end, that facility encompassed the largest profiling capacity under one roof anywhere in Canada.

The Aerospace plant in Wiesbaden, West Germany, continued to ship rotating equipment and servovalves for the Concorde SST, the Jet Falcon, various SAAB programs, the Fokker F-28, and Agusta-Bell helicopters. Follow-on orders were received for Fiat G91Y production ships. The plant also received orders to supply pumps and flap-drive motors for the VFW 614 and tailplane actuator motors for the Japanese CX aircraft. Among

the newer programs were the BAC-311, the Sud Airbus A-300, the MRCA-75, the Dassault transport, and the Boelkow BO 105 helicopter. The plant added to its contract overhaul work for hydraulic pumps and components used on NATO fighters and commercial aircraft.



This 4-spindle profiler is part of Abex Corporation's Montreal plant, Canada's largest profiling facility.

The Denison Division of Abex continued to be involved in many phases of ground-support activities, in space as well as in military and commercial aviation. Denison hydraulic power units activate highly sophisticated flight simulators such as the Boeing 727 commercial flight simulator and the F-111 flight and mission simulator.

Denison furnished hydraulic power for the elaborate static testing facilities for the giant C-5. Test stands, such as those for the Navy F-8 Crusader fighter, utilize Denison fluid power components.

The Apollo missions owe a measure of their success to ground-support equipment that utilizes Denison fluid power components and systems. For example, the 5,500,000-pound crawler transporter is steered and maintained level with Denison hydraulics. Denison pumps also supply power to operate service arms and work enclosures on the mobile launcher and service structures, to actuate erectors raising rockets into firing position, and to actuate engine gimbaling systems and engine valves before launch.

Large Denison piston pumps supply fuel under pressure to vehicles at launch until the on-board system reaches 90 percent thrust. These pumps also supply fuel for static firing and quality control

check-out, as well as power for ground-support stands for jet aircraft check-out.

The Friction Products Group of Abex, a major manufacturer of friction (braking) materials for aircraft, was selected as supplier of brake materials for the Learjet, the LTV A-7D, the Beechcraft 99, the Mitsubishi MU-2, the McDonnell Douglas DC-10, and the Grumman F-14.

At the Abex Research Center in Mahwah, development continued on large superalloy castings for gas turbine rotors. These castings are vacuum melted and cast utilizing special ceramic molding techniques.

Refractory and intermetallic type coatings were being evaluated as possible aircraft braking materials. Extensive dynamometer testing preceded the initial tests on aircraft, which were in progress at year-end.

AERODEX, INC.

Aerodex, Inc., continued to lead in the field of repair and overhaul of reciprocating and jet engines and components for U.S. government agencies. The company was awarded Air Force contracts for the overhaul of T56 and R4360 engines. Aerodex has overhauled the R4360 engine and component requirements continuously since 1959. Since 1965, when the Air Force initially placed T56 engine overhaul requirements with commercial sources, the company has been awarded that job. Commercial jet engine overhaul and sales processed through the new Aerodex jet facility also included the Allison 501 series and the Pratt & Whitney Aircraft JT8D.

Contracts signed with Alaska Airlines and Frontier Airlines for overhaul of the Allison 501-D turbo-prop engines will produce an estimated \$4,500,000 in annual revenue. Other 501-D overhaul contracts were pending at year-end. The company purchased and overhauled spare 501-D engines in addition to processing engines for airline customers. An inventory of 501-D spares is maintained and parts are airlifted to customers on an on-call, exchange basis.

Aerodex continued to process JT8D jet engines and engine sections for various airlines. The company is qualified for performing the extensive type of parts rework, materials engineering, and engine testing required in JT8D overhaul. The volume of other jet engine parts overhaul was increased. For example, the processing of JT3D and JT4 jet engine transition ducts advanced to assembly line fashion and the volume on the overhaul of the No. 4 bearing housings on the JT8D engine achieved a level of approximately 50 per month.

In other areas of the company's business, the materials engineering facilities, installed principally to process engine parts during manufacture or overhaul, resulted in new industrial customers. The

same furnaces used to heat-treat and braze parts at 2,400 degrees Fahrenheit began to process surgical instruments and many other commercial items for manufacturers.

The company received a contract to serve as a jet aircraft engine service center for the AiResearch Manufacturing Company of Arizona, a subsidiary of The Garrett Corporation. AiResearch is a major supplier of airframe parts, gas turbine auxiliary power units, and flight control and other systems for the forthcoming "giant jet" engine programs such as the Boeing 747 and the McDonnell Douglas DC-10. AiResearch customers are principally commuter airline, business aircraft, and helicopter operators. The engine involved is the Garrett TPE 331 Century series turboprop, which powers such aircraft as the Turbo Commander, the Mooney-Mitsubishi MU-2F, the Pilatus Turbo Porter, the Swearingen Merlin IIB, the Volpar Turboliner, the Carstedt Jetliner, and the Short Brothers & Harland Skyvan.

To further expand the efficiency and capabilities of the company, complex and sophisticated equipment was added to the inventory, including items such as Brown & Sharp numerical controlled comparator, DeVlieg numerical controlled Type K jig mill, Wideman numerical controlled punch press, Olivetti 12 station numerical controlled equipment, LaPointe "90" broach, 30-horsepower Gisholt balancer, Keco electrochemical machining, Verson 500-ton press brake, and Arrow Profiler 3D milling machine.

In a far-reaching and scope-broadening activity, Aerodex instituted at its subsidiary API Corporation newer and bolder approaches to its widely accepted capability in metals and alloys treatment, processing, and manufacture. In addition to existing heat-treat equipment, the company installed a vertical-loading vacuum furnace and a shaker hearth furnace with a continuous and automatic hardening, wash, and draw system and a capacity of 500 pounds per hour of light section through hardening types of material. Also installed was a deep-freeze unit with minus 180 degrees Fahrenheit capability.

In 1969, substantial advances were made in the state of the art for manufacturing and repair processes involving electron-beam welding, plasma spraying, and investment castings. Techniques and processes were developed and utilized for repairing honeycomb structures, jet engine compressor blades, and a large variety of turbine engine and airframe parts. Fabrications included 5,000 first-, second-, and third-stage turbine vane weldments for the TF39 engine and several hubs, frames, chambers, and struts for advanced developmental turbine engines, using casting and electron-beam welding techniques to an unprecedented extent.

The company continued its development and manufacturing activities at its Casting Facility, ACI, and demonstrated its unusual capability to produce large castings involving very complex coring as well

as large volumes of castings requiring the mating of quartz and ceramic cores. Evaluation programs were completed on 2 large turbine blades of a land-based gas turbine engine, and the company was tooled by a large manufacturer for fabrication of the blades. These buckets run up to approximately 24 inches in length and are vacuum-cast. Capability was developed in feeder housings and large volumes of the housings were produced for one of the prime armament manufacturers in the United States.

The Landing Gear Overhaul Division continued to expand its capabilities and customers during the year. Complete assemblies and/or shipsets undergo disassembly, complete dimensional inspection, and overhaul and/or replacement as necessary. At year-end, total-in-house capability, production facilities, and technical data permitted accommodation of most aircraft utilized by the airline industry. Customers included many foreign operators as well as approximately 80 percent of the domestic airlines.

Aerodex increased its laboratory capability. Development, research, and analysis capabilities include many varied chemical and metallurgical processes and procedures and the preparation and test of various alloys and diffusion coatings. The facility was expanded into such additional areas as agriculture (leaf, plant, and fertilizer analysis), industrial hygiene, pollution (fluid and air), environmental tests, transportation (fuels, lubricants, and rubber), investigatory procedures into reasons for failures, and repair procedures.

AEROJET-GENERAL CORPORATION

Aerojet-General Corporation in 1969 played a key role in landing men on the moon and began preparation for future manned space flights with development of highly advanced rocket engines and initial work on a laser communication system.

Aerojet's Service Propulsion System (SPS) rocket engine, the main spacecraft engine, provided the power for the astronauts to attain lunar orbit, and then fired again as the only means of propulsion available to escape lunar orbit and begin the journey home.

Looking to the future, Aerojet conducted highly successful tests of its NERVA nuclear rocket engine and designed a novel concept for a space shuttle propulsion system.

Aerojet, a subsidiary of The General Tire & Rubber Company, also contributed to many other aerospace programs during the year through its 9 operating divisions: Liquid Rocket Division, Solid Rocket Division, and Nuclear Division, all of Sacramento, California; Industrial Systems Division, Frederick, Maryland; Environmental Systems Division, Space Division, and Surface Effect Ships Division, all of El Monte, California; Electronics

Division, Azusa, California; and Ordnance Division, Fullerton, California, with other facilities at Downey and Chino, California.

On Apollo, Aerojet's SPS engine, a restartable system generating 20,500 pounds of thrust, was called on for multiple firings in each flight. All principal firings came when the spacecraft was behind the moon and out of communication with the earth; the burns were made to slow the vehicle to gain an orbit around the moon, to circularize that orbit, and to "come home." There is no backup system for this engine, and it must work in order to insure success of the mission. Aerojet produces the engine for NASA under subcontract to North American Rockwell's Space Division.

Other rocket systems provided during the year included liquid-fuel engines for the Air Force Titan III, the second stage for NASA's Delta, second and third stages for the Air Force Minuteman III ICBM, kick motors for the Intelsat 3 communications satellites, and numerous other small rocket motors, both solid and liquid propellant systems.

NERVA, the nation's only nuclear rocket engine under development, achieved a major milestone in 1969 with the first full-duration, nozzle-down static firings of the complete system. There were 28 engine start-ups in the March-August period, operating for a cumulative test time of 3 hours 48 minutes. Peak thrust achieved was 55,000 pounds, proving the concept of the engine and paving the way for development of a flight engine with 75,000 pounds of thrust. NERVA was mentioned prominently in the Space Flight Task Force Report to President Nixon as vital to the future of manned space flight.

A space shuttle system was also mentioned prominently in that report, and Aerojet offered its design of an engine to power those vehicles. The reusable engine would operate on high-energy liquid hydrogen/liquid oxygen propellants and could be easily maintained. Aerojet has had long experience in the use of liquid hydrogen as a rocket engine propellant.

Aerojet recorded significant progress in 1969 in development of controllable solid-propellant rocket motors, offering a flexibility of design not available in the past. Thrust variability is achieved through changing, on command, the position of a pintle in the area of the nozzle throat. Aerojet completed a number of programs with variable-thrust and stop-start solid motors which are applicable for space vehicle control systems, post-boost propulsion systems, and tactical weapons systems.

In a continuation of NASA's program to demonstrate the advantages inherent in the application of very large solid-propellant rocket motors for space launch vehicles, Aerojet was called upon for additional development work for motors 260 inches in diameter. Aerojet test-fired 3 motors with diameters of 260 inches in earlier years.

Development of modern manufacturing tech-

niques led to the selection of Aerojet to produce titanium propellant tanks for the descent engine of the Apollo Lunar Module. Aerojet continued to make the tanks for the ascent stage engine.

The company also received numerous contracts to produce metal components for nuclear reactors.

Aerospace technology played a major role in Aerojet's engineering and design of a 100-ton surface-effect ship which rides at high speeds over water on a cushion of air. This vehicle, being designed under contract to a joint office of the Navy and the Maritime Administration, utilizes many techniques from aircraft and spacecraft. Because of their high speed (80 knots or higher), such vehicles could revolutionize naval strategy and worldwide shipping practices.

The SES design by Aerojet uses aircraft-type engines to provide the lift and to power the waterjets which provide both propulsion and steering by drawing water in the front of the vehicle and expelling it out behind.

Principal work of the Electronics Division was on a classified unmanned satellite program for the Air Force. Many advanced concepts in a number of fields were required for work on this program. The Air Force also awarded Aerojet a contract for development of a space program data reduction center, with initial funding of \$5,700,000.

Aerojet was selected late in the year for development of an advanced optical satellite communications experiment. It will be the first Light Amplification by Stimulated Emission of Radiation (LASER) communication system to be used on a satellite. The use of lasers appeared a promising way to obtain efficient communications over extremely long distances. Laser communications capability could make live TV color coverage possible for a manned landing on Mars. Lasers provide an extremely wide band communications function, and would be able to transmit hundreds of TV channels around the world, a great increase over present microwave capabilities.

The infrared experiment will be aboard NASA's Applications Technology Satellite F (ATS-F), scheduled for launch into a synchronous orbit in 1972.

Successful full-system operation of a single set of components for extensive breadboard testing was achieved for the first time in the SNAP-8 nuclear-electric power conversion program. Designed to convert nuclear reactor energy into 35 kilowatts of electrical power, SNAP-8—the largest space power generator system in development—has many potential applications including large orbiting space stations, lunar exploration, direct television broadcast satellites, manned planetary missions, and power for life-support and communication systems.

Aerojet was selected to fabricate and help launch 2 spacecraft designed to test the balance mechanism of the inner ear during periods of weightlessness and repeated acceleration.

The company was commended by Naval Ordnance Systems Command for "superior program management and dedication" which resulted in the delivery of Mark 56 antisubmarine warfare mines ahead of schedule.

Aerojet was also concerned with helping solve some of the down-to-earth environmental problems facing the nation. The applications of microwave technology were expanded under a NASA contract to develop an airborne radiometry system applicable to earth resources programs. The system will be utilized to gather important data for scientific studies related to geology, oceanology, hydrology, agriculture, and forestry.

A developmental medical analyzer, designed to rapidly identify the presence of invading bacteria in humans, was completed and field tests were begun. Initially, the instrument was being used in the identification of streptococcus, a major cause of rheumatic heart disease. Future tests will be directed at the identification of a number of other major disease-causing bacteria, such as staphylococcus, tuberculosis, gonorrhea, and salmonella. Production and sales of the SeroMatic System, an automated diagnostic instrument used in the detection of syphilis, increased during the year.

Sim One, the computer-controlled medical manikin used in the training of doctors, was being modified to provide additional training capabilities for nurses, interns, medical students, and hospital ward attendants. A contract was received to outfit Sim One with a new right arm and a special-purpose computer which will allow new training techniques coupled with portability. The modified arm has identifiable "muscle," "nerves," "bone," and "pulse" with internal instrumentation to identify and measure the quantity of 3 different simulated drug injections. It will be possible to withdraw "blood" by venous puncture.

Work also progressed on an atomic power source for artificial hearts and on an artificial kidney machine.

A modern liquefied natural gas facility went on-stream near Lowell, Massachusetts, to provide more efficient use of natural gas as an energy source. The facility liquefies and stores gas during periods of low usage (gas in its liquid form takes less space than in its natural state by a ratio of 1 to 600). The facility then reconverts the liquid to gas and releases it in times of heavy demand. The use of liquefied natural gas also permits transportation of the gas to areas with no existing pipelines.

Waste management was another area of Aerojet interest. A dual version of the AVAC (Automated Vacuum Collection) system—handling both trash and linen—was completed on schedule for the Martin Luther King Memorial Hospital in Los Angeles. A trash-handling AVAC system was being designed for a 3,000-apartment housing complex in New York.

Techniques in the mass production of tubular reverse osmosis units led to the development of AROS (Aerojet Reverse Osmosis System). Requirements for the purification of water from tens of gallons to millions can be met through "building blocks" consisting of bundles of membrane-lined tubes.

New methods to improve materials handling were also developed and installed by Aerojet. Facilities included those for United Air Lines, Union Carbide, the U.S. Post Office Department, and many department stores. Computerized equipment provides economical, effective handling and distribution systems.

AERONCA, INC.

The high point of the year for Aeronca, Inc.—shared with the many other organizations involved—was the extraordinarily successful mission of Apollo 11 and man's first steps on the surface of the moon. The technology which Aeronca contributed, brazed stainless steel honeycomb panels which make up the outer structure of the Command Module, led the company into several new areas of honeycomb structures application.

During the year, Aeronca joined a team of 8 major Boeing subcontractors for the construction of 2 U.S. supersonic transport prototypes. The company's extensive work in developing titanium honeycomb sandwich structures will be applied to the wing trailing edge flaps and flaperons (a combination of flap and aileron). There are a total of 8 flap and flaperon assemblies per airplane; the largest is approximately 20 feet long and 9 feet wide. The trailing edges of these assemblies will consist of full-depth brazed titanium honeycomb sandwich wedges. Outer skin panels of the flaps and flaperons will be of titanium honeycomb sandwich supported by electron-beam-welded titanium ribs and spars.

Other brazed honeycomb sandwich structures produced by Aeronca in 1969 included the thrust reverser exhaust plug assemblies for the 747 engines. Well over half the area of these assemblies is of brazed Inconel honeycomb material. Of added significance to the thrust reverser plug program in 1969 was the incorporation of sound-suppression brazed honeycomb panels. These panels incorporate a perforated outer skin for sound absorption and are probably the first production application of brazed honeycomb sound-suppression panels. Aeronca developed a wide range of lightweight sound-suppression honeycomb panels in a variety of materials for application in both hot and cold areas of jet engines and engine nacelles.

In a new entry, the company competed successfully for the design and production of complete engine power plant pods, including thrust reversers

and associated systems, for the Garrett-AiResearch ATF 3 turbofan engine. ATF 3 engines were slated initially for the North American Rockwell Series 60 Sabreliner; they will extend the aircraft's range to continental.

Named executive director of Aeronca's power plant programs was Robert E. Johnson, long associated with Curtiss-Wright Corporation and a well-known authority in aircraft propulsion systems with wide experience in design, installation, and flight testing of aircraft power plants. Another well-known designer of aircraft power plant installations, Carl A. Weise, was named technical director of Aeronca's engine power plant programs. He has over 30 years' experience in power plant installation projects. At McDonnell Douglas, he was design manager of power plants for all versions of the DC-7, DC-7C, and DC-8 and was closely associated with many other DC series power plant installations, including the DC-9 and DC-10.

Over several years, Aeronca acquired the personnel and facilities required for the highly specialized technologies involved in jet engine power pod development and production. In this activity, the company is able to utilize its high-temperature materials technology, fabrication, and forming techniques for high-strength, lightweight structures.

The jet engine field applied another Aeronca honeycomb structure during the year. Circular seals made of an outer ring with honeycomb brazed to the inner diameter were ordered by General Electric Company's Large Engine Division for use in the CF6 jet engines which will power the McDonnell Douglas DC-10 jetliner. The seals were the development of a joint-venture company, Aeronca-Burnley, Inc. Jet engine seals of this type were also being produced by Burnley Engineering Products Ltd. for Rolls-Royce engines.

In more conventional aircraft structures, Aeronca continued to be deeply involved in the latest programs, including the Lockheed L-1011 TriStar. For this aircraft, the company was producing all wing flaps and wing vanes (16 per shipset) under a contract from Avco's Aerostructures Division. Fabrication of these assemblies involves aluminum, titanium, and bonded components. Forgings and extrusions are used extensively, and surfaces require compound contours held to extremely tight tolerances. Tooling for the leading edge wing slats on the McDonnell Douglas DC-10 was also in process.

Volume production continued at Aeronca on flap track fairings, wing tips, and inspar wing ribs for the Boeing 747. The fairings and wing tips utilize the company's extensive bonded fiber glass facilities in Middletown, Ohio; the wing ribs, produced in Torrance, California, utilize exclusive stretch forming equipment and a special fabrication building. Cargo containers, specially shaped to fit the contour of the aft end of cargo aircraft, were in production for American Airlines' jet cargo fleet.

Aerospace programs continued to account for approximately two-thirds of Aeronca's sales and practically none of it was related to the Vietnam conflict. The other third of the company's business came from sales of its Environmental Control Group. A supplier of highly engineered environmental control systems in this country for commercial and industrial buildings, the group was successfully rounding out its product offering to supply a much higher percentage of the elements in the total system. Expansion of the group's activity abroad was heightened by acquisition of the Light Products Division of Britain's diversified Powell-Duffryn Ltd. Already a licensee for production and distribution of Aeronca's environmental control equipment, the Light Products Division also held manufacturing licenses from W. W. Sly Manufacturing Company of Cleveland and was marketing Carrier Corporation products in the United Kingdom, sold under the Carlyle brand name. Aeronca International Ltd. was formed to handle the activities of this group as well as the operations of Aeronca-Winslow Filters Ltd., a wholly owned subsidiary of Aeronca which was also acquired from Powell-Duffryn Ltd. Aeronca-Winslow Filters Ltd. is a manufacturer of industrial filters and of filters for truck and marine engines.

Operations of Aeronca in the 9-month period ended September 30, 1969, resulted in a 70 percent rise in net earnings over the comparable period a year earlier. Net earnings increased to a record \$954,396, equal to 78 cents per average common share, from \$528,984, or 47 cents per share, in the 1968 9-month period before utilization of a federal tax loss carry-forward of \$592,000, or 53 cents a share, in that 1968 period. Net sales for the 9-month period increased to a record high of \$36,651,205, from \$36,114,281 in the corresponding 1968 period.

THE AEROSPACE CORPORATION

On May 23, 1969, a Titan IIC, generating over 2,000,000 pounds of thrust, lifted from the launch pad at Cape Kennedy. Following a highly complex flight plan, 5 satellites were placed in selected orbits ranging from near-earth orbit out to 60,000 miles.

For the Air Force, for The Aerospace Corporation which provides it with technical management assistance, and for the aerospace industry, it was the culmination of research and development for the Titan III family of space boosters which had its beginnings almost 9 years before.

In all respects, the program had been successful. The flight-test achievements had been met. The billion-dollar cost of the program was gratifyingly close to budget, and the launch vehicle system produced had proved serviceable for future operations.

The Titan III concept and The Aerospace Corporation began together. Many of the tasks Aerospace

undertakes have been characterized by the work the nonprofit organization has performed on the Titan III booster system: what is called general systems engineering and technical direction. This work is technical management on systems, first to identify potential advances and then to achieve them as needed, effectively, expeditiously, and economically. As systems engineer, the corporation provides the cement that binds all elements of a system together into an optimum whole. The corporation must possess the highest scientific and technical competence across the full spectrum of disciplines; it must be objective and impartial.

In addition to Titan III work, systems engineering continued on 2 other space boosters. One, Standard Launch Vehicle II, is an adaptation of the Thor missile. By year-end, there had been 110 consecutive successful Thor launches in support of Air Force programs. The other, Standard Launch Vehicle III, is based on the Atlas missile. In 1969, 7 launches were made, all successful. Forty-six consecutive successes had been experienced since 1966.

The family of military communication satellite programs constituted a major part of the systems engineering tasks for Aerospace. These programs evolved from communication satellite activity which the corporation has been carrying out since its founding. At the end of June 1969, 26 defense comsats were scattered in random orbits at an altitude of 18,200 nautical miles. Development of a second-generation system, 4 satellites at synchronous orbits, progressed through the preliminary design review.

Another defense communication satellite program, for the United Kingdom, was being carried out by the United States. As a result of international agreements, the United States designed a stationary communication satellite with a telemetry tracking and command station at Oakhurst, England. The station was turned over to the Royal Air Force. Aerospace participated in the program from the beginning, in 1966, and was responsible for technical direction of the program.

A program to provide NATO with a military communication satellite, similar in design to the United Kingdom satellite, was well under way. Fabrication began on the first flight-model spacecraft for the NATO program. Aerospace supports the U.S. Air Force in its technical interfaces with NATO, particularly with the Supreme Headquarters Allied Powers, Europe.

The latest tactical communication satellite, TACSAT-1, is a triservice activity permitting use of satellite communications by aircraft, ships, submarines, and land vehicles. It was orbited in February 1969. In addition to its usual systems engineering and technical direction roles, Aerospace participation included coordination of earlier experiments and technical assistance to the contractor in diverse fields.

The corporation also continued general systems

engineering/technical direction for the Advanced Ballistic Reentry Systems Program, contributing to the technologies and designs for several new highly survivable ground-based missile systems.

Development and planning at Aerospace covered a wide spectrum of activities, from detailed technologies to the broadest of systems and strategies. Analyses and studies in such fields as accuracy and survivability improvements for airborne missile subsystems led to technology development programs. Ground system emphasis was placed on ground motions which might be experienced by silos in a nuclear attack, on silo closure problems, and on communications. For satellites, emphasis was on advanced space guidance, on low-thrust propulsion, on instrumentation, on thermal control, and on reliability.

Orbital systems planning included navigation satellites and data relay satellites. Studies on space escape and rescue techniques for high-altitude space stations and on meteorological satellite applications were carried out.

The corporation also made inputs to the President's Space Task Group, particularly in the area of a Space Transportation System (STS). A 7-volume report was prepared to document this activity, with 6 additional volumes concerned with technology. These STS studies were evolving into a joint NASA/Air Force program.

Working with Jet Propulsion Laboratory, the corporation participated in a lunar gravity study which assisted in identifying gravitational anomalies on the moon. Research was performed on materials for a proposed defense system, under contract to the Army Watertown Arsenal. Two small contracts from NASA utilized infrared television systems to measure aircraft exhaust plumes and aircraft surface temperatures.

The U.S. Department of Health, Education, and Welfare granted a contract to study a biomedical communications network. Among other types of links considered for this purpose were communication satellites which could broadcast television to hospitals and medical centers for reception with small antennas. This directly applied corporate experience in military communication satellites to a problem of civilian communications and education.

The corporation continued to expend a large percentage of its earnings on research programs. These included research on the chemical composition of smog, based on reaction theories developed for studying combustion in rocket motors; analysis on alleviation of sonic booms by injection of heat into the airstream; a civilian aviation satellite service study; analysis of urban transportation problems and evaluation of certain design concepts; development of interactive computer console techniques; preliminary design of a millimeter wave telescope with large aperture; millimeter wave measurements of cosmic temperatures; and a study to define the next-

generation space launch system which furnished much of the background for the major NASA/Air Force task on Space Transportation Systems.

Two programs which had been previously funded from earnings received partial outside support during the year. An interdisciplinary cardiac study, conducted jointly with Loma Linda University Medical Center, received a grant from the National Heart Institute. A video magnetograph which shows the sun's magnetic field in real time was under development with financial support from NASA. It will be utilized at the corporation's San Fernando Solar Observatory.

Corporate-sponsored studies on air traffic control and on aircraft utilization were focusing on short-haul transportation. The Western Conference of States, involving 13 state governments including Alaska and Hawaii, authorized a contract to study this problem.

ALLISON DIVISION GENERAL MOTORS CORPORATION

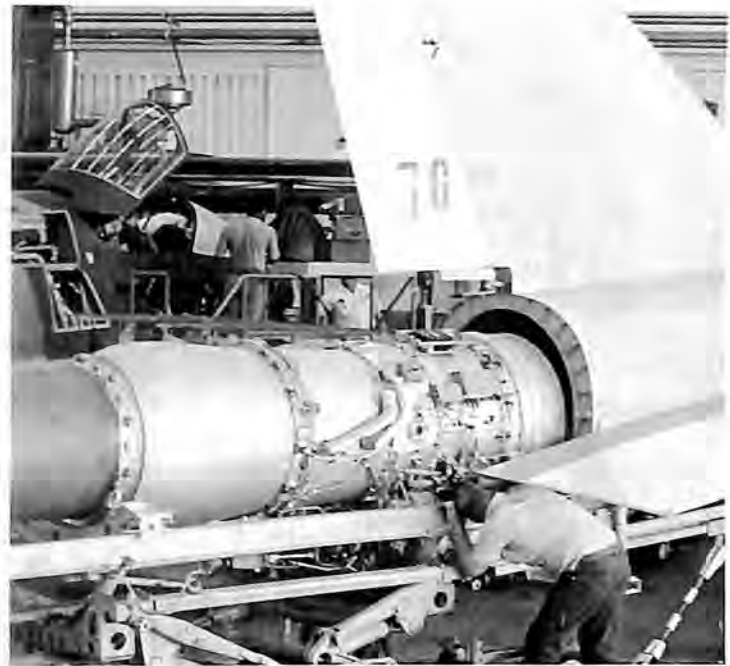
For the Allison Division of General Motors, 1969 was a year of achievement and progress in several different areas of aerospace activity.

Sales of small turboshaft engines continued to increase in proportion to a rapidly growing demand for light helicopters. A small turboprop was to enter production in 1970. Official qualification tests were completed on a new turbofan engine. An advanced gas generator demonstrator engine completed a series of highly successful test runs. Significant progress was made in high-temperature studies aimed at developing more efficient gas turbine engines using less fuel than present power plants.

Allison also had a role in the historic manned landing on the moon. High-strength titanium tanks developed and manufactured by Allison carried the propellant for the Apollo 11 Service Module and Lunar Module. One or both types of Allison tanks were aboard each Apollo flight.

Allison's turbofan engine program continued to expand with delivery of the first TF41-A-2 engines for the Navy A-7E carrier-based light attack aircraft. The Navy version of the TF41 produces 15,000 pounds of thrust. The TF41-A-1 engine, rated at 14,250 pounds thrust, went into production at Allison in 1968; it powers the Air Force A-7D attack bomber.

Production of Allison T56 series turboprop engines continued for the Lockheed C-130 Hercules, used by the Air Force, the Navy, the Coast Guard, and the Marine Corps; for the Navy/Lockheed P-3 Orion antisubmarine warfare plane; and for the Grumman carrier-based E-2A Hawkeye reconnaissance plane.



Allison started deliveries of the 15,000-pound-thrust TF41-A-2 engine, shown here being fitted into the engine compartment of the Navy A-7E light attack aircraft.

Testing and evaluation of several other T56/Model 501 engine applications continued, including a unique ground application of the Model 501 which will be the first use of an aircraft-type turbine in the fight against air pollution. The engine will power a special generator set designed to purify the air released from the San Diego, California, sewage plant. Scheduled for installation early in 1970, the generator set will burn odorous gases given off during the processing of sewage and will neutralize the odor. And, by burning the gases as fuel, it will generate power for the San Diego Gas and Electric Company network.

Allison's T63/Model 250 series engines gained increased visibility and popularity in the helicopter and light fixed-wing aircraft markets during the year. In March, the Federal Aviation Administration awarded Allison a Type Certificate for the 317-horsepower Model 250-B15 turboprop for light fixed-wing planes.

In May, the first T63-powered OH-58A light observation helicopter was delivered to the Army. The helicopter, which uses the T63-A-700 turboshaft engine, is the first of 2,200 OH-58As to enter the Army inventory. The new model, named Kiowa, is the Army version of the commercial Bell JetRanger. The Army/Hughes OH-6A light observation helicopter also uses the Allison T63 engine.

Commercial versions of the T63 were in full-scale production for the Bell JetRanger, the Agusta-Bell JetRanger, the Fairchild Hiller FH-1100, and the Hughes 500 helicopters. The Model 250-B15 turboprop version of the engine, soon to be in production, is essentially a Model 250 turboshaft with a propeller reduction gearbox attached.

The Model 250 engines were attracting wide attention from commercial charter and air taxi operators, law enforcement agencies, municipalities, and business firms interested in turbine-powered helicopters and light planes. As the Model 250 compiled more and more flight hours, its performance and reliability continued to improve. Effective July 1, 1969, Allison increased its warranty coverage on the engine from 500 hours or 6 months to 750 hours or 9 months.

While pursuing vigorous product improvement programs directed toward broadening application of its current engines, Allison continued development of new power plants for future military and commercial aviation requirements. The XJ99 advanced lift-jet, being developed jointly by the Aero Engine Division of Rolls-Royce and Allison, successfully completed its first test runs at Derby and Indianapolis. In addition, Allison had under study a more efficient jet engine for combat aircraft of the 1980s. This new concept is the basis of an aircraft application study which focuses on turbine engines with high operating temperatures. Allison also completed the initial test run of its GMA 100 gas generator approximately 2 months ahead of schedule. The GMA 100 is an advanced-technology demonstrator which will provide the basic building blocks for new generations of turbine engines.

AVCO CORPORATION

AVCO AEROSTRUCTURES DIVISION

After 18 months of preparation that included construction of 500,000 square feet of facilities and installation of some \$45,000,000 worth of equipment, tooling, and fixtures, Avco began hardware production of wings for the Lockheed-California TriStar jetliner in mid-October. The order for 350 sets of wings for the 350-passenger L-1011 was received April 1968. The wing sets Avco was building for the wide-cabin intermediate-range jet span 155 feet, with a fabrication area of approximately 3,500 square feet.

Avco subcontracted 3 L-1011 wing orders during the year. These contracts, for subassembly work, went to Aeronca, to CCI-Marquardt, and to Short Brothers & Harland Ltd. of Northern Ireland. The 3 orders totaled \$59,000,000. In addition to assembling the entire L-1011 wing, Avco was fabricating the complete wing box assembly and the fixed leading and trailing edges. The first wing was to be delivered to Lockheed's L-1011 assembly plant in Palmdale, California, in the first quarter of 1970.

In February, the division received orders from Lockheed-Georgia for 57 additional wings for the C-5 transport. This follow-on order, valued at \$38,000,000, called for deliveries of the 57 wings to begin in the fourth quarter of 1970, following com-

pletion of the initial contract for 60 C-5 wings. Avco was building for Lockheed under a \$55,000,000 contract that started in 1966. According to the schedule, the final wing, the 115th, was to be shipped to Lockheed's plant in Marietta, Georgia, by the end of 1972.

In 1969, Avco received a follow-on contract, valued at \$14,400,000, from Grumman Aerospace Corporation to build 36 additional wing assemblies for the Gulfstream II executive jet aircraft, and orders of \$4,000,000 from Bell Helicopter Company to continue fabricating tail-boom sections for the Huey helicopter. By year-end, Avco had produced and shipped to Bell's Fort Worth plant more than 6,000 helicopter assemblies since work began on the Huey program in 1964. Deliveries included hardware for both the military and the commercial versions of the Huey series.

The division commenced its 17th consecutive year of producing tail assemblies for all military and commercial versions of the Lockheed C-130 Hercules cargo and troop transport. More than 1,100 completed empennages had been delivered to Lockheed's plant in Marietta.

The division continued fabricating outer cases for the extended-range Lance ballistic missile, under contract to the Army, and thermal-conditioning panels used on the Apollo Lunar Module.

All the metal office furniture sold by Globe-Wernicke (over 6,000 items), with the single exception of desk chairs, has been produced at Avco Aerostructures since 1964. The company was executing a 5-year production contract awarded by Globe-Wernicke in 1967.

The division's role in the supersonic transport program was redefined during the year when a bid from The Boeing Company to build an approximately 45-foot-long section of the plane's fuselage was accepted. Up to the time the transport was redesigned to a fixed-wing configuration, Avco had been selected to build the center wing section.

Some 500 employees were scheduled to be added by the end of 1969, bringing the total plant work force up to 4,300.

AVCO APPLIED TECHNOLOGY DIVISION

In 1969, Avco Space Systems Division changed its name to Avco Applied Technology Division to reflect more appropriately the division's technical strengths and business lines.

During the year, the division continued to find a broad range of applications for its strong technology in support of ICBM and Apollo reentry systems. In the area of thermal protection, a goal established over 10 years earlier was realized when the Avco-developed heat shield for the Apollo Command Module protected the 3-man Apollo 11 crew as the spacecraft reentered the earth's atmosphere at 5,000 degrees Fahrenheit. Extensions of the Apollo heat

shield work led in 1969 to contracts to protect fins of the Navy's high-speed Zero Antiaircraft Potential (ZAP) missile.

Much of Avco's 1969 work in heat shielding was related to division-developed 3-dimensional materials. The materials, which are reinforced in 3 directions, possess significant mechanical and thermal characteristics not obtainable in normal reinforced plastic materials. The division is continually updating production methods and developing new military and commercial applications for the materials.

Avco/ATD, one of 2 producers of boron filament in the United States, continued production of high-strength boron fibers for the Air Force and was in the process of completing a multimillion-dollar boron production facility. Output from this new plant, which was to be operating in the fall of 1970, is expected to be used on aircraft such as the F-14 and F-15 and on future commercial aircraft. Aircraft manufacturers have indicated that future military and commercial aircraft will use boron-reinforced plastic and metal structures and that such units will provide weight savings of 20 to 50 percent. In addition, the Air Force approved production components made from boron composites to be flown on the F-4, the C-5, and the F-111.

In 1969, the division was awarded a contract by NASA's Ames Research Center to evaluate and apply to military aircraft several ablative foam composites for containing or preventing on-board fires. In addition to military fire problems, the division was surveying and investigating civilian and space fire hazards. A unique fire simulator which will make possible evaluation of many fire-resistant materials was developed.

Production of lightweight, optically transparent ceramic and composite armor systems under Air Force contracts and company-funded research continued at the division. The Avco-developed armor systems are designed for protection of personnel and of vehicles such as riverine craft, helicopters, and aircraft against a variety of ballistic threats.

The division's auxiliary propulsion equipment, called Resistojet, was operating successfully in orbit aboard NASA's Applications Technology Satellite (ATS-5), launched in August 1969. Weighing only 6 pounds, the Avco-designed and -developed Resistojets are required for the accurate positioning and orbital control of communications and reconnaissance satellites.

The division operated 2 sterilization units at the Jet Propulsion Laboratory and was under contract with NASA's Langley Research Center to design and build the Model Assembly Sterilizer for Testing (MAST). The facility, which can be rolled to the foot of a launch pad for on-the-spot spacecraft sterilization, is a trailerized prototype facility for the terminal sterilization of the planned Mars 1973 probe.

Avco/ATD's unique acrothermal simulation facili-

ties continued in use for production monitoring tests on the Apollo Command Module and for evaluation of various thermal protection materials for military and space vehicles.

Because of Avco's interest in space age materials and subsystems, the company continued the investigation of conditions encountered by vehicles re-entering the earth's atmosphere from outer space. High-intensity infrared metal vapor lamps were developed and produced by Avco for application to protective systems for aircraft and naval vessels against attacking enemy missiles. In addition, the division carried out tests on erosion resistance of a variety of advanced aerospace materials in its unique Rain and Dust Erosion Facility. The facility permits firing of heat shield material pellets at 15,000 miles per hour through dust and rain fields to simulate passage through the earth's atmosphere. Avco/ATD was also designing and fabricating special hardware for the 10-megawatt arc at NASA's Manned Spacecraft Center.

AVCO ELECTRONICS DIVISION

The Electronics Division continued its leadership in development and production of high-frequency communication systems and equipment for both ground and airborne communications.

Production at the Evendale, Ohio, headquarters site during the year continued on 2 systems for the F-111A: the AN/ARC-123 radio system and the AN/AAR-34 countermeasures receiving system. Avco's AT-440 HF transceiver for the C-5 Galaxy continued in production. The year saw increased output of the AN/TLQ-17 electronic countermeasures equipment which entered production late in 1968. Other classified ECM work based on division technological advances was begun in 1969.

Government- and company-funded research into infrared detectors and systems was carried on for potential programs involving all military services and selected high-level civilian applications. Testing of new systems in combat environments increased during the year.

At Evendale, the division remained heavily involved in space electronics, radar, and antenna research and development.

The division's Huntsville Operation continued its 2-year-old growth in information systems design and fabrication with several contracts under \$500,000 as well as a \$1,000,000 contract to produce a high-speed data acquisition system for use in structural testing of the Navy F-14A fighter. In its first year of operation, Avco/Huntsville won a contract to produce and design the world's largest combined computer-controlled structural loading and data acquisition system for structural load testing of the Air Force C-5.

In 1969, Avco/Huntsville introduced, in the data systems area, new models of signal conditioning

front-end amplifiers, new models of servo controllers, a new cross-bar scanner, and a number of new logic cards.

For the second straight year, the division's Tulsa Operation increased its share of the shock-test equipment field, from approximately 35 percent in 1968 to 55 percent in 1969. A new product in the shock-test field, the SM-1000, was placed on the market.

Avco/Tulsa operated one of the nation's 3 mass spectrometer laboratories certified by the Atomic Energy Commission. The laboratory offered complete isotopic analysis of gases and solids by electronic bombardment. The Tulsa facility was also designing and building mass spectrometers to special order.

In a major entry into the consumer market, Avco/Tulsa began production and nationwide sales of all-fiber-glass luxury travel trailers and of a motor home.

The division's Field Engineering Department expanded its domestic and foreign operations in aviation support, depot maintenance, and technical services.

The division was also active in producing electronic teaching equipment under contract to a leader in the electronic teaching aids industry.

Foreign sales of equipment and licensing of technology produced and developed at Avco Electronics Division played an increasing part in the division's business volume.

F. C. Shadley became vice president and general manager of the division on March 1, 1969.

AVCO EVERETT RESEARCH LABORATORY

Avco Everett Research Laboratory in 1969 continued its research and development of high-power gas lasers. The Model C950 pulsed gas laser, operable on either nitrogen (3371 Å) or neon (5401 Å), was being marketed for research and commercial uses.

For the National Air Pollution Control Administration, U.S. Department of Health, Education, and Welfare, the laboratory staff was using the C950 laser to study air pollutant characteristics. Included were field experiments which used laser light to analyze, from a remote location, pollutants in smoke-stack exhaust. The studies were expected to lead to the development of a remote monitoring system for field use by air pollution control agencies.

A major achievement in 1969 was the division's success in using the C950 laser to stimulate lasing action in a variety of dyes. This accomplishment made possible the design of a laser tunable to any visible wavelength; wide application was expected in such fields as oceanography, upper-atmosphere studies, and analytical chemistry. Other applications for the C950 include data processing, micromachining, photochemistry, and high-speed photography.

The laboratory was also investigating for the Army the practicality of transforming chemical energy into laser energy for military and space applications. The division was studying electrically excited gas lasers, which may be among the most efficient methods of achieving very high average-power outputs.

The intra-aortic balloon pump was designed to give immediate aid to heart victims by reducing the heart's work load. The laboratory worked with Massachusetts General Hospital in this program. Blood flow and clotting studies continued for the National Institutes of Health, the Air Force, and NASA.

The laboratory continued its effort to develop large commercial magnetohydrodynamic (MHD) power generation systems and MHD plants to meet emergency demands for peak power and to prevent power blackouts. MHD power generators produce electric power by forcing ionized gas through a magnetic field. The Air Force awarded the division a contract to study the practicality of light-weight MHD generators for specialized use aboard aircraft.

Research in reentry physics for the Department of Defense continued its important role in 1969 at Avco Everett. Programs involved monitoring and studying vehicle performance during atmospheric reentry. Information gained in these programs was being used in developing new reentry technology.

Research in superconducting coils continued in 1969. The Air Force awarded the laboratory a contract to study the feasibility of using superconducting coils in inductive energy storage units for airborne systems which require high energy bursts for brief time periods. Compact size and light weight make superconducting coils attractive for this application. For the Navy, the division studied the use of superconducting generators for propulsion and of superconducting motors to meet the service power requirements of ships.

NASA extended its contract for study of a plasma radiation shield to protect future astronauts against interplanetary radiation storms. Additional federal funds were received to enable laboratory scientists to continue work on the heavy ion plasma accelerator, which will be used to study the nuclear structure of heavy atoms.

AVCO LYCOMING DIVISION (STRATFORD)

Avco Lycoming Division, Stratford, continued in 1969 as one of the world's leading suppliers of gas turbine engines for helicopters and fixed-wing aircraft; at the same time, it began to find more and more applications in the non-aircraft fields.

During the year, Avco Lycoming industrial and marine gas turbine engines were selected for use by the Federal German Railway System for booster locomotive operation; by Euclid, Inc., for powering

a new 105-ton off-highway ore hauler; by Pan American Petroleum Corporation for offshore oil well operations in Cook Inlet, Alaska; by the Navy for the prime propulsion of a second type of patrol boat; and by Aerojet-General Corporation for the prime propulsion of a new Surface-Effect Ship (SES) being developed for the Joint Surface Effect Ships Program Office (JSESPO).

Also during the course of the year, industrial and marine engines previously selected were installed and began successful operation in England in the Vosper VT-1 hovercraft, and in Canada, by Winnipeg Gas Company, in a turbocompressor system for the manufacture of synthetic natural gas.

To support this expanded effort on a worldwide basis, Avco Lycoming executed agreements with Gas Turbine Power, Inc., of Houston, Texas, for the distribution and service of gas turbine packages, and with Amalgamated Power Engineering Ltd. of Bedford, England, for the distribution and service of the complete line of Avco Lycoming engines. A license agreement with Kloeckner-Humboldt-Deutz (KHD) of Cologne, Federal Republic of Germany, which had covered only military requirements in Germany, was extended to incorporate commercial activities.

Avco Lycoming continued its aircraft activities and in 1969 shipped its 15,000th engine; shipments included the higher-rated, 3,750-shaft-horsepower T55-L-11 engine for the advanced Boeing Chinook helicopter. The division also completed FAA qualification tests on its new 1,800-shaft-horsepower T53-19A helicopter engine.

Research and development activities were centered on a higher-rated version of the T55 series, a 4,370-horsepower model aimed at the Air Force requirement for a new close-support aircraft.

Development of a new advanced-technology engine with a scalable rating of between 4,000 and 10,000 horsepower continued, and a 5,000-horsepower demonstrator engine was run on the test stand. This new design incorporates major technological advances to provide improved survivability, a 25 percent improvement in specific fuel consumption over earlier models, and a power-to-weight ratio approaching 9 to 1.

Several other aircraft engine development programs were in process including turboprop versions of the T53 and T55 series of engines and preliminary development of new 800-horsepower and 2,000-horsepower models.

Avco Lycoming's tank engine efforts continued under a new contract aimed at qualifying the engine for the Army's Main Battle Tank, the MBT-70.

AVCO LYCOMING DIVISION (WILLIAMSPORT)

Unit sales of aircraft reciprocating engines for fixed-wing and helicopter aircraft for the general aviation market declined somewhat in 1969 at the

Williamsport, Pennsylvania, plant of Avco Lycoming. However, unit sales of engines for multi-engine airplanes, as well as export sales, showed increases over 1968.

Several new engine models were introduced in 1969, including a 6-cylinder, geared, turbocharged model developing 450 horsepower, with provision for cabin pressurization and cabin cooling, for use in corporate-type airplanes. A second aerobatic engine, a 4-cylinder, 160-horsepower model, was also introduced; a 200-horsepower aerobatic engine had been introduced the previous year. Turbocharging was added to more engine models as the demand for altitude operation continued to increase in the general aviation field.

Increased recommended time between overhauls—in some cases as much as 50 percent—was offered during the year for most engine models, resulting in significantly lower maintenance for airplane owners.

A continuing development program included refinements to existing engine models and a new series of reciprocating engines in the lower horsepower, with the objective of reducing weight and costs.

AVCO ORDNANCE DIVISION

The bulk of the Ordnance Division's business continued to be the manufacture of bomb and rocket fuzes, bomb parts, mortar shells, and other non-nuclear munitions. Arming and fuzing for the Navy Polaris missile and for the Air Force Minuteman continued to be an important division activity.

A major contract was obtained for the production of a second-generation submunition. The production line for this item will be highly automated for a monthly production in excess of 1,000,000 items. In addition, the automated production line for M33 grenades was reactivated and modernized to double previous production capacity and reduce unit costs by 25 percent.

To accommodate changing market trends, the Ordnance Division was examining areas for product line expansion, including commercial products.

New engineering programs evolved in the areas of incendiary fragmentation bomblets, armor-piercing projectiles, and land mines.

Another major program was the division's AVROC (Avco Rocket), which spans the full range of fuzed, tube-fired ammunition and special applications. In the field of small rocket-propelled, extended-range munitions, the division continued to develop the 40-millimeter AVROC round for the M79 grenade launcher as well as a comparable round to fit the M75 and M129 automatic grenade launchers used so effectively by helicopter gunships in Vietnam.

Major research and development effort included miniaturization of components, circuitry for ICBM fuzes, and investigation of fluidic systems for ordnance devices. Other programs included develop-

ment on retarded bomb fuzes, low drag sensors, point-detonating mortar fuzes, digital command and control systems, 40-millimeter magnum cartridges, fragmenting bombs, and a fragmentation wrap for 500-pound bombs.

Facility improvements at the Ordnance Division in 1969 included the initial preparation of a new test site and the acquisition of advanced testing equipment and modernized manufacturing equipment. The division planned an investment in excess of \$1,000,000 in 1970 for facility and equipment modernization.

A Department of Defense Achievement Award was received in 1969 (the division was one of 10 defense contractors cited) for having made the largest single cost reduction of all companies in the area of specification and design change of a defense product.

AVCO SYSTEMS DIVISION

Avco Systems Division, formerly Avco Missile Systems Division, experienced a number of changes in 1969, reflecting a broader charter of operations, entry into new business areas, and its new name. Avco Missile Systems Division had been involved primarily in strategic missile reentry systems and penetration aids for strategic and tactical weapons systems. Avco Systems Division possesses capabilities in the design, development, and fabrication not only of missile systems but also of space systems, and in the application of the division's expertise to emerging areas outside the missile and space fields.

New systems activities, aimed at diversification of customers, technologies, and products, included the division's role as prime contractor in building a magnetic storm spacecraft system for the Air Force; design and development of prototype hardware, using fluidics technology, under contracts for the U.S. Post Office Department; and entry into the laser systems business.

Avco Systems Division continued its role as a vital industrial resource in meeting the nation's defense needs through expansion of the technologies associated with its efforts in ICBM reentry systems and through receipt of new contracts, including support to the Safeguard system, development of flight tests of advanced penetration aids, and a reentry antenna test program.

In the nation's space exploration program, the division was awarded a prime contract by the Air Force's Cambridge Research Laboratories for the design, fabrication, integration, test, and launch support of the Magnetic Storm Satellite (MSS). The division also received 3 study contracts from NASA related to the Delta-class Venus probe mission.

Establishment of a fully staffed and integrated professional organization to focus attention on the potential applications of laser systems was completed during the year, and significant advances

were achieved in the high-power laser market in conjunction with Avco Everett Research Laboratory.

Avco Systems Division's nondefense business activities focused on innovative applications of its technology and systems management skills: environmental systems for transporting people and cargo, for reducing pollution in waterways, and for urban planning; systems for mail processing in post offices; and municipal information systems.

BEECH AIRCRAFT CORPORATION

In 1969, Beech Aircraft Corporation, for the fourth successive year, set a record in fiscal year sales. Total sales for the year amounted to over \$186,000,000, which included over \$143,000,000 for commercial products, also a record. In international markets, Beechcraft sales also established a new high, totaling \$29,107,715 for the fiscal year. Export sales were bolstered by fleet sales of 10 Beechcraft Super 18s to Japanese buyers, of 9 Beechcraft Bonanza E33s to Miyazaki Aeronautics College, Japan, and of 11 Beechcraft Queen Air 70s to Société de Travail Aerien, Algeria.

Sales leader in the 1969 Beechcraft commercial fleet was the turboprop, pressurized Beechcraft King Air 90 series. With total deliveries at 478, the King Air 90 series accounted for nearly 22.1 percent of all turbine-powered aircraft and 58.2 percent of all turboprops in its class delivered for corporate use.

Highlight of the year was Federal Aviation Administration certification and first deliveries of the new Beechcraft King Air 100, a faster and larger version of the King Air B90. The 10-place King Air 100 provides approximately 20 percent more usable cabin, with spacious seating for additional passengers and twice the baggage space; it cruises at 287 miles an hour.

A \$6,000,000 award by the Naval Air Systems Command continued production of the supersonic rocket-powered AQM-37A target missile through July 1971 and brought revenue from the program since 1959 to over \$70,000,000 and unit production to almost 2,500. An additional 20 units of the Stiletto, a modified version of the AQM-37A, were ordered by the Defense Ministry of the United Kingdom.

Under a \$6,000,000 award by Bell Helicopter Company, production of panels for the Army UH-1 Huey helicopter continued. Awards to Beech Aircraft for the UH-1, including spares, totaled over \$30,000,000.

Under contracts totaling over \$75,000,000, production continued on airframes for the Bell Jet-Ranger series helicopter. The 5-year contracts include about 4,000 airframes for the commercial 206A JetRanger, the Army's light observation heli-

copter, and the Navy's light turbine training helicopter.

Beech Aircraft's Boulder Division, continuing its role in the nation's space program, was awarded a follow-on contract for fabrication of additional cryogenic gas storage systems used aboard the Apollo spacecraft. The Beech system supplies oxygen to the Command Module's environmental system and hydrogen and oxygen to the fuel cells for electrical power and drinking water.

BELL AEROSPACE COMPANY DIVISION OF TEXTRON INC.

Editor's Note: On January 3, 1970, Bell Aerosystems Company became Bell Aerospace Company Division of Textron Inc.

For Textron's Bell Aerosystems Company, a research, development, and systems engineering leader for 35 years, 1969 was highlighted by the flawless performance of its Apollo and advanced Minuteman ICBM hardware and technology, by the implementation of a Surface-Effect Ship (SES) program, and by the first manned free flight of a unique backpack, jet-powered individual mobility system. The year also marked significant developments on a number of other technological fronts, including aircraft landing, fire-control, and communication systems; vertical/short takeoff and landing (V/STOL) research; and advanced manufacturing.

The historic Apollo 11 mission represented a major test for all 5 aspects of Bell's \$100,000,000 role in the nation's lunar landing program. The company's equipment and technology were proved in a variety of Apollo assignments extending from lift-off to splashdown.

In addition to the Lunar Landing Training Vehicle (LLTV) and the Lunar Module (LM) ascent engine, Bell's Apollo contribution included a family of zero-gravity positive expulsion propellant and water tanks, a series of computer structural analyses, and the Lunar Module Rendezvous Simulator.

Prior to their missions, the astronaut commanders of both Apollo 11 and Apollo 12 practiced the final 400 feet of an actual moon landing during a series of LLTV training flights at Ellington Air Force Base, Houston, Texas. The wingless trainer is a highly instrumented free-flying platform that simulates the control characteristics of the LM; astronauts practice the intricacies of a manual lunar landing with the LLTV. Astronaut Neil Armstrong's success in overriding the Lunar Module guidance computer and averting the boulder-strewn crater encountered during Apollo 11 was attributed in part to his training on the Lunar Landing Training Vehicle.

Bell engineers designed and helped develop the

Lunar Module's 3,500-pound-thrust ascent engine, used to propel the astronauts from the lunar surface. As the ascent engine boosts the Lunar Module into lunar orbit for rendezvous with the orbiting Apollo Command Module, the astronauts rely on experience gained from another Bell trainer, the Lunar Module Rendezvous Simulator. Housed at NASA's Manned Spacecraft Center, the system electronically generates all the out-the-window visual sensations of an actual linkup in lunar orbit.

Bell's General-Purpose Structural Analyses Computer Program—one of the few in the world capable of such large-scale computations—scrutinizes the structural integrity of the Apollo/Saturn V third stage, simultaneously tracing and defining the thermal and mechanical stresses at some 5,000 key points throughout the intricate framework of this portion of the vehicle.



In a dust-free clean room, Bell Aerospace technicians check an inner bladder of an Apollo positive expulsion propellant tank. Bell provides 31 such tanks for each Apollo spacecraft.

Bell positive expulsion tank technology, which raised the total time of operation in space to over 22,000 hours in 1969, provided fuel and oxidizer to the Command, Service, and Lunar Modules as well as to the Saturn S-IVB's auxiliary propulsion system during all 4 1969 Apollo missions. Similar tanks also furnished water for the Lunar Module's environmental control system. A total of 31 Bell tanks go aloft with each Apollo.

In addition to Apollo, Bell tankage serviced the Mercury space capsule, the Gemini/Agenda target vehicles, the Surveyor spacecraft series, the Applications Technology Satellite, and the Orbiting Astronomical Observatory. Upcoming applications include the S-IVB Orbital Workshop program.

On February 28, Bell marked the 10th anniversary of the first space flight of its famed Agena rocket engine. Since putting its first payload in orbit in 1959, the Agena participated in more than 250 Air Force and NASA launches and played a major role in establishing orbital maneuvering control and other space exploration techniques.

In early 1969, Bell accelerated a pair of programs aimed at improving astronaut mobility—the Lunar Flying Vehicle and the Space Maneuvering Unit. Both were being conducted under contracts from NASA's Manned Spacecraft Center.

The company's one-man Lunar Flying Vehicle preliminary design study is aimed at optimizing vehicle design and developing system specifications. Included is the task of developing a preliminary plan outlining the steps for development, test, and fabrication of the vehicle, as well as a program for qualifying the system for lunar operation.

The Space Maneuvering Unit effort includes the development of a demonstration model of a simple, cold-gas-powered system with which the company will explore the feasibility of such devices for providing a high degree of extravehicular activity with a minimum of astronaut physical effort. In addition to the demonstration model system itself, Bell was constructing a special low-friction air bearing floor upon which the unit will float during performance testing in all 6 degrees of freedom.

In 1969, Bell began quantity production of the Post Boost Propulsion System (PBPS) for the Advanced Minuteman intercontinental ballistic missile; the company is developing the system for the Air Force's Space and Missile Systems Organization. The Bell PBPS performed perfectly on all Minuteman research and development launches conducted during the year from both the Air Force's Eastern Test Range at Cape Kennedy and its Western Test Range at Vandenberg Air Force Base, California.

A pioneer in Air-Cushion Vehicle (ACV) design, development, and production in the United States since 1960, Bell in 1969 embarked on a major program to determine the feasibility of building and operating large, high-speed transoceanic surface-effect ship transports that would ride on a cushion of air.

Bell's SES program was initiated in January following selection by the U.S. Joint Surface Effect Ships Program Office (JSESPO) to implement a 100-ton SES test craft program. The initial Maritime Administration contract covered detailed engineering design work. The 100-ton SES test craft is a major phase in JSESPO's long-range effort to examine the feasibility of multithousand-ton SES transports capable of reaching speeds of 80 or more knots.

Detailed studies during the year resulted in a Bell test craft configuration measuring approximately 72 feet long and 33 feet wide. It is being designed for speeds in excess of 80 knots. Three lift-fan systems

generate and maintain the air cushion beneath the craft with the propulsion provided by a pair of supercavitating propeller systems—one located astern each of the craft's 2 solid side hulls. Power is provided by marine gas turbine engines.

By mid-September, the company reached a major SES program milestone—completion of the JSESPO design engineering inspection. It included a detailed review of the technical progress in design development and inspection of the full-scale mock-up of the craft's cabin and crew quarters. Participants included senior JSESPO officials and selected representatives from the Department of Defense, the Department of Commerce, and other interested government agencies. Completion of the inspection set the stage for the final production design of the test craft.

To accommodate its SES test craft program, Bell established a special engineering team and a new division at NASA's Michoud Assembly Facility, New Orleans, Louisiana. The site was selected because of its year-round accessibility to the Gulf of Mexico and Lake Pontchartrain for testing purposes.

William M. Smith, formerly the company's chief scientist and presidential assistant, was named vice president-New Orleans operation in January. Reporting directly to him is Owen Q. Niehaus, executive director of the SES program. By year-end, the new division was employing approximately 140 persons.

On February 19, during operations on ice-bound Lake Erie in conjunction with a Canadian water pollution study, a Bell SK-5 air-cushion vehicle logged the 10,000th hour of operation for this family of 8-ton, high-speed craft. Initiated in 1964, the company's SK-5 log includes the operation of 10 SK-5 craft, 6 of them deployed with the U.S. Army and Navy in Vietnam.

By midyear, the 3 Navy craft had completed their second, and final, Vietnam evaluation deployment program. They returned to the United States, where they were subsequently delivered to the Coast Guard for use and evaluation. The Army ACVs during 1969 continued operation in the Mekong River Delta region of Vietnam, where by year-end they had increased their operational time to over 3,000 hours.

On July 25, a Bell SK-5 completed a 31-day operational evaluation program with the Coast Guard at St. Petersburg, Florida. The test marked the first use of an ACV by the Coast Guard. During the test period, the ACV performed a series of typical day/night all-weather missions on Tampa Bay and along the Florida coast in the Gulf of Mexico, including quick response to and towing of vessels in distress, long-range search operations, servicing navigational aids, lighthouse supply, and support of water pollution control programs. The month-long SK-5 Lake Erie water pollution operation was designed to establish the feasibility of using ACVs for transporting

scientists and their equipment across ice-covered lakes to water-sampling stations, an activity now possible only during the ice-free months of the year.

During the year, the company initiated a series of studies of the oil-rich North Slope area of Alaska: the studies were designed to establish the applicability of air-cushion vehicles to the environment of the area and to the needs of the oil companies.

Concurrent with its ACV programs, Bell was developing an aircraft landing gear which employs the same air-cushion principle. Designated the Air-Cushion Landing System (ACLS), it made possible the first takeoff and landing on water by an aircraft employing an air cushion. The first overwater test was conducted on Lake Erie near Buffalo, New York, on September 11. The ACLS-equipped LA-4 test-bed aircraft successfully completed its takeoff and landing in choppy water conditions and in winds of 20 miles per hour.

Earlier in the year, the ACLS completed a series of overland terrain taxiing tests, successfully demonstrating its ability to taxi over a variety of surfaces including mud, plowed ground, ditches, and tree stumps. The system also landed on a bulldozed, makeshift airstrip; the smoothness of the strip was comparable to that of a rough dirt road, but the texture was inadequate for conventional wheeled vehicles.

Partially sponsored by the Air Force's Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio, Bell's ACLS program continued to document the concept's potential for larger military and commercial transport aircraft.

Another Bell-developed aeronautical innovation, a backpack, jet-powered individual mobility system, achieved its first manned free flight on April 7, 1969. Designated the Jet Flying Belt, the system established the feasibility of such a compact, lightweight propulsion system for propelling man in controlled free flight over significant distances for a variety of missions.

Sponsored by a contract awarded by the Defense Department's Advanced Research Projects Agency and administered by the Army's Aviation Systems Command, the feasibility model Jet Belt development program during 1969 included a series of tethered and manned free flights which verified the system's performance during such maneuvers as vertical takeoff and landing, transition to and from horizontal flight, coordinated turns, and precise hovering. The test flights were conducted at speeds up to 30 miles per hour and at altitudes up to 45 feet. As Jet Belt development continues, Bell engineers anticipate ranges in excess of 20 miles and speeds of 100 miles per hour.

Pilot self-rescue was another subject of Bell advanced technology during 1969; the company was selected by the Air Force's Flight Dynamics Laboratory to build and flight-test an experimental system designed to explore the feasibility of utilizing

a jet-powered parawing to help pilots maneuver ejection seats away from hostile territory.

Developed in conjunction with the Air Force's Integrated Air Crew Escape/Rescue Capabilities (AERCAB) program, Bell's system was to consist of a rigidized V-type parawing coupled to an ejection seat housing a T65 Continental turbojet engine. Scheduled for initiation in 1970, all flight tests were to be manned and remote controlled. The feasibility model, with its parawing predeployed, was to be taken aloft by helicopter for a series of powered and unpowered drops to evaluate glide as well as controlled and powered free flight characteristics.

In the field of avionics, long a specialty at Bell, a number of major developments occurred. One of the more significant took place at midyear when the Navy placed the Bell AN/SPN-42 All-Weather Carrier Landing System (AWCLS) on operational status aboard the USS *Saratoga*. This made the *Saratoga* the world's first carrier with a fully automatic operational touchdown landing system.

Prior to becoming operational aboard the *Saratoga*, the AWCLS had been used by the Navy for some 18 months for modified automatic landings in which the pilot assumed control of his aircraft a half-mile from the carrier. In the fully automatic mode, the system handles the complete operation—from radar acquisition 7 miles from the ship to touchdown, day or night. By the end of 1971, the Navy planned to have fully operational AWCLS units aboard 12 carriers.

The Bell X-22A triservice V/STOL research aircraft is a marriage of flight systems and avionic capabilities. On May 19, the program reached a milestone when the aircraft was formally delivered to the U.S. government, marking the completion of the military evaluation phase of a flight-test and demonstration program which began in 1966 and included 220 flights and over 110 hours of operation.

Remaining at the Bell main plant, the X-22A has since completed a NASA and military pilot training program and a pilot evaluation program for NASA air terminal approach studies. At year-end, the aircraft was being prepared for additional evaluation of basic V/STOL handling qualities.

The only dual-tandem, ducted-propeller aircraft of its type in the world, the X-22A during 1969 increased its lifetime total of takeoffs to 454, vertical landings to 475, short takeoffs to 273, short landings to 252, and inflight transitions to 254.

For NASA's Electronics Research Center, Cambridge, Massachusetts, Bell initiated a program involving the integration, installation, and flight qualification of an experimental computer-aided avionic system for use in evaluating all-weather flight control, guidance, and navigational concepts for V/STOL aircraft. The objective is to integrate the navigation, guidance, and flight control functions, using an inertial sensing unit and standard navigational aids with a digital computation and data

processing subsystem. The experimental system will be installed in a CH-46C helicopter which NASA will use as an airborne simulator for analyzing and establishing the technical and economic feasibility of various V/STOL navigational and control concepts.

Under a contract sponsored jointly by the Air Force Avionics Laboratory, Wright-Patterson Air Force Base, and the Army Satellite Communications Agency, Fort Monmouth, New Jersey, Bell began development of a new above-rotor helicopter communications antenna subsystem for use in conjunction with a Tactical Communications Satellite (TACCOMSAT) network. The demonstration model of the superhigh-frequency unit was to be ready for flight testing aboard a Bell UH-1F helicopter in 1970.

In early 1969, a Stabilized Optical Sight (SOS) system, developed by Bell for the Army's new helicopter Multiweapon Fire-Control System (MWFCFS), successfully completed its acceptance flight-test program. The Army's Frankford Arsenal, Philadelphia, Pennsylvania, subsequently formally accepted the gyro-stabilized system as qualified for integration with the overall MWFCFS. In addition to the SOS, Bell was responsible for integrating MWFCFS components and designing their installation aboard their Bell UH-1B test-bed. Later in the year, Bell began SOS and design installation work on a similar fire-control system for the Bell AH-1G HueyCobra gunship.

Prior to the SOS, Bell had developed an XM-58 helicopter-mounted fire-control sighting system. In February, the company completed its first overseas sale of this system. The units included in the initial sale were delivered to Giovanni Agusta Costruzioni Aeronautiche S.p.A. of Gallarate, Italy. Agusta, a Bell Helicopter Company licensee, installed the systems in Italian Navy Bell UH-1B helicopters for operational evaluation. Follow-on orders for the Italian Navy and Air Force were contingent upon the results of the preliminary evaluations.

The company's Arizona Operation at Tucson was awarded a one-year, \$3,170,000 contract continuation by the Army's Electronic Proving Ground at Fort Huachuca, Arizona. The award covered operation, maintenance, and future development of the Army Electromagnetic Environmental Test Facility, a 4-part testing complex devoted to the prediction, analysis, and elimination of radio frequency interference in electronic communications systems.

The area of advanced manufacturing technology at Bell was highlighted in 1969 by significant developments in the company's composite materials program. In July, one new contract and an extension to another earned Bell a role in the Defense Department's 2 largest graphite composite materials programs and brought to \$2,400,000 the company's involvement in this area of advanced composite materials technology.

Under its new contract, Bell teamed with Northrop Corporation in an effort aimed at fabricating flightworthy primary structural components for the F-5 supersonic fighter aircraft from graphite composite materials. Responsible for design, analysis, fabrication, and test, Bell engineers will concentrate on the aircraft's vertical and horizontal stabilizers, considered the most complex of the 5 structural components selected for this research program.

Bell's second major graphite composite program was under the direction of the Defense Department's Advanced Research Projects Agency. Incorporating the development of analytical methods as well as component design and test, the program was aimed at speeding the application of advanced composite materials to operational military vehicles. The contract extension brought the company's total involvement on this program to over \$1,000,000.

In addition to its main plant near Niagara Falls, New York, and its New Orleans and Arizona operations, Bell maintained an avionics instruments laboratory in Cleveland, Ohio, and a sales/marketing operation in Canada—Bell Aerosystems-Canada, a division of Textron Canada Ltd., in Toronto. Company field offices are located in Washington, D.C.; Dayton, Ohio; Huntsville, Alabama; Eatontown, New Jersey; Houston, Texas; and Los Angeles, California. During 1969, Bell Aerosystems Company employment averaged 6,250.

BELL HELICOPTER COMPANY

A TEXTRON COMPANY

Textron's Bell Helicopter Company, concluding the sixties as one of the world's foremost producers of rotary-wing aircraft, headed into the seventies with substantial orders for twin-engine helicopters that presaged continued leadership in the industry.

During the latter part of the year, Bell passed the 13,000 mark in helicopter production for military and commercial customers. These aircraft were being utilized on every continent in a steadily growing number of applications.

Sharing the 1969 spotlight with the emerging twins were Army acceptance and deployment of the OH-58A Kiowa light observation helicopter to Southeast Asia and to Europe; an unofficial title of "World's Fastest Rotorcraft" for Bell's high-speed compound research helicopter, which reached 316 miles per hour in level flight; and 4 contracts from U.S. government agencies for advanced proprotor technology programs involving 2 different Bell concepts.

The nation's first commercial twin-engine medium-size helicopter, the Twin Two-Twelve, began its test-flight program in the spring; additional pre-production aircraft joined it in the summer and fall. Federal Aviation Administration certification was

anticipated in the spring of 1970, touching off full-scale production. Customer deliveries were scheduled to begin in the summer of 1970.

The military version, designated UH-1N (CUH-1N in Canada), was to be delivered to the Air Force early in 1970 and to the Navy, the Marine Corps, and the Canadian armed forces in 1971. The Air Force had on order 79, the Navy 40, the Marines 22, and the Canadians 50 with an option for 20 more.

Major features of the twin-engine helicopters are added safety plus high-altitude and hot-day hover performance capabilities.

Powering both the commercial and the military twin-engine helicopters is United Aircraft of Canada PT6T Turbo Twin-Pac, militarily designated T400. Two turboshaft engines are coupled to a combining gearbox with a single output shaft. The package produces 1,800 shaft horsepower flat rated to 1,250 shaft horsepower for takeoff and 1,100 shaft horsepower for continuous operation. Cruise speed is in excess of 120 miles per hour and range exceeds 300 miles. In the event that one engine becomes inoperative, the remaining engine produces sufficient horsepower for cruise, even at maximum gross weight of 10,000 pounds.

In standard configuration, the Two-Twelve seats 15 and carries up to 400 pounds of luggage in its separate 28-cubic-foot baggage compartment. As a corporate executive transport, it is available in deluxe limousine configuration with seating arrangements for 6, 8, or 10 persons.

Unveiled in October was the Marine Corps AH-1J SeaCobra, also powered by the T400 Turbo Twin-Pac. It went immediately into test flight. The first of 49 production models was to be delivered in the spring of 1970.

The SeaCobra was expected to further enhance the assault helicopter reputation established by the single-engine AH-1G HueyCobra, which has been in combat with the Army for over 2 years and more recently joined the Marine Corps inventory. The twin-engine SeaCobra will retain the HueyCobra's capabilities as well as its outstanding maneuverability.

Both of these tandem-seat helicopters are armed with advanced weapons systems for improved stand-off capabilities. Armament for the AH-1J includes a 3-barrel, 20-millimeter cannon in the nose turret and a variety of ordnance loads for the wing pylons. Operational on the AH-1G are wing-mounted 20-millimeter cannons. Other potential improvements include 30-millimeter cannon turrets, antitank missiles, and advanced fire-control systems with stabilized optics, laser, and computer.

The Army's new light observation helicopter, the OH-58A Kiowa, was delivered in May. By early autumn, it had been introduced in Vietnam by a Bell-trained group of Army specialists who began indoctrinating combat area helicopter units in every

aspect of the Kiowa's operation and maintenance. Shortly afterward, another OH-58A New Equipment Training Team accompanied the initial shipment of Kiowas to Germany.

Bell received the first OH-58A order in March 1968 when the Army named the company winner of its reopened light observation helicopter competition. Two additional increments of a 5-year contract raised to 1,200 the number of Kiowas purchased out of an anticipated overall procurement of 2,200. Deliveries will continue through mid-1972.

Another variant of the commercial 206A JetRanger, the TH-57A SeaRanger, was rounding out its initial year of service as the Navy's light turbine trainer. Forty SeaRangers were based at Pensacola, Florida, with the Naval Air Training Command.



Bell Helicopter Company received 4 new government contracts for advanced proprotor technology programs. One study involved the folding proprotor concept in which the blades operate helicopter-fashion for takeoff, propeller-fashion in low-speed forward flight, and folded into the nacelles (photo) for high-speed flight using turbine engines in fanjet mode.

Bell continued to figure prominently in development of rotorcraft for the future. During the year, the company received 4 additional contracts from U.S. government agencies for advanced proprotor technology programs, bringing the total of such grants to 6. Of the new contracts, 2 came from the Army Aeronautical Research Laboratory and NASA's Ames Research Center, and 2 from the Air Force Flight Dynamics Laboratory.

All of the research involved 2 Bell concepts for aircraft that would take off vertically, then tilt rotors forward to serve as propellers. Some of the studies were investigating the folding-proprotor configuration in which high-speed flight would be attained by stopping the blades, folding them back to minimum-drag position, and using turbine engines in fanjet mode for forward propulsion.

In April 1969, the fastest known rotorcraft speed,

316 miles per hour in level flight, was recorded by Bell's high-performance compound helicopter, the Model 533, a research vehicle with a past dating back to 1956. The 3-times-modified YH-40 attained this speed in a configuration that included a standard production UH-1H 2-bladed semirigid rotor hub, with low-twist, thin-tipped blades. It was powered by a Lycoming 1,400-shaft-horsepower engine and 2 Pratt & Whitney Aircraft 3,300-pound-static-thrust engines mounted on stub wings. The Model 533 later was equipped with a new 4-bladed flex-beam rotor system for another phase of its flight testing.

These flight tests were part of a continuing Bell/Army Aviation Laboratories program, begun in 1959, to determine the potential for and gather basic data on pure, winged, and full compound helicopters in high-speed range. Through this and the company's independent research programs, much has been learned about rotor control at high speed, slowed-rotor operations in the compound mode, drag reduction, and use of wings on rotorcraft.

In October, the Army Aviation Systems Command awarded Bell a contract to act as technical adviser for AVSCOM's Automatic Inspection Diagnostic and Prognostic System (AIDAPS) test-bed program. Purpose of the program is to demonstrate the capability of off-the-shelf diagnostic hardware to detect malfunctions; identify faulty components; and, to a limited degree, provide malfunction or failure prediction. AVSCOM will test the systems on UH-1D helicopters after preliminary testing in test cells.

Bell will provide a data package which will identify helicopter components that warrant monitoring and the physical parameters of these components that will indicate malfunctions, and will establish maintenance requirements for these problems.

Equally important, but less publicized because of their classified nature, were company- and government-funded research and development projects ranging from product improvement to concept studies in anticipation of VTOL requirements a score or more years in the future.

On the production scene, in addition to the Kiowas and the HueyCobras for the Army and the Marine Corps, Bell manufactured 9 other models for military and commercial customers.

The Army continued to receive 15-place UH-1H Huey tactical transports and OH-13S 3-place observation helicopters in quantity.

Navy deliveries during the year included the TH-1L and UH-1L, 2 variants of the Marine Corps UH-1E but with more powerful T53-L-13 engines. The Navy selected the TH-1L as its advanced rotary-wing trainer and the UH-1L as a utility helicopter. Another version, designated HH-1K, was ordered for sea-air rescue missions. It was to be delivered in 1970.

Commercially, the JetRanger continued to capture the lion's share of the industry's light turbine helicopter market as it had done since it was first delivered in January 1967.

Other commercial models marketed in 1969 and scheduled for continued production in 1970, when the addition of the Twin Two-Twelve would increase the lineup to 6, were the 15-place, turbine-powered 205A and 3 workhorse versions of the reciprocating engine Model 47 series—the 47G-3B-2, 47G-4A, and 47G-5 3-place machines. The G-5 is available also as a 2-seater for aerial application.

Despite the heavy impact and widespread acceptance of turbine helicopters, the 47 series is a paradox. Although descendants of the machine that merited the world's first commercial helicopter license in 1946, these helicopters still account for approximately half of the company's civil sales.

In August, Bell Helicopter and the Republic of China signed a license agreement to enter into a co-production contract for manufacture of the Model 205 helicopter, essentially the same as the UH-1H. While the quantity was not defined, production will be phased over a period of several years, with some of the manufacturing and assembly work being done in Taiwan. Deliveries were to begin in 1970. The aircraft will be operated by the Chinese Army.

Bell was in the third year of a similar co-production program with the Federal Republic of Germany to provide approximately 350 UH-1D helicopters by the end of 1970. Prime contractor in West Germany is Dornier, GmbH.

Bell helicopters were also being built under license by Giovanni Agusta Costruzioni Aeronautiche of Milan, Italy; Mitsui & Company Ltd. of Tokyo, Japan; and Westland Aircraft Ltd. of Yeovil, England.

Noting that commercial and foreign government sales volume had grown tremendously, the company named Frank M. Sylvester to the newly created position of vice president for international marketing. Sylvester had been director of international sales for Piper Aircraft Corporation for the previous 6 years.

Dwayne Jose, vice president for commercial marketing, concentrates on U.S. and Canadian commercial and Canadian government marketing. Hans Weichsel, Jr., military marketing vice president, retained his responsibilities for sales to the U.S. government and for total customer support.

Two major new facilities were occupied early in 1969: a 200,000-square-foot Logistics Center and an 80,000-square-foot addition to an office structure, both at the main Fort Worth plant.

Moving to meet increasing customer needs, the company announced plans in October for construction of a 30,000-square-foot training school and delivery center on land adjoining the main plant. The facility was to be completed by March 1970.

Bell President E. J. Ducayet said the new complex would consist of an instruction building with classrooms, a library, an audiovisual system, delivery offices, and a customer lounge, plus 2 hangars. One hangar is for teaching complete overhaul capabilities and the other will house delivery aircraft. Ample ramp and landing space will be available for flight operations. The complex allows consolidation of the training program, formerly housed in plants at Saginaw and Grand Prairie, as well as expansion of new aircraft delivery operations, Ducayet noted.

Employment in 1969 averaged approximately 11,000, including the work force at Amarillo, where Bell has a facility to overhaul and modify airframes of battle-damaged helicopters from Vietnam as well as other aircraft.

THE BENDIX CORPORATION

COMMUNICATIONS DIVISION

In 1969, as in previous years, the Communications Division, a prime government contractor, was engaged primarily in the development and production of communication and radar equipment. Recognizing the demands for advanced communication and radar systems to meet future needs, the division was conducting research and development programs designed to keep it abreast of the latest state-of-the-art techniques in the general field of electronics.

Production of the AN/APX-72 IFF transponder continued; the work being done represented the largest single contract for IFF transponders ever let by the U.S. government. The contract marked the first time that a major electronic subsystem of such complexity had been procured on a triservice basis. A universal transponder, the AN/APX-72 is installed aboard lightweight aircraft, helicopters, jet aircraft, and Navy ships. The transponder performs the dual functions of enhancing air traffic control operations and providing friend-or-foe identification capabilities. Plans called for the units to be installed in most new aircraft configurations and for retrofitting existing aircraft with the transponder. Universal application of this transponder is part of a government program to develop a completely integrated and standardized air traffic control system. Advantages gained from such a program will aid in the solving of technical and logistical problems for the military.

The AN/FPS-85 Space Detecting and Tracking (SPADAT) radar, completed in fiscal 1968, was the first operational ground-based phased-array radar in the country. Designed and built by Bendix for the Air Force, the system is completely computer controlled. During 1969, Bendix engineers, systems analysts, and programmers worked on a number of different contracts in support of the system. These

programs enable the radar to detect and track more than 1,000 different objects in space.

Over a period of 13 years, the division developed a unique capability in the digital communications field. Among the many specialized equipments offered are such items as digital terminal equipments, power supplies, interface modification equipments, and custom items to meet special needs of customers.

The division's microelectronics capabilities grew during 1969. The facilities are vertically integrated, providing the division with the capability to design, develop, and produce in quantity, microelectronic circuits for application in the division's products and as outside sales items.

Most notable among recent developments in this area was a temperature-control microcircuit which will hold the temperature of an electronic circuit constant in environments ranging from minus 60 degrees to plus 212 degrees Fahrenheit. The temperature of the circuit within that range will remain within a few degrees of plus 250 degrees. The microcircuit was still in the experimental and development stages, but it was being used by the military in equipment which requires very stable frequency or voltage control.

The division developed a frequency synthesizer to cover the range of 162 MHz to 174 MHz. It was designed primarily for application in military tactical radio sets where low power consumption is required. The unit employs a single crystal as a frequency reference. Locking the output frequency oscillator to a desired channel is accomplished through the use of digital microcircuit techniques. With medium-scale integration techniques, the unit, exclusive of the selector switch, occupies a volume of 1 cubic inch. These design features make the synthesizer especially applicable to personal portable receiver-transmitter designs.

The division was engaged in a NASA-supported program for the calibration of airborne antennas. The antennas are used by NASA for calibrating space tracking radar sites throughout the world. The division developed a unique approach to the problem of calibrating airborne antennas which makes possible accurate calibration of the antennas while the aircraft is in flight. This approach is more accurate than other methods since distortions caused by the aircraft fuselage and other antennas can be taken into consideration.

To meet the demands of tomorrow's sophisticated radar and communication systems, the division was conducting an extensive research and development program. Major areas of divisional concentration included microwave developments adaptable to phased-array radars, pattern- and signal-recognizing machines, digital communications techniques, and microcircuitry materials processes and circuitry development.

The Communications Division has developed elec-

tronically steerable antenna beam radars since 1958. Much of this effort culminated in the delivery of the AN/FPS-85 radar to the Air Force. From this store of knowledge, the next-generation phased-array antenna techniques were being developed. Objective for the new antenna systems is to provide fast-scan and multiple-scan capability in a light-weight mobile configuration.

In the field of communications, next-generation systems, it was recognized, will be primarily in a digital format. The division, therefore, was exploring the areas of frequency synthesizers, digital filters, and spread spectrum. The advantages to military usage of digital communication systems include a high degree of reliability and maintainability, greater security, multichannel capability, frequency agility, and greater adaptability to microcircuitry commonality.

A third general area of product development at the Communications Division was in adaptive pattern- and signal-recognizing systems. Such machines, which augment or replace human judgment in the control loop, are adaptable for use in unmanned signal-processing systems. Primary development of the judgment machine at this time is in the area of adaptive matched filters to accommodate a desired signal. Optical filter techniques, as well as electronic techniques, were being developed for pattern recognition. The optical filter techniques centered on the use of holography to process multiple signals simultaneously. The holographic technique was visualized as a powerful instrument in the future because of its parallel readout capability, efficiency, low power drain, and ability to be confined in a small space.

NAVIGATION & CONTROL DIVISION

In 1969, The Bendix Aerospace-Electronics Company's Navigation & Control Division continued its role as a major supplier of avionics to the aerospace industry. Its activities were highlighted by the introduction of new flight guidance systems for aircraft, increased activities in the production of guidance equipment for missiles, and continuing involvement in the advancement of space exploration.

The Bendix FGS-70 flight guidance system, developed for application to a wide range of subsonic aircraft, was officially introduced in 1969. Designed to offer maximum flexibility for multi-optional installations, the FGS-70 can be supplied in a number of configurations including autopilot, autopilot director, or the flight director itself. A common computer provides guidance signals for both autopilot and flight director functions. At the operator's option, the system can include a flare computer for complete automatic landing capabilities.

Orders for these systems were received for installation on the West German VFW-614 twin-jet passenger-cargo transport and on the XC-1 twin-

turboprop transport built by the Nihon Aircraft Manufacturing Company, Ltd., of Japan. Domestically, Cessna Aircraft Company placed orders for the FGS-70 for installation on the new Citation 500 series aircraft. The Cessna Citation, which made its first flight on September 15, 1969, is a 6- to 8-place fanjet-powered aircraft designed for the executive aircraft market.

Also included in its new product activities was the award the division received to produce a flight management system, consisting of automatic flight control and central air data systems, flight displays, and an interfacing unit, for the Navy's carrier-based S-3A antisub patrol plane. This 450-knot, 2-engine jet aircraft will replace the piston-powered S-2 Tracker in service.

Significant in the field of digital computation was a new airborne general-purpose digital computer offered during the year to satisfy the requirements of various avionic applications such as guidance, control, and navigation. Designated the Bendix BDX-800, it was being applied to such installations as a jet engine control system, an inertial guidance system, and a digital air data program.

Extending its line of support equipment, the division offered 2 new test sets during the year. The Bendix Series 50 automatic module tester rapidly and automatically bench-tests to a faulty part, malfunctioning electronic modules. The Bendix Series 100 automatic component tester tests and fault isolates malfunctioning electronic components of complex avionic systems. Tape-programmed for automatic operations, both testers are controlled by a Bendix BDX-6200 digital computer for mathematical and logic computations.

A new head-up display system designed and manufactured by the Navigation & Control Division during 1969 enables a properly equipped aircraft to make aerial recoveries of parachute-suspended objects. Designed originally as a flight data display for commercial aircraft applications, this version was developed under an Air Force contract. With it, a flight crew can track a beacon on a falling object, determine the rate of descent, and maneuver the aircraft to the exact location where recovery can be made. The original system was specified for use on C-130 aircraft assigned the task of making aerial recovery of space payloads returning to earth.

Follow-on contracts from both foreign and domestic customers played a large part in the division's product activities during the year. Additional quantities of the Bendix PB-20 automatic flight control system were ordered by the British Aircraft Corporation for installation on its BAC One-Eleven short-haul commercial transport aircraft. The U.S. Navy also contracted for additional PB-20 systems for installation on the P-3C antisubmarine patrol aircraft and the A-4 attack aircraft.

Also received from the Navy were follow-on contracts for weapons release systems. For application

on the Navy A-4 and A-7 attack aircraft, the system permits the pilot to program the automatic release of stores from the weapons stations in whatever quantity, mode, and drop interval he desires.

The Air Force issued follow-on contracts for air data computer units for the F-111 fighter aircraft. The computer converts information on the physical properties of the air through which a plane is flying into data for operation of such subsystems as autopilots, flight instruments, and navigation systems.

In the area of navigation equipment, the division supplied the Navy with Type ASN-46A dead-reckoning navigation computer systems. Scheduled for installation on Navy Phantom aircraft, this system continuously computes, transmits, and displays information needed by the pilot for the navigation of his aircraft.

The Navigation & Control Division was awarded Air Force contracts for stability augmentation systems to be operated on B-52 bombers. The system extends the life of the aircraft by reducing structural bending and is the first system application to provide fatigue alleviation on production aircraft.

Lockheed-Georgia Company placed orders with the division for additional quantities of vertical scale indicators and flight director components for installation on the C-5 Galaxy aircraft, operated by the Air Force.

The division's commercial aircraft activities were also accelerated by contracts from various airlines that had ordered Boeing 747 aircraft. Orders included such equipment as air data computers, Mach trim couplers, and autothrottle and yaw damper systems. Instrumentation included radio distance digital magnetic indicators, flight director indicators, and engine vertical scale indicators.

In the field of automatic check-out equipment, the division received a contract for a Bendix Model 200 computer-controlled automatic test station from Alitalia. Capable of checking out avionic equipment operated by this airline, the Model 200 will also meet the additional test requirements of avionic equipment on upcoming aircraft. Continental Airlines and Trans World Airlines have already ordered the Model 200 computer-controller as an integral part of their maintenance program.

In its helicopter-related activities, the division was awarded contracts by Boeing's Vertol Division for throttle actuators and actuator test equipment for the CH-47. During the year, the Navigation & Control Division designed a power-remaining system applicable to helicopters. This system furnishes the pilot necessary information concerning the load his vehicle can carry. Included in the data are his margin of safety in lifting the load and his aircraft's ability to transport the load for the distance of his assigned mission. The system includes the necessary sensing units, computer interface, and pilot display instruments.

Man's landing on the moon was a fitting climax to many years of successful space efforts at Navigation & Control. The division continued as a part of the Saturn/Apollo lunar landings and had a major study and production role in the Apollo Applications Program (AAP). In the area of missiles, the division remained a major supplier of inertial guidance equipment for such programs as the Navy's Poseidon, the Army's Pershing, and the Air Force's Minuteman.

For NASA's Apollo program, the Navigation & Control Division provided the ST-124 inertial guidance platform which supplies the attitude and acceleration data necessary to keep the launch vehicle on course. In addition, the division provided the Apollo Lunar Module with 2 important units, the range rate indicator and the descent engine throttle actuator. The indicator shows moonbound pilots the distance from and rate of descent to the moon. On the return trip, it shows the distance from and rate of approach to the Command Module. The throttle actuator helps provide the Lunar Module with the proper rate of descent for a soft landing on the moon's surface.

Under the technical direction of the Massachusetts Institute of Technology, the division was awarded a contract to build and test inertial reference integrating gyros. These were intended for use in the inertial guidance systems of the Apollo Command Module and Lunar Module. In addition, a program was developed with the Massachusetts Institute of Technology and NASA to improve the life and performance of this gyro's spin-axis bearing.

Follow-on contracts were received from Martin Marietta Corporation, with which the division was teamed as principal subcontractor, for continuing efforts on NASA's Apollo Applications Program. Under this program, NASA scheduled a 1972 manned flight of the Apollo Telescope Mount (ATM) for a 56-day study of the sun. The Navigation & Control Division's responsibilities include the complex pointing control system, the controls and displays from which the astronauts will conduct solar experiments, and work on analysis of crew stations and operational communications.

Also as part of the Apollo Applications Program, NASA contracts were received for the construction of control moment gyros and star trackers. The ATM will employ 3 Bendix control moment gyros to stabilize the entire AAP cluster, consisting of the ATM, the Apollo Command and Service Modules, the Multiple Docking Adapter, and the Saturn S-IVB Workshop. The Bendix star tracker will give the angular position information needed for attitude reference calculations.

In 1969, the Navy placed additional orders for 2 vital units used in the inertial guidance system of the submarine-launched Poseidon missile. One unit, the Inertial Reference Integrating Gyroscope, is a precise liquid-floated gyroscope that forms the basis

of the missile's inertial guidance system. The second unit, the Permanent Magnet Pulsed Integrating Pendulum, is an acceleration-sensing device that helps determine the missile's flight position.

The division moved into its 12th year of production under the Army's Pershing missile program. Contracts were received for the missile's highly successful inertial guidance system as well as for a new digital computer to replace the missile's current Bendix-produced analog computer. The digital computer is smaller and more accurate and performs more functions than the analog computer.

During the year, the division received follow-on contracts from The Boeing Company for command signal decoders for Minuteman's electronic launch system. The decoders form part of a security network that prevents the missile's unauthorized firing.

The Navigation & Control Division was contracted by the Air Force to provide recorder data packages that record a missile's reentry vehicle flight pattern and are recoverable after impact. These packages are used on a range of missiles including Minuteman I and II and Titan III.

Under a special Air Force detailed study contract, the division initiated a program to evaluate non-destructive screening techniques to assure the nuclear hardness of semiconductor parts of advanced missile guidance systems. The screening techniques under examination included various combinations of electrical, thermal, and infrared measurements.

Also in the missile field was an Air Force contract for the versatile AN/GSM-133 general-purpose programmer comparator to check out the SRAM short-range attack missile. Testing complexes—designated Service Star—to check out the MR-12/MK-11D reentry vehicles for the Minuteman were ordered by the Air Force.

A number of significant changes in divisional facilities were made during the year. The division's support equipment activities were centralized in a newly refurbished 60,000-square-foot area of a building formerly occupied by the Bendix Foundries Division. The move not only centralized these activities for more efficient operation but also eliminated the need for the leased facilities formerly utilized. Centralization of the division's extensive and complex electronic manufacturing facilities was made possible by the addition of a 1,500-square-foot area to the division's Plant No. 3.

Two new West Coast facilities were occupied during the year, providing increased capabilities for support of the division's products. A 15,580-square-foot building in Lakewood, California, was leased to provide office and laboratory space for personnel assigned to support the division's DC-10 program. Personnel assigned to this facility had product responsibility for the DC-10 flight guidance system and other avionics equipment under subcontract from McDonnell Douglas Corporation. In the state of Washington, the division's Northwest sales and

service activities were moved from Seattle to Tukwila. Located in the corporation's newly completed West Coast Aerospace Support Division building, the Navigation & Control Division's activity occupies over 3,000 square feet of working space. In addition to a sales office, this area houses repair facilities capable of performing overhaul, maintenance, and modification.

AEROSPACE SYSTEMS DIVISION

Two lunar successes highlighted the year for the Aerospace Systems Division. The Early Apollo Scientific Experiments Package (EASEP) was built for the National Aeronautics and Space Administration and was successfully deployed on the moon during the historic Apollo 11 lunar landing. The Apollo Lunar Surface Experiments Package (ALSEP) was successfully deployed by the Apollo 12 astronauts.

EASEP utilized the passive seismometer and electronics which had been designed originally for ALSEP. Solar panels powered the unit during the lunar day and radioactive heaters helped the package survive the cold lunar night. The EASEP Laser Ranging Retro-Reflector became a target for earth-based lasers to help scientists measure the earth-moon distance to within 6 inches.

EASEP achieved 100 percent mission success in spite of the 10 percent degradation in thermal control caused by damage from the ascent blast of the Lunar Module.

A new ALSEP was being built for NASA to replace the unit modified for EASEP. In all, 4 ALSEP experiment arrays were scheduled for lunar deployment. A passive seismometer like the one carried on EASEP was to be included on each ALSEP; a Lunar Atmosphere Detector was also to be carried on each ALSEP. An ALSEP active seismic investigation will use controlled explosions to study lunar structure to a depth of 500 feet. A magnetometer will sense lunar magnetic fields. A heat-flow instrument will be placed in 2 10-foot holes drilled in the moon to investigate lunar thermal properties. Three instruments—the solar wind, lunar ionosphere, and charged particle—will investigate the nature of charged particles near the lunar surface.

The ALSEP deployed on Apollo 12 included the passive seismometer, solar wind, magnetometer, lunar atmosphere, and ionosphere instruments.

Lunar scientific activity was not limited to EASEP and ALSEP at the Aerospace Systems Division; both manned and unmanned lunar vehicles were studied extensively during the year. The design of a 4-wheeled Lunar Roving Vehicle for NASA paralleled a study of a 6-wheeled convertible (manned/unmanned) lunar vehicle. The unmanned vehicle will use automatic hazard sensors and live TV to enable it to cross the rugged lunar terrain while being controlled from the earth.

The year was especially active for the Earth Re-

sources Department, formed in 1969. This department was building a 24-channel multispectral scanner and ground data processing unit for NASA. The scanner will be carried in an airplane initially and will collect data from the ultraviolet to the far infrared. It focuses imagery collected by a rotating mirror and telescopic optics through gratings which distribute the image to detectors for the various spectra. The ground data station will process the output of the airborne scanner to select parts of the imagery of special interest to scientific investigators. The data processing will produce black-and-white or color reproductions of the imagery, as well as computer print-outs of processed information.

Bendix thermal mapper production began during the year and a new, modularized version of the mapper was introduced. This new model has interchangeable detector units to permit the mapper to collect data from the ultraviolet to the far infrared. Computer programs to define quickly the areas of interest (targets) with the greatest accuracy were being developed in another section of the Earth Resources Department. Imagery collected using the Bendix 9-channel scanner and the thermal mapper was being processed to detect preselected areas of interest.

Also within the Earth Resources Department, Bendix was developing a device to monitor ozone and other air pollutants. A digital infrared telespectrometer is used with an active infrared source to provide information on air pollution over a range of about 1.5 miles.

The Aerospace Systems Division was also involved in instrumentation scheduled to go to Mars in 1975 aboard the Viking spacecraft. Study contracts for a life-detection instrument and a pyrolysis-mass spectrometer instrument were awarded to Bendix by NASA. The life-detection instrument will sample Martian soil for evidence of growth and metabolism. The pyrolysis-mass spectrometer will investigate the gases given off by samples of Martian soil which have been heated to very high temperature.

The Transportation Systems Department continued to investigate the transportation design for Columbia, Maryland. Various types of vehicles to move people with optimum convenience and minimal cost were being examined. Computer-dispatched, demand-activated vehicles appeared to be an immediate possibility.

ELECTRIC POWER DIVISION

The Electric Power Division began production in 1969 of electric power systems for the Boeing 747 superjet. The electric systems, consisting of brushless generators, solid-state control components, and static inverters, carry a rating of 360,000 watts.

An important safety feature—an auxiliary bearing and sensing system—was designed into the 747

generators during the year. This system signals the flight engineer when a main bearing shows signs of failure and also signals auxiliary bearings to take over the generator load. Generators can be operated unenergized on the auxiliary bearings without hazard until the main bearing is replaced.

The division continued to supply electric systems for such general aviation applications as the Gulfstream II, the JetStar, and the Learjet; and for such military applications as the F-4 Phantoms, the P-3 Orions, and the CH-53 and UH-1 helicopters.



Bendix Electric Power Division's test system for checking electric systems used in 7 different aircraft includes this test console. The open drawer contains a program recorder which prints out test characteristics.

In October 1969, the division shipped to Rome, Italy, a versatile test system designed to check out constant-speed drives and generators used in 7 different commercial aircraft. The test system will be used to check electric generating equipment installed in commercial jets operated by the 4 foreign airlines—Air France, Sabena, Lufthansa, and Alitalia—which form the Atlas Consortium. The test system will be installed in a new facility at the Rome airport and will be operated by Alitalia personnel. As part of Atlas, Alitalia will have cognizance and responsibility for overhauling and checking the electric systems of all 4 airlines. Electric systems installed in the DC-8s, DC-9s, and 747s used by the Atlas group will be checked by the test system.

In May 1969, the division's new lightweight integrated-drive generator was chosen for the Navy/Grumman F-14A. Rated at 60/75 KVA, the generator is the lightest aircraft generator for its output. Capable of 90 KVA output in emergencies, the unit weighs only 46 pounds and has the highest specific

output of any 400-Hz generator now available. Oil is used to cool the generator. The oil passes through helical passages around the generator, through the generator shaft, and then back again to the constant-speed drive. Heat produced by the generator is picked up by the oil (through conduction) and carried away. An important feature of the generator design is that, in addition to being oil cooled by conduction, the generator stator windings get an oil-mist spray which keeps them extra cool. This oil-mist spray cooling technique, developed by Electric Power Division, is an important advance in the state of the art of oil-cooled generators. For high-performance aircraft, the oil-spray feature keeps generators operating at peak efficiency and reliability, and provides protection to all parts of the generator in the event of a fault.

Continuing its cost-reduction program to increase production efficiency and pass the savings on to customers, Electric Power Division installed a number of modern production machines during the year. Among these was a solid-state, tape-controlled milling machine which performs myriad milling and drilling operations at close tolerances automatically. For some jobs, this modern machine cut labor costs in half.

Also put into operation during the year was a programmed printed-circuit-board assembly unit which speeds up electronic assembly of PC boards. The unit sends a light beam to indicate proper placement of components and automatically opens bins holding the correct parts.

The total number of employees at the Electric Power Division was 1,000, and 25 percent of that number were engaged in engineering and other technical assignments.

ENERGY CONTROLS DIVISION

The Energy Controls Division of The Bendix Corporation set a brisk sales pace by growing more than 10 percent in fiscal 1969. One of the major contracts received during the year was for the design, development, and production of landing gears for the Navy's new air superiority fighter, the F-14A. In the commercial field, the division was awarded a production contract for carbon heat sink brakes on the long-range Boeing 747B aircraft.

The division increased helicopter tie-bar applications during the year by furnishing 3 prototype units in England. Continued research and development expanded the utilization of tie bars.

Several other key projects were close to completion, including a hydromechanical control system for Pratt & Whitney Aircraft for use on the model JTF-22 demonstrator engine for the F-14B/F-15 engine. The inlet guide vane and the nozzle area actuation were included as complete systems in the overall control being developed.

The Energy Controls Division, working with the

Navigation & Control Division, demonstrated the microelectronic engine control system for Pratt & Whitney Aircraft on the Advanced Manned Strategic Aircraft (B-1A) demonstrator engine.

Plans were completed for adapting current fuel control systems for the Pratt & Whitney Aircraft TF30 engine to the requirements of the F-14A aircraft.

Fuel control systems continued to play an important part in the work of the Energy Controls Division. Engine testing of the main fuel control system was being developed for the General Electric GE12 engine. The T63 engine fuel control systems continued to expand into commercial helicopter application, in addition to the Bell OH-58A, and prospects for control systems business for this engine looked bright.

During the year, a manual control system for the TF41 engine was put into production and Federal Aviation Administration certification of the fuel control system for the AiResearch TPE 331 engine was near. This was expected to increase the division's general aviation business, consisting of a nucleus of fuel injector systems for reciprocating engines used on light aircraft.

INSTRUMENTS & LIFE SUPPORT DIVISION

The year 1969 saw considerable advancement at Instruments & Life Support Division on new techniques for measuring fluid quantity and flow, including a means of measuring the quantity of fluids contained in random-shaped tanks, such as aircraft external fuel tanks, or that are subjected to a weightless space environment. The technique, called RF mass gauging, involves exposure of the fluid to ultrahigh-frequency electromagnetic energy. The amount of energy absorbed by the fluid is a function of the quantity of fluid remaining in the tank.

The division was active on 3 research and development contracts for RF gauging systems. One called for design, fabrication, and testing of a system to measure the mass quantity of liquid oxygen as well as a variety of ratios of liquid nitrogen to oxygen in a Dewar with a capacity of approximately 8 cubic feet. A second NASA contract called for a breadboard of a system capable of measuring various cryogenics plus room-temperature fluids contained in random-shaped tanks. The third contract, let by the Air Force, was for development, fabrication, and testing of an external tank gauging system for the F-4 aircraft.

The other key program concerning fluid measurement was the development of a time-base flowmetering system which provides a true-mass indication of jet engine fuel flow. The term "time base" denotes the system's independence of the constant-speed requirement of current motor-driven, true-mass flowmeters. The typical system includes flow

THE BOEING COMPANY

rate and total-fuel-consumed indicators, transmitter, and signal conditioning equipment.

In the area of cryogenic gas storage and control systems, the division continued to be actively engaged in programs to advance the state of the art. In final stages of completion was a capsule-shaped system which will store approximately 32 cubic feet of cryogenic fluid for over 6 months. On the drawing boards were cryogenic gas storage systems that will maintain cryogenics for well over a year.

In life-support equipment, several new products were introduced during the year. One was the first flight crew oxygen breathing regulator that can be completely tested without removal from the aircraft. Interchangeable with all panel-mounted regulators in use by the U.S. Air Force and by many foreign governments, the regulator promised to reduce preventive maintenance costs significantly. The Air Force estimated that it would save over \$1,000,000 annually by transitioning to regulators with the in-aircraft test feature. Another new life-support product was a backpack, a modification of one designed to convert liquid air to breathing air for personnel engaged in loading highly toxic engine propellants aboard spacecraft. Produced for applications such as fire fighting and mine rescue, the backpack contains 4 times more air and is several pounds lighter than the standard compressed-gas system.

Several flight instruments produced by the division were used aboard the year's Apollo flights, including the successful Apollo 11 and 12 lunar landing missions. In the Command Module were a longitudinal accelerometer, which displays fore and aft acceleration forces during all mission phases, and a barometric altimeter, which indicates the proper altitude for parachute deployment during manual reentry into the earth's atmosphere. Used aboard the Lunar Module was the thrust-to-weight ratio indicator. This instrument, simply by measuring lunar g's, reveals the rate at which the descent engine slows the spacecraft as the moon's surface is approached.

BENDIX FIELD ENGINEERING CORPORATION

Bendix Field Engineering Corporation, a subsidiary of The Bendix Corporation, continued during 1969 to provide integrated field engineering and management services to the U.S. and foreign governments and to industry. Services provided included operation, maintenance, and logistics planning; systems engineering; documentation; training; data acquisition and presentation; radio frequency interference/electromagnetic compatibility measurements and analysis; depot repair and modifications; and electromechanical disciplines associated with space exploration, ocean environments, air and water pollution, air traffic control, and biomedicine.

On February 9, 1969, the first Boeing 747 superjet made its initial flight from Paine Field near Everett, Washington. The highly successful first flight highlighted a year in which The Boeing Company consolidated commercial efforts and moved more deeply into government programs.

Unfilled orders at September 30, 1969, were \$5,301,000,000, including \$4,743,000,000 for commercial aircraft, \$294,000,000 for military aircraft, and \$264,000,000 applicable to missile and space programs.

By mid-November, the company had delivered 1,800 commercial jetliners from a total of 2,090 ordered by the world's leading airlines. The delivery schedule of 707 and 727 jet airliners reflected the previously projected reductions, with fourth-quarter projections indicating an even lower delivery rate for these 2 models. The fourth quarter, however, saw initial deliveries of 747 superjets, with 5 of the aircraft going to Pan American World Airways and Trans World Airlines by year-end.

The first flight of the 747 marked the start of over 10 months of concentrated test flights by 5 production airplanes. By November 1, the 5-plane fleet had amassed a total of over 1,000 hours in the air and had completed much of the certification work. The No. 4 aircraft made an appearance at the Paris Air Show, departing Seattle for the nonstop flight with less than 20 hours of flight time on the log. The entire tour, including a stop at Washington, D.C., on the return trip, was completely trouble free and was overwhelmingly received. Individual aircraft had flown as fast as Mach .997 and had become airborne at speeds as low as 102 knots. They had flown as high as 45,000 feet and had taken off at a gross weight 4 tons heavier than the weight for which they were to be certified. By the end of the third quarter, the 747 production line was rolling out one aircraft every 4½ working days.

In September, President Richard M. Nixon strongly recommended government funding of 2 prototype supersonic transport aircraft. In mid-November, the U.S. House of Representatives approved the initial financing of the program on a schedule that could have the first SST in the air late in 1972. Initial governmental approval started activity in behalf of some long-lead-time items of equipment and a readiness for the initial parts tooling for fabrication of the airframe. Work was also started on engineering mock-ups, including a metal mock-up of the entire fuselage and one wing of the SST. The Boeing supersonic transport prototypes will lead to a new generation of airliners capable of speeds of 1,800 miles an hour with a passenger capacity of up to 300. It was planned that the first commercial versions would be in service in 1978.

While the 747 and SST programs captured the public attention for much of the year, The Boeing

Company continued to devote a large share of its corporate energy to existing military programs. Deliveries of CH-47 Chinook and CH-46 Sea Knight helicopters reached a total of nearly 1,200 by mid-November. The Vertol Division, located near Philadelphia, also received a follow-on order for 48 of the new CH-46F Sea Knight helicopters, to be delivered in 1970. The Minuteman III intercontinental missile, a larger and more advanced version, went into the test program during the year. A second missile, SRAM (Short-Range Attack Missile), entered the test phase with several powered launches successfully achieved. SRAM is a supersonic air-to-ground weapon with nuclear capabilities, planned for deployment on late-model B-52 bombers and on FB-111 fighter-bombers.

A second generation of one of the nation's most successful space booster upper stages was under development during the year. Burner IIA, a 2-stage version of the compact Burner II, will help place a larger variety of payloads into more precise earth orbit. The Boeing contract called for the manufacture and delivery of 6 Burner IIAs and one ground-test unit.

An object of competition during the year 1969 was AWACS (Airborne Warning and Control System). The Boeing design is an 8-engine 707-320 intercontinental aircraft with a 30-foot-diameter radome mounted above the fuselage. The large surveillance radar unit would be backed by on-board computers, displays, communications, and other electronic gear to serve as a flying command post for tactical and air defense forces.

The company also mounted a maximum effort in 1969 aimed at gaining a contract for the contemplated Air Force B-1A advanced bomber, a replacement for the veteran B-52. Following issuance of the request for proposal and completion of a design competition, airframe and engine contractors were to be selected to start full-scale development work.

Late in October, The Boeing Company was awarded a contract by the National Aeronautics and Space Administration for the design and fabrication of 4 Lunar Rover vehicles. The 400-pound self-propelled units will give lunar astronauts greater surface mobility. They will carry up to 970 pounds of equipment, be driven by battery-powered electric motors, and have a cumulative range of 75 miles.

The space highlights of the year were, quite naturally, centered on the tremendously successful Apollo 11 and 12 missions. The Boeing Company, in addition to fabricating the first stage of the Apollo V booster, is responsible for systems engineering and integration of the entire launch vehicle as well as for ground support and testing. In May, Boeing was assigned the responsibility for technical integration and evaluation for the entire Apollo/Saturn moon program.

Corporate changes in 1969 included the establish-

ment of the Military Airplane Systems Division and the restructuring of the various divisional units into comprehensive groups. In April, Boeing President T. A. Wilson was designated chief executive officer of the company. William M. Allen, former president and chief executive officer, was to continue as chairman of the board of directors and of the newly formed finance committee.

Employment levels at Boeing declined somewhat during the year, reducing the payroll to approximately 115,000 by the end of the third quarter. A continuing slight decline was projected, though successful bidding on some government projects could change the trend.

THE BUNKER-RAMO CORPORATION AMPHENOL CONNECTOR DIVISION

A new 20,000-square-foot addition was made to Amphenol Connector Division's Space and Missile Systems operation in Chatsworth, California, primarily for the manufacture of cable assemblies used in the Minuteman guidance and control system. Also a manufacturer of advanced-design umbilical and interstage connectors, Amphenol received major contracts from the Army for components of TOW, a tube-launched, optically tracked, wire-guided missile; from the Army for SAM-D surface-to-air missile connectors; and from the Navy for Sea Sparrow, a surface-to-air missile, and for the Poseidon fleet ballistic missile.

In addition to working on military programs, Space and Missile Systems produced fuel gauge interconnection assemblies for the Boeing 707, 720, 727, 737, and 747 commercial jet aircraft. The thousands of assemblies supplied by year-end had amassed over 80,000,000 flying hours.



Amphenol was producing this cable assembly for the Navy's Sea Sparrow missile.

CCI CORPORATION

The aerospace activities of CCI Corporation of Tulsa, Oklahoma, are represented by The Marquardt Company operations at Van Nuys, California, and Ogden, Utah; Murdock Machine and Engineering Company at Irving, Texas; and Controlled Products and Electronics, Inc., at Huntington Park, California. Since the merger of CCI and Marquardt in 1968, CCI Corporation has broadened its capabilities and products to serve a diversity of industries. These include large aerostructure assembly work for commercial aircraft; proprietary ordnance systems; aircraft controls and accessories; railroad and airline transportation controls and communication equipment; carriers for the construction, mining, and materials-handling industries; marine navigation and docking systems; biomedical systems; and management information services.

In the aerospace field, CCI Corporation, through its Aerospace Manufacturing Group, was awarded 2 major programs totaling \$63,000,000 for the manufacture and assembly of engine pylons and leading edge wing slats for the Lockheed L-1011 TriStar program. The 3 plant operations of the Aerospace Manufacturing Group—Murdock, Marquardt at Ogden, and Controlled Products—were participating in the production of these major assemblies. Under contract to Lockheed, CCI was to build 350 shipsets of the wing engine pylons which support 2 of the 3 Rolls-Royce 40,000-pound-thrust engines. Under contract to Avco, CCI was to produce 350 shipsets of the leading edge slats, or 14 slats per aircraft, for the L-1011 wing. The company expanded its facilities and was engaged in an extensive tooling program to accommodate the new large commercial aerostructures production and assembly activities.

The Marquardt division at Ogden expanded its commercial aircraft activity and was to provide air-driven generators for the McDonnell Douglas DC-10 commercial jetliner. The unit serves as an emergency electric power source for the trijet.

In September 1969, as a result of an extensive joint proposal effort between Marquardt at Van Nuys and the AiResearch Division of The Garrett Corporation, the AiResearch/Marquardt team was selected by Grumman Aerospace Corporation to build the F-14A air superiority fighter's air inlet control system. Of the \$14,000,000 contract, over \$7,000,000 was allocated to Marquardt to build the inlet control's servo cylinders.

The epochal mission of Apollo 11 represented the continued flawless performance of Marquardt attitude control thrusters on the Apollo spacecraft and the operation of its 208th Apollo rocket engine. For all the Apollo missions through Apollo 11, the Marquardt engines accumulated an estimated one-third of a million separate firings. Thirty-two of the 100-pound-thrust bipropellant engines, mounted in clus-

ters of 4, are used on the Apollo Service and Lunar Modules for precise directional thrust to control the spacecraft in roll, pitch, and yaw attitudes.

During the year, General Applied Science Laboratories at Westbury, New York, a company subsidiary, completed and put into operation a unique facility designed to accurately simulate the sonic boom effects generated by supersonic aircraft. Contracts to use the facility were received from NASA and the Federal Aviation Administration. In addition, several contracts relating to high-speed ground transportation were received by GASL from the Federal Railway Administration.

At the end of fiscal year 1969, CCI Corporation reported a 36 percent increase in earnings on slightly lower sales. Consolidated sales were \$104,000,000 and net earnings were \$3,700,000, or 89 cents per share, as compared with 1968 sales of \$112,000,000 and earnings of \$2,700,000, or 66 cents per share. Corporate-wide employment at year-end was approximately 3,000 employees.

At year-end, CCI felt that it was successfully achieving its objective of establishing a favorable balance between its commercial and government business content.

CESSNA AIRCRAFT COMPANY

In fiscal 1969, for the eighth consecutive year, Cessna Aircraft Company set a new high for total consolidated sales. Cessna maintained its No. 1 position among general aviation manufacturers, delivering a total of 6,074 aircraft during the company's fiscal year, which ended September 30. The company has led the industry in unit deliveries every year since 1956. Total consolidated sales exceeded \$283,000,000, an increase of \$19,000,000, or approximately 5 percent, over fiscal year 1968.

For the first time in the company's history, multi-engine aircraft contributed more to Cessna's total dollar volume than did single-engine airplanes. This reflected a growing acceptance of business use of private aircraft from business and industry.

Acceptance of Cessna twins was paced by the company's 400 series aircraft, especially the pressurized Model 421, top-selling pressurized twin on the market. A total of 143 Model 421s were delivered during the fiscal year.

The popularity of Cessna airplanes appeared due in large measure to the wide variety of products offered to business and private aircraft buyers. Cessna was offering 35 models in its 1970 product line—26 single-engine and 9 twin-engine aircraft. As recently as 1960, the company's product line consisted of 10 single-engine airplanes and only one twin-engine aircraft.

Cessna was marketing aircraft in 4 broad categories: learn-to-fly aircraft, used for flight instruc-

tion and for low-cost personal or business ownership; medium- and high-performance single-engine models; utility aircraft, used for special transportation and cargo needs; and multi-engine models, used primarily for business travel.

A fifth market category, business jets, came a step closer for Cessna on September 15, with a successful first flight of the company's new fanjet-powered Citation business jet. The first flight came on exactly the day predicted over a year earlier when the aircraft was still on the drawing boards.

At year-end, the 6- or 7-place Citation was well into its flight-test program with development completely on schedule. Cessna anticipated that first customer deliveries would be made in late 1971 instead of the previously announced target date of early 1972.

The company announced that the Citation will be only the first of a family of business jets which Cessna will offer in the future. Cessna established a Commercial Jet Marketing Division, headed by Vice President James B. Taylor.

The price of \$590,000 for a basic standard airplane, announced in 1968, held firm. In addition, the Citation was to be offered as a complete business jet package for \$695,000. This price includes factory-installed avionics and interior, ground and flight training, and one year of computerized maintenance service. The Citation was to be marketed on a direct company-to-customer basis.

Among benefits of this complete package are a single warranty for the airplane and all its equipment, a carefully engineered system that matches equipment performance to the airplane, simplified crew training, and no incurring of interest and insurance charges while an airplane is in a conversion center.

Because of the aircraft's operational versatility, ability to operate at a wider range of altitudes and stage lengths, short-field capabilities, and relatively low cost, Cessna expected to sell the Citation to many customers who have not yet considered utilizing jets. The company anticipated marketing at least 1,000 of the aircraft during the first 10 years.

Further growth of Cessna occurred in 1969 with the formation of Cessna International Finance Corporation. The new firm, a Cessna wholly owned subsidiary, was set up to assist retail purchasers outside the United States and Canada in financing business and pleasure aircraft. CIFIC also provides an extensive wholesale financing program for Cessna's worldwide distribution system.

Several delivery milestones were reached in 1969, including the delivery of Cessna's 3,000th Model 310, to Holiday Inn of America, Inc. The Holiday Inn Cessna 310 joined a fleet of 10 aircraft.

Another milestone was the delivery of Cessna's 250th Model 421, just 20 months after the airplane was introduced. It was sold to the Union Nationale de Productores de Azucart, S.A., an organization

composed of sugar producers and the Mexican government.

A Cessna Turbo-System Centurion, piloted by Dr. Alvin Marks, Sacramento, California, set a world's speed record for round-the-world flights in a general aviation airplane. Dr. Marks set 15 point-to-point speed records in addition to the round-the-world mark. The Centurion took the world's altitude record—43,699 feet—for single-engine nonjet airplanes.



A late-year addition to the 1970 Cessna line was the 150 Aerobat, acrobatic version of the popular Cessna 150 trainer.

During the year, Cessna participated in a nationwide "Discover Flying" campaign, designed to create a greater awareness of the vital role of general aviation in daily American life. The campaign reached its peak in June, with good success in meeting the objective of increasing the interest in general aviation.

Success was also recorded in the company's 1969 Air Age Education programs. A 500 percent increase in activity at the high school level and a 400 percent increase at the college level were measured by the company since starting the programs 2 years earlier. Prior to the Cessna program, there was virtually no industry support available for elementary educators who wanted to set up units on air age education. By year-end, more than 10,000 kits of teaching material developed by Cessna had been circulated to the education community.

Near the end of the year, Cessna announced introduction of a new acrobatic version of the world's most popular flight trainer, the Cessna 150. The 150 Aerobat joined 3 other Cessna 150s, the standard, the trainer, and the commuter.

Cessna's military sales showed an increase over the previous year. Sales to the U.S. and overseas governments totaled over \$74,000,000, up from \$73,000,000 in 1968.

Contracts received during the year for the continuing production of twin-jet A-37 attack aircraft

and twin-engine O-2 forward air controller aircraft, combined with T-37 jet trainer orders on hand, maintained delivery rates of 20 per month each for the jets and the O-2s.

Worldwide facilities of the company and its affiliates at year-end covered over 3,800,000 square feet. Most recent addition, completed in late 1969, was a \$1,600,000 Engineering Research and Development Center at the Commercial Aircraft Manufacturing Division in Wichita, Kansas.

Cessna has 2 aircraft manufacturing divisions and 2 marketing divisions in Wichita. In addition, the company was producing fluid power products at its Industrial Products Division in Hutchinson, Kansas, and at Cessna Industrial Products Ltd. in Scotland. Aircraft Radio Corporation, Boonton, New Jersey, and McCauley Division, Dayton, Ohio, were producing aircraft electronics and accessories for the company and for other manufacturers. Two financial subsidiaries, Cessna Finance Corporation and Cessna International Finance Corporation, were financing aircraft throughout the world, both wholesale and retail.

An affiliate company, Reims Aviation in Reims, France, was manufacturing 5 Cessna airplanes for overseas markets. These aircraft were the Models F150, Reims Aerobat 150, F172, Reims Rocket, and Reims Skymaster.

Cessna was also operating an assembly plant for its Model 150 at Strother Field, Kansas, southeast of Wichita.

At year-end, employment at Cessna worldwide was approximately 13,000.

CHANDLER EVANS CONTROL SYSTEMS DIVISION OF COLT INDUSTRIES

Throughout 1969, Chandler Evans maintained its high volume production of gas turbine controls for the Lycoming T53 engine, which powers the Bell Iroquois and HueyCobra helicopters and the Grumman Mohawk observation aircraft. At the same time, the division provided the Army with a 48-hour delivery of zero-time units on receipt of controls returned for overhaul.

Production of controls, pumps, and other accessories for all major engine manufacturers placed Chandler Evans products on virtually all American military and commercial aircraft as well as on numerous international commercial airliners. Positive displacement fuel pumps were produced for the Pratt & Whitney Aircraft engine-equipped Lockheed SR-71, General Dynamics F-111A, Sikorsky CH-54A Sky Crane, LTV A-7A Corsair II, Lockheed C-141A StarLifter, and Boeing KC-135A Stratotanker and Boeing B-52, as well as the McDonnell Douglas DC-8 and Boeing 707. Chandler Evans pumps were also produced for use on the North

American Rockwell Jet Commander, the Gates Learjet Corporation Learjet, the French-built Dassault Fan Jet Falcon, and the German-produced Hamburger HFB-320 Hansa jet, all employing General Electric engines.

Increased use of gas turbine engines for industrial and marine applications resulted in the use of Chandler Evans pumps on the Pratt & Whitney Aircraft FT3, FT4, and FT12 engines found in electric generating plants and, at sea, providing propulsion for Coast Guard ships.

Production of the MC series fuel controls continued for the Continental J69 engine powering the Air Force, Army, and Navy Ryan Firebee drones. Newer models of the control were produced for the supersonic Firebee II.

A substantial commitment in the field of airframe and engine controls and accessories resulted in significant new applications for Chandler Evans products in hydraulic, pneumatic, and fuel systems. Airframe components were produced for the Lockheed C-5, the Boeing 747, and the McDonnell Douglas DC-9. In addition, Chandler Evans engine de-icing hot air valves, bleed control valves, surge detectors, and pressurizing and dump valves were in use on the Pratt & Whitney Aircraft-powered 747 and F-111, and on the Hughes OH-6A and Bell OH-58A light observation helicopters which use the Allison T63 engine.

The greater part of Chandler Evans' work in the missile control field was of a classified nature. Quantity shipments of gas-actuated flight control systems for the Hughes TOW antitank missiles were made during 1969.

Among long-range projects under way was the development of main fuel pumps for the General Electric GE4 engine to be used on the Boeing supersonic transport and for the General Electric CF6 engine which powers the McDonnell Douglas DC-10 trijet.

Of major significance was the hybrid control for the ST9 engine being developed by Pratt & Whitney Aircraft. This concept is an extension of several years of research and development carried on by Chandler Evans in hybrid electronic configurations.

New research and development programs were initiated for advanced vehicular turbine controls, a control/pump for a General Electric 15,000-kilowatt power plant, and fuel pumps for the Pratt & Whitney Aircraft JFT22 engine being developed for the F-15 and the F-14.

The Chandler Evans West Hartford, Connecticut, facilities consisted of a modern unilevel plant occupying over 335,000 square feet. In 1969, additional manufacturing facilities consisting of 17,000 square feet were acquired in Clare, Michigan. At year-end, the company employed more than 2,400 persons and had field offices in Los Angeles, California; Seattle, Washington; Dayton, Ohio; and Munich, Germany.

CURTISS-WRIGHT CORPORATION

Curtiss-Wright Corporation is a first-tier supplier of a wide variety of aerospace components. Corporate headquarters are in the Wood-Ridge (New Jersey) Facility, at One Passaic Street. Other facilities are located in Caldwell, Hackensack, East Paterson, Carlstadt, and Jersey City, New Jersey; Buffalo, Smithtown, Farmingdale, Long Island City, Hempstead, and Riverhead, New York; Cleveland, Ohio; Los Angeles and Vernon, California; St. Louis, Missouri; Addison, Illinois; Windsor, Connecticut; and Toronto, Canada.

Curtiss-Wright received significant new business in 1969 from prime airframe and engine manufacturers involved in the design and manufacture of new-generation jet aircraft.

The Aerospace Group of Curtiss-Wright played an important part in the success of the maiden flight in February of the Boeing 747, the world's largest commercial jetliner. Curtiss-Wright was producing landing gear components, titanium extrusions, and rotary actuators for the 747. Wood-Ridge production consisted of shipsets, each comprising 8 main axles and one nose axle; one nose steering collar assembly; and 8 tow fitting assemblies, used for handling the aircraft on the ground.

Zarkin Machine Company, a wholly owned subsidiary of Curtiss-Wright, was producing 4 jury strut assemblies for both the wing and the body landing gear, and 2 trunnion fork assemblies, used to pin the landing gear onto the wing structure.

Zarkin, of Long Island City, New York, was also producing 4 side body and wing strut assemblies, which, when actuated, lower and retract the gears, and also serve as the structural member which takes a high percentage of side loading during takeoff and landing. Prime contractor for these components was Cleveland Pneumatic, a wholly owned subsidiary of Pneumo Dynamics Corporation, prime contractor for the 747 landing system.

The Buffalo Facility was extruding titanium angles, used to fabricate the landing gear beam assembly, and was also extruding 20-foot-long upper and lower gear support beams which are part of the wing structure of the 747. At the Caldwell Facility, rotary actuators that move the jetliner's leading edge flaps were being produced. There are approximately 40 actuators used per aircraft.

In June, Curtiss-Wright received a substantial contract to produce a new main landing gear beam assembly for the Boeing 747B. Work was being performed by Zarkin. Deliveries were to begin in 1970 for installation on the first of the B models of the 747.

This new assembly was to be the largest machined one-piece titanium structure ever installed on an aircraft. The unique capabilities of Zarkin Machine Company made possible the new configuration of this assembly in high-strength titanium,

which is machined by the modern, heavy-duty, multispindle profile milling machines at Zarkin's new 100,000-square-foot headquarters at Smithtown, New York.

Work continued in support of the Lockheed C-5 Galaxy. The C-5 flew in April, equipped with landing gear components produced by Curtiss-Wright at the Wood-Ridge Facility, the Caldwell Facility, and the Zarkin Machine Company and Comet Tool and Die Company subsidiaries. Engine components for the C-5 were being produced at the Buffalo Facility and wing panels were shot-peened by Metal Improvement Company, a Curtiss-Wright subsidiary.

Two Curtiss-Wright subsidiaries received contracts from McDonnell Douglas Corporation for work on the intercontinental Super DC-8-63 and on the DC-10 trijet. Zarkin Machine Company was to manufacture the main landing gear cylinder for the DC-8-63. The part, made of one of the strongest of steels, is the major structural member of the landing gear system and is superimposed over the piston assembly. Metal Improvement Company was shot-peened forming the wing panels on the DC-10. The contract, representing the largest such order received by Metal Improvement, will be performed over a 5-year period.

Caldwell received a contract for torque limiters for the leading edge slat actuation system being supplied by Sundstrand Aviation for the Lockheed L-1011 TriStar jetliner.

Metal Improvement and the Comet Tool and Die Company, another subsidiary, contributed to the successful moon landings of Apollo 11 and Apollo 12. Comet precision-machined 11 different aluminum structural components of the Lunar Module descent stage under contract to the prime contractor, Grumman Aerospace Corporation. Metal Improvement shot-peened the socket fittings for the leg attachments of the module. Both Comet and MIC performed similar work for the Apollo 10 and Apollo 9 space missions.

Curtiss-Wright increased its holding of common stock of Dorr-Oliver, Incorporated, Stamford, Connecticut, to approximately 55 percent. Dorr-Oliver was producing a variety of industrial process equipment and systems including filters, centrifuges, thickeners, clarifiers, screens, pumps, thermal reactors, dryers, and air cargo handling equipment. It was also engaged in engineering and consulting services in such areas as ultrafiltration, air and water pollution, chemical fertilizers, and waste disposal.

The East Paterson Facility received prototype development and production quantity contracts for design and fabrication of System Maintenance Trainers (SMT) by the Naval Training Device Center. The SMTs will be utilized at the Naval Air Technical Training Center, Memphis, Tennessee, to train advanced Navy and Marine Corps electronic technicians in the operation and maintenance of

UHF direction finding systems, airborne search radar systems, and IFF (identification) systems. The trainers will be used for demonstration and practice in conjunction with classroom lectures and laboratory work.

General Electric Company awarded Curtiss-Wright a contract for nuclear components, supplementing earlier nuclear work being performed by Curtiss-Wright for General Electric. All work was to be done at a Curtiss-Wright facility at Wallington, New Jersey, formerly used for the manufacture of rocket cases for the Titan III. The Wallington plant was renovated and expanded. An additional 40,000 square feet of floor space was added and new machine tools were installed or on order.

East Paterson was producing the Tactical Imagery Interpretation Facility (TIIF) under contract to the Army Electronics Command in Philadelphia, Pennsylvania. TIIF consists of a mobile, self-supporting unit which provides viewing, comparison, interpretation, and distance measuring of aerial photographic, infrared, and radar images to furnish tactical information to military intelligence teams.

Wood-Ridge received an add-on order for 400 carrier assemblies from Avco Lycoming Division for the T53-L-13 gas turbine engine which powers the Bell UH-1H helicopter. The carrier assemblies serve as a planetary gear carrier for the engine's main reduction transmission system. The new add-on order brought the total number of carrier assemblies produced by Curtiss-Wright for Avco Lycoming to more than 3,000 since 1967.

Three major contracts highlighted activities of the Curtiss-Wright overhaul department at Wood-Ridge. The Navy's Aviation Supply Office, Philadelphia, awarded a contract for conversion kits for J65 engines which power the Martin B-57 and the Republic F-84 and RF-84. Wood-Ridge also received Air Force contracts to overhaul J57 series engines and components and to manufacture spare parts for other Air Force engines.

Curtiss-Wright exhibited its products, capabilities, and skills at the U.S. Pavilion of the 1969 Paris Air Show. The theme of the Curtiss-Wright display was "Process Technology," examples of which included electrical discharge machining (EDM), electrochemical machining (ECM), shot-peening, peen-forming, profile milling, and samples of forgings and extrusions produced by the company.

A remanufactured Curtiss-Wright J65 aircraft engine was being marketed by Wood-Ridge as a gas generator for industrial application in the 5,000- to 10,000-horsepower range.

Late in 1969, the Curtiss-Wright RC2-60 rotating combustion engine flew in an aircraft for the first time. It flew in the Q-Star "quiet" reconnaissance-type light airplane, an experimental test vehicle developed by Lockheed Missiles & Space Company of Sunnyvale, California. The flight of the Q-Star

marked the first time in aerospace history that a liquid-cooled engine installation proved to have a higher power-to-weight ratio than its air-cooled equivalent.

Curtiss-Wright exercised options to purchase 600 acres in Manatee County, Florida, for a land development project in which the company will invest about \$5,000,000. Curtiss-Wright planned a marine-oriented community developed by private individuals and builders at a cost of about \$50,000,000 upon completion. The company started land fill and other major construction.

Metal Improvement Company announced acquisition and expansion moves designed to better serve its customers by extension of shot-peening and peen-forming sales and service to new areas. MIC opened a new 40,000-square-foot facility in Toronto, Canada, and a 20,000-square-foot facility in Farmingdale, Long Island, and acquired Bemco Controlled Peening Specialties, Inc., of California and Apex Hard Chrome Company of Cleveland. An additional peening facility, at Blue Ash, Ohio, was added to serve Cincinnati and the tristate area of Ohio, Kentucky, and Indiana.

FAIRCHILD HILLER CORPORATION

Fairchild Hiller's 1969 advanced design effort was focused on 2 contracts, a definition phase award on the F-15, a supersonic air superiority fighter for the Air Force, and a contract to design Applications Technology Satellites (ATS) F and G for the National Aeronautics and Space Administration.

At the same time, the company was rebounding financially. In 1968, because of the cancellation of a major program, Fairchild Hiller suffered a \$20,000,000 loss. Other programs remained vibrant, however, and as 1969 came to a close, Fairchild Hiller appeared almost certain of achieving its earnings and sales goals for the year. Moreover, 1970 looked still brighter.

Fairchild Hiller began 1969 with a backlog of \$330,000,000. By October 1, with sales for the 9 months at some \$225,000,000, the backlog had grown to \$370,000,000. Management reported to stockholders at that time that it was preparing the 1970 budget to reflect a 5 percent increase in sales and a significant increase in pre-tax earnings over its 1969 figures.

During the year, the company received contracts worth approximately \$90,000,000 for design, fabrication, and production work on the new Navy F-14 fighter aircraft being built by Grumman Aerospace Corporation. Three Fairchild Hiller divisions were participating in the F-14 program. Republic Aviation Division was to build aft fuselage sections, the Aircraft Division was to produce fin and rudder structures, and the Space and Electronics Systems

Division was to design and manufacture the coded integrated armament control system. Fairchild Hiller assisted Grumman in its successful efforts to win the production phase of the F-14 competition.

While the Aircraft, Republic Aviation, and Space and Electronics Systems divisions were the only Fairchild Hiller units involved in the F-14 program, all of the company's divisions and operating subsidiaries were playing significant roles in the company's many other activities.

The Aircraft and Republic Aviation divisions were teamed up in 2 other large-scale programs: production of assemblies for Boeing's 747 superjet and supersonic transport.

The 747 was in production and the wing control surfaces manufactured by Fairchild Hiller divisions were being produced at the maximum rate by year-end. A third Fairchild division, Stratos, was manufacturing bleed air turbine drives for the jetliner. The company's contracts with Boeing covered 20 airplanes and were expected to add substantially to Fairchild Hiller's income.

As one of 8 major subcontractors associated with Boeing in the design and manufacture of the SST, Fairchild Hiller was to work on the entire empennage section when production begins. By late 1969, President Nixon had authorized the building of 2 prototypes and funding was awaiting Congressional approval. Boeing predicted a market of approximately 500 SSTs.

Company efforts on the 747 and the SST, plus studies in propulsion, metallurgy, and design, placed Fairchild Hiller well along the road toward hypersonic aircraft, a development viewed by many experts as almost certain during the 1980s. As with other facets of aerospace such as VTOL and STOL flight, air commuter service, air ambulance service, manned and unmanned spacecraft, and electronic information collection and management, Fairchild Hiller intended to be a leader in the industry.

But Fairchild Hiller was not neglecting current work. The company had most of its 12,000-plus employees busy turning out products and services needed by a variety of customers.

The F-28 was flying, and sales for the F-27 and FH-227 continued. Fairchild Hiller sold some 200 F-27s and FH-227s to regional airlines and corporations in the Western Hemisphere, and Fokker Aircraft Factories, designer of the F-27, sold 300 in its market area—making these turboprop transports 2 of the most popular in aircraft history. At least one of these airplanes was in the air every minute of every day somewhere around the world. As the F-27 and FH-227 started to phase out, replaced in many instances by the slightly larger, 500-mile-an-hour pure-jet F-28, Fairchild Hiller was preparing to give them new life as quick-change cargo aircraft by installing large 6-foot-wide cargo doors.

Another transport that appeared to have a great future was the Fairchild/Swearingen Metro, which

made its first flight in August. Designed and manufactured by Swearingen Aircraft of San Antonio, Texas, the Metro is marketed to airlines by Fairchild Aircraft Marketing Company. This 20-passenger, 300-mile-an-hour turboprop airliner offers to the air commuter, for the first time, all of the comforts and features of large luxury jetliners. Although initial deliveries were not scheduled until early 1970, sales were brisk. Market studies showed this segment of the air traveling public to be the fastest growing of all.

Two other, smaller aircraft, the STOL Porter and the FH-1100 helicopter, also gained popularity. The Porter is one of the most unusual aircraft in the world. Powered by a turbine engine, this 8-place utility aircraft cruises at 150 knots but can travel as slowly as 45 knots without stalling. What makes Porter unique are its takeoff and landing capabilities: it can take off with a full 2,000-pound load in less than 300 feet and land in 150. Unlike a helicopter, the Porter can also land on a hillside (providing, of course, the grade is not too steep). Because it needs no prepared landing strip, the Porter has been found extremely useful in such diverse locations as the jungles of Central and South America and the Alaskan North Slope. At each of these areas, petroleum companies use the Porter to transport executives and technicians as well as to haul equipment, tools, and food to and from isolated, inaccessible sites.

Fairchild Hiller's FH-1100, like the Porter, is a turbine-driven machine servicing remote desert and arctic outposts. In 1969, it received widest attention as an air ambulance. With a toughness proved by 200-hour-a-month service in northern Alaska, this helicopter was being purchased in increasing numbers. State and local government agencies were using the FH-1100 as an air ambulance for carrying litter patients plus attendant and pilot. Nassau County, New York, police used the FH-1100 on numerous occasions in crime control work as well.

The FH-1100 is a 5-place craft that cruises at 125 miles an hour and has exceptional high-altitude capabilities. Like the Porter, the FH-1100 is used frequently as a utility and executive transport.

Fairchild Hiller had a hand in still other major aircraft programs in 1969. The company's Aircraft Service Division worked closely with the Air Force in transforming the FH-built C-119 Flying Boxcar into a formidable gunship. The reconfiguration program, according to the Air Force, was one of the quickest in Air Force history. These gunships were flying fire-suppression missions in Southeast Asia at year-end.

Modification of the FH-produced C-123 cargo transport from a 2- to a 4-engine aircraft was completed during the year by the Aircraft Division at Hagerstown, Maryland. Jet engines give the large craft STOL capabilities. The C-123 was being used extensively in Southeast Asia.

The Aircraft Division, builder of the F-27, the FH-227, the Porter, the FH-1100, the C-119, and the C-123, was working on an additional responsibility: bonded assemblies for the F-111 fighter.

In 1969, Republic, the company's division famed for building the Thunder series of military fighter planes, produced its 3,000th tail assembly for the McDonnell Douglas F-4 triservice fighter program. An addition to that contract brought the number of such assemblies to 3,500. Titanium accounts for half the weight of these 2,000-pound assemblies. Fairchild Hiller has long been a pioneer in the fabrication of titanium, and the firm's history of innovation in working with this space age metal has made the company one of the industry's leaders.

Republic continued to update its F-105 Thunderchief fighter-bomber, workhorse of the Vietnam air war. Among the more notable additions keeping the F-105 tops as a fighter-bomber is the all-weather bombing system known as T-Stick II. The system was installed in the F-105 during the year as conditions in Vietnam permitted.

Fairchild Hiller's Space and Electronics Systems Division designed the firm's version of the Applications Technology Satellites (F and G) for the National Aeronautics and Space Administration. As a prime contractor, the division has been successful. Most notable of its space programs were 3 Pegasus satellites; designed for an 18-month life, these satellites were still in orbit over 3 years after launch.

In 1969, the Space and Electronics Systems Division pushed forward on several fronts. Its simple and compact stores management system was being manufactured for the F-111, and a related system, the coded integrated armament control system, was selected for the Navy F-14 fighter aircraft.

Other products finding increasing favor during the year were the division's airborne data annotation system, film processing and enlarging equipment, code matrix readers, and unusual film incinerator and silver recovery unit. This unique incinerator destroys large amounts of film (the destruction of classified film has been a growing problem with the military and intelligence services), and recovers hundreds of dollars worth of silver from the film daily.

The Space and Electronics Systems Division continued to produce radar and meteorological systems and was generally looked upon as the world's leader in tubular extendible elements. Administrative, research, and development facilities for the division are located at Germantown, Maryland (site of the company's corporate headquarters); the manufacturing plant is at Winston-Salem, North Carolina.

At Manhattan Beach, California, Stratos-Western introduced a new type of mobile beverage cart to airlines and won contracts to manufacture galley modules for the new generation of wide-bodied jetliners. The division earlier had concentrated its resources on the manufacture of flare and sonobuoy launch systems, underwater sound source dispensers,

cryogenic valves, and other spacecraft systems. The new product lines brought with them a substantial expansion in facilities.

Other Stratos Group divisions, at Bay Shore, Long Island, New York, and Winston-Salem, North Carolina, continued to manufacture products which won wide acceptance. At Bay Shore, the company was producing a large family of ground air-conditioning units for aircraft and other uses, environmental control systems, vapor cycle cooling systems, energy conversion systems, and temperature control systems, as well as turbine drives similar to those used on the 747.

At Winston-Salem, the Industrial Products Division was finding a growing demand for its pneumatic pressure regulators, pneumatic relays, pneumatic control accessories, chain and gear-driven transmissions, and related products. These components were in use on industrial machinery in paper making, petroleum, food processing, and printing.

The Technical Services Division continued to offer technical and management capabilities in all aerospace technologies for on-site, off-site, and field support efforts. Technical Services Division was involved in the development of specialty products such as materials-handling equipment and oceanographic instrumentation. Several of its 1969 contracts were aimed at streamlining the postal service and speeding the physical handling of mail.

Burns Aero Seat Company in Burbank, California, prepared for the production of seats for the Boeing 747 and for the new wide-bodied advanced-technology trijets, the McDonnell Douglas DC-10 and the Lockheed L-1011 TriStar. Burns continued to lead the world's commercial aircraft seat industry by manufacturing one-third of all commercial jetliner seats.

S. J. Industries was established originally to fulfill the unusual requirement of mounting solar cells on spacecraft panels, but it moved in an entirely different direction when it sought to diversify. SJI entered the beverage machinery industry by manufacturing bottle and can warmers, flow-control tables, and uncasing tables. In 1969, that phase of SJI's business grew considerably and contributed substantially to its revenues.

The year 1969 was a significant one for Fairchild Hiller. In traditional and new product lines, the company reached new highs and new markets, spelling continued leadership and success.

THE GARRETT CORPORATION

Greater acceptance of its traditional products and deeper penetration into new market areas in 1969 further established The Garrett Corporation's position as one of the world's leading producers of sophisticated aerospace equipment.

Particularly noteworthy were Garrett's achievements in aircraft propulsion engines. By year-end, 6 separate engines, including turboprop, turboprop, and turboshaft propulsion units, were either in production or in advanced stages of development. This relatively new field (Garrett's first turboprop was test flown in 1964) represented a significant portion of the company's sales and backlog. By October 1969, Garrett had orders and options for 3,500 propulsion engines for helicopters and aircraft, a figure indicative of the industry's widespread acceptance of the company's advanced turbine engine technology.

At year-end, total sales and production backlog for the corporation reached a record high. Employment in Garrett's 8 divisions and 5 subsidiaries stabilized at about 13,000, a decrease of less than 4 percent from 1968. Garrett's relative stability in the industry was attributable primarily to its broad product diversity. More than 4,000 different products for commercial, industrial, and military customers constituted Garrett's 1969 product list.

General aviation, another relatively new field for Garrett, also contributed substantially to the company's overall progress. Propulsion engines, environmental controls, auxiliary power units, turbochargers, and other equipment produced by Garrett found excellent reception by business and private aircraft builders and represented a prominent source of growth and future income for the company.

Garrett also made substantial inroads in non-aerospace fields. High-speed ground transportation, industrial gas turbines, heat-transfer equipment, recuperators, and microelectronics were a few of the areas in which Garrett was actively applying its aerospace knowledge.

A small but valuable contributor to Garrett's product capabilities was added early in 1969 with the purchase of Aero Technical Corporation, Fort Lauderdale, Florida. This new Garrett subsidiary, renamed Aero Hydraulics, Inc., manufactures hydraulic pumps, motors, and dampers for aerospace applications.

Another new Garrett subsidiary, Garrett Micro-Circuits Corporation, began operation late in the year. Temporarily quartered in Escondido, California, the firm was to begin construction of new facilities near San Diego in early 1970. GMCC will manufacture microelectronic components for commercial, industrial, and aerospace applications.

GARRETT-AIRESEARCH LOS ANGELES

In a year characterized by many notable achievements, some of the most significant for AiResearch Manufacturing Division of Los Angeles, Garrett's largest division, were the strides made in propulsion systems.

Major progress was made by the division in de-

velopment of the new ATF 3 advanced-technology fanjet engine designed to provide business jets with nonstop transcontinental range. First aircraft to utilize the 4,050-pound-thrust ATF 3 was to be the North American Rockwell Series 60 Sabreliner. In September, it was announced that the HFB Hansa Fan Jet would also be powered by the ATF 3.

Milestones reached during the year included attainment of full thrust by an early prototype engine, completion of a 155,000-square-foot development and production facility, and construction of 6 test cells in Torrance, California. It was planned to fly the engine in the spring of 1970 in a special Sabreliner test-bed, with certification and production scheduled for 1971.

In addition to accelerated development of the turboprop aircraft engine, AiResearch Los Angeles continued work in other propulsion methods. Under contract to the U.S. Department of Transportation's Office of High Speed Ground Transportation, the division designed and fabricated a radically new electric propulsion device, the Linear Induction Motor (LIM). The LIM is expected to be capable of propelling ground transportation vehicles at speeds up to 250 miles per hour. First low-speed tests of the LIM in a specially constructed test vehicle were begun by AiResearch before year-end. High-speed tests were to be conducted by the Department of Transportation.

In other ground transportation systems, initial tests began on a dual-mode, gas turbine-electric propulsion system for rail cars. A demonstration program to prove the system's feasibility was to be conducted by The Budd Company and the Long Island Railroad. The system can operate on electricity from a third rail or can generate its own electrical power via the gas turbines where track-side power is not available.

Much higher on the propulsion scale, AiResearch, under NASA contract, continued development of a hypersonic research ramjet engine. This engine, capable of operating between Mach 3 and Mach 8 (2,000 to 5,000 miles per hour), will provide advanced technology for application in future hypersonic transports, missiles, and spacecraft.

The nation's space program provided major milestones for AiResearch. When Apollo 11 made its historic journey to the moon, an AiResearch environmental control system provided the life-supporting atmosphere for the astronauts. In every U.S. manned flight, from Mercury to the moon, AiResearch life-support systems have played this vital role. The system not only supplies oxygen for breathing but also provides hot and cold water, heating, air conditioning, cabin pressurization and ventilation, and atmospheric purification. Apollo 11's perfect performance further testified to AiResearch's leadership in spacecraft life-support systems.

Development for future space missions continued

in AiResearch laboratories throughout the year. Under contract to McDonnell Douglas, a regenerable carbon dioxide removal system was undergoing qualification testing. This unit is the key element in second-generation space life-support systems. It will extend ECS capabilities well beyond 14-day missions. Primary application is the Apollo Applications Program, but space stations and shuttles of the future may incorporate advanced versions.

Development continued on space suits. Under contract to NASA, AiResearch was developing an advanced suit designed to give astronauts greater mobility on the lunar surface. An extended-duration optimized portable life-support system (backpack) was also under development by the division.

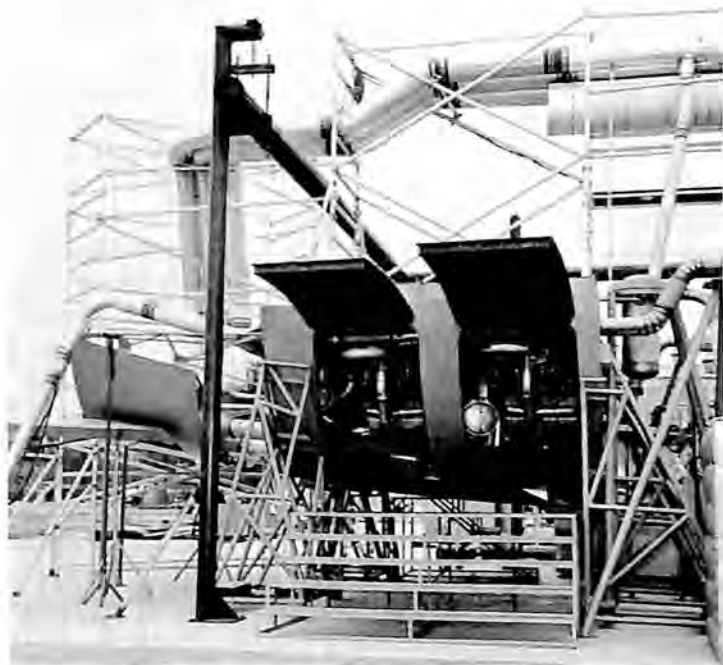
Military and commercial aircraft builders and the airlines were major customers for AiResearch in 1969. Four major contracts for the Navy's new F-14A multimission fighter were awarded to AiResearch by Grumman, prime contractor. The systems AiResearch will build include the environmental control refrigeration system, central air data computing system, air inlet control system, and liquid cooling system. All will be advanced designs. For example, the central air data computing system will be the first military air data system incorporating all-solid-state circuitry and a fully digital computational technique. The air inlet control will also use solid-state electronics.

For McDonnell Douglas, AiResearch was developing the complete integrated pneumatic system for the DC-10 trijet. The system includes air conditioning and pressurization, temperature control, auxiliary power unit, wing anti-icing, and main engine starters. To facilitate system testing, one of the most extensive aircraft environmental test facilities ever built augmented AiResearch's laboratories in Torrance, California.

While development continued on new systems during the year, AiResearch was producing environmental systems for the McDonnell Douglas DC-9, the Boeing 707, 720, 727, and 737, the Grumman Gulfstream II, and numerous other airliners and business aircraft. Production for military aircraft included the Lockheed C-5 and C-141, the McDonnell Douglas F-4 series, the Northrop F-5, the General Dynamics F-111, and the LTV A-7.

In its electronic systems activities, AiResearch achieved a notable breakthrough in 1969 with the development of a solid-state pressure sensor, the key item in its digital air data computer. The solid-state system affords a higher degree of accuracy and reliability than previous analog systems yet is smaller and lighter. First system was to be delivered in 1970 for the Grumman F-14A.

Electronic fuel controls were being developed for several turbine engine applications including auxiliary power units and primary propulsion engines. The AiResearch ATF 3 was one application for the advanced, solid-state controls.



Late in 1969, Garrett-AiResearch Los Angeles began qualification testing of the air-conditioning system for the McDonnell Douglas DC-10 (2 of 3 refrigeration units are shown in simulated bay).

Aircraft Integrated Data Systems (AIDS), another electronics product, were in production. AIDS automatically monitor selected engine and aircraft systems performance in flight and record the data for ground computer analysis. American Airlines, Alitalia, and CP Air use versions of the system. During the year, Alitalia announced that it would incorporate an expanded AiResearch AIDS on its Boeing 747 aircraft.

Also being perfected was an electronic multiplexing system for the new breed of jetliners. The system combines passenger entertainment and service into a single wiring network, reducing weight by hundreds of pounds and providing increased reliability at considerably less cost.

Other notable highlights for AiResearch in 1969 included introduction of a new heavy-duty industrial gas turbine generator designed specifically for the petroleum industry, flight tests of a cryogenic cargo refrigeration system, development of an onboard personnel and service elevator for the Boeing 747, and delivery of an uninterruptible power system for a Federal Aviation Administration air route traffic control center.

GARRETT-AIRESEARCH PHOENIX

Garrett's AiResearch Manufacturing Company, Phoenix, continued to expand traditional product lines and add new ones during 1969.

The company's position as a major supplier of prime propulsion turbine engines was firmly established by continued growth of its TPE 331 turbo-

propulsion engine line and Federal Aviation Administration certification of its new TPE 331-3 series engine rated at 840 shaft horsepower. Increase in time between overhauls for the TPE 331-1 and -2 series from 1,500 to 2,000 hours was effected. The TPE 331 series engines were being offered in a range of horsepower options from 575 to 840.

While the turboprop aircraft engine was finding broad application in the small business/commercial airplane market, AiResearch Phoenix announced its further penetration of the small engine market with a new-technology, geared front-fan turbofan engine, the TFE 731, rated at 3,406 pounds of thrust and weighing only 600 pounds. With a low specific fuel consumption of .49, the Garrett-AiResearch TFE 731 turbofan engine will provide, for the first time, nonstop transcontinental range to business jets in the 12,500- to 15,000-pound weight class. Scheduled for certification in August 1971, the new 731 turbofan engine will power the Learjet Model 25 and Swearingen SA-28T business jets.

In the helicopter engine market, Garrett-AiResearch followed its earlier lead in 1968, when it introduced the 240-shaft-horsepower TSE 36-1 turboshaft engine for light helicopter applications, by announcing its new lightweight (174 pounds) 474-shaft-horsepower TSE 231 engine. The TSE 231 will power the new 6,000-pound Gates Twinjet helicopter, an 8- to 12-place VTOL aircraft with a cruise speed of 180 miles per hour and a range of over 400 miles. Initial orders and options for the TSE 231 engine amounted to more than 1,000. Gates Learjet Corporation anticipated an industry market for up to 5,000 corporate helicopters by 1980.

Another Garrett-AiResearch turbine engine application for helicopters was announced by Aviation Specialties, Mesa, Arizona, which placed an initial order for 100 TSE 331 series turboshaft engines for use in its S-55T Sikorsky helicopter conversion to turbine power. The S-55T will use the 840-shaft-horsepower 331 engine (flat-rated to 700 shaft horsepower) for a weight saving of approximately 900 pounds over the piston version. The S-55 turbine conversion was expected to find ready application among utility, military, and agricultural users in the United States, South America, Canada, and Europe.

In traditional gas turbine products, AiResearch Phoenix maintained its posture as a world leader in on-board auxiliary power unit (APU) installations with units on the Boeing 747 and the McDonnell Douglas DC-10 jet transports.

These engines produce shaft power or compressed-air energy, or combinations of varying amounts of each. The shaft power is used to drive generators, alternators, pumps, compressors, and other driven equipment. The pneumatic energy is used in a variety of applications for aircraft jet engine starting systems, air-conditioning systems, and anti-ice and heating systems. Typical applications include airline and military transport aircraft ground-support and

on-board auxiliary power units, and mobile electric generator sets. The extensive product line includes many variations of the basic engine frame sizes ranging from 60 to over 1,000 horsepower.

Pneumatic actuation systems produced by AiResearch Phoenix continued to find application on the world's newest aircraft. The Boeing 747, the McDonnell Douglas DC-10, and the Lockheed L-1011 utilize AiResearch pneumatic actuation systems in reversing the thrust of their giant engines. The new AiResearch systems feature a lightweight positive-displacement air motor of high efficiency and a new concept of high-speed drive through lightweight flexible shafts. AiResearch pneumatic systems also power the leading edge wing flaps on the Boeing 747 and drive the electrically synchronized pneumatic-mechanical kneeling system of the giant Lockheed C-5. The C-5's system permits the fully loaded 769,000-pound aircraft to kneel to proper cargo-handling height. Within 2 minutes, the C-5 can be raised or lowered 39 inches.

In the field of secondary power systems, the Air Force announced procurement of the newly developed AiResearch JFS 100 series jet fuel starters for the A-7D light attack aircraft. Essentially a small gas turbine engine which requires only 1.5 pints of the aircraft's fuel to start the main engine, the new starter weighs only 75 pounds. It mounts directly on the aircraft's main engine and provides independence from ground-support start equipment. The Air Force was considering its use in future aircraft and retrofit on the F-101, the F-4, and the F-111.

During the year, AiResearch-developed advanced power systems for space applications were subjected to extensive test and evaluation by NASA's Manned Spacecraft Center, Houston, and NASA's Lewis Research Center, Cleveland. At Houston, a 3-kwe closed Brayton cycle demonstrator unit, the first closed Brayton cycle prototype for space power to be operated, logged over 140 hours of operation. Its primary electrical system is designed to operate with any of several heat sources—*isotope, reactor, or solar receiver*—at turbine inlet temperatures of 1,200 to 1,400 degrees Fahrenheit. At Lewis, an AiResearch Phoenix-designed and -developed Brayton turbo-alternator compressor operating on gas lubricated bearings completed 1,000 hours of testing.

In a related development, North American Rockwell's Space Division selected AiResearch Phoenix to assist in its definition study of a NASA space station planned for operation in the mid-1970s. AiResearch's contribution deals with electrical power system requirements for a 12-man earth orbital space station, as well as for a 50-man modular space base that can be assembled in low earth orbit in the late 1970 to 1980 time period. The AiResearch study is based on extensive turbomachinery technology already developed by the company in the design of closed Brayton cycle power conversion systems utilizing radioisotope and reactor heat sources.

GARRETT-AIR CRUISERS DIVISION

At Air Cruisers Division, 1969 was highlighted by the completion of a plant expansion program which doubled the company-owned operating facilities at the Belmar, New Jersey, site. The new plant houses manufacturing facilities, administrative offices, an expanded engineering department, and a consolidated materials laboratory.

During the year, the largest single production contract for dual-wall inflatable shelters was completed for the Army Medical Services. An outgrowth of the activity was the adaptation of this type of shelter for Philco-Ford Corporation as primary housing for that company's tactical air communications center. Development of the communications center's shelter complex was completed in July 1969.

In the first 6 months of 1969, Air Cruisers Division completed development of inflatable escape slides and life rafts for the Lockheed C-5 military transport aircraft. Qualification testing of this equipment was successfully conducted and all items went into production on schedule.

Backlog of commercial business as of September 1969 was 34 percent above the same date in 1968. This percentage of growth was attributable to the increase of activity within the airline and airframe industry serviced by the Air Cruisers Division.

Application of inflatables technology was broadened in 1969 with the development of an underground emplacement form for the Atomic Energy Commission. The device employs a dual-wall structure which provides a flexible form for construction of concrete-walled chambers at extreme depths beneath the surface of the earth.

In support of this and other potential business not related to normal aerospace activities, a separate engineering group was formed in 1969 to provide technical support for Air Cruisers' ground structures. Business potentials being explored by the newly formed group included inflatable shelters of a variety of sizes and applications for both military and industrial users. In addition, development activity was progressing on inflatable devices to be used in the containment of oil spillage from offshore drilling operations.

The sale of inflatable helicopter floats increased Air Cruisers' total backlog in this major product line by 30 percent over 1968. This growth was due primarily to broader use of existing designs and to the development of emergency equipment for a number of new models. Forecasts into 1970 appeared optimistic as a result of several proposals in evaluation for new helicopters being developed in the export market.

Air Cruisers continued to maintain a position as a primary competitor in the field of survival equipment for new aircraft under construction. Company-sponsored developments of new lightweight life rafts and life preservers were running parallel to the

development of combination evacuation slide/life rafts. The division was an active participant in programs sponsored by manufacturers and airline representatives in the drafting of regulations pertaining to this equipment.

A totally new family of inflatable escape slides for DC-8 and 707 aircraft was introduced by Air Cruisers in 1969 as a direct result of the company's efforts to reflect improved design features and lighter-weight materials in major product lines.

GARRETT-AIRESEARCH AVIATION

Garrett-AiResearch Aviation Division attained new heights in sales in 1969 with continually expanding facilities and support services. Both the Los Angeles and Long Island centers set record Gulfstream II, DH-125, Falcon, and JetStar interior and avionics completions. Groundbreaking began during the year in Houston, Texas, for a third complete service facility.

With Merlin sales double those of the previous year, 2 sales offices—at Atlanta and Cincinnati—were added, a Merlin spare parts center was opened in San Antonio, and a Merlin service facility was opened at the William P. Hobby Airport in Houston. DH-125 sales were also at an all-time high and Gulfstream II sales continued at a rapid pace.

AiResearch Aviation moved its Airline Products facility into a 100,000-square-foot building in 1969. The Airline Products group will concentrate on airline interiors and components such as the 747 upper lounges for Pan American.

In addition to the 2 facilities on the East and West coasts and the Houston facility building program, 4 additional completion/service facilities were planned at strategic locations across the country for a new AiResearch Aviation support program of national scope.

GARRETT-AIRESEARCH INDUSTRIAL DIVISION

With the steady growth of general aviation and an increasing demand for lighter, more powerful reciprocating aircraft engines, AiResearch Industrial Division in 1969 furthered its position as the leading producer of exhaust-driven turbocharger systems. Though still a small segment of its overall turbocharger production, aircraft turbocharger systems made significant gains during the year.

Product advances, coupled with improved production methods, were instrumental in keeping costs at a minimum and the division a step ahead of competition.

An example of product improvement was AiResearch's drive to reduce the size, weight, and complexity of its turbocharger system. A significant step toward this goal was the development and extensive testing of a new waste-gate valve integrated into the turbocharger turbine housing. The new waste-

gate and turbocharger combination was under flight and durability testing on a number of aircraft engines.

A second innovation introduced by AiResearch was a pressure relief valve mounted in the turbocharger outlet, obviating the possibility of overboosting the engine under all operating conditions. All 1969 Cessna aircraft with turbocharged engines incorporated the new safety feature.

GARRETT INDUSTRIAL SUPPLY DIVISION

Garrett Industrial Supply Division, which has served industries in southern California and Arizona for over 30 years, reached an all-time high in sales in 1969. Expansion of its facilities, services, and stocked items continued throughout the year in order to meet the growing needs of old and new customers.

A new facility to serve the eastern states was opened June 2 in Fort Washington, Pennsylvania. Garrett Industrial Supply planned further expansion at locations in other parts of the United States.

New highs for the year were experienced by both the southern California and the Arizona locations. Significant gains in a new machine tool department contributed to the overall record. To augment sales, a complete display and demonstration area was established in both locations.

Garrett stocked more than 100 famous brands of industrial tools and supplies ranging from tools, power transmission equipment, grinding wheels, and machine tools to office furnishings.

GARRETT MANUFACTURING LIMITED

Garrett Manufacturing Limited, Rexdale, Ontario, the Canadian subsidiary of Garrett, experienced continued growth in 1969. Sales and backlog increased, as did employment, which exceeded 700 during the year.

Traditional product lines continued to make up the bulk of deliveries, with environmental temperature control systems and digital and cam-driven programmable pneumatic signal generators representing the largest volume.

In 1969, a distributor/dealer network was set up throughout the United States, Canada, and Europe for the sale of downed aircraft locator emergency beacons and other equipment for use in the general aviation field.

Garrett Marine, a division of GML, continued to expand, with contracts from the U.S. Navy for a prototype self-propelled vehicle and study contracts from the German Navy for a similar device.

Diversification of product line activity continued, not only in development and manufacturing but also in the overhaul area. During the year, support activity was engendered with all major Canadian airlines.

GARRETT-AIRSUPPLY DIVISION

The Garrett Corporation's Airsupply Division, headquartered in Santa Monica, California, continued to furnish sales engineering and distribution services on a nationwide basis for suppliers of aircraft and aerospace equipment. The division had more than 20 sales offices located strategically in the major aerospace market areas in the United States.

Airsupply International, with headquarters in Plainview, New York, and Airsupply International GmbH, headquartered in Munich, West Germany, subsidiary companies, were providing sales coverage throughout western Europe. Among the principals of these companies were Garrett-Air Cruisers and Garrett Manufacturing Limited.

GATES LEARJET CORPORATION

Record sales volume, a corporate name change, a significant merger, and continued expansion and strengthening of product lines keynoted activities in 1969 for the Gates Learjet Corporation, formerly Lear Jet Industries, Inc.

In the fiscal year ended April 30, 1969, the company reported combined sales of its corporate divisions and subsidiaries of \$58,016,000, highest in its history and a 67 percent increase over the previous year. Net earnings were \$2,024,000, following losses in fiscal 1967 and 1968.

At the company's annual meeting, held December 2, shareholders approved 2 recommendations by corporate directors. The firm's name was changed to identify the corporation more clearly with its principal product, the Gates Learjet aircraft. Also, shareholders approved an agreement with Gates Aviation Corporation shareholders for the exchange of Gates Learjet Corporation stock for Gates Aviation stock. Gates Aviation had acted since 1967 as the distributor for Learjet executive aircraft throughout the United States and Canada and also operated 3 fixed-base facilities. Gates Aviation is a subsidiary of Gates Learjet Corporation.

William P. Lear, Sr., company founder, resigned as chairman of the firm's board of directors early in 1969, citing pressing commitments of his Reno, Nevada-based interests. Concurrently, he announced sale of all his remaining financial interests in the company to The Gates Rubber Company, which at year-end owned slightly more than 60 percent of the firm's common stock. Company-wide employment exceeded 2,600 at year-end, an appreciable increase over 1968.

AIRCRAFT DIVISION

Gates Learjet in 1969 lengthened its worldwide lead in delivery of corporate jet aircraft, in which it

had led the industry since 1965. By year-end, more than 275 units had entered service.

Sales highlights in 1969 included receipt by Gates Aviation Corporation of 18 orders from U.S. customers during the month of April, the highest number of retail orders for business jet aircraft ever received in a one-month period. April customer deliveries totaled 11 units, highest in the industry since December 1965, when 14 Learjets were delivered. In addition to a record number of domestic orders, Gates Learjet received more than 15 orders outside the United States in 1969, again highest in the firm's history.



Gates Learjet Corporation's Aircraft Division increased production of Learjets at Wichita by 50 percent in 1969, to 6 units a month.

Four new aircraft—3 fixed-wing aircraft and a helicopter—were announced or unveiled during the year.

In June, at the Paris Air Show, plans for an advanced model of the 10-place Learjet 25, to be powered by 2 new Garrett-AiResearch TFE 731-2 turbofan jet engines, were announced. The highly efficient engine, when combined with significant aerodynamic and other engineering refinements, will boost the Learjet 25's range by some 75 percent, to approximately 3,000 miles plus 45-minute fuel reserve. Delivery of production engines, which were being designed specifically for the Learjet 25, was to begin late in 1971 with completed aircraft going to customers in 1972.

In September, at the National Business Aircraft Association annual meeting in Washington, D.C., company officials announced 2 new Gates Learjets to be available for mid-1970 deliveries, bringing to 4 the number of business jet models offered by Gates Learjet Corporation.

The new Learjet 24C is the world's first business jet competitive with leading turboprop executive aircraft in initial purchase price, operating costs, and takeoff/landing distance requirements—yet offering true jet performance including speeds in excess of 500 miles per hour. Seating 6 passengers,

plus crew of 2, the Learjet 24C will be certificated under FAR-25 Air Transport Category regulations. Its base price will be \$627,900. Serving as top of the Gates Learjet line, the Learjet 25C will carry a fully equipped price of about \$950,000. Offering a Los Angeles to Washington, D.C., nonstop range, the new aircraft's most unique feature will be its passenger cabin in which the standard seating configuration can be converted in flight into a comfortable sleeping compartment.

The present Learjet 24B and Learjet 25 will remain in continuous production after mid-1970, with improvements, as the Learjet 24D and Learjet 25B, respectively.

Also in September, Gates Learjet Corporation unveiled the Gates Twinjet helicopter, the world's first twin-turbine-powered rotorcraft designed specifically for corporate transportation. The new helicopter, scheduled to make its first flight in 1971, with initial deliveries beginning late in 1972, is designed to serve as a stablemate to the growing fleet of business jets entering service in the 1970s.

Carrying 8 passengers in plush, spacious comfort, plus a 2-man crew, the Gates Twinjet executive model will cruise at 180 miles per hour for ranges of over 400 miles with an exceptional level of safety. It will be powered by 2 Garrett-AiResearch TSE 231-P2400 turboshaft engines, rated at 474 shaft horsepower each for takeoff and designed specifically for the new helicopter. Price of the Gates Twinjet executive model will be approximately \$450,000. In addition to the primary market of corporate operators, Gates Learjet predicted high utilization by utility, air taxi, ambulance, police/fire protection, military, and government organizations.

In gearing for expanding production at its Wichita, Kansas, Aircraft Division facilities, the company completed 2 plant additions in 1969, bringing its total plant area to about 450,000 square feet.

JET ELECTRONICS & TECHNOLOGY, INC.

Sales of Jet Electronics & Technology during fiscal 1969 were double those of the previous year. This was due in part to increased production rates of Learjet 24 and Learjet 25 aircraft, for which J.E.T. was supplying autopilots, gyroscopes, solid-state inverters, and other electronic components. The volume rise was the result also of substantially increased military requirements for attitude gyro indicators and rate gyroscopes produced by J.E.T., as well as of component sales recorded to many new commercial customers for use with their products designed for high-performance aircraft.

In January 1969, J.E.T. occupied a new 57,000-square-foot building adjacent to Kent County Airport, Grand Rapids, Michigan. The facility was designed specifically to meet increasing requirements of manufacturing and developmental activities at J.E.T. Included is a 4,000-square-foot clean room

essential to production of precision electromechanical instruments.

Also during the year, J.E.T. established a nationwide commercial sales organization to further penetrate the fast-growing general aviation market and by year-end had appointed 15 established avionics installation and sales firms to market J.E.T. products domestically.

Moving into production status in 1969 were a new 3-inch gyro indicator and a flight control system servo actuator. Marketing potential was significant.

LEAR JET STEREO, INC.

In 1969, the Lear Jet Stereo Division became a wholly owned subsidiary of Gates Learjet Corporation, with a new name, Lear Jet Stereo, Inc.

In June, Lear Jet Stereo introduced its new product line for 1970: 20 different automotive, home, and portable units, an addition of 6 products over 1968 and the broadest line in the Lear Jet Stereo 8 field. The new automotive line has both standard and deluxe models, with the deluxe model featuring a new direct-drive motor with a completely new case and electronics. The new product line also offers significant recording features in both home and auto units.

During the year, company-owned master warranty stations were established across the nation, including 3 already in operation—in New York City, Detroit, and San Francisco. The San Francisco facility also serves as reception center and quality check station for all imported player units.

In conjunction with stereo import programs, a company office was established and staffed in Tokyo to handle projects pertaining to Japanese-purchased components. Plans were also revealed to expand stereo facilities into the Tucson, Arizona, area.

AVSCO, INC.

The first year of Gates Learjet's ownership of Avsco, Inc., was highly successful. Avsco sales more than doubled over the previous year, with commensurate increases in profits.

Already one of the largest injection molding facilities in the United States, Avsco completed a \$2,250,000 expansion program in facilities and equipment in 1969. The expansion program, geared to increased demand for Avsco's wide variety of plastic products and Lear Jet Stereo 8 tape cartridges, increased floor space at Excelsior Springs, Missouri, facilities by more than one-third, to 134,000 square feet. The number of presses, used to insure highest-quality automatic precision in component production, increased from 39 to 69 units.

Another important element accomplished in 1969 was total integration of Lear Jet Stereo 8 cartridge activities with the Avsco operation, including physical relocation of key personnel to Excelsior Springs.

STATIC POWER DIVISION

Under its new operating status, the Lear Jet Static Power Division, formerly the Research and Development Laboratory, at Santa Ana, California, continued to provide 2 important functions in 1969: charting and researching new product areas to contribute to company growth, and working closely with each Gates Learjet activity on improvements to existing products.

In the new product area, important progress was made in development and marketing of Lear Jet static power conversion systems for ground and airborne use. These systems, based on advanced proprietary technology, with patents pending, convert incoming AC electrical power of varying voltage and frequency to unvarying high-quality power of any desired frequency, voltage, and power level. They are useful in ground applications in providing unfailing electrical power to critical communications and computer loads, and in airborne applications as static inverters and variable-speed, constant-frequency (VSCF) AC generating systems.

Lear Jet ground power conversion systems were delivered to the Naval Observatory in Washington, D.C., and to Langley and Vandenberg Air Force bases. Other units were in various phases of production. All types and models of Lear Jet systems supply power to critical loads where power failures or even slight interruptions cannot be tolerated.

A Lear Jet 60-KVA airborne VSCF system completed full-scale tests for a major airframe manufacturer with favorable results. Also, a second-generation system for flight-test evaluation was produced under an Air Force contract. These systems offer improved reliability and performance over the hydraulic constant-speed drives now universally used in the electrical power generating systems of military and airline jet aircraft.

Development work for other Lear Jet operations included an improved, lower-cost tape cartridge and tape drive motor for Lear Jet Stereo, providing basic technology for a new static inverter to be manufactured by J.E.T., and fundamental development work for the Aircraft Division on electrical systems for the 1970s.

GENERAL DYNAMICS CORPORATION

General Dynamics maintained its prominence in the aerospace industry during 1969. Military and space work accounted for approximately 85 percent of over \$2 billion in sales recorded by the corporation.

The corporation's research and production activities spanned a variety of aircraft, missile, electronics, and space exploration programs that involved 6 major operating units.

General Dynamics had 5 versions of the versatile F-111 in production during 1969. By year-end, more than 200 of the variable-sweep-wing airplanes had been built for the U.S. Air Force and the Royal Australian Air Force. The F-111 passed 50,000 flying hours in November.

First deliveries of 2 new F-111 versions were made in October; the Strategic Air Command accepted the FB-111A strategic bomber at Carswell Air Force Base, Texas, and the Tactical Air Command accepted the F-111E fighter-bomber at Cannon Air Force Base, New Mexico. The last group of F-111A fighter-bombers was delivered to Nellis Air Force Base, Nevada, during the year, and production started on the F-111D fighter-bomber. A new version, the F-111F, entered development in 1969. The F-111F is similar to the F-111D, but it features simpler and less costly avionics. The Air Force announced that deployment of F-111s to Europe was scheduled late in the spring of 1970.

In space, the Atlas and Atlas/Centaur boosters produced by General Dynamics for the Air Force and NASA continued to launch major missions, including the Mariner 6 and 7 spacecraft.

A \$25,581,000 contract was received from NASA in late October to design and build the first of a new series of improved Centaur upper stage rocket vehicles. The improved version of Centaur primarily involves developments in the fields that have occurred since Centaur was first designed. In addition to being updated and simplified, the vehicle will be designed for compatibility with the Titan III booster. Earlier in the year, Atlas/Centaur was selected as the booster for Intelsat 4 communication satellites. Through mid-October, Atlas had been successful on 96 of 99 missions, including 47 consecutive successful launches. The Centaur second stage was successful on 11 of 12 operational missions.

A leading producer of tactical guided missiles for over a decade, General Dynamics led one of 3 industry teams that submitted proposals in 1969 for the Navy's Advanced Surface Missile System (ASMS). Other new guided missile concepts entered development and 3 missile systems continued in production. The latter group included Standard for the Navy, Standard ARM for the Navy and the Air Force, and Redeye for the Army and the Marine Corps.

Three aircraft programs were under way at the corporation's Canadair subsidiary in 1969. Three CL-84-1 V/STOL aircraft were in production for the Canadian armed forces. A flight-test program to determine operational potential and capabilities of this type of tilt-wing aircraft was scheduled to begin in early 1970. By the end of October, 40 of 220 CF-5 and NF-5 tactical/support fighter aircraft on order had been delivered to the Canadian armed forces and the Royal Netherlands Air Force. Production also continued on the water-bomber ver-

sion of the CL-215 amphibious aircraft. This aircraft entered operational service in 1969, fighting fires in France, Spain, and British Columbia.

Also entering production in 1969 was the AN/USD-501 airborne surveillance system, a drone system designed to provide tactical intelligence in the forward battle areas. Conformance trials were concluded during the year by members of the armed forces of Canada, Britain, and the Federal Republic of Germany.

The corporation was involved in a number of aerospace electronics programs in 1969. General Dynamics was prime contractor for the Apollo instrumentation ships which played an important part in the tracking, communication, and command network that supported the successful moon landing mission. Other programs ranged from new aerospace ground equipment and radar systems for aircraft to sonobuoy receivers and a deep-sea laboratory for testing sonar systems.

FORT WORTH DIVISION

F-111 variable-sweep-wing aircraft production in various versions had passed well beyond the 200th article by year's end at the Fort Worth division of General Dynamics. General Dynamics is prime contractor for the F-111 family of aircraft.

In 1969, F-111A tactical fighter-bomber production for the Tactical Air Command was completed and production of the next TAC fighter-bomber model, the F-111E, began—and was still under way at year-end.

Deployment to Europe was due in 1970. The U.S. Air Force's 20th Tactical Fighter Wing announced in September that it was transferring to RAF Upper Heyford, Oxfordshire, and would convert 2 squadrons to F-111s by late spring.

The first FB-111A bomber went into the Strategic Air Command inventory in ceremonies at Carswell Air Force Base, Texas, on October 8, 1969. Air Force announcements of the event included the fact that the FB-111A was the first new bomber to go into SAC in nearly 10 years. On August 1, 1960, another General Dynamics-built bomber, the B-58 Hustler, entered SAC.

In the ceremony, General Bruce K. Holloway, SAC commander in chief, accepted the first FB-111A from Major General Lee V. Gossick, Aeronautical Systems Division commander. The FB-111A delivered was the 3,369th strategic bomber built at the Fort Worth plant. Others were B-24s, B-32s, B-36s, and B-58s.

The FB-111A was to be used first at Carswell Air Force Base to train flight crews. During the 1970 spring and summer, the bombers were to become operational at Pease Air Force Base, New Hampshire, and Plattsburg Air Force Base, New York.

Even as the FB-111A delivery ceremony was

taking place at Carswell Air Force Base, General Dynamics engineers across the field were preparing for the company's entry in the contract competition for the next strategic bomber, the B-1A, or Advanced Manned Strategic Aircraft (AMSA). A request for proposals from the Air Force was received in November.

The FB-111A bombers for SAC have a wingspan 7 feet longer than that of the tactical fighter-bomber version, a heavier landing gear, different avionics, and different (more powerful) engines. To SAC, the FB-111A offers greater speed, better penetration of defenses because of advanced avionics and automatic terrain-following radar, higher navigation and bombing accuracies, and easier maintainability than the B-52 it will supplement. The FB-111A is capable of employing both nuclear and conventional weapons, including SRAM (Short-Range Attack Missile).

Along with strategic bombers, F-111E tactical fighter-bombers were also on the Fort Worth division assembly lines as 1969 neared an end. The F-111E is much like the earlier F-111A models, but it incorporates an air inlet that improves operation at high speeds and altitudes and during flight maneuvers, and blow-in doors that improve maintainability and reliability.

The F-111E, as does the F-111A, uses TF30-P-3 turbofan jet engines. These Pratt & Whitney Aircraft turbojets feature variable afterburning; previous jets were limited to all-on afterburning.

The F-111E went first to Cannon Air Force Base, New Mexico, the second base to activate F-111 units. The first was Nellis Air Force Base, Nevada, which was still flying the F-111A at year-end. Arrival of the first F-111Es at Cannon Air Force Base was celebrated in ceremonies both at the base and in nearby Clovis, New Mexico, on October 11.

Following the F-111E on the production line at General Dynamics was the F-111D. It uses TF30-P-9 engines which provide increased thrust in military power and in afterburner, as do the -P-7 engines on the FB-111A. Principal distinguishing feature of the F-111D is the advanced avionic system, which includes attack radar, integrated displays, inertial navigation set, Doppler radar, and a computer complex.

Newest model in the F-111 family is the F-111F. The F model is similar to the D model but incorporates simpler and less costly avionics.

CONVAIR DIVISION

In 1969, Convair's Atlas booster and Atlas/Centaur combination continued to launch major NASA and Air Force missions. Early in the year, Atlas/Centaur boosters successfully launched for NASA the Mariner 6 and 7 spacecraft. Mariner 6 completed its 156-day earth-to-Mars journey on July 31, when it reached a point in space only 2,000

miles from the planet. Mariner 7 flew by Mars on a similar mission August 5. Also in August, an Atlas/Centaur booster successfully injected Applications Technology Satellite 5 (ATS-5) into a near-perfect transfer orbit with an apogee of 22,700 miles.

Through mid-October, the Atlas reliability record as a space booster was 96 successes out of 99 missions, with 47 consecutive successful launches. The Centaur second stage had 11 successes in 12 operational missions.

Recycled Strategic Air Command Atlas missiles were used as boosters to launch several Advanced Ballistic Reentry Systems (ABRES). On a 20-missile average, recycled Atlas reliability was 85 percent.

In October 1969, a \$14,303,150 contract for the manufacture of 6 Atlas space launch vehicles for NASA and the conversion of one Air Force launch vehicle was awarded Convair by the Air Force Space and Missile Systems Organization (SAMSO). The contract called for Convair to fabricate, assemble, test, inspect, and deliver the NASA Standard Launch Vehicles 3C (SLV-3C) and the Air Force Atlas (SLV-3) in the period 1970-71. The 6 new vehicles were slated to become the first stages for Atlas/Centaurs 22 (AC-22) through AC-27. Planned mission assignments were: AC-22, Orbiting Astronomical Observatory (OAO-C); AC-23 and AC-24, 1971 Mariner Mars orbiters; AC-25 and AC-26, 2 Intelsat 4 communications satellites; AC-27, Pioneer F on a Jupiter flyby mission.

Earlier in the year, the Communications Satellite Corporation selected Atlas/Centaur as the booster for the launch of Intelsat 4 communications satellites.

Atlas/Centaur boosters were chosen to launch West Germany's Project Helios solar probe satellites in 1974 and 1975. Project Helios is a joint venture of the United States and West Germany to study the sun.

An incentive fee of \$500,000 was awarded Convair by SAMSO for achieving 100 percent flight reliability in 22 consecutive Atlas space launches. The fee was a feature of an incentive contract awarded Convair in 1965 for production and launch of the Atlas SLV-3.

The 22 Atlas missions began in December 1966 with an ATS launch and ended in August 1969 with another ATS mission. Other missions included Precision Recovery Including Maneuvering Entry (PRIME), Air Force Agena, Lunar Orbiter, Mariner Venus flyby, Mariner Mars flybys, Surveyor lunar soft landing, and Orbiting Astronomical Observatory.

The Convair division continued to be a major producer of F-111 components for the Fort Worth division of General Dynamics.

Convair was also producing aerospace mechanical and electronic ground equipment (AGE) for the F-111. The mechanical AGE ranges from specially designed drills and reamers to hoisting slings ca-

pable of lifting the entire airplane. The electronic AGE varies from single adapter cables to complex electronic test equipment, all designed to test and check out the F-111 weapon system.

The Convair division was chosen in August 1968 to manufacture a major portion of the fuselage for the DC-10 trijet. The contract, awarded by McDonnell Douglas, will have a value of approximately \$500,000,000 by 1975. An estimated 4,000 Convair division employees were to be assigned to the DC-10 program when production reaches its peak. Convair was building the fuselage at the division's Lindbergh Field plant at San Diego.

Deliveries of empennage sections for the Air Force C-5 jet transport continued. By year-end, 21 empennages had been delivered.

POMONA DIVISION

Six new tactical guided-missile system concepts were in development and 3 missile systems continued in production during 1969 at the Pomona division.

Among the new concepts in development were Harpoon, an air-to-surface missile, and Phalanx, a radar gun control system, both for the Navy; MANPADS (Man-Portable Air Defense System) and LOFAADS (Low-Altitude Forward Area Air Defense System), both for the Army; and the Short-Range Missile for the Air Force.

Meanwhile, 3 missile systems continued in production: Standard for the Navy; Standard ARM for the Navy and the Air Force; and Redeye for the Army and the Marine Corps.

Standard production involved 2 versions, for extended range and medium range. A key feature of the system is interchangeability of hardware between the 2 versions. The principal difference is in the propulsion systems. The medium-range version has an integral dual-thrust rocket motor; the extended-range version has a separable booster and a sustainer rocket motor. Standard missiles will eventually replace Terrier and Tartar missiles for shipboard fleet air defense.

The original version of Standard ARM was succeeded on the production line by a missile system with improved guidance capabilities and more effective response to countermeasures. The system consists of a medium-range Standard missile modified to be carried and launched from Navy A-6B and Air Force F-105F aircraft. Their mission is location and destruction of hostile ground-based radar installations.

The U.S. Army in Europe was equipped with the shoulder-fired Redeye missile. The 4-foot-long, heat-seeking missile is designed to protect infantrymen from low-flying enemy aircraft. Redeye training programs were being conducted for the Marine Corps at Twentynine Palms, California, and for the Army at Fort Bliss, Texas.

CANADAIR DIVISION

Three CL-84-1 V/STOL aircraft were ordered by the Canadian armed forces following the successful flight testing of the CL-84 tilt-wing prototype. These Canadair aircraft were given the military designation CX-84. They will be used to determine the operational potential and capabilities of twin-engine, tilt-wing V/STOL aircraft. The evaluation program was to begin with flight testing early in 1970.

The CL-84-1 (CX-84) is powered by 2 T53 turbo-prop engines, each producing 1,500 shaft horsepower. A later model of the airplane was being studied; it would use an updated version of the T53 engine in the 1,800-shaft-horsepower class, enabling the CL-84 to lift over 2 tons in the VTOL mode. For STOL operation, the payload could be increased to 3 tons and only 140 feet of ground roll would be required. This model would have a cruise speed of 325 miles per hour and a dash speed of 375 miles per hour.

The CL-84 is suitable for utility transport, close air support, helicopter escort, and hover rescue roles. In the latter role, the aircraft could fly 275 miles at a speed of 325 miles per hour, hover for 40 minutes while rescuing 8 men, and return to its base at the same speed. The reaction time from takeoff to rescue is less than half that required by in-service helicopters.



General Dynamics' Canadair Limited introduced into operational service its CL-215 amphibious water-bomber. Canadair was producing 20 of the planes for the Province of Quebec and 10 for France.

Production of 115 CF-5 tactical support/fighter aircraft for the Canadian armed forces and of 105 NF-5s for the Royal Netherlands Air Force was well under way. By the end of October, a total of 40 aircraft had been delivered to the 2 customers. Production of these aircraft will continue into the summer of 1971. The CF-5 and the NF-5 are Canadian versions of the basic Northrop F-5 fighter aircraft.

Canadair was also manufacturing the rear fuselage section for all F-5s built by Northrop Corporation in California.

Twenty CL-215 twin-engine amphibious aircraft in a fire-fighting water-bomber configuration were in production for the Province of Quebec in Canada and 10 were in production for the Republic of France. Four aircraft entered fire-fighting service for the French Protection Civile Service in early summer. In addition, 2 CL-215 aircraft performed fire-fighting roles on a contract basis: one in Spain, the other in British Columbia. The latter aircraft dropped over 300 tons of water on a fire in one day. The CL-215 can load up to 6 tons of water in just 12 seconds through 2 hydraulically operated pickup probes as it planes over a suitable body of water.

Members of the armed forces of Canada, Britain, and the Federal Republic of Germany concluded demonstration of conformance trials in 1969 of the AN/USD-501 airborne surveillance system (started by Canadair in 1959 as the CL-89 drone). The test firings were carried out at Canadian Armed Forces Base, Shilo, Manitoba, by a trination group. The cost of design, development, test, and evaluation was shared by the 3 governments participating. Production was under way at Canadair.

The AN/USD-501 is a reconnaissance drone system designed to provide tactical intelligence in the forward battle areas. The drone design emphasizes small size and high speed and uses a rocket motor for initial boost and a turbojet engine for in-flight power. After launch, the drone accurately follows a preselected course, takes photographs as it flies over the target area, and then returns to a predetermined recovery point, where it lands by parachute. The 8.5-foot-long drone is reusable. The sensors are 2 70-millimeter cameras equipped for day and night operation. Other types of sensors were being evaluated.

The AN/USD-501 system can be operated under adverse battle conditions; because of its small size and high speed, it has a particularly high probability of surviving against a strong enemy air defense.

ELECTRONICS DIVISION

Electronics division programs and equipment contributed to the success of the Apollo mission to land men on the moon and to obtain scientific information from the surface.

Apollo Instrumentation Ships, for which the divi-

sion was prime contractor, served as the midocean eyes, ears, and voice of the global tracking, communication, and command network. The division provided program management to convert 3 oil tankers specifically for the mission and supplied 8 of the 12 major electronic systems on board.

The scientific package left on the moon was provided with equipment that reduced analog data to digital for transmission to earth.

Also in the Apollo Manned Space Flight Network were 46 Electronics division systems to process data transmitted to earth from the spacecraft.

For another space program, the Defense Satellite Communications System, the division was providing telemetry and signal-processing equipment.

Deliveries of aerospace ground equipment (AGE) for the F-111 aircraft continued. The building-block configuration makes this computer-controlled system adaptable for use with all advanced operational aircraft planned through the late 1970s.

Another test equipment development was in SCATE Mk V, which provides a unique combination of stimulus, measurement, and computer techniques. Using on-line English language programming, SCATE Mk V determines, analyzes, and evaluates operational characteristics from DC through microwave.

The division's AN/ARN-96 microelectronic TACAN was flown extensively, and it passed environmental test and evaluation. A 10-watt AM UHF mobile transceiver that can be mounted in all types of vehicles was designed for communication between the vehicles and aircraft on the ground or in flight.

Development work continued on radar systems including a forward-looking, low-altitude radar that looks down and ahead and at a wide angle to left and right, performing terrain avoidance, terrain following, and ground mapping simultaneously. A new radar altimeter so small that it can be held easily in one hand was introduced for use on helicopters, V/STOLs, and low-flying aircraft.

The division's AN/ARR-72 miniature sonobuoy receiver was designed for the Navy's A-NEW advanced ASW system, which integrates ASW sensors with an airborne digital computer.

The Electronics division was also building the world's first deep-sea laboratory for testing sonar systems. The Atlantic Undersea Test and Evaluation Center sonar range in the Grand Bahamas will be the first research and development facility to compare actual and predicted performances of sonar systems in operational and acoustical environments like those encountered during fleet operations at sea. The range comprises 4 major systems: calibration array, acoustical and optical tracking, data acquisition, and data reduction.

A central element in this complex is UNIDAR™, the Universal Data Recording System independently developed by the Electronics division for

ultradensity digital data recording. It compresses within a given bandwidth twice the data that can be recorded by any other system. The system has a 33,000-bit-per-track-inch capacity.

STROMBERG DATAGRAPHIX

Stromberg DatagraphiX completed the first production order of airborne display equipment for the A-NEW P-3C system. The display is the link between man and the computer, which receives submarine intelligence from acoustic sensors in the water. Production was under way on the second order. A \$6,100,000 letter contract was received for the third.

Stromberg DatagraphiX was also producing other displays, such as those used in the Pan American World Airways reservation systems. Stromberg DatagraphiX computer output microfilming systems were installed at an increasing rate in many industrial and military facilities.

GENERAL ELECTRIC COMPANY

AEROSPACE GROUP

Aircraft Equipment Division

In 1969, General Electric's Aircraft Equipment Division, with headquarters in Utica, New York, increased its contribution to the defense and commercial aerospace markets. A leading worldwide supplier of aerospace electrical and electronic equipment, the division during the year made application of such new technologies as fly-by-wire flight control, lasers, low-light-level television, computed displays, and solid-state rate sensors, opening new fields for product development and growth.

Employing more than 16,000 people, the division in 1969 consisted of 4 product departments and an advanced systems department: Aerospace Electrical Equipment at Erie, Pennsylvania, Lynn, Massachusetts, Waynesboro, Virginia, and Wilmington, Massachusetts; Aerospace Electronics at Utica, New York; Armament at Burlington, Vermont, and Springfield, Massachusetts; Avionic Controls at Binghamton, New York; and Advanced Systems and Planning at Utica, New York.

The Advanced Systems and Planning Operation saw its second full year of operation and markedly strengthened the division's contribution to military and commercial contracts for aerospace equipment.

The Aerospace Electrical Equipment Department has product responsibility for the development, design, and production of instruments and electrical equipment for aircraft and space applications. These equipments include navigation systems, fuel management systems, engine condition monitoring in-

struments, liquid level measurement systems, fuel cells, and electrical systems.

The department continued production of various equipments for commercial and military aircraft, as well as for certain space programs such as the Lunar Module, Biosatellite, and SNAP-8.

Electrical systems were delivered for the C-5 Galaxy cargo aircraft, which made its first flight in 1968. The C-5 electrical system consists of 5 generating channels, is capable of producing 400 KVA, and weighs approximately 400 pounds. This compares with earlier systems weighing as much as 50 percent more per KVA.

The department introduced a new oil and fuel quantity indicating system. GE developed a simple, lightweight, highly reliable electric dipstick with appropriate readout that provides a direct measurement of the quantity of fluid contained in the tank being measured.

Development work started on a self-contained oxygen system for use on high-performance military aircraft. Such a system will eliminate the need for liquid oxygen facilities at remote bases. The key element in the system is an oxygen concentrator that will extract oxygen from jet engine compressor bleed air and deliver pure oxygen to the pilot's face mask on a continuous demand basis.

The department began work on the development and manufacture of the main electrical power generating system for the Boeing supersonic transport. Over a 10-year period, General Electric has developed and tested a variable-speed, constant-frequency (VSCF) electrical system for aircraft application. The Boeing SST is the first aircraft to call specifically for a VSCF system. The SST's electrical facilities include a 4-generator 60-KVA variable-speed, constant-frequency electrical system.

The VSCF system approach has been recognized by both military and commercial interests as an ideal source of constant-frequency electrical power for a wide variety of ground power requirements. A number of applications were under consideration or test at year-end.

A number of 1969 developments at the Aerospace Electronics Department highlighted the division's activity in the area of lightweight electronic systems and equipment which GE develops and manufactures for a wide variety of mission requirements covering detection, guidance, and data processing.

Production of attack radar systems for the F-111A and of new AN/APQ-114 radar systems for the FB-111 fighter-bomber version continued. The AN/APQ-113 and the AN/APQ-114 were the latest production systems in a long line of radars developed and manufactured by the division. Microelectronics and solid-state circuitry were used extensively in the new radar systems to meet stringent size, weight, and reliability requirements.

Delivery of production quantities continued on the guidance and control group for the Army's new

Chaparral guided missile which will defend forward areas against attacking enemy aircraft. The missile's sophisticated heat-seeking sensor automatically guides the missile after launch to the point of interception. This equipment contains some of the most advanced infrared techniques available for production today.

Significant electronic warfare hardware of the barrage and deception type continued to flow from the division to the Air Force in 1969. Other high-activity programs were satellite command systems, development work on the airborne early-warning radar for the Navy's new E-2C aircraft, and significant production effort on the data processing system for the Navy P-3C antisubmarine warfare aircraft.

In conjunction with GE's work on military applications of low-light-level television, the division delivered 2 1,000-line resolution TV cameras for NASA's Marshall Space Flight Center. Designated UVR-700 focus projection and scanning vidicon cameras, each weighs only slightly over 5 pounds and is at least 30 percent smaller than any previous miniature camera with equal high-resolution capability. Another low-light-level television system moved from development and testing into production for use on the P-3C aircraft.

To continue to meet the demands of the Vietnam conflict, full production was maintained at the Armament Department on the 20-millimeter Vulcan cannon and the 7.62-millimeter Minigun, members of the division's family of high-performance rapid-fire aircraft and ground vehicle armament systems. These Gatling-type weapons utilize a cluster of rotating barrels to deliver as many as 6,000 shots per minute.

The department also continued deliveries of the 20-millimeter Vulcan Air Defense System (VADS) to the U.S. Army and the system underwent combat test and evaluation in Vietnam. The VADS fires up to 3,000 shots per minute in its air defense role and the same ground vehicle weapon system fires a 1,000-shot-per-minute rate against ground targets. The VADS was being produced in 2 versions, self-propelled and towed.

Development and production of the XM-197, a lightweight 3-barrel version of the 6-barrel Vulcan gun, was accomplished, and first application of the system was made on the HueyCobra helicopter in a new turret produced at the Burlington, Vermont, facility. Arming of HueyCobras with 20-millimeter Vulcan gun kits also began in 1969.

Development work started on the ammo-handling system on the new F-14 fighter aircraft. Other development activity included a Vulcan gun system for the Navy's shipboard air defense system. A feasibility model of an ammo-handling system for the F-106 fighter aircraft was delivered for testing by the Air Force.

Production continued on F-111, A-7D/E, F-4E, and A-37 armament systems; on Vulpods, Minigun

pods, and modules for gunships; and, at the department's Springfield Operation, on M-85 and M-75 machine guns.

A major research and development effort was continued on the concept of caseless ammunition and new weapons to utilize it. Other weapon research and development activities included new rapid-fire gun concepts, improved gun barrel technology, single-barrel vehicular cannons, machine guns, antiaircraft vehicular systems, and fuzes.

Within the Avionic Controls Department at Binghamton, New York, were consolidated the division's technologies, capabilities, and facilities for the design, development, and production of commercial and military avionic control systems.

The product scope of the department included flight controls, aircraft engine controls, weapon delivery and control systems, displays and simulation, lead computing optical sight systems, control moment gyros and adaptive logic systems for spacecraft attitude control and stabilization, solid-state rate sensors, laser systems, distributed logic microelectronic digital computers, and high-temperature liquid metals research for flight control systems.

In-house production programs during the year included automatic flight control systems for the F-4 and the F-111; weapon control systems for the F-4, the F-105, and the F-111; lead computing sights for the Vulcan Air Defense System (VADS); control moment gyros for spacecraft attitude stabilization; and jet engine nozzle controls.

GE's automatic flight control system aboard the F-111 variable-wing aircraft provides triple redundancy with median selection majority logic voting. In the event of a fault, this triplex system provides a major improvement in reliability and fail-operational control after the first fault. Microelectronic integrated circuits (MIC) are used to help achieve high reliability, low cost, and ease of maintenance. The experience gained in the technology and design of the F-111 automatic flight control system was being applied to commercial supersonic aircraft.

An optical tracking system was developed to provide the gunner of the Army's Aerial Fire Support System with a dynamically stabilized line of sight to insure accurate weapons delivery. It provides the gunner with a 360-degree zone of coverage in train, enabling him to continuously engage and fire upon targets during flyby without the pilot being required to veer from course. Integrated elements of the system include a periscope sight, direct sight, laser range finder, missile guidance sensors, controls, displays, and provisions for night vision operation.

Avionic development activities of 1969 included a new long-life solid-state rate sensor, called VYRO; an electronic attitude director indicator (EADI) to replace conventional flight director instruments; advanced flight control and digital autoland work; electric propulsion and automatic throttle control systems; and control moment gyroscopes and re-

lated computers for space vehicle stabilization and attitude control.

A microelectronic digital computer for automatic flight control and autoland underwent flight test on Boeing's Dash 50 aircraft. Subsequently, a triplex flight control system was mechanized for advanced digital autoland applications. Flight testing of the VYRO solid-state rate sensor continued at Boeing on a 707 aircraft.

A major development milestone was reached with successful testing of an electronic fly-by-wire system on a VTOL aircraft. This flight control system eliminates mechanical linkages to the aircraft's control surfaces.

A multiweapon fire-control system for application to future helicopters progressed with development of microelectronic digital and analog computers. Engineering prototypes were manufactured and equipment was being evaluated and tested on the UH-1B helicopter.

Electronic Systems Division

The Electronic Systems Division, headquartered in Syracuse, New York, continued to serve as GE's competence in land- and sea-based electronic systems and equipment. ESD at year-end had a total employment in excess of 10,000 persons in 4 major organizations: Ordnance Systems in Pittsfield, Massachusetts; and Heavy Military Electronic Systems, the Electronics Laboratory, and the Advanced Systems and Requirements Operation, all in Syracuse, New York.

Under the direction of Dr. R. H. Beaton, vice president, the systems engineering capabilities were significantly strengthened. The division's competence is in radar, sonar, weapon control, and associated electronic technologies in the land- and sea-based electronic systems area.

The division continued its role as a major contributor to the Navy's Polaris and Poseidon fleet ballistic missile (FBM) program, which included the development and production of the Mark 3 guidance system; the design, development, and production of the Mark 88 fire-control system; and the development and production of associated support equipment. In addition, the division's Ordnance Systems expanded its scope of activity to encompass many areas of weapon control.

In October 1968, H. J. Kindl was appointed general manager of Weapon Control Programs at Ordnance Systems. Under Kindl's direction, Weapon Control Programs continued its excellent support of the FBM program, performed comprehensive studies for the Navy's Undersea Long-Range Missile System, and was doing research on advanced submarine and torpedo fire-control systems of the future. WCP was also participating in the division's effort to establish GE's role in the Advanced Attack Submarine Program.

Some of the high points of the FBM program at GE during 1969 included the early shipment of the first tactical Mark 88 fire-control system to the Navy and the successful firing of 5 of the first 6 Poseidon pad launches at Cape Kennedy. The Department of Defense stated in its quarterly contractor evaluation report that GE performance in support of the Poseidon fire-control and support equipment programs was "excellent" for a long-term research and development contract.

Heavy Military Electronics Systems, directed by T. I. Paganelli, general manager, was headquartered in Syracuse, New York. It is the center of General Electric's activities in the undersea electronics and surface-based electronics fields. In support of these military products, the department was organized into 3 areas for program direction and control.

During 1969, Undersea Electronics Programs, under the direction of R. T. Bruce, general manager, continued to deliver the AN/SQS-26 CX sonar, the world's largest surface-ship sonar, for installation aboard Navy destroyers and destroyer escorts. It was also planned for installation aboard future vessels of the DX and DXG class. Another product was the AN/SQQ-14 mine detecting/classifying sonar for installation on oceangoing minesweepers. General Electric's undersea research and development activities included the design and development of an advanced submarine sonar system as well as increased activity in advanced undersea surveillance systems.

The 1969 scope of activity for the second area, Major Radar Electronics Programs, under the guidance of D. S. Beilman, general manager, included continuation of the engineering design, development, and release for manufacture and testing, of the Safeguard prototype Perimeter Acquisition Radar (PAR), to be installed as the initial tactical equipment at Grand Forks, North Dakota, in the Phase I program. A second production equipment was in the planning stage for installation at Malmstrom Air Force Base. A major training equipment to support PAR operation and maintenance was in the design stage to support overall Safeguard deployment. PAR is the long-range sensor which performs the functions of surveillance, detection, and tracking for Safeguard.

A second major effort in this program area was MFAR, the proposed multifunctional array radar for the Navy's Advanced Surface Missile System (ASMS). The system, an innovative 4-faced phased-array radar for 360-degree surveillance coverage and zenith tracking, will provide instantaneous energy management for optimum utilization in a wide variety of operational modes.

The third major program effort was the development of an over-the-horizon radar technology base and capability. Specific areas of competence were system engineering, propagation, and high-frequency component development for very-long-range surveillance for future strategic defense.

In 1969, Surface-Based Electronics Programs, with P. J. Teich as general manager, produced additional quantities of the Marine Corps' AN/TPQ-10 radar course directing central and the Army's AN/MPQ-4 mortar locator for use by ground forces in Southeast Asia. New programs being pursued in this area included both the triservice lightweight 3D radar, a mechanically rotating phased-array radar for tactical air-lifted and/or ground operations, and the target acquisition system radar for the Navy's Improved Point Defense System. The operation and maintenance of existing HMES-designed systems throughout the world (in the United States, Europe, Greenland, Alaska, and Southeast Asia), as well as the installation and check-out of new and/or improved products, continued during 1969 to be a major GE business activity.

In March 1969, an operational phased-array radar system, a General Electric-owned test facility, went on the air at Antenna Park, near Syracuse, New York. The experience gained from this facility will provide design credibility of phased-array radar techniques for power generation, beam-steering control, and signal processing, as well as ECCM. Modular construction allows substitution of sections and/or components of the radar for specific experiments, or to meet the individual need of its users.

During the year, the Electronics Laboratory continued development work on the STD (Semiconductor on Thermoplastic on Dielectric) process which permits batch fabrication of circuit interconnections. Further development was continuing.

The Electronics Laboratory announced the development of a 2,048-line-per-frame, 30-frame-per-second television camera with a bandwidth of 45 megahertz. The camera employs a focus projection and scanning (FPS) vidicon tube which permits high-resolution performance in a camera tube of small size, low voltage, and low power consumption.

Engineering prototype of a high-reliability fluid-film light valve television projector was delivered to the Defense Communications Agency. Use of a 5,000-watt xenon arc lamp enables the device to project a television image on a screen in dimensions from 6 by 8 feet up to 24 by 32 feet; brightness of 3,000 lumens allows viewing of the 6- by-8-foot-size picture in a normally lighted room.

Encouraging results were achieved in the area of rapidly detecting and identifying microorganisms by analyzing gaseous by-products with gas-liquid chromatography techniques. Further experimentation was being done in this area.

Study of police management and personnel practices by E-Lab scientists led to implementation of the Crime Control Team concept experimentally in Syracuse, New York. Results were encouraging enough that Syracuse Police Chief John O'Connor added a second team to his operation, and both teams were under study as "operational research laboratories" to test new methods of reducing crime.

Re-entry and Environmental Systems Division

Re-entry and Environmental Systems Division (RESID), formed during 1969, became part of the company's Aerospace Group. The division's headquarters were at the Re-entry and Environmental Systems Center in Philadelphia.

Six organizations within RESID were developing and producing the division's hardware products and conducting its research. Strategic Systems Programs carries out research and development of reentry systems for military and scientific experimental purposes. Space Re-entry Systems Programs is responsible for research and development and production of systems which reenter the earth's atmosphere from orbit and which enter the atmospheres of other planets. Operational Systems Programs produces reentry systems for strategic missiles. Ocean Systems Programs carries out development of systems for use on or under the sea, as well as associated technologies, for research, industrial, and military use. Urban Systems Programs carries out studies and development of systems aimed toward solution of major social and urban problems. Research and Engineering performs research under contract in such areas as structural and reentry materials, electronics, aerodynamics, and the biosciences and provides research and engineering support for the other product organizations.

These efforts included work on such strategic systems as the Mark 12 reentry system for the Minuteman III intercontinental ballistic missile, on reentry research and test vehicles such as NASA's Reentry F program, on scientific recoverable satellites such as Biosatellite, on lifting entry and planetary entry system programs, and on space transportation systems.

The division continued applying basic space systems and technologies to social and economic problems. Notable among such applications was the organization's work in the field of housing research and development. The organization investigated new concepts of residential construction for the development of high-quality, lower-cost military family housing for the Department of Defense. Teamed with the architectural firm of Hugh Gibbs and Donald Gibbs, the division provided architectural and manufacturing engineering services for a 200-unit project at George Air Force Base, California. Construction will be included in a subsequent phase of the project, and it was predicted that significant cost savings would result when the mobile factory concept begins producing prefabricated building sections on the site.

In addition, many projects in the fields of health, education, and air and water pollution were being conducted.

Another major area of technology application was in the field of oceanics. Project Bottom-fix is a Re-entry Systems concept for a future manned deep

ocean station. Technology and system studies of potential military significance in high-strength materials and nuclear power were being conducted. A titanium-pyroceram model of the Bottom-fix module underwent preliminary pressure tests in 1968 and additional tests at the Navy's Research and Development Center were scheduled for 1969.

Another division oceanics program, Tektite I, was completed in 1969. In that program, sponsored jointly by the Navy, the Department of the Interior, NASA, and General Electric, 4 marine scientists lived at a water depth of 50 feet for 60 continuous days. In and around an underwater habitat designed and constructed by the division, the aquanaut-scientists conducted exhaustive and comprehensive marine geological and biological experiments. While the 4-man crew conducted its underwater research mission, it was observed continuously by Navy and NASA behavioral and biomedical teams. The objectives were to identify man's psychological and physiological reactions to a long-term mission performed in the isolated, hostile environment common to undersea and space missions.

Other ocean systems programs conducted during the year included Tektite II, expected to be submerged in the Virgin Islands area early in 1970 and used by more than 50 scientists as an experimental base for 7 months; a highly sophisticated respirator, prototypes of which were to be delivered to the Navy; and Sea Robin, a buoy system being developed as part of a buoy-satellite communication network.

Space Division

General Electric's Space Division, established in June 1969, was deeply involved with a wide variety of NASA and Air Force space programs in both the manned and unmanned spacecraft areas.

More than 11,000 persons at 10 different locations throughout the country were employed by the Space Division, headquartered at GE's Valley Forge Space Center in Pennsylvania. Approximately 3,500 of them were engineers and scientists.

The division in 1969 consisted of 4 major operating components: Apollo Systems Organization, with headquarters at Daytona Beach, Florida, and other facilities at Cape Kennedy, Huntsville, Alabama, and Houston, Texas; Management and Technical Services Department at Bay St. Louis, Mississippi; Space Systems Organization, with headquarters at the Valley Forge Space Center and other facilities at Evendale, Ohio, and Vallecitos, Sunnyvale, Vandenberg Air Force Base, and Los Angeles, California; and Space Sciences Laboratory at the Valley Forge Space Center.

Typical of the division's involvement in both manned and unmanned space programs were its major contributions to Apollo, Saturn workshop, and Saturn V test operations; the Nimbus weather satel-

lites; the SNAP-27 thermoelectric isotope power source for the lunar experiment package; the Orbiting Astronomical Observatory stabilization and control system; the Mariner 71 attitude and scan control subsystem; and the color TV transmission system used on all Apollo recovery operations at sea.

The Space Division was one of the largest and most diverse of the 20,000 separate contractors involved in the Apollo program. More than 6,000 General Electric employees in 26 locations provided support ranging from check-out of the spacecraft, booster, and launch facilities to color TV transmission of the splashdown of Apollo.

Prelaunch check-out systems, built by the division's Apollo Systems Organization in Daytona Beach, Florida, conducted thousands of tests on the Apollo spacecraft and its Saturn launch vehicle, and on the launch facilities themselves.

Fourteen Apollo Systems ACE (Acceptance Check-out Equipment) stations tested the Apollo 11 spacecraft from factory to launch. Each 3-room ACE station comprises racks of equipment which conduct critical tests, acquire data, analyze findings, and report on those findings. They are capable of checking all of the spacecraft's more than 3,000 test points automatically, receiving data at the rate of 200,000 bits per second.

Similar GE Apollo Systems equipment inspects all of the thousands of checkpoints on Saturn V's 3 stages; conducts all switching operations in the final 3 minutes of countdown; checks fueling of the Saturn stages; and controls communications, telemetry, water control, and launch complex operations.

Another division component, the Management and Technical Services Department, operated and maintained NASA's 25-square-mile Mississippi Test Facility (MTF) near Bay St. Louis. Services provided NASA at MTF, proving ground for the first and second stages of the Apollo/Saturn V space vehicles, included range maintenance, systems modifications, central control, and the transport, storage, and transfer of cryogenic propellants and high-pressure gases.

The department also operated high-pressure water systems on the test stands, performed test and range data acquisition and processing, and operated the laboratories which provide electronics, instrumentation, materials, calibration, photographic, acoustic, and video services.

The division's Space Systems Organization made 2 principal contributions to the Apollo program. A color TV transmission system, built and operated by GE for Western Union International, Inc., provided live color television coverage of all Apollo recoveries via satellite from the recovery carrier. A radioisotope thermoelectric power system, called SNAP-27, was providing electricity to power lunar surface experiments left on the moon by Apollo 12 astronauts.

Simultaneous transmission via satellite of color television, newspaper copy, and radio commentary

was accomplished for the first time from a ship at sea during the Apollo 11 recovery mission on the USS *Hornet* in July 1969. In less than half a second, these 3 news media reached the United States from the *Hornet*, a distance of some 4,500 miles, via the Intelsat 3 satellite hovering 22,500 miles above the Pacific Ocean. From the time the *Hornet* left Pearl Harbor on July 12, all newspaper stories were transmitted by the system via satellite back to the United States. During the Apollo 11 recovery operations, the system was also utilized for color TV transmission and simultaneous transmission of radio commentary for Mutual Broadcasting System and the Voice of America.

Since the system is portable, it makes possible the transmission to the United States via satellite of a wide range of media coverage of events taking place in the remotest areas of the world. A key element of the system is a unique 15-foot-diameter paraboloid antenna which folds like an umbrella for air shipment.



A key element in the transmission of Apollo recovery TV coverage was this paraboloid antenna, built by General Electric's Space Division, which folds like an umbrella for shipment.

SNAP-27, the division's radioisotope thermoelectric generator (RTG), provides a minimum of 63.5 watts of electrical power for over a year, operating continuously throughout the lunar day and night. It contains no moving parts and weighs 43 pounds, or just slightly over 7 pounds under the moon's $\frac{1}{6}$ gravity conditions. The ability of the RTG to operate continuously during the temperature extremes (minus 280 degrees to plus 170 degrees Fahrenheit)

of the lunar day-night cycle was a prime consideration in choosing this type of power supply.

Electric power is produced by applying a heat source utilizing plutonium-238 to a thermopile composed of lead telluride thermocouples. The thermocouples produce electricity when a temperature difference is maintained across their length. Because of its high strength and light weight, beryllium is the main structural material.

The Space Division was also working on advanced generations of RTGs capable of producing 100 to 1,000 watts of electrical power for extended periods. These generators can be used to provide power and heat for long-duration earth-orbital missions, for lunar shelters and bases, and for interplanetary exploration where there is little or no sunlight for solar cell power. Nuclear power devices for manned and unmanned explorations of Mars were also being studied.

The Space Division, teamed with North American Rockwell, was selected to perform 11-month design and planning studies of a NASA manned space station that could reach flight status by the mid-1970s. The 12-man earth-orbital space station will be designed to have an operational life of 10 years with resupply of equipment and supplies and rotation of crew. This was not the Space Division's first entry into NASA's space station program. At Apollo Systems, G. T. Smiley, general manager, announced a new \$10,750,000 study contract for supplying electrical equipment for the Apollo Telescope Mount and launch check-out for the Saturn workshop and Multiple Docking Adapter.

The NR/GE study work will also include the conceptual design of a 50-man space base made up of specialized modules assembled in low-earth orbit in the late 1970s and the 1980s. The space base was envisioned as a centralized facility in orbit, comparable to an earthborne scientific and technical research, development, and operations center.

In April 1969, NASA successfully launched Nimbus 3, which was assembled and tested by the Space Division in only 9 months. The results of this new meteorological satellite were outstanding. Beginning about 6 weeks after the Nimbus 3 launch, the U.S. Weather Bureau began using the data collected from SIRS in a daily hemispheric weather analysis. The success of this venture led to the installation of a computer link between NASA's Goddard Space Flight Center in Greenbelt, Maryland, and the National Meteorological Center. This link provides regular use of data in analyses of weather conditions over the eastern Atlantic and most of the Pacific Ocean from the surface to an altitude of 53,000 feet.

The SIRS soundings were part of the 3 major analyses of Northern Hemisphere weather being prepared on a daily basis by the computers at the ESSA-Weather Bureau's National Meteorological Center in Suitland, Maryland.

AIRCRAFT ENGINE GROUP

The Orbiting Astronomical Observatory was another success story for the division, which developed the spacecraft's ultraprecise stabilization and control system for NASA. Launched in December 1968, the spacecraft operated successfully throughout 1969, sending back ultraviolet data about the stars. Scientists collected twice as many data in one day as they received in 15 years using sounding rockets. They studied more than 50,000 stars during 1969.

The stabilization and control subsystem provides a stable telescope platform that can be pointed accurately to any celestial target during sky mapping and related work. In providing this stability and high degree of pointing accuracy (1 minute of arc), the subsystem stops the Orbiting Astronomical Observatory's initial tumbling rate (a maximum $1\frac{1}{2}$ degrees per second) and locks the spacecraft's sensing devices on preselected stars and star patterns. The course pointing potential for this mission is equivalent to selecting an eye of a person 500 feet away, then holding steady for up to an hour for a detailed study of its color and brightness.

In 1969, GE was awarded one of 2 competitive contracts to study spacecraft systems design and ground data processing on the Earth Resources Technology Satellite (ERTS) program. The contract called for studies to show how the design of existing spacecraft can be adapted with minimum modification to meet the ERTS requirements and to evaluate orbital and ground-based data processing requirements for the ERTS.

Specific tasks in the study of ground systems included identification of the interrelationship between the spacecraft, the sensors, and the processing of sensor outputs; approaches to the system; arrangements for processing earth resources data; and evaluation of proposed new data processing systems which could be ready in time for the first launch.

In planetary missions, the division was working with Jet Propulsion Laboratory on a scan and control system for Mariner '71. Other technology programs included thermoelectric outer planets spacecraft power conditioning equipment, roll-up solar arrays, thermionic reactor spacecraft study, and MHD spacecraft studies.

The division's Space Sciences Laboratory was developing a lightweight optical system, SISYPHUS, for the Pioneer F/G spacecraft and potentially for use on the lunar surface. The device will be used to determine location and velocity of meteoroids and asteroids in the planning of interplanetary missions.

The division was also applying its space-gained technology to such projects as the management of the renovation of a jet engine test facility at Wright-Patterson Air Force Center; VISTA programs; management support to Hancock County, Mississippi; consulting services to Iowa Power and Light; atomic reactor power plant simulators; and air pollution sensing equipment.

The dramatic growth pattern of General Electric's Aircraft Engine Group continued through 1969, particularly in its commercial aircraft engine market. The Aircraft Engine Group in 1969 was one of the company's 11 major operating organizations. Within the group were 5 divisions with clear separation between military and commercial business. AEG was one of the company's largest groups, with 29,000 employees at 2 major plant locations, Evendale, Ohio, and Lynn, Massachusetts, and satellite facilities at Hooksett, New Hampshire; Rutland and Ludlow, Vermont; Albuquerque, New Mexico; and Everett, Massachusetts. The group also had 4 service shops, located in Ontario, California; Seattle, Washington; Arkansas City, Kansas; and Cincinnati, Ohio—plus a flight test center at Edwards Air Force Base, California, and outdoor engine testing facilities at Peebles, Ohio.

The year 1969 marked the continued success of the commercial CF6 turbofan engine in the marketplace as well as in its testing program. Seven additional airlines selected GE-powered DC-10 trijets. In addition to American Airlines' and United Air Lines' decisions in 1968 to purchase DC-10 Series 10 aircraft was National Airlines' selection in 1969 of the Series 10, which uses CF6-6 turbofans producing 40,000 pounds of thrust. KLM, Swissair, SAS, and UTA of France chose the intercontinental range DC-10 Series 30 trijets with CF6-50A engines that produce 49,000 pounds of thrust. In the United States, Trans International Airlines and Overseas National Airways also picked the DC-10 Series 30.

The CF6 testing program continued in high gear. Early in the year, the engine was released for production, and flight-test engines were being shipped by the end of the year. The CF6 will enter airline service in late 1971.

In another commercial area, development testing of the GE4 supersonic transport engine continued on schedule with a total of over 1,000 hours accumulated. Eight engines in 3 configurations were built and tested. GE's new Altitude Test Facility, which simulates speeds up to Mach 3 and altitudes over 80,000 feet, was utilized extensively in the GE4 test program.

Well over 1,000,000 hours of flight time had been accumulated by GE's business jet engines, which power approximately 600 business jets in operation, including the Learjet, the Commodore Jet, the Fan Jet Falcon, and the Hansa 320.

The Aircraft Engine Group's military activities were highlighted by the continued high production rate of the J79 turbojet for the McDonnell Douglas F-4 Phantom and the North American Rockwell RA-5 Vigilante, and by the start of high-volume production of the TF39 high bypass turbofan engine for the world's largest aircraft, the C-5 Galaxy logistics transport. More than 170 production TF39 en-

gines were shipped in 1969; by the end of October 1969, TF39 engines had accumulated well over 4,000 hours of flight time in the C-5. The first C-5 was scheduled to be accepted by the Military Airlift Command in December 1969.

GE's TF34 high bypass turbofan for the Navy S-3A antisubmarine warfare aircraft began its testing program in April 1969 after winning the engine competition in 1968.

During 1969, both the Navy's and the Air Force's precision flight demonstration teams began flying J79-powered McDonnell Douglas F-4 Phantoms.

GE continued to mass-produce J85 turbojets for the Northrop T-38 and F-5 aircraft, for the Cessna A-37 attack aircraft, and for research vehicles. T58 and T64 turboshaft engines also continued in high production for a number of military and commercial helicopters for use throughout the free world.

In research and development areas, the Aircraft Engine Group continued to test a number of new power plants. The GE1/10 demonstrator augmented turbofan was tested both at the Evendale Plant and at NASA's Lewis Lab in Cleveland. This engine testing is part of GE's F100/F400 engine development program in the competition for the Navy's F-14B and the Air Force's F-15 fighters. Over 370 hours were accumulated on the GE1/10 demonstrator.

Also continuing in test was the GE9 engine, proposed as the power plant for the B-1A bomber, the advanced manned strategic aircraft (AMSA). This engine is also an advanced augmented turbofan engine.

An Army contract with GE to demonstrate a 1,500-shaft-horsepower turboshaft engine continued in 1969; in October, GE showed the GE12 engine publicly for the first time. Development testing continued on this advanced-technology engine at the Lynn, Massachusetts, plant.

GE was also developing an advanced version of the J85, designated the -21. It produces 5,000 pounds of thrust, well above the 4,300 pounds of thrust of the J85-15 turbojet. The J85-21 was flying in a modified Northrop F-5 at Edwards Air Force Base, California.

GE marine and industrial gas turbines included the LM100, the LM350, the LM1500, and the LM2500. These engines ranged in power from 1,000 to 25,000 horsepower. They were being used as power plants for hydrofoils, air-cushion vehicles, displacement marine vessels, electrical power generation, pipeline pumping, and locomotive boost propulsion.

The newest entry in the Marine and Industrial Department product line was the LM2500 gas turbine. Derived from the TF39 aircraft engine, it was unveiled in 1968 at the 13th Annual ASME Gas Turbine Show in Washington, D.C. The LM2500, an advanced-technology marine gas turbine in the 25,000-horsepower class, boasts the lowest fuel rate

and best marinization materials of all production marine gas turbines in its power class. The engine was being offered as main propulsion for the Navy's new DD-963 destroyer project.

Other GE gas turbines in marine service included the LM1500 in the Navy's new aluminum-hulled PG patrol gunboats for high-speed operation, and the LM100 for emergency power generation and take-home power aboard commercial cargo carriers and Coast Guard *Hamilton*-class cutters. LM100 gas turbines were also powering air-cushion vehicles for both the Army and the Navy.

LM1500 industrial gas generators were in widespread use for liquid and gas pipeline pumping. One such unit went over 20,000 hours before overhaul.

B. F. GOODRICH AEROSPACE AND DEFENSE PRODUCTS

Clinton B. McKeown, formerly general manager of B. F. Goodrich Aerospace and Defense Products, a division of The B. F. Goodrich Company, was named president of the division in 1969. McKeown joined the company in 1937 and held various technical and managerial positions before transferring to BFG Aerospace and Defense Products in 1952.

In 1969, B. F. Goodrich increased its volume of commercial aircraft tire sales over the previous year by an estimated 10 percent. The company maintained its industry-leading position in military aircraft tire sales.

Three aircraft tire service centers, located near major airports in New York City, Kansas City, and Los Angeles, came fully on-stream in 1969. Each center contains the latest in retreading equipment and maintains substantial inventories of new and retreaded aircraft tires. B. F. Goodrich is the only producer of aircraft tires that owns and operates its own coast-to-coast retreading facilities, enabling it to provide fast, efficient service from initial production and delivery through multiple retreading.

Late in 1969, B. F. Goodrich made first deliveries of main landing gear wheels, brakes, and tires and nose landing gear wheels and tires for the Lockheed L-1011 TriStar passenger airliner. Working under a \$5,750,000 contract, BFG was to supply 350 ship-sets. These are the first high-efficiency graphite heat sink brakes for a commercial application.

Main landing gear tires are 30-ply and measure 50 inches in diameter and 30 inches wide. Nose landing gear tires are 20-ply and measure 36 inches in diameter and 11 inches wide. Tires were to be manufactured in Akron and the wheels in Troy, Ohio. The TriStar, which will carry from 250 to 345 passengers, was scheduled to be placed in use by major airlines by late 1971.

Production of beryllium brakes for the Air Force C-5 Galaxy, the first such brakes used on any pro-

duction aircraft, was proceeding on schedule at the Troy plant. Officials of Lockheed-Georgia Company, builder of the C-5, reported that BFG-designed and -manufactured beryllium brakes are an important factor in the aircraft's short landing roll—little more than 6 times its own length.

On an Air Force resupply mission, the Galaxy, weighing 532,114 pounds, can come to a dead stop on a paved runway in just 1,700 feet, as compared with the 8,000 to 9,000 feet required by jetliners only half as large, according to Lockheed-Georgia.

Beryllium disk brakes for the 24 main wheels of the C-5 weigh much less than comparable steel disk brakes, thus shaving approximately 1,500 pounds off the gross weight of the aircraft. B. F. Goodrich was also supplying the aircraft builder with tires, load rated at 40,000 pounds each.

For the world's largest commercial airliner, the Boeing 747, BFG was producing tires and a system of lightweight fabric escape slides capable of evacuating the plane's load of passengers in less than 90 seconds.

The company qualified tires for use on the first supersonic transport, designed for flight approaching 3 times the speed of sound (Mach 2.7). Tires for the SST will withstand heat-soak temperatures of 200 degrees Fahrenheit.

Other important products made by BFG Aerospace and Defense Products during 1969 included electrical and pneumatic de-icing systems, inflatable seals, erosion shoes, reinforced plastic structures, pressure sealing zippers, flotation bags, and a rigid structural foam material, called Rigidcell, for structural use in aircraft.

GOODYEAR AEROSPACE CORPORATION

An integrated systems approach in tactical warfare to cope with current and projected limited-war harassment was developed by Goodyear Aerospace Corporation (GAC) in 1969. Combined with an emerging concept of global mobility, it offered an order-of-magnitude improvement for U.S. military forces around the world.

The tactical warfare concept is Tactical Search and Strike Supersystem (TSASS). It would combine existing and projected tactical warfare systems capabilities so that enemy threats could be detected early and quickly, and then efficiently countered within current state-of-the-art tactical warfare systems.

TSASS ingredients include coherent side-looking radar systems to allow all-weather, day/night aerial surveillance of tactical targets; air-mobile modular processing and support systems to provide on-site processing and interpretation of aerial reconnaissance imagery; automatic-correlation guidance systems to provide highly accurate terminal guidance

for missiles, as well as precision aircraft navigation and bombing; trainers and simulators to reproduce complex tactical warfare equipment and operations; and modular ground-support systems to provide instant forward area housing and work areas for military personnel.

By combining these and several other of GAC's existing capabilities, the TSASS concept synergizes the benefits of each contributing system. TSASS shows promise of enabling tactical forces to operate more effectively in the "now" environment of modern warfare.

Coherent, side-looking, high-resolution radar built by Goodyear Aerospace has been operational for years with the U.S. Air Force. In 1969, the German Ministry of Defense took its third step with a major contract for radar units for the McDonnell Douglas RF-4E.

Goodyear Aerospace also is responsible for furnishing the Ground Environment System (GES) for the German Air Force RF-4E program. The GES consists of 2 subsystems: a modified photographic processing and interpretation facility, and a data link ground station.

Photographic processing systems for aerial reconnaissance photography and radar imagery were also being provided to the Air Force by Goodyear Aerospace. A \$30,000,000, 4-year program covering 41 systems for both black-and-white and color processing was replaced in 1969 with a new program to process film from strike cameras of tactical aircraft.

An ultrafast computer developed by GAC was adapted to the TSASS concept to speed real-time decision making in electronic warfare and data base management. The computer, an associative processor, makes possible the execution of thousands of computing operations, both "search" and "arithmetic," simultaneously. A conventional computer can perform only one operation at a time. The associative processor can be installed in both airborne and ground-based systems and used to avert data jams and to make quick reaction possible.

The associative processor was proposed for a number of projects requiring real-time service. One proposal involved commercial air traffic control, and the Federal Aviation Administration entered into a contract with GAC to study its potential in breaking air traffic jams around the nation's jetports.

The first of 8 sophisticated trainers, to be used to teach Navy pilots to handle the TA-4J jet, was delivered to the Kingsville, Texas, Naval Air Station in 1969. Four units were to be provided to Kingsville and 4 to Chase Naval Air Station in Texas under a contract with the Naval Training Device Center, Orlando, Florida.

The Air Force took a giant leap toward global mobility in 1969, with Goodyear Aerospace providing the "bare base" shelters for personnel sent to advance areas. GAC built 300 shelter units that can be air transported in units 8 feet high, 13 feet long,

and 3 feet thick. On the ground, they unfold like an accordion to provide instant housing 39 feet long, 13 feet wide, and 8 feet high. Tested at Operation Coronet Bare at North Field, South Carolina, in October, the units were expected to become standard Air Force hardware.

The lightweight airborne shelters were an outgrowth of GAC bonded structures capabilities, which included producing more than 15,000 standard 463L cargo pallets for the Air Force in 1969. GAC also entered the commercial cargo pallet business with an initial order from Pan American World Airways.

Baggage/cargo containers for the big new jets continued as a major product. After gaining the industry's initial order from Pan American in October 1968, GAC went on to win contracts for cargo/baggage units from United, BOAC, National, Northwest Orient, Aer Lingus, and Continental airlines.

Major production of Boeing 747 airframe components continued at GAC's Arizona Division at Phoenix. Through 1969, the division supplied 57 center wing sections, 51 sets of landing wheel doors, and 62 shipsets of passenger windows consisting of 182 double pane windows per shipset.

In Akron, Goodyear Aerospace's Wheel & Brake Division was building the wheels, brakes, and antiskid system for the McDonnell Douglas DC-10 and the antiskid device for the Lockheed L-1011.

Development work continued on advanced composites materials. GAC was named to build the graphite/epoxy speed brake for the F-5 jet as one of 5 subcontractors to Northrop. It also built a large boron/epoxy gear housing for use on the engine of a Navy helicopter. Under contract to General Electric and Lockheed, it built 3 plastics components for the C-5 aircraft: an oil/air seal and fanjet outlet guide vanes for the TF39 engines and a metal/grid honeycomb antenna for VHF and FM communications.

A Phase II contract was received from the Air Force to continue development of the Pilot Airborne Recovery Device (PARD). The system uses a hot-air balloon, fueled with a propane burner, to keep pilots who are shot down over enemy territory from drifting downward into the small-arms range. The PARD system is capable of lifting the pilot to higher altitudes and keeping him aloft for up to 30 minutes, giving friendly planes time to rescue him through the air-snatch technique.

Work on the Subroc antisubmarine missile, under way since 1958, continued, along with work on other advanced undersea warfare systems. In addition, drawing on a heritage dating to 1918, Goodyear Aerospace finished construction of 3 lighter-than-air craft and associated advanced electronic "skyacular" signs, for use by Goodyear in its nationwide promotion programs utilizing the Goodyear blimp.

GRUMMAN AEROSPACE CORPORATION

In 1969, Grumman entered its 40th year with continued growth, an increase in sales and earnings, and significant modernization of its facilities in preparation for new aircraft programs. Research and development continued to play an important part in the corporation's growth, and Grumman continued work on several new aircraft.

At year-end, Grumman employed 32,000 people in more than 30 plants. Production of the Gulfstream II corporate jet transport had been completely transferred to the Savannah, Georgia, facility. Grumman's machine shop facilities at Glenarm, Maryland, and Sterling, Virginia, were in full operation. The test facility at West Palm Beach, Florida, became the home base of the hydrofoil gunboat *Flagstaff* and of the submersible *Ben Franklin*; the facility is Grumman's center for oceanographic activities.

The corporation produced a variety of military and commercial aircraft, the Apollo Lunar Module flight and test spacecraft, and the second of the series of Orbiting Astronomical Observatories, and it remained extremely active in ocean technology. Ten model types of aircraft were in production and in service in Southeast Asia.

One of the most important developments in 1969 was the contract award for the F-14A air superiority fighter. The award was for 6 prototypes, with first flight of the F-14A scheduled for early 1971. Follow-on versions of the new variable-geometry aircraft were already under study.

The A-6A Intruder, built for the Navy and the Marine Corps, remained the mainstay of the all-weather attack effort in Vietnam. With a load capacity of almost 18,000 pounds, the A-6A operates from either advanced forward air bases or off the attack aircraft carriers on station in the South China Sea. Advanced versions of the A-6A—the A-6C and the A-6E—were also undergoing development.

The EA-6A tactical countermeasures aircraft, in service with the Marine Corps, continued in production. A 4-place version of this aircraft, the EA-6B, was undergoing extensive flight and avionics tests, paving the way for the Navy to expand its electronic warfare capability.

The TC-4C, an A-6A bombardier/navigator trainer based on the Gulfstream I, was in service with the Navy and the Marine Corps. A contract for 9 of these highly specialized aircraft was completed and all aircraft were delivered on schedule. A follow-on version, a navigation and radar intercept officer trainer based on the Gulfstream II, was being studied.

While the E-2A Hawkeye continued in active service with Navy fleet units, Naval Air Systems Command awarded Grumman a contract to initiate development of a successor. Known as the E-2C, this new version of the E-2A early-warning aircraft

will feature greatly improved and more reliable avionic systems. The aircraft, like the E-2A, will carry its detection antenna in a large-diameter rotodome atop its fuselage. The interim E-2B, outfitted with a new microminiaturized general-purpose computer, was undergoing flight test.

The Army's OV-1 Mohawk battlefield surveillance aircraft continued in production and a continuous modification program paralleled the effort. Work continued on the OV-1D. All 3 versions of the OV-1 were in service in Vietnam, Korea, and West Germany as the "eyes in the sky" of the Army.

With deliveries of 14 S-2 Tracker antisubmarine aircraft to Australia, production of the S-2, which had been continuous since 1952, came to an end. More than 1,500 of the aircraft had been delivered. Proposals for a modification program were prepared.

The C-2A Greyhound carrier on-board delivery aircraft supported the ships of the Seventh Fleet with deliveries of vital supplies ranging from typewriter ribbons to jet engines. Several of these aircraft were also assigned to units of the Sixth Fleet in Europe.

With 6 model types no longer in production (E-2A Hawkeye, C-2A Greyhound, C-1A Trader, E-1B Tracer, S-2 Tracker, HU-16 Albatross), the company nevertheless had 10 different types of aircraft operating in 1969 in Southeast Asia.

Production of aft fuselage sections for the Air Force F-111 aircraft series continued at the company's Garden City factory. More than 300 had been delivered by year-end.

With delivery of the 200th Gulfstream I aircraft, the production line of this model was closed.

More than 60 turboprop-powered Gulfstream II aircraft were delivered to customers. The aircraft was being flown regularly on nonstop transoceanic and transcontinental flights—the only jet-powered corporate aircraft in its class to do so. Delivery rate of the Gulfstream II was 3 aircraft per month.

The newly certificated Super Ag-Cat continued to be a top seller in the agricultural crop-dusting market. More than 650 had been produced since 1958.

The Apollo Lunar Module program was crowned by success in 1969 when 4 American astronauts landed on the moon.

The second Orbiting Astronomical Observatory, OAO-2, completed a year in orbit; by year-end, its life expectancy had exceeded the planned 30 days by nearly one year.

In the Ocean Systems Department, the mesoscale *Ben Franklin*, built in cooperation with Dr. Jacques Piccard, successfully completed its assigned Gulfstream drift mission from Florida to Nova Scotia. The Navy hydrofoil PGH-1 *Flagstaff* was also launched and christened. After undergoing preliminary tests, the hydrofoil gunboat was evaluated by the Navy off the coast of California before being shipped to Vietnam for combat evaluation.

Grumman continued to work in the area of advanced materials, with emphasis on improved titanium manufacture and further development of techniques involving the use of boron and graphite filaments.

GYRODYNE COMPANY OF AMERICA, INC.

During 1969, Gyrodyne continued to produce QH-50D pilotless helicopters and supporting DASH equipment for the U.S. Navy and for the Japanese Maritime Self-Defense Force. In addition, a limited number of QH-50s, modified to perform surveillance, reconnaissance, and other tactical missions, were produced for the Advanced Research Projects Agency of the Department of Defense.

Multimission flight-test programs were conducted to determine the drones' capabilities to perform high-risk missions. Armed with a variety of weapons such as miniguns, rockets, grenade launchers, and multibomb racks, successful "attack" flight tests were performed. The installation of sonobuoy racks and other sensing devices was utilized to prove out the drones' detection capabilities. Day and night television cameras, laser range finders, and covert illuminators were used to ascertain the feasibility of utilizing the remotely controlled vehicle for target detection, gunlaying, and enemy troop movements.

Further advances were made in utilizing sea-ground-air control stations to vector the drone in its flight regimes and provide "hand-off" control from one command station to another. The utilization of auxiliary fuel tanks provided the capability to extend the QH-50's flight endurance from 1.5 to 6 hours, depending upon the payload trade-off between weapons and fuel supply.

The company continued to forge ahead in other important areas. Gyrodyne Petroleum, Inc., a wholly owned subsidiary, reported that at year-end it held interests in more than 380 producing gas and oil wells. The subsidiary's most interesting program was the Rulison Field Project whereby the Atomic Energy Commission and private enterprises, on September 10, 1969, by means of an underground nuclear explosion, created a deep chimney to economically release the vast reserves of natural gas known to exist in this field. The explosion site was to remain sealed until March 1970 to allow the heat from the explosion to cool and much of the radioactivity to die, after which time various tests of the gas as to quantity and radioactivity were to commence. Gyrodyne will realize 16 percent of the gas production sales that result from the program.

Flowerfield Properties Inc., another wholly owned subsidiary, had a participating interest in the development of a large citrus grove in Florida. Started in 1966, there were more than 400,000 trees planted by year-end 1969 and expansion was continuing.

HARVEY ALUMINUM, INC.

In September 1969, J. Donald Rauth succeeded Lawrence A. Harvey as president and chief executive officer of Harvey Aluminum. A graduate of Drexel Institute of Technology, Philadelphia, Pennsylvania, Rauth was president for many years of the 25,000-man Martin Marietta Aerospace Group.

Harvey Aluminum, a fully integrated aluminum producer, is headquartered at Torrance, California. Other company operations are an aluminum reduction plant at The Dalles, Oregon; extrusion facilities at Adrian, Michigan; a sheet and plate rolling mill at Lewisport, Kentucky; an alumina plant at St. Croix, Virgin Islands; and A/S Alnor Aluminum, Norway, owned by Harvey Aluminum in partnership with Norsk Hydro-Elektrisk Kvaestofaktieselskab.

Company plans for a new reduction facility proceeded with the purchase of several thousand acres of land near the John Day Dam, 25 miles southwest of Goldendale, Washington. Financing for this new facility was arranged. When the new smelter is finished in 1971, the company will have added 2 pot lines with a rated annual capacity of 100,000 short tons. The new addition will bring the company's production of primary metal to 190,000 short tons annually.

Harvey was supplying aluminum components for the Boeing 707, 720, 727, 737, and 747; the McDonnell Douglas DC-8, DC-9, and DC-10; and the Lockheed C-5, C-130, C-141, and L-1011. The components included window frame forgings, heat-treated sheet, wing spars, and a multitude of extrusions and forgings. Working closely with jet aircraft designers, Harvey metallurgists developed a new temper for alloy 7075, designated 7075-T736, which minimizes stress corrosion cracking problems without depreciating the metal's mechanical properties. This represented a breakthrough for users of aluminum in the aerospace industry as it will allow designers to use high strength levels while decreasing stress corrosion considerably. The immediate commercial result was high-volume production of components made of 7075-T736 from the Forging Division.

A related application of this research was made in the Extrusion Division, where the alloy developed was designated 7075-T76. Early in the year, the Extrusion Division started a production program using the alloy in extrusions for the L-1011. Materials from this undertaking are superior in resistance to stress and exfoliation corrosion.

HARVEY ENGINEERING LABORATORIES

The Harvey Engineering Laboratories for Research and Development continued its excellent performance in special research and in the development of metal matrix composites. The division re-

ceived national recognition and was awarded honors by the Industrial Research Editorial Advisory Board for its pioneering work in the field of composites, considered by leading scientists and engineers to be one of the 100 most useful and important industrial developments of the year.

Since 1962, Harvey Aluminum has been developing fine wire and filament reinforced metal matrix composites under company and government agency sponsorship. The company pioneered pressure-diffusion bonding processes for producing these composites in the form of sheet, plate, and clad wire. The sheet and plate are produced by hot pressing, and the wire is produced by co-extrusion.



Harvey Aluminum, producer of aluminum-steel and aluminum-boron composites, was expanding for development of additional composite systems, particularly those containing beryllium wire, silicon carbide, and carbon filaments.

Harvey Aluminum, one of the few American producers of aluminum-steel composites, has been successful in producing higher-strength aluminum-boron composites than those produced by other researchers. Scale-up of filamentary metal matrix composites from laboratory specimen sizes to sizes suitable for structural use is another first for the company. As far back as 1964, the Engineering Laboratories produced aluminum-steel composites in thicknesses up to .75 inch and in sizes up to 12 inches in width and 8 feet in length. With new tooling, the size can be increased to 4 feet in width and 10 feet in length.

The company was furnishing aluminum-steel and aluminum-boron composites to a number of government, industrial, and education organizations, and it was expected that this interest would increase as the full potentials are assessed. Harvey's activities were being expanded for development of additional composite systems, particularly those containing beryllium wire, silicon carbide, and carbon filaments.

Harvey Research continued its efforts in advancing the art of extruding. Developments in advanced

techniques and methods attained unprecedented accuracies, finishes, and physical properties. The mutual support extended between the company's production and research impacting departments made many innovations possible. Particular advantages of impact extrusion introduced into production-engineered items are improved metallurgical properties, versatility of form, excellent finish, dimensional accuracy, integral component construction, helium leak-proof structure, reduced cost, and reduced material supply.

TITANIUM DIVISION

During 1969, Harvey maintained its position as a leading supplier of titanium and titanium-base alloys and other materials for the aerospace industry.

Aerospace production programs such as the 747, the L-1011, the C-5, and the DC-10 continued to be substantial consumers of products from the Titanium Division. However, titanium and its various alloys were finding their way into many other industrial applications because of their unique combination of light weight, corrosion resistance, and strength. Automobile racing dramatizes the values of titanium to a wide variety of potential users. Dan Gurney uses a Harvey titanium exhaust system in his Can-Am racer for greater strength and reliability. Titanium has also been featured in Formula I and Indianapolis type cars with great success.

The Titanium Division installed equipment to handle increasing forge and extrusion billet requirements as well as a modern, efficient bar turner to materially increase the capacity for rolled bar. A new stocking warehouse program for titanium products was introduced in 1969 to service independent distributors.

Harvey's close-tolerance titanium hex bar, introduced in 1968, was well received throughout the aircraft industry and continued growth of this production was anticipated.

HERCULES INCORPORATED

An interesting aspect of the aerospace year for Hercules Incorporated was the company's rapid growth in the field of advanced composite materials. Boron fibers and graphite fibers in resin matrices, which offer tremendous stiffness-per-pound advantages over metallic structures, continued to win acceptance in advanced engineering applications. Three major development contracts for aircraft engine and aircraft structures were undertaken with prime contractors in support of Air Force requirements. In addition, the company continued to manufacture broad goods utilizing graphite and boron with a variety of resin systems to supply the highest-quality materials in the marketplace. At year-end,

Hercules was firming plans to construct a facility for manufacture of graphite fiber and to utilize this fiber and others in the manufacture of broad goods, tape, and preforms of all kinds.

Solid propulsion activities continued as the mainstay of the company's aerospace effort. Poseidon propulsion advanced through the development phase with a series of highly successful flights. Hercules is propulsion system manager for this 30-ton, MIRV-capable, 2-stage missile. First- and second-stage propulsion for the Sprint program continued through qualification, also with a series of highly successful flight evaluations. The Upstage program was initiated, with Hercules to qualify and deliver a high-acceleration booster which will provide the velocity increment necessary for performing experiments with the unpropelled second stage of this advanced interceptor. The Sparrow dual-propellant motor for the AIM-7F missile system moved into the first stages of production at the recently erected Hercopel composite propellant facility.

In 1969, Hercules worked closely with arms manufacturers in the development of guns capable of firing caseless ammunition. Of particular interest were the impressive strides made in the development, for an automatic aircraft weapon, of ammunition which weighs approximately 30 percent less than conventional ammunition. To support the development of caseless, consumable case, and other types of ammunition, a ballistic test facility was erected at the company's Bacchus Works near Salt Lake City. This facility will permit study, in a carefully controlled environment, of the ignition, internal ballistics, flight ballistics, and terminal characteristics of a growing family of ordnance items.

Application of aerospace technology to water purification and sewage treatment continued, with marked attention to reclaiming natural resources with new techniques for processing solid wastes.

HONEYWELL INC.

Apollo was the story of 1969 for Honeywell—as well as for the United States and for the world. The Command Module stabilization and control system, built by Honeywell as a major subcontractor to North American Rockwell, performed flawlessly in 4 Apollo flights, 2 of which put men on the moon and brought them back safely.

Honeywell hand controls, panel displays, and flag indicators on the Grumman-built Lunar Module also worked perfectly. The precision performance of the hand controls landed astronauts Neil Armstrong and Buzz Aldrin safely away from a rock-strewn surface. The firm also provided fuel probes for the Saturn S-IVB booster.

The reliability engineered into Apollo controls was duplicated in the other major space success of

the year, Mariners 6 and 7. Honeywell made sensors and pointing instruments which aimed the platforms of scientific instruments and equipment at Mars in the closest flyby yet.

The 3 Honeywell divisions in the Aerospace and Defense Group with primary involvement in aerospace were Aerospace Division-Minneapolis, Aerospace Division-Florida (St. Petersburg), and Systems and Research Division. While each shared in the Apollo successes, significant developments were recorded by them individually in aerospace and avionics programs as the company moved toward new frontiers of the 1970s.

AEROSPACE DIVISION-MINNEAPOLIS

Latest concepts for space exploration of the 1970s were expected to result in programs rivaling the multibillion-dollar Apollo program.

Honeywell teamed with North American Rockwell on the space shuttle program with responsibility for stabilization/control and guidance/navigation systems. In addition, Honeywell teamed with McDonnell Douglas on the space station program with responsibility for the attitude reference and control system. Both the space shuttle and the space station were to be operational by the end of the decade.

Major contract developments in space for 1969 included building a prototype for a new attitude reference system, the Space Precision Attitude Reference System (SPARS). The division said the system would serve as a technological basis for many of the nation's future space projects.

Definition and design of an active control system for Advanced Technology Satellites F and G were completed under a contract from Fairchild Hiller Corporation, which contemplated the extension of this effort early in 1970. The ATS will be used in a direct-broadcast educational television experiment in 1972 in which TV signals will be beamed directly to 5,000 public television sets provided by the Indian government.

Nippon Electric Company of Japan and Honeywell Space Systems organization were under contract to supply space equipment and software to the Japanese government. Japan had plans to launch communications satellites beginning in 1971.

International orders increased sharply, with new business awards in each of the divisional product lines. Many of the new orders were obtained as a direct result of expanding license activities with key avionic companies in Europe and in Japan.

In commercial aircraft, the division won important contracts with McDonnell Douglas for equipment on the DC-10 performance and failure assessment monitor (PAFAM) for assessing overall performance of the automatic landing system, including a multicolor CRT display and the digital air data computer (DADC) to provide vital sensor data to 13

avionic systems aboard the aircraft. The DADC was the first digital unit of its kind to be selected for a commercial transport aircraft.

Eastern Airlines meanwhile ordered retrofitting of its fleet of 727s, one of the largest, with HG 180 air data computers and factory installation of the unit on its new 727-225s.

An altitude-alert indicator designed to meet new Federal Aviation Administration requirements was ordered by Boeing for factory installation on all standard 727 and 737 aircraft. The contract also included supply of an electric altimeter more accurate than barometric units. The altitude-alert indicator gives pilots both a visual and an audio signal when the aircraft approaches a preselected altitude level.

Military avionics capabilities were recognized with significant contract awards in 3 areas: flight controls, collision avoidance, and all-weather landing systems.

Grumman Aerospace Corporation, as prime airframe contractor for the Navy F-14, awarded Honeywell a contract for design and development of the automatic flight control system (AFCS). Five months later, the breadboard of the stabilization augmentation system was delivered for the air superiority fighter. The total contract could exceed \$30,000,000, the division said. Production was scheduled for 1971.

A "first" was claimed with production orders from the Army for a proximity warning system (PWS) designed to warn helicopter pilots in training of nearby aircraft. The cooperative radar system is the first in the overall collision avoidance system classification to win a contract for production.

The STATE portable system for use in landing combat aircraft in remote areas was tested in Southeast Asia under a Department of Defense contract for evaluation. The all-weather system can be set up in 5 minutes. STATE stands for Simplified Tactical Approach and Terminal Equipment. The program was shifted from Honeywell Radiation Center at Lexington, Massachusetts, to Aerospace Division-Minneapolis for production.

The Air Force expressed interest in fluidic technology at Honeywell with the award of a \$2,900,000 contract to a 3-company team for a hybrid turbojet engine control system. Honeywell is responsible for fluidic elements to be integrated with hydromechanical and electronic controls under prime contractor Pratt & Whitney Aircraft. Controls were being sought for the advanced military and supersonic transport engines expected in the 1970s.

Radar altimeter sales passed the \$18,000,000 mark with sale of the popular AN/APN 171 to Great Britain for the Royal Navy and Royal Air Force; Great Britain was the ninth country to order the unit. A new, microminiature altimeter went into production for a classified program to further expand Honeywell's role of leadership in production of pulse radar systems.

Progress in development of laser gyroscopes continued with Honeywell putting on its shelf the world's smallest, measuring 1.3 inches on each side of the triangular laser path. Production contracts were awarded by McDonnell Douglas for laser triad rate gyros for the experimental Upstage missile and by Naval Weapons Center for miniature laser gyroscopes, measuring 2.6 inches on each side, for inertial guidance of advanced tactical missiles. The Upstage application is a first for use of basic angular rate sensors on that type of missile.

AEROSPACE DIVISION-FLORIDA

Developments in Florida operations, significant in 4 major areas, included a \$40,200,000 award to qualify as a second source for the Minuteman III guidance system and the design of a new computer: the industry's first production contract for a strapdown inertial guidance and navigation (SIGN) system for a space booster; technological and marketing progress for a family of digital computers and plated wire memories; and funding for continued production of inertial components and low-cost gyroscopes.

The Minuteman III award called for the division to build a number of guidance and control units for extensive ground and flight testing over a 31-month period. The improved computer, a Honeywell Digital Computer (HDC) Model 701P, will contain a plated wire, nondestructive readout memory designed in the division's memory group.

The multimillion-dollar award placing the Honeywell H-448 strapdown system on the Agena rocket was only one of several important developments that saw strapdown guidance come of age in 1969. Early in the year, the division's H-429 SIGN system made aerospace history at Holloman Air Force Base, New Mexico, when it became the first such system to successfully complete a flight-test program.

An engineering prototype of the unique strapdown navigator, the first inertial system—strapdown or gimbaled—to use lasers instead of conventional gyros, was about to begin system tests at year-end.

In a related guidance development, the division was awarded an Air Force contract for over \$5,000,000 for advanced electrostatic gyroscope (ESG) development and 1970 flight test of its Gimbaled Electrostatic Aircraft Navigation System (GEANS). The ultraprecise ESG system will include the division's newly developed HDC-601 computer with a plated wire memory.

The division celebrated its 10th year on the Centaur guidance program, directed by NASA's Lewis Research Center, with flawless performance as Atlas/Centaur lifted Mariners 6 and 7 to historic flybys of Mars, as well as with a successful guidance performance in the launch of ATS-5. NASA acceptance tests were successfully completed on an improved Centaur Inertial Measurement Group, to replace the earlier Centaur guidance system in 1972.

In the field of navigation aids, a lightweight Mini-Locator was under development to provide military forward observers a precise means of locating their own position and target locations by processing signals from one or more of the 4 Navy Navigation Satellites in low-altitude earth orbit.

Continued development in digital computer technology saw the division offer, for the first time, a complete spectrum of 6 computers for a wide range of aerospace and military applications. They included the HDC-201, an 8-pound unit which was to be flight-tested on the DC-10 in 1970; the HDC-401, with extremely low power requirements for use on navigation, attitude control, or deep-space missions; the HDC-601, to be flight-tested in late 1970 with the GEANS aircraft navigator; and the 700 series computer, a model of which was accepted for the Minuteman III guidance computer role.

Increased computer production required building a 40,000-square-foot addition to one plant.

In related technology, the division announced it was developing a unique Mini-Wire memory for the aerospace and military computer market. The wire, only 2 mils in diameter and married to large scale integrated circuit electronics, was expected to have marked advantages over standard 20-mil core memory units. A production version of the memory was expected to be completed in mid-1970.

During 1969, the division's 5-mil plated wire was successfully used in the memory of the Poseidon missile guidance system.

SYSTEMS AND RESEARCH DIVISION

Honeywell's advanced research and development division made significant technical advances at its centers in Minneapolis, Minnesota, and Lexington, Massachusetts.

Research scientists at the Systems and Research Center in Minneapolis, studying military requirements for advanced computer technology, developed concepts for next-generation modular computer systems and an associative communication multiplexer. Work in information processing resulted in implementation. Advancement of laser technology won national recognition with the IR-100 award. Research centered on the characteristics of helium-neon laser gyros and carbon dioxide laser systems for long-range space-oriented communications.

In the human factors area, a number of Department of Defense-funded programs analyzed the development of behavioral principles for learning, retention, and performance for possible application to design of training systems. Physiological and behavioral studies were performed in order to better estimate pilot performance as a function of pilot work load.

The Systems Engineering Department continued significant growth with funded projects in rotary-wing avionics (LAMPS and UTTAS), tactical recon-

naissance (TACREACT), and battlefield command and control studies.

The Navy awarded a basic study contract for the advanced Light Airborne Multipurpose System (LAMPS) concept. The study was to determine mission and systems criteria applicable in the design of an airborne system to operate off the decks of destroyers.

Air Force studies on the Tactical Reaction Reconnaissance System (TACREACT) entered a new evaluation phase. The system uses a head-mounted helmet sight worn by pilots to gather data, process the data through airborne and ground computers, and enable immediate pinpoint location of what the pilot is looking at while flying high-performance aircraft.

Work on battlefield studies included command and control, all elements of tactical surveillance, target acquisition, border security, and base camp and air base security. These funded programs were complemented by studies dealing with ground sensor improvements for early warning, line detection, and verification.

New developments in the department's airborne fire-control program centered on improvements and flight demonstrations for the helmet sight and a new head-up display which is called the Hot Line Gun Sight.

Electrooptics research at the Honeywell Radiation Center, a Systems and Research Division unit at Lexington, Massachusetts, made significant gains in aerospace and aviation in 1969.

Research and development of an advanced infrared mapping system led to a contract to build 2 engineering models of an infrared reconnaissance set (AN/AAD-5) for testing on the Air Force RF-4 high-performance aircraft. Flight tests were planned for early 1970. Production potential was estimated at over \$40,000,000.

A Canopus star tracker and a planet sensor set consisting of a far-encounter planet sensor and a narrow-angle Mars gate were supplied for the successful flybys in July of Mariners 6 and 7. For the 1971 flights, in addition to the Canopus star tracker, HRC was to build the acquisition sun sensor, the cruise sun sensor, and the sun gate. These sun sensors provide the attitude control system with information to turn the spacecraft and its solar panels toward the sun and to hold that position throughout the mission.

For over a decade, Honeywell has been engaged in research, design, and development of infrared detectors. Since 1961, it has supplied individual production detectors for infrared line scan systems. Having established unique capabilities in mercury-cadmium-telluride detectors, HRC in 1969 was developing arrays of these detectors under government sponsorship.

An infrared detector array study program encompassed a 12-month effort sponsored by the

Avionics Laboratory to investigate the state of the art in high-performance infrared detector arrays.

NASA's Electronics Research Center accepted for evaluation an oculometer which could record eye movements by astronauts in flight without encumbrances of electrical connections. Fine sun sensors for the Apollo Telescope Mount mission of the 1970s were assembled for delivery.

HUGHES AIRCRAFT COMPANY

For Hughes Aircraft Company, 1969 was highlighted by mankind's first giant step on the moon and by the dramatic return of parts of Surveyor 3.

On earth, work progressed on the world's largest commercial satellite, Intelsat 4, and on a new, computerized air defense system for the NATO nations of Europe.

Apollo 11 and 12 astronauts were aided in their moon landings by more than 86,000 photographs of the lunar surface taken by 5 successfully launched unmanned Surveyors developed by Hughes Aircraft Company.

Among the lunar experiments set up by Apollo 11 astronauts was a special reflector designed to receive giant "pancakes" of laser light fired from a Hughes-built range-finder system installed on a 60-inch telescope in the Catalina Mountains near Tucson, Arizona. The range finder, built for the Air Force Cambridge Research Laboratories, can measure the relative earth-to-moon distance to within 1.5 meters.

In another lunar project, an inorganic paint developed by Hughes scientists for the Surveyor spacecraft was used to coat a special photographing aid ("gnomon") set up by the astronauts to measure the spectral quality of color photos they took of the moon's surface. The paint is able to withstand the moon's daylight temperatures of up to 250 degrees above zero Fahrenheit and is resistant to ultraviolet radiation in space.

Hughes-built synchronous-orbit communications satellites ringed the world during the Apollo 11 lunar landing mission. Telecasts from the Apollo spacecraft and the moon were transmitted around the world via Intelsat 2 over the Atlantic. ATS-1 and ATS-3 (Applications Technology Satellites) provided weather pictures of the launch and recovery areas as well as voice and TV. ATS-1 provided the main voice link between the USS *Hornet* in the Pacific recovery area and Washington. TACSAT-1 was the primary UHF voice link between the Apollo crew and aircraft, ship, and ground stations during recovery operations.

It was during the second moon walk that the dramatic visit to Surveyor 3 took place. The spacecraft, launched in 1967, had landed about 150 feet down the sloping wall of the crater, but astronauts had no

trouble reaching it and removing parts for return to earth.

Continuing its progress in satellite technology since the launch of tiny Syncom 2 in 1963, Hughes was building 4 Intelsat 4 communications satellites with 25 times the capacity of any satellite now in service. The \$72,000,000 program, using 12 subcontractor companies in 10 foreign countries, is under the direction of the Communications Satellite Corporation as manager for the 69-nation International Telecommunications Satellite Consortium.

About 100 engineers from 10 nations were working at a Hughes Aircraft site in El Segundo, California, on the program. The new satellites will be capable of carrying simultaneously nearly 6,000 2-way telephone calls or 12 color television programs, or various combinations of voice and video transmissions.

A unique feature of Intelsat 4 is its ability to focus power into 2 "spotlight" beams and to point the beams at any selected areas, thus providing a stronger signal and more channel capacity in areas of heaviest communication traffic. For transatlantic transmissions, for example, the beams could be aimed at western Europe and eastern United States or they could link South America with Europe or North America.

The first Intelsat 4 was scheduled to be launched into synchronous orbit 22,300 miles above the earth early in 1971.

Another major satellite program at Hughes came to fruition in 1969 with the launch of a giant experimental tactical communications satellite built for the Department of Defense under a \$30,000,000 contract.

The 2-story-high, 1,600-pound spacecraft was launched early in February into a synchronous orbit 22,300 statute miles above the earth by the Air Force aboard a Titan IIIC booster. It will be used by the Army, the Navy, and the Air Force to test the feasibility of using synchronous satellites for tactical communications with small mobile ground stations, aircraft, and ships at sea. The satellite carries a cluster of antennas whose powerful signals can be picked up by all types of terminals, even those with antennas as small as 1 foot in diameter.

At the Hughes ground systems group in Fullerton, California, NADGECO Ltd. unveiled equipment that will be the heart of NATO's \$300,000,000 computerized air defense system stretching from Norway to Turkey. NADGECO Ltd. is the 6-nation consortium constructing the system, called NADGE (NATO Air Defense Ground Environment), to guard free Europe from air attack with what has been described as the biggest project of fixed installations within the North Atlantic Treaty Organization. The Fullerton test center, where equipment was being integrated, is operated by Hughes, the U.S. member of the consortium.

NADGE will operate from approximately 80 sites

in West Germany, the Netherlands, France, Italy, Belgium, Norway, Denmark, Greece, and Turkey. It will provide western Europe with an electronic warning and weapons control system, including a continental network of radar and air traffic sensors, in the 1970s.

A major link of NADGE already was operational in Belgium, the Federal Republic of Germany, and the Netherlands, which banded together in 1957 as an International Planning Group (IPG) to develop a mutual air defense system. The 3-nation system, built by Hughes, was turned over to the group early in 1969, and was undergoing expansion for eventual phasing into the NADGE program.

Overall, NADGE operates on computer technology and is designed to detect hostile aircraft and to give near-automatic commands to NATO weapon installations, fighter planes, and missile batteries.

The year also saw Japan's new computerized air defense system, built by Hughes, go into full tactical operation as scheduled. The system, called BADGE, covers Japan and the surrounding Pacific area with an electronic network that detects, tracks, and identifies airborne targets automatically, evaluates and compiles incoming data, and provides to-the-target control for Japan's modern fighter-interceptor aircraft and surface-to-air defense missiles.

The milestone event climaxed over 9 years of planning and work on the project, during which time the system was built in Japan and the United States under contracts totaling \$56,000,000. BADGE is installed at sites extending from the northern tip of Hokkaido to the southern end of Kyushu.

Hughes was also building and installing an advanced air defense network for Switzerland and in July shipped the last of the complex electronic equipment to that country for on-site testing. Called Project FLORIDA, the Swiss system consists of new long-range 3-dimensional data radars; high-speed general-purpose computers, the nerve center of the system; multipurpose consoles that display data from radars and computers and enable operators to enter new data into the system; and digital data transceivers that allow the system to send and receive coded information rapidly.

In the field of radar, system tests began in the summer on a new advanced radar prototype, forerunner of what could be the world's most powerful radar for defense against missile attack in the 1970s and beyond, at an isolated mountaintop site near the company's Fullerton facility. When the transmitter is completed, the prototype, a scale version of a proposed long-range system called ADAR (Advanced Design Array Radar), will be the most powerful radar yet built by Hughes. Total system testing was to continue until the end of 1969; final-phase testing under Army scrutiny—demonstrating the radar's overall concept, stability, and reliability—was scheduled to begin in January 1970 and continue through the year.



A Hughes Aircraft technician adjusts an antenna, one of several in the 1/10-scale prototype of ADAR, a new phased-array radar and the most powerful yet built by Hughes, a pioneer in the field.

In another major radar project, Hughes received a Navy contract calling for an electronic face-lifting to provide the nuclear-powered USS *Long Beach* with a battle control capability unmatched in naval history. The program is in line with plans to improve the electronic air defense powers of the *Long Beach*, the world's most advanced missile cruiser. The *Long Beach* and the carrier USS *Enterprise*—with air control radar systems developed and built by Hughes—are the most sophisticated ships afloat. During the *Long Beach's* 2 tours in Vietnam waters, the ship's radar-computer system and displays tracked and monitored, around-the-clock, all aircraft in a battle zone covering hundreds of square miles of land and sea.

The ability of the *Long Beach* to accomplish its highly sophisticated missions is based on Hughes-designed Scanfar radars, combined with the Naval Tactical Data System (NTDS), a high-speed computerized system of displaying and evaluating collected information. The electronic "eyes and ears" of the system are the radars and radar-computers, designated AN/SPS-32 and AN/SPS-33 by the Navy. These are the world's first operational fixed-array radar equipments able to detect and automatically track hundreds of targets simultaneously.

Hughes-Fullerton was also building new radar equipment for warships of 3 free world nations under U.S. Navy contracts. Five complex radar-computer systems, designated AN/SPS-52, were destined for guided-missile destroyers of Spain; and five planar, or billboard-shaped, radar antennas, designated AN/SPA-72, were being built, 4 for France and one for Japan. The equipment will be

installed aboard warships of those countries to provide simultaneous 3-dimensional information—height, range, and bearing—about air targets. Delivery of the units was expected to be completed by the summer of 1970 under contracts exceeding \$7,000,000.

In May, Hughes-Fullerton announced that the U.S. Navy was operating its first 3-dimensional radar able to detect and automatically track a large number of moving targets through severe natural or man-made clutter. The Hughes-built radar, AN/FPQ-12, is installed on the island of Kauai in Hawaii, where it is operating as part of the Navy's Barking Sands Tactical Underwater Range, a 50-square-mile antisubmarine warfare range used for all-weather tactical exercises. The radar's clutter cancellation ability is due to special solid-state circuitry, developed in a Moving Target Indicator (MTI), which eliminates or filters out clutter radar returns competing with the desired targets.

The company's aerospace group, Culver City, California, and its missile systems division, Canoga Park, California, were deeply immersed in new and continuing missile development.

The flight-test phase of a \$95,000,000 Air Force contract to develop and produce the Maverick missile got under way in the fall. Maverick is a TV-guided air-to-ground weapon designed to knock out enemy tanks, armored vehicles, and field fortifications. In operation, the pilot selects a target on a television screen in the cockpit, locks the missile's guidance system on it, and launches the missile. The pilot then can leave the area while the missile continues to the target, guided by an electrooptical TV homing device in its nose.

Ten TOW missiles, part of the first TOW production hardware delivered to the Army, were test-fired in the summer at the Army Missile Command, Redstone Arsenal, Alabama. All struck a stationary target with pinpoint accuracy, the Army revealed. TOW project officials said the antitank missiles, which were fired at targets over a mile from the launcher, passed their critical development tests with flying colors. TOW, a tube-launched, optically tracked, wire-guided missile, is capable of being fired from a ground emplacement or from helicopters and a variety of vehicles. It can knock out field fortifications or destroy any known enemy armor. In the Army's arsenal, TOW is expected to replace a 106-millimeter recoilless rifle and Entac and SS-11 missiles.

In March, for the first time in the history of air weapons development, 2 missiles launched from a single aircraft at virtually the same moment scored hits on 2 airborne targets during a test on the Navy's Phoenix missile and its AWG-9 missile control system, which are being developed by Hughes.

The missile firing, held off the California coast at the Naval Missile Center, Point Mugu, was a test of the multiple-launch capability of the AWG-9

system, which will enable one aircraft to defend against several attacking planes. The AWG-9 system and the Phoenix missile will be used in the Navy's new F-14A fighter.

Several months after the historic launch, Hughes delivered to the Navy the first Phoenix missile system trainer, a computerized simulator that will be used to train missile control officers for the F-14A. The trainer can simulate a complete mission of the Phoenix system, from target acquisition to lock on and missile launch.

In other missile development, Hughes was awarded a \$6,800,000 contract to produce guidance electronic systems for the Navy's new Poseidon missile, which is designed for launching from submerged nuclear submarines like the Polaris. Under the contract, Hughes was establishing a production line for manufacture of the assemblies at its El Segundo, California, factory, where the company was to produce 12 systems. The company completed \$126,000,000 in Polaris program contracts over 7 years, building guidance systems, electronic assemblies, submarine fire-control systems, and training equipment.

At Hughes-Fullerton, the initial systems check-out phase was completed on a new type of Semi-automatic Flight Operations Center (SAFOC), which has the potential of regulating all Army air traffic in a combat zone or elsewhere. The new system is designed to monitor automatically the position of all aircraft under its control. It will provide a collision-avoidance capability, pinpoint the location of distressed or downed aircraft, identify friendly aircraft, provide ground-to-ground coordination of aircraft movement, and disseminate air-warning information to pilots. The center is composed of data processing equipment, displays, and communication links.

Hughes was also developing a close air support control system for forward-area applications; it will enable pilots of tactical aircraft to perform blind missions, using electronic "eyes" on the ground. The new system, known as TASCs (Tactical Air Support Control System), was being developed for the Air Force. Initial tests were completed on the first of 2 experimental systems.

TASCs is designed to provide pilots of tactical aircraft with navigation, guidance, and weapon release information for such missions as close air support, blind bombing of selected targets obscured from the pilot's vision, delivery of troops and material to designated landing or drop zones, and air reconnaissance.

Work was under way in Fullerton on a contract calling for 1,036 Manpack radios for the Army Electronics Command. The radio's signals are propagated by both ground and sky waves. The radio, designed to be carried easily by one man wearing a standard Army shoulder harness, weighs only 24 pounds with a newly developed dry battery pack.

More than 3,600 of the current 16,000-channel and the original 10,000-channel high-frequency, solid-state radios had been delivered to the Army under previous contracts.

An interesting project of the company's aeronautical systems division was a night-vision system that will give a helicopter crew the ability to swoop down out of a black sky and locate an enemy illuminated only by starlight. The system, called INFANT (Iroquois Night Fighter and Night Tracker), was installed in a UH-1M Iroquois helicopter and successfully demonstrated during night operations in the California desert. It was developed under direction of the Army Electronics Command's Night Vision Laboratory, Fort Belvoir, Virginia, and was being installed in a number of helicopters.

In June, the company delivered to the Army 5 laser range-finder systems for use on the M60A1E2 battle tank. The tank range finder consists of a ruby laser, telescope-like optics, and associated control panels. The 5 units, described as the first completely militarized laser put into production, were the first of 419 laser range-finder systems being built at the company's El Segundo facility under a contract with the Army's Frankford Arsenal at Philadelphia.

Delivery was made during the year of the first mobile flight line tester for the West German Air Force. The unit, weighing approximately 3 tons fully equipped, is designed specifically for testing the inertial navigation system of the F-104G aircraft but can be adapted to test other avionics systems.

Among the technical innovations of Hughes space engineers in 1969 was a "window shade" of solar cells that will collect sunlight to power orbiting satellites with electrical energy. The company was fabricating the new solar power supply system for the Aero Propulsion Laboratories of the Air Force under a \$2,500,000 contract. The featherweight system of extendible solar cell sheers, which resemble a window shade, is known as LRSCA (Large Retractable Solar Cell Array).

A precision instrument designed and built by the Santa Barbara Research Center, a subsidiary of Hughes, performed the key role of taking the temperature of Mars during a flyby of 2 Mariner spacecraft in the summer. The instrument, a 2-channel radiometer, measured temperature in 2 basic ranges, aiding scientists in their knowledge of the Martian surface.

In October, the Santa Barbara facility announced that it had developed an infrared communicator that transmits and receives either voice or digital information over a laser beam for distances up to 6 miles. The device was expected to find use in such areas as ship-to-ship, ship-to-shore, and other industrial and military situations that require secure communication.

At the company's Newport Beach division, work began on a new order for the passenger entertain-

ment-service system for the DC-10 trijet. Hughes was designing and building the system, which brings microelectronic techniques developed for space technology into the commercial aircraft field. The entertainment-service system provides 16 channels of high-fidelity music or inflight movie sound track to passengers' earphones. It also controls passenger reading lights and attendant call lights and chimes at each seat.

A highlight of 1969 was the presentation to Lawrence A. Hyland, Hughes vice president and general manager, of the distinguished Order of the Sacred Treasure, one of the highest honors the emperor of Japan can bestow on an individual. Hyland received the medal during special ceremonies in Tokyo. It cited him for his "contributions to the Japanese electronics industry through the peaceful use of spacecraft and for the Japanese Air Defense System." The spacecraft alluded to in the citation is Syncom 3, which was used to beam the 1964 Olympic Games from Tokyo to the United States and other areas of the world. Japan's air defense system, BADGE, was built by the company's Fullerton facility and put into tactical operation in 1969.

The year 1969 proved to be an expanding one for Hughes, not only in contracts but in work force and proposed new facilities. At Hughes-Fullerton, it was announced that 3 manufacturing buildings would be built during the next year and a half, with basic construction costs estimated at about \$8,500,000. The new buildings will enlarge the facility's present engineering park by some 500,000 square feet, nearly doubling Hughes-Fullerton's existing manufacturing space. Plans called for the buildings to be completed and occupied by January 1971.

Overall employment at Hughes stood at over 30,000 as the year neared an end, an expansion of some 5,000 engineers and support personnel since the beginning of the year. The firm had 11 facilities: Culver City, Fullerton, El Segundo, Canoga Park, Los Angeles, Malibu, Santa Barbara, Torrance, Oceanside, and Newport Beach, California; and Tucson, Arizona. The company's gross sales exceeded \$500,000,000 for the fourth consecutive year.

HUGHES TOOL COMPANY

AIRCRAFT DIVISION

Introduction and first deliveries of the new Hughes Model 500 helicopter were among the most significant events of 1969 at Hughes Tool Company's aircraft division. The first 500s outfitted for executive travel were delivered in May. Later in the year, production increased at the firm's main plant in Culver City, California. The first U.S. executive to receive a deluxe 500 helicopter was Barron Hilton, president of Hilton Hotel Corporation.

The Model 500 at year-end could be found in 13 foreign countries: Argentina, Australia, Colombia, the United Kingdom, Italy, Japan, Ireland, Switzerland, India, Taiwan, Korea, Mexico, and the Philippines.

In addition to the Model 500 program, Hughes maintained production during 1969 of its Model 300 and OH-6A Cayuse helicopters as well as of military ordnance systems.

The company's aircraft unit is one of several semi-autonomous divisions that make up Hughes Tool Company, wholly owned by Howard R. Hughes.

In 1969, the division, a recognized leader in helicopter research and technology, maintained its employment level of about 5,000 persons in the fields of engineering, administration, and manufacturing. The division occupied over 1,000,000 square feet of structural facilities in California at sites in Culver City, Los Angeles, and San Diego.

Hughes Tool Vice President Rea E. Hopper is general manager and Vice President Thomas R. Stuelpnagel is assistant general manager. Robert A. Wagner is director of aeronautical engineering.

By year-end, more than 1,270 Cayuse helicopters had been built at Culver City for the Army. They had logged over 500,000 combat flying hours since first being deployed in Vietnam in November 1967. Army contracts called for ultimate delivery of 1,415 OH-6As. The Cayuse, used primarily as a low-level scout ship, recorded an outstanding combat mission availability rate and a maintenance rate of less than one hour to each hour of flight. The lightweight aircraft was officially cited by Army aviators for its superior crash survivability characteristics.

The Model 500 helicopter offers as civilian credentials the unequaled record of performance and reliability achieved by its military counterpart, the Cayuse. The 500 is certified at 2,550 pounds and is structurally similar to the OH-6A. It features a unique A-frame construction, built around the ship's center of gravity, which combines with energy-absorbing crew compartment seats to provide the ultimate in pilot-passenger safety. The 500 is available at a base price of \$95,000 with a standard interior designed for utility missions. A deluxe interior is optional at extra cost to the purchaser.

Production of an international military version of the 500, designated 500M, also continued in 1969. The ship, capable of being equipped with armament, has been purchased by many foreign countries.

The versatile Model 300 continued to be produced during the year at the division's Rose Canyon facility near San Diego. It was at this plant that the company also produced 793 TH-55A helicopters for use by the Army's primary trainer school at Fort Wolters, Texas.

Another facility, at Palomar County Airport near San Diego, was maintained for production flight testing of all the company's military and commercial helicopters.

The last TH-55A trainer was delivered to the Army in March. By year-end, the TH-55A fleet had flown over 1,000,000 training hours since the first ship was delivered in 1964.

The Hughes 300, sister ship to the TH-55A, combines low cost, smooth operation, reduced maintenance, ease of flying, and maneuverability in one responsive, compact package. It will continue to sell for a \$33,630 base price.

More than 70 major U.S. cities were seriously considering the Hughes around-the-clock law enforcement concept that utilizes the Model 300 patrol helicopter. The company expected to boost production of the Model 300 ship to keep in step with an anticipated increase in demand. At year-end, there were nearly 1,000 Model 300 helicopters in use on every continent in the world.

Other applications of the 300 include agriculture, student flight training, mosquito abatement, rescue, and recreation.

In 1969, the company bared plans to compete for the Navy's new Light Airborne Multiple Package System (LAMPS) project by offering a modified version of its OH-6A helicopter. The LAMPS program calls for destroyer-based helicopters to perform anti-submarine warfare and other activities.

In the area of ordnance, Hughes continued production for the Navy of its Mark 4 gun systems using the Mark II 20-millimeter cannon. The weapon, slung beneath the fuselage of an attacking aircraft, can fire 4,000 rounds a minute.

The company also maintained production of the XM-27E1 armament subsystem, a high-rate-of-fire machine gun that arms the Cayuse helicopter.

In advanced development stages for the Army were 2 projects: a helicopter grenade launcher subsystem and a high-velocity, 350-shot-a-minute, 40-millimeter self-powered grenade launcher.

A second foreign firm, Nardi S. A. per Costruzioni Aeronautiche of Milan, Italy, was licensed in 1969 to manufacture and market versions of the Model 500 helicopters. Kawasaki Heavy Industries of Gifu, Japan, was licensed in 1968. Under terms of the Nardi agreement, the Italian firm was to sell the ship in the European Economic Community (Common Market) and in some North African countries. The Kawasaki pact authorizes the Japanese company to do the same in its area.

INTERNATIONAL BUSINESS MACHINES CORPORATION

FEDERAL SYSTEMS DIVISION

IBM continued to contribute to the nation's space and defense programs during 1969.

Work in support of NASA's Apollo program received major attention because of the successful landings on the moon. The IBM facility in Hunts-

ville, Alabama, builds the Instrument Unit for the Apollo program. The 3-foot-high, 21-foot-wide ring is the guidance and control system for the Saturn V launch vehicle, guiding the flight from lift-off until the spacecraft is on the way from earth orbit to the moon. Some 57 space age components, including an IBM digital computer, provide precise control for Saturn V.

IBM computers at the Manned Spacecraft Center in Houston constitute the Real-Time Computer Complex, an installation that monitors the trajectory of and interprets telemetry data from the spacecraft. Five System/360 Model 75s were available to support flight controllers during lunar missions.

Similar IBM computers were in use at NASA's Goddard Space Flight Center to help control the manned space flight network of worldwide communication systems for space programs.

At the Kennedy Space Center launch site, IBM specialists assisted in the electronic check-out of Saturn V and in the operation of the launch support complex.

Another Huntsville-developed system will soon be helping commuters in California's Bay Area travel faster and more efficiently. The San Francisco Bay Area Rapid Transit District (BARTD) was building a 75-mile all-electric transit system that will include an automatic fare collection system developed by IBM. The system includes a coin/bill-operated ticket vending machine that issues magnetically encoded tickets, an add-fare machine that permits a ticket's value to be increased, and commuter passenger gates designed to accept the magnetic tickets and deduct fares from the magnetically recorded values.

Electronic monitoring equipment designed by IBM in Huntsville will be used by the Seaboard Coast Line to help diagnose repair and maintenance needs for locomotives. The equipment was to be installed on 20 locomotives to collect information on 96 operating functions and to record the information on magnetic tape. The tape is removed from the locomotive for analysis of maintenance requirements by an IBM 1800 data acquisition and control system.

In 1969, IBM continued working on the Combat Service Support System, CS3, as the system is known, is an IBM System/360 Model 40 on wheels; it moves when and where a field army moves. CS3 pools logistics and personnel records in a central computer that supplies field commanders with instant information on their troops and supplies. The systems are mounted in 5 35-foot vans and 2 1/2-ton Army trucks. Six of the data processing and communication systems were completed successfully and were delivered to the Army.

Concerned with a broad scope of advanced technologies, IBM Owego was involved in avionics systems, computer development, radar/ECM, sonar, lasers, solid-state displays, and other programs under

study, development, and production contracts. The facility boasts highly automated manufacturing and modern testing and laboratory facilities, including a simulation lab and an anechoic chamber for proving out advanced avionics concepts.

IBM's System/4 Pi, a multipurpose aerospace computer manufactured at Owego, comes in a variety of models and is suitable for land, air, and sea applications. System/4 Pi was being used in the F-111 and A-7 aircraft for navigation and weapons delivery. On the A-7 programs, in addition to providing a computer, IBM has avionic subsystem integration responsibility. The first navigation/weapons delivery test sets for advanced models of the A-7 aircraft were turned over to LTV Aerospace Corporation, aircraft builder and prime contractor. A major F-111 program milestone was passed with delivery of the 100th System/4 Pi CP-2 computer to Autonetics. System/4 Pi models were also in use in the A-6 and EA-6B aircraft and for such applications as target identification, reconnaissance/surveillance, and antisubmarine warfare.

The division made a major move into the field of digital communications with the introduction of special devices to speed the transmission of errorless digital data from computer to computer. Further developments were under study for Project Mallard, a mobile digital communication system intended for field armies in the 1970s.

IBM's Federal Systems Division, headquartered in Gaithersburg, Maryland, concentrated on advanced technology and special systems for the ground-based, airborne, and spaceborne requirements of military, scientific, and civil government agencies. The division employed at year-end 13,000 people and had 5 operating centers: the Electronics Systems Center, Owego, New York; the Federal Systems Center, Gaithersburg, Maryland, with operations at Houston, Texas; the Space Systems Center, Huntsville, Alabama, with operations at Cape Kennedy, Florida; the Communications and Engineering Sciences Center, Gaithersburg, Maryland; and the Center for Scientific Studies, Gaithersburg.

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

ITT DEFENSE-SPACE GROUP

ITT Defense-Space Group, headquartered in Nutley, New Jersey, includes ITT Avionics Division and ITT Defense Communications Division, both of Nutley; Federal Electric Corporation, ITT Commercial Services, and ITT Arctic Services, Inc., all of Paramus, New Jersey; ITT Aerospace/Optical Division, San Fernando, California, and Fort Wayne, Indiana; ITT Gilfillan, Inc., Van Nuys, California; ITT Electron Tube Division, Easton, Pennsylvania, Roanoke, Virginia, Fort Wayne, Indiana, and San

Fernando, California; ITT Electro-Physics Laboratories, Hyattsville, Maryland; and ITT Space Communications, Ramsey, New Jersey.

The mission of the ITT Defense-Space Group is to aggressively pursue new marketing opportunities that arise as sweeping technological advances are made in the aerospace and military fields.

ITT Avionics Division

ITT Avionics Division extended the development of electronic warfare and navigation systems significantly with major engineering and production advances during 1969.

Well known for its continued engineering and production of TACAN and other point-source navigation, hyperbolic navigation, and electronic warfare systems, the division announced the culmination of 7 years of work on an all-new advanced integrated airborne TACAN transceiver. The new airborne system utilizes solid-state circuitry and circuit board pull-out cards to perform all-round TACAN functions with increased accuracy and reliability while adding a complete set of related features such as data link, inverse mode, digital control, and spoof detection.

In another TACAN development, ITT Avionics bolstered its reputation in TACAN antennas by receiving a contract from the Air Force for a newly developed airport terminal high-band antenna which eliminates signal deflection from hangars and runways.

In the field of electronic warfare, a new solid-state microwave reconnaissance and electronic warfare receiver series was unveiled by the division in 1969. Engineering and production on highly classified electronic warfare equipment continued under contract from all major branches of DoD.

Electronic defense systems under development and in production included reconnaissance, electronic countermeasures, direction finders, radar trainer systems, and sonar trainer devices.

Under contract to the Air Force for Loran-C/D hyperbolic navigation systems, the division shipped a system a day from its Nutley-Clifton, New Jersey, complex during the latter part of 1969.

Omega global navigation receivers went into production during the year, and the first unit was shipped to the Navy in mid-1969.

Production facilities at the division's complex were being completely revamped. The division invested almost \$1,000,000 for modernization of its manufacturing plant and production equipment as part of a new 5-year renovation program.

ITT Defense Communications Division

ITT Defense Communications Division began production of AN/GRC-143 tropospheric scatter radio sets. The radio equipment is destined for opera-

tion around the world as the communications backbone of the Army Area Communications System. The radio systems are designed to meet the Army's multichannel tactical requirements and to offer a wide range of characteristics and reliable operating features not provided by any other equipment now available. Being produced under contract to Army Electronics Command, the AN/GRC-143 sets will satisfy Army requirements for multichannel tropospheric scatter communications within a field army without the necessity of installing a large number of intermediate repeater stations.

ITT Defense Communications was also preparing for production of AN/GRC-144 line-of-sight radio sets, being built under contract to Army Electronics Command. The division began delivery of additional AN/TTC-22 tactical mobile telephone circuit-switching systems for use by the Air National Guard.

Command, telemetry, and communication subsystems designed and manufactured by the division orbited the earth as the electronics payload of the Intelsat 3 series of global communications satellites.

A satellite communication earth station designed, manufactured, installed, and rendered operational by ITT Defense Communications for the Indonesian government began operation in Djatiluhur, Indonesia. The station will provide Indonesia with a communication gateway to the world via the Intelsat 3 satellite network. The terminal is equipped with a 90-foot-diameter parabolic reflector antenna. Other satellite communication earth stations built by ITT Defense Communications were in operation in Spain and in the Canary Islands. The Spanish terminal, equipped with an 85-foot-diameter antenna, is located 40 miles north of Madrid. The Canary Islands terminal, on Grand Canary Island, is a duplex system equipped with twin 42-foot-diameter antennas. This station was used to relay spacecraft tracking network communications across the Atlantic to the National Aeronautics and Space Administration's Manned Spacecraft Center, Houston, Texas.

The division provided full support of the U.S. Department of State's Automated Terminal Station, a message-switching communication center for which ITT Defense Communications is prime contractor. Full support also was provided for the 465L Strategic Air Command and Control System, headquartered in Omaha, Nebraska. ITT Defense Communications is prime contractor for this vital command and control center which features large color displays of computer-generated decision-aiding information to SAC force commanders.

The ITT Defense Communications Division also engaged in the development, design, and manufacture of antennas for military submarines and surface vessels, for aircraft, and for satellite communication systems.

ITT Arctic Services, Inc.

The sun rarely sets on the projects of ITT Arctic Services, Inc., one of ITT's newest corporate units. With management-type contracts for operation, maintenance, and support of the Air Force's 4 largest communication and surveillance systems in the far north, ASI's domain extends throughout Alaska in the White Alice Communications System; stretches across the roof of the North American continent from Alaska's Cape Lisburne through Canada to eastern Greenland in the Distant Early Warning (DEW) System; and runs from Angmagssalik, Greenland, across Iceland to the United Kingdom in the North Atlantic Radio System (NARS). The 2 Ballistic Missile Early-Warning System (BMEWS) sites—at Thule, Greenland, and Clear, Alaska—operated for the Air Force by ASI are the largest radar installations in the world.

ASI was formed by ITT in October 1969 to provide a sharper mission and customer focus for the northern contracts formerly held by ITT's worldwide service associate, Federal Electric Corporation. Of its 2,500 employees, only 350 are at corporate headquarters in Paramus, New Jersey, making it by far the largest industrial contractor in the northern area it serves. Its contracts total almost \$180,000,000 through 1972.

White Alice is a network of nearly 100 communication sites in Alaska. The system provides the backbone of all long-distance telephone, telegraph, and data communications in the entire state, serving military, government, and civilian users. With an undersea cable link to Seattle and a tie-in to the national Canadian microwave system, it is Alaska's communications lifeline to the "south 48."

The DEW System has been managed and operated for the Air Force by ITT since becoming operational in 1956. Its 33 sites not only are a radar fence protecting North America against aircraft attack from the north but also form a toll-quality communication system across 3,500 miles of the world's most inhospitable terrain. Its radars also provide position and weather information as well as flight-following services to commercial and NORAD flights crossing its identification zone.

The mission of BMEWS is to detect and provide warning of missile attack from the Eurasian land mass. Giant stationary antennas 400 feet wide and 165 feet tall send narrow fans of energy 3,000 miles or more into space at 2 different angles. Four of these at Thule and 3 at Clear pick up their first fix as a missile passes through the lower fan. Seconds later, as the missile passes through the upper fan, a second radar fix is obtained. With this information, high-speed computers almost instantaneously compute launch location, impact time, and impact area. The sites also have huge 84-foot scanner-tracker radars to provide additional coverage.

ASI performs 5 major logistics support functions

at both Thule and Sondrestrom air bases in Greenland. Site II at Clear, Alaska, also supports the Air Force's Spacetrack program by reporting position and status of orbiting satellites and space vehicles within its range. NARS provides an alternate communication system for U.S. military forces in Europe as well as a rearward route for a third BMEWS site, operated by the RAF in the United Kingdom.

Recent mineral and petroleum discoveries in the far north have focused worldwide attention on the potential riches locked within the area's snow, ice, and permafrost. In addition to meeting military and defense requirements, ITT Arctic Services, Inc., expected to provide a substantial share of the services needed to develop these natural resources.

ITT Aerospace/Optical Division

Air traffic control, marine position fixing, night vision, surveillance and information gathering, and communications are the broad categories with which the Aerospace/Optical Division was concerned during 1969. The division is headquartered at San Fernando, California, where its Aerospace Electronics operations are located. Electro-Optical operations are in Fort Wayne, Indiana.

Aerospace Electronics laboratories continued development work in the areas of space rendezvous and docking; missile guidance and fuzing; reconnaissance, surveillance, and detection; space guidance, navigation, and communications; position-location equipment; low-light-level television and night vision binoculars; small satellites; and armament control systems.

Major advances were made in satellite navigation. The division continued production of the Navy's AN/SRN-9 satellite navigation receiving system which, used with the U.S. Navy Navigation Satellite system (Transit), provides position location accuracies for ships to approximately .1 mile in all types of weather and on a worldwide basis.

A nonmilitary version of this system was being marketed to commercial shipping customers including oil exploration companies, geodetic survey teams, oceanographic research activities, passenger liners, and merchant fleets. ITT satellite navigation systems are operating aboard the luxury liner *Queen Elizabeth 2* and the icebreaker/tanker *SS Manhattan*, which sailed the Northwest Passage in search of more economical routes for transporting oil from the North Slope of Alaska.

The division was providing the tracking receivers for use in Intelsat and NASA stations around the world.

Electrooptical work continued in the areas of laser communications, laser rendezvous radar, star trackers, high-resolution space cameras, infrared technology, low-light-level television, and various types of electrooptical tracking systems.

AOD developed what is believed to be the most

advanced space rendezvous system available in the world for use in future space missions involving rendezvous of large vehicles and space stations. The company also received a study contract to define a laser hazard detector for use on the Lunar Roving Vehicles under development.

Exploratory development continued on both TV and RF missile seekers of advanced designs and on both laser (optical) and RF fuzes. Several advanced low-light-level television systems were produced for Navy use in reconnaissance helicopters.

The division continued to produce hand-held and vehicular-mounted night vision devices, rocket and weapons control systems for close-support aircraft and helicopters, and precision visual display equipment. An advanced rocket control and display system for Army helicopter use was placed in production. Scientific computer display systems were in production and deliveries were made during the year to the Federal Aviation Administration.

Electro-Optical operations continued an impressive record of successful aerospace developments throughout 1969, placing special emphasis on spaceborne opto-electronic cameras for meteorological and earth sciences programs, specialized visual and audio information systems for air traffic control and data management, ordnance and fuzing products for missileery, night vision and light amplification equipment and systems, and related componentry.



ITT Aerospace/Optical Division developed the unique conical antenna, high atop the mast of the *Queen Elizabeth 2*, which permits the liner to receive satellite signals for precise position location data.

NASA's Nimbus 3 weather satellite, launched in April 1969, provides pole-to-pole photographic coverage of the earth with weather and cloud cover data for meteorologists. The satellite is equipped with daytime image dissector and nighttime high-resolution infrared space television cameras developed by ITT's scientists and engineers in Fort Wayne.

Air traffic controllers in the United States were utilizing new BRITE radar displays produced in Fort Wayne for use by the Federal Aviation Administration and by the military services. Significantly improved brightness and contrast was gained in these information displays, easily viewed by controllers in the very high and variable light levels of airport control towers.

Another major air traffic control development was a new generation of advanced-design solid-state radio receivers and transmitters for military ground-to-air communications. As a part of the Triservice Joint UHF Modernization Program, the 3-unit receiver, transmitter, linear amplifier combination features modular construction with maximum commonality of parts and modules. Military facilities in the United States and worldwide will be receiving this equipment, which is installed in remote-control site facilities and is designed particularly for conditions requiring collocation.

Elsewhere in space achievements, ITT Fort Wayne's image dissector camera in NASA's Applications Technology Satellite (ATS-3) completed its second year of reliable performance in November 1969, taking clear pictures of the Western Hemisphere from the ATS synchronous orbit over 23,000 miles in space.

Nimbus 4, to be launched in 1970, was to contain a daytime television camera along with a new experiment, the Filter Wedge Spectrometer, which will measure the water vapor content of the earth's atmosphere, thus adding one more dimension to weather understanding. Additional earth environment sensor projects included a very-high-resolution radiometer and a very-high-resolution image dissector camera programmed for future meteorological experiments.

Electro-Optical operations also contributed to improved weather forecasting through installations of radar telephone transmission systems developed for the U.S. Weather Bureau to permit remote user viewing of weather radar data. The system gained wide acceptance as a significant advance in providing visual availability of current weather data from remote weather sites, greatly extending the usefulness of weather radar itself.

Other specialized audio and electrooptical products developed and produced in the division's facilities included a broad range of radio frequency communication products for aerospace use, display and data systems products, airborne night vision systems, and infrared illuminators.

Federal Electric Corporation

From its inception in 1952 as a 3-man outfit, ITT's Federal Electric Corporation had grown by 1969 into a worldwide organization with some 8,000 employees performing a diversity of communications, instrumentation, reliability, air defense, command and control, electronic warfare, strategic information, logistics, documentation, training, and systems support services both at home and in more than 30 other countries around the globe.

In 1969, the year of Apollo, ITT's Federal Electric Corporation participated as a major service contractor in support of Apollo 11 in 5 key areas. At Kennedy Space Center, FEC supported NASA in communications, computation and calibration, timing, telemetry, and environmental measurements. At the Marshall Space Flight Center, FEC, as prime contractor for reliability support services, assisted Apollo 11 by checking and testing and predicting the reliable performance of the giant Saturn V launch vehicles; at the Manned Spacecraft Center, ITT's service associate documented the center's many research findings which serve as the basis for the entire lunar landing program; as prime contractor at the Air Force's Western Test Range, FEC supported Apollo 11 by its work aboard the 4 ocean-going Apollo communications ships assigned to the range; an FEC-implemented submarine cable system in the Caribbean, extending from Cape Kennedy to Grand Turk Island, provided real-time data on Apollo 11 during the immediate lift-off period.

At NASA's theater of launch operations, the Kennedy Space Center, Federal Electric is prime contractor for communications and instrumentation support services. It conducts a beehive of activities ranging from timing, tracking, and telemetry to environmental measurements, calibration, computer programming, and data reduction. Prior to each launch, Federal Electric workers are busy installing, maintaining, and operating communication systems. FEC's communications and timing department is responsible for the operation and maintenance of the space center's operational television setup, a space-center-wide closed-circuit system; of its operational intercom system, which carries voice and data transmissions throughout the center; of its central timing area, which provides split-second timing references for the entire space center area; and of its intercom and signal circuits ranging from fire alarms to press conference broadcasts.

In 1969, the communications and timing department of Federal Electric maintained the operational intercommunications system (OIS), which ties together the basic parts of the huge Launch Complex 39. OIS "broadcasts" on a cable, in much the same way as a radio transmitter broadcasts through the air. Use of a cable provides absolute dependability, and the use of radio-frequency signals allows the cable to carry many times the number of messages

a normal telephone-type cable would handle. Some 60 closed-circuit television cameras are operated and maintained about the launch pad by this department. They are remote-controlled as they turn, focus, and peer intently at critical connectors, valves, and other equipment.

FEC's measurements department at Kennedy handled the maintenance of measurement standards, including temperature, voltage, mass weight, and dimensions, to assure consistency in measurements throughout the space center. It also calibrated and maintained the 42,000 precision measurements instruments used at the center and made vital measurements for NASA in such areas as weather, acoustics, vibration, pressures, and fuel-flow rates.

At Kennedy Space Center, Federal Electric's telemetrics department gathered and retransmitted electronic data from the launch vehicle and displayed the data for engineering and management use. In addition, the department tracked launch vehicles within range of the space center and looked for interference which could adversely affect electronics at the center. Other telemetry sections handled line-of-sight tracking assistance to NASA with the operation of several Doppler velocity measurement units, and received real-time signals from the launch vehicles and spacecraft and relayed the telemetered data to other NASA centers, to the real-time computer, and to the data display branch.

Federal Electric's computation department handled NASA's scientific computation chores having to do with launch vehicle, spacecraft, and mission performance.

At Kennedy Space Center, Federal Electric's data retransmission branch sent data to other NASA centers. It also maintained and operated the Apollo launch data system, the Apollo mission simulator data transmission system, the launch information exchange facility system, and the meteorological radar recording system which records radar weather balloon data.

At the Manned Spacecraft Center in Houston, ITT's service associate continued to serve as prime contractor for logistics and technical information support services. The Federal Electric team at Houston was performing such functions as technical writing, editing, report preparation, test documentation, data storage and retrieval, microfilming, graphic arts, warehousing, and procuring supplies.

Materiel receiving, processing, shipping, and storage were managed by the FEC logistics support department at Houston. This group also performed for NASA such services as the maintenance of catalogs listing some 20,000 separate items and the operation of the Manned Spacecraft Center logistics library.

Another FEC function at the Manned Spacecraft Center involved translation of telemetered information and computer data on flight and ground tests into maps, charts, pictures, or graphs for use by

astronauts in orbit as well as by scientists at the center. At Houston, FEC specialists handled technical documentation in 22 different test categories ranging from space environment to simulation laboratories.

At Huntsville's Marshall Space Flight Center, ITT's Federal Electric Corporation continued as prime contractor for reliability support services covering research and development, advanced studies, analysis, and documentation. Federal Electric also monitored other NASA contractors to assure the highest levels of reliability in the manufacture and assembly of the Saturn launch vehicles and associated systems.

At Marshall and at other contractor locations, Federal Electric engineers and specialists performed reliability assessments on critical hardware, systems, and stages of the giant Saturn launch vehicle, identifying problem areas and recommending appropriate corrective action. They also generated the mathematical modeling capability for NASA's use in evaluating the individual stage contractor's reliability performance.

The Saturn Vs used through the Apollo 11 mission demonstrated a reliability of 99.9999-plus percent. Saturn V has 5,600,000 parts; if the average automobile with 13,000 parts were to have the same reliability, it would not experience its first defective part for 100 years.

At the Air Force Flight Test Installation at Palmdale, California, ITT's Federal Electric Corporation, through its subsidiary, ITT Technical Services, Inc., continued to perform a wide variety of services.

At this famous "cradle of tomorrow's military aircraft," ITT's service associate managed preventive and corrective maintenance of all ground and airborne radio and telephone communication equipment; security patrols and the cleaning, repair, and maintenance of 17 miles of runways and taxiways, 23 miles of operational roads, and 15 miles of security fences and gates; and the operation and maintenance of crash-rescue helicopter service. Other services ranged from fire protection and safety and medical first aid to the procurement of all needed supplies and materials.

Another important assignment at Palmdale called for the ITT service team to conduct a massive runway modernization program that will enable the installation to handle heavy jumbo jets and supersonic transport planes. To help determine precisely how thick the new runway should be at any given point, ITT engineers introduced a revolutionary new technique using computer analysis.

As prime contractor to the Air Force's Western Test Range, ITT's Federal Electric Corporation performed a host of operational, maintenance, and technical support services both ashore and afloat, ranging from communications, tracking, instrumentation, and telemetry to data storage, retrieval, and reduction; logistics; timing; and quality control.

Federal Electric engineers and technicians operated and maintained instrumentation facilities at Vandenberg Air Force Base and Pillar Point, California, and in Hawaii and the Marshall Islands. FEC specialists also manned the radar, optical, telemetry, and communication equipment aboard 9 ocean-going range ships operating in the Atlantic, Pacific, and Indian oceans. Three of the larger Apollo ships, assigned to support the manned lunar program, are equipped with 445 tons of electronic gear each, enabling them to provide not only radar, telemetry, and communications but also command control, satellite communications, timing, and computation and data reduction on all missile and space shots launched from the Western Test Range.

Another FEC range responsibility was the maintenance and operation of a new automated telemetry system, AFWTR-VADE, which forms a vital communications link to support Apollo and other space programs.

Besides operating and maintaining the Western Test Range's technical facilities, ITT's Federal Electric Corporation maintained at Vandenberg Air Force Base a team of engineers involved in various other Air Force contracts ranging from the implementation of communication and switching systems to a diversity of ground-support systems and the operation of communication systems for the Air Force's Space and Missile Systems Organization. This Federal Electric Vandenberg projects group engineered, furnished, and installed communication and electronic systems for Vandenberg's test management center and implemented a new communication switching and display system for the range.

At Vandenberg, FEC engineers completed a contract to engineer, furnish, install, operate, and maintain a technical communication and electronic system for the Ballistic Missile Reentry System (BMRS) launch facilities at Vandenberg. The system embraces closed-circuit television, microwave, administrative telephones, direct lines, networks, public address systems, and other communications required by the Air Force Systems Command's 659th Aerospace Test Wing.

Under another contract, FEC's Vandenberg group was expanding the area frequency monitoring capability at the Frequency Control and Analysis (FCA) facility at Vandenberg. The monitoring capability will be modernized to meet the increased work load of the frequency spectrum as more sophisticated electronic devices are adapted to missile and space requirements.

Still another contract gave Federal Electric the responsibility for the maintenance, operation, installation, and test evaluation of ground communication systems in support of space launch and related activities of the 659th Aerospace Test Wing.

Another FEC implementation achievement was the engineering, design, supply, installation, and activation of a 72-channel tropospheric scatter com-

munication system between Berlin and Breitsol. Linking U.S. armed forces in West Berlin with other military centers in West Germany, the new system can provide for further extensions to connect it with other U.S. military communication systems in Europe.

In the Federal Republic of Germany, the U.S. Army Communications System Agency entrusted Federal Electric with the responsibility for the engineering design, installation, operation, and maintenance of the European Wideband Communications System.

Federal Electric also implemented a new segment of the NATO Signal Communications System which became part of the U.S. Army's European Tropospheric Scatter System (ET-A). The new segment, bypassing France, became necessary when NATO relocated its headquarters from France to Belgium.

ITT's Federal Electric Corporation, systems implementation contractor for the European Mediterranean Tropo Scatter Communications System (Project 486L), continued its interest in this vast system which extends from Spain across the Balearic Islands, Sardinia, Italy, Greece, and Crete to Turkey. The U.S. Air Force Communications Service gave ITT's service associate the responsibility for training Air Force technicians to operate and maintain the sophisticated electronic equipment of this network, which Federal Electric completed in 1966.

ITT Electron Tube Division

ITT Electron Tube Division, operating from locations in Easton, Pennsylvania, Fort Wayne, Indiana, San Fernando, California, and Roanoke, Virginia, is responsible for all of ITT's special-purpose vacuum activities. At its headquarters in Easton, the division performs research, development, and volume production of communications, industrial, and microwave tubes for commercial, industrial, and military markets.

In 1969, under a contract with the Army Electronics Command, the research and development group at Easton developed a new microwave traveling wave tube that allows U.S. missile systems to be battle-strike ready with only 2 seconds of cathode warm-up time. The new tube is regarded as a technological breakthrough since other fast warm-up tubes require at least 15 seconds before delivering full output power. Tests and check-out repeatability show no sacrifice or deterioration of reliability or life in tubes made with these cathodes.

The year witnessed the division's entry into the xenon lamp field with its 1-, 2-, and 20-kilowatt short-arc high-intensity xenon product line. The spectral output of these lamps is close to that of natural daylight and includes a substantial content of infrared and ultraviolet energy. These features are extremely important in military night illumina-

tion applications, but commercial usage is forecast in theater projection systems (replacing the carbon arc), stadium lighting, and large area city-street illumination.

The Easton plant possesses excellent capabilities for the development and production of a full line of high-vacuum power tubes—water-, air-, or vapor-cooled diodes, triodes, and tetrodes. These power tubes have a variety of applications in commercial broadcast transmitters, military communications transmitters, industrial oscillators for induction and dielectric heating, linear accelerators, radar modulators, Loran navigation equipment, and vibration equipment for environmental testing.

Typical of ITT's response to customer needs was the development in 1969 of Type F1091 superpower triode. Tests of the first F1091 prototype at the High Voltage Laboratory of Rome Air Development Center proved that the tube is capable of delivering 40 megawatts of peak power at 1 percent duty. During these tests, the tube also operated at plate voltages of 65,000 volts and at pulse widths of 1,000 microseconds. Another power tube development involved the engineering of the 1086V high-power hard tube modulator which possesses outstanding high voltage hold-off characteristics and secondary grid emission suppression. This tube has excellent applicability in new-generation accelerators requiring high power input as well as pulse coding and shaping capabilities.

ITT Electron Tube Division continued to maintain a prime research and experimental center, the Tube and Sensor Laboratories, in Fort Wayne. The major activity was the design and pilot production of a long line of electrooptical devices with applications in direct-view storage display; image dissection, intensification, and conversion; and image correlation (pattern recognition). Image converters and intensifiers were being used in high-speed and low-light photography, for pulsed light systems, for infrared viewing and surveillance, and for ultraviolet detection.

The Tube and Sensor Laboratories were active in many areas of the electrooptical design field. This facility created the Vidisector and Uvisector (image dissector tubes), which surpass all other camera tubes in resolution capability, linearity, and response speed. These 2 families of magnetically focused and deflected tubes provide a wide spectral response ranging from the ultraviolet to the near infrared. In addition to their high resolution, they offer features such as non-storage, variable raster size, fast turn-on, no thermionic cathode, wide dynamic range, and simplicity and reliability of operation.

Introduced in 1969 was the correlation tube, called the See-Saw® because it compares what it sees with what it saw (a programmed input, for instance) and delivers an electrical signal whose amplitude is a function of the existing degree of corre-

lation. Another model provides an optical readout of the factor of correlation. In bringing out this tube, the Tube and Sensor Laboratories made possible a whole new generation of equipments for pattern recognition, including fingerprint identification and voice matching (verifying credit cards over the telephone by analyzing an applicant's voice).

The year 1969 saw the introduction of the 2-color CRT by the Tube and Sensor Laboratories. This tube, which can be substituted for monochrome CRTs with little or no circuit modification, can display data in 2 separate points of the color spectrum ranging as far apart as yellow and green. The new CRT was designed and produced for applications in medical electronics, airborne cockpit displays, air traffic control consoles, and alphanumeric displays of all kinds.

The research and experimental center was also at work improving the technology of multiplier phototubes for star tracking and laser detection; vacuum photodiodes for scintillation detection high-speed switching; electron multipliers for single-particle counting radiation detection; vacuum monochromators; and demountable vacuum systems.

ITT Gilfillan, Inc.

Receipt of a multimillion-dollar contract to produce long-range tactical surveillance radar systems for the Marine Corps was a major 1969 highlight at ITT Gilfillan, Inc. The ITT subsidiary received the order in April from the Naval Electronic Systems Command, Marine Corps and Amphibious Electronics Division.

Termed AN/TPS-32, the radar provides a unique combination of 3-dimensional accuracy, extensive coverage, high data rate, electronic counter-countermeasures capability, and overall reliability in a transportable tactical system. It can handle a large number of aircraft targets almost simultaneously and give accurate information on their locations in range, azimuth, and altitude.

In the air traffic control radar field, Gilfillan completed and shipped an order for 12 AN/FPN-52 precision approach radar systems during the year. The radars were ordered for naval air stations under a multimillion-dollar contract from the Air Force, which handled procurement and administration for the Naval Electronics Systems Command under an interservice arrangement. The FPN-52 type system, a precision approach radar which assists in landing aircraft under adverse weather conditions, has been in use throughout the world since 1952.

In July, Gilfillan received a \$1,500,000 contract from the Army Electronics Command to produce 28 AN/TPN-18 radars. The TPN-18 is a lightweight, tactical, ground-controlled approach radar which provides landing capability for fixed-wing aircraft and for helicopters in all weather conditions. The

system provides surveillance information for air traffic control and obtains and displays precision height, range, azimuth, and elevation data for purposes of controlling the aircraft along the correct glide path and azimuth approach course line.

Gilfillan continued production of the AN/SPS-48 long-range shipboard radar systems for the Navy: 7 systems were produced during the year. A major research and development effort to develop advanced models of the radar was also continued. The radar provides improved range performance for target designation to the Terrier, Tartar, and Talos missile systems.

Throughout 1969, Gilfillan was engaged in developing a quick-reacting omnidirectional mortar-locating radar for the Army. Termed AN/TPQ-28, it uses computers for almost instant data on target fixes. System tests of an advanced feasibility/development model were being conducted at Yuma Proving Ground, Arizona.

Best known as the builder of more than 90 percent of the free world's military ground-controlled approach radar, Gilfillan also has been a primary supplier of several other types of military radar for years. The company was engaged in 3 principal product areas: air defense radar, air traffic control radar, and combat surveillance radar.

KAISER AEROSPACE & ELECTRONICS CORPORATION

The business of Kaiser Aerospace & Electronics Corporation during 1969 continued to include the production of solid-fuel rocket motor nozzles, machined aircraft structural components, and aircraft precision gears and gear assemblies; the design and production of airborne Kaiser Flite-Path® navigational aids; and the manufacture and installation of community antenna television (CATV) equipment.

The corporation had a backlog of orders totaling \$35,539,647 as of September 30, 1969, as compared with \$32,477,000 on September 30, 1968; the volume of sales in 1969 was about the same as in 1968.

At San Leandro, California, Kaiser was operating one of the most modern numerically controlled machining facilities in the United States, performing work on the F-111 program and the Boeing commercial 727 and 707 aircraft. The San Leandro Plant, winner of the Air Force Zero Defects Achievement Award, was also one of the nation's leading producers of nozzles for major missile programs such as Poseidon, Polaris, Minuteman, and SRAM.

At Palo Alto, California, manufacture of the Kaiser Flite-Path system and the associated Kaiser Radar Data Converter for use by the Navy in the Grumman A-6A aircraft continued. Work was started on a major contract for the design and production of the vertical display adapter group

(VDIG) for the new Navy F-14 aircraft. In addition, there was limited production of other new integrated display systems for use in both military and civilian light aircraft. Considerable research and development work was being accomplished at the Palo Alto plant and it was expected to advance the state of the art significantly in the area of airborne TV displays.

The Embe Gear Plant at Glendale, California, acquired in 1966, continued the manufacture of precision gears and electromechanical systems for the aerospace industry. The Embe Gear Plant was also involved in various production programs related to the fabrication and assembly of anti-intrusion detection devices for the Army.

In Phoenix, Arizona, the company was designing and manufacturing military electronics support equipment. Kaiser CATV Division, also located at Phoenix, was producing CATV equipment for sale in the United States and was installing the equipment under turnkey construction type contracts.

Kaiser Aerospace & Electronics Corporation is a wholly owned subsidiary of Kaiser Industries Corporation.

KAMAN CORPORATION

Kaman Corporation restructured its diversified business into independent market-oriented operations, including the establishment of Kaman Aerospace Corporation as a wholly owned subsidiary with headquarters in Bloomfield, Connecticut, to carry on Kaman's helicopter, airframe component, bearing, and automation businesses. Kaman Sciences Corporation carried on the Kaman business in nuclear and weapons research, oceanography, systems analysis, and other advanced technologies. AirKaman, Inc., the company's participation in general aviation, operated bases at Hartford, Connecticut, Omaha, Nebraska, and Jacksonville, Florida. Corporation sales for the year were projected to be close to \$75,000,000.

KAMAN AEROSPACE CORPORATION

New helicopter designs for the 1970s were the major activity of 1969, marking a turnaround point for Kaman's rotary-wing programs.

Among the designs developed for military and commercial uses was the K-700 medium-size synchropter incorporating the contrarotating, intermeshing rotor system that characterized earlier Kaman service helicopters such as the HH-43B/F, HH-43A, HOK, HUK, and HTK. The K-700, with a gross weight of 11,000 pounds, is a larger and faster, streamlined and twin-engine outgrowth of the Air Force HH-43B/F. Designed as a modern military rescue helicopter, the K-700 will be mar-

keted for commercial applications also, the company announced.

For the Navy LAMPS program, Kaman proposed a twofold approach involving the company's UH-2C Seasprite and a lighter helicopter, SeaLite, which is based on the UH-2 flight dynamics system. For the heavier role, the UH-2 type helicopter is named SeaLamp. SeaLite would fulfill the LAMPS mission on existing destroyers until the Navy takes delivery of new and larger destroyers, at which time either the UH-2C SeaLamp would take over the LAMPS mission or the SeaLite would be continued as the sole LAMPS aircraft. By offering commonality of dynamic systems between SeaLamp and SeaLite, development costs of the LAMPS systems using the Kaman approach would be considerably less than other alternatives.

In gunships, Kaman established 2 programs in 1969: the K-800, a high-speed compound helicopter with stub wings and a pusher propeller, and the K-850, a tandem-seat lightweight gunship.

In addition, deliveries were started on the Navy HH-2C gunship for search and rescue missions. The HH-2C has chin- and waist-mounted machine guns and extensive armor protection. The Navy will deploy the HH-2C from destroyer decks for search and rescue missions in Southeast Asia.

The HH-43F Huskie, which has borne the brunt of air rescue missions in Southeast Asia, continued in limited production.

The UH-2C, twin-engine version of the original single-engine Seasprite, continued to be delivered to the Navy in ever larger numbers. Kaman also received several contracts for overhaul and repair of UH-2A/B/C models.

Rescue systems, a Kaman specialty, moved forward on 3 fronts other than helicopters. A multi-petal bonnet for the company's Sweet Chariot rescue seat was ordered into production by the Air Force, adding another dimension of safety and reliability to the highly successful forest-penetrating rescue system. A mechanical foam Fire-Suppression Kit with a capacity of 1,300 gallons of foam was developed and introduced in 1969 for use at military installations and by civilian fire-fighting forces. Production of the proven 850-gallon Fire-Suppression Kit for rescue helicopters continued.

Under Navy cognizance, Kaman was selected as a prime contractor to develop a prototype flying rescue seat for pilots ejecting from disabled aircraft. Called SAVER (Stowable Aircrew Vehicle Escape Rotoseat), the flying seat is basically a gyroplane with stowable and telescoping rotor blades. The system would enable disabled pilots to avoid detection by the enemy by flying away from the crash scene.

Using the HH-43 Huskie, Kaman conducted programs to reduce noise levels under Army Aviation Material Laboratories' Quiet Helicopter Program. As a production aircraft, the HH-43 is the quietest helicopter in the world, and Kaman will signifi-

cantly reduce the levels further under Army direction.

In other research areas, work continued on Kaman's Controllable Twist Rotor and in the examination of the effects of new materials on rotor-blade dynamics. Other research contracts were received for further work on vibration isolation, misalignment couplings, and drones.

Kaman's diversified subcontracting program was strengthened significantly in 1969 by a contract from Grumman Aerospace Corporation to produce slats, flaps, and spoilers for the Navy F-14 fighter. Kaman continued to deliver flaps, spoilers, and thrust reversers for the C-5, under contract to Lockheed and General Electric; components for the OV-1 and A-6, under contract to Grumman; and components for the DC-8, under contract to McDonnell Douglas.

Plant expansion included a new 60,000-square-foot manufacturing facility in Bloomfield, Connecticut, for C-5 subcontracting programs, a new machine shop in Moosup, Connecticut, and a new office and manufacturing building in Bloomfield to house all Kaman Aerospace Corporation accounting and purchasing functions plus Kaman Automation, a division of Kaman Aerospace engaged in the design and sale of automatic machinery.

Kaman Aerospace's other division, KAcarb Products, expanded its line of bearings for helicopters and fixed-wing aircraft. KAcarb bearings, featuring a ceramic-coated titanium ball running in a carbon race, are used in UH-1, UH-2, AH-1, HH-43, and AB 204 helicopters and are being evaluated for several fixed-wing applications. They feature long life, resistance to corrosion, and self-lubrication.

As part of the company's increased efforts in the helicopter market, significant management realignments were accomplished under Jack G. Anderson, president of Kaman Aerospace, and personnel increases were noted in sales and engineering.

KAMAN SCIENCES CORPORATION

Kaman Sciences Corporation, encompassing Kaman's 4 science and technology businesses, is headquartered at Colorado Springs, Colorado, with offices in Tucson, Arizona; Burlington, Massachusetts; Bethesda, Maryland; and San Marino, California.

Kaman Nuclear continued to concentrate on work for the Department of Defense in theoretical studies and laboratory experiments concerning nuclear weapons, weapons vulnerability and reliability, antennas, and fallout. The company also pursued further development of its unique ceramic material, K-ramic, and new applications for its line of highly sensitive pressure transducers and activation analysis systems.

Other sections of Kaman Sciences worked in oceanography, advance aerodynamics research, systems analysis, and communications reliability.

AIRKAMAN, INC.

AirKaman, Inc., Kaman Corporation's subsidiary in general aviation, operates from 3 bases—in the Northeast, the South, and the Midwest—rendering a national service to business and personal flying. The original AirKaman at Bradley International Airport, serving Hartford and Springfield, AirKaman of Omaha at Eppley Field (this AirKaman facility also serves the industrial airport of Millard, Nebraska), and the recently opened AirKaman of Jacksonville at Jacksonville's new International Airport provide sales, service, and storage for general aviation.

The scope of AirKaman services includes flight school, charter, fuel, maintenance, overhaul, NAV-COM, and Beech and Cessna sales. At Bradley, AirKaman is a franchised dealer in Beechcraft, has a jet maintenance center, and operates a jet charter service. At Omaha, AirKaman is a franchised Beechcraft distributor covering 4 states of the Midwest. AirKaman's new general aviation passenger terminal at Jacksonville is a dramatic fulfillment of the company's promise to give general aviation passengers service equal or superior to that available on the scheduled airlines.

KOLLSMAN INSTRUMENT CORPORATION

Kollsman Instrument Corporation continued in 1969 as the major supplier of air data instrumentation to the commercial airlines and the military services. The year was marked also by rapid development of a growing line of test equipment for both avionic and industrial usage. Kollsman and the Radio Systems Division of Plessey Company Limited implemented a licensing agreement to market, produce, and service one of the British company's aircraft integrated data systems in the United States. Kollsman expanded operations at its Seattle, Washington, facility in line with the agreement. The company found increasing application in military and other nonspace markets for its optical capabilities while still working in the Apollo and Orbiting Astronomical Observatory programs.

Kollsman continued to supply more than 60 different aircraft instruments to McDonnell Douglas Corporation under a \$4,000,000 contract. The instruments are for the DC-8 and DC-9 jet transports.

Kollsman received the first orders for its new Altitude Alert Device from 4 major airlines: TWA, Delta, Eastern, and National. The device, required equipment on all commercial U.S.-registered jet aircraft by February 28, 1971, provides the pilot with audio and visual signals as his plane approaches or departs from a preselected altitude. The signals are presented in sufficient time to permit the pilot to level off the plane at the assigned altitude or to

alert him if he flies the aircraft beyond the assigned level.

The company manufactured altitude reporting equipment for the commercial airlines and developed the Alti-Coder altimeter, which combines altitude indication, an output for automatic altitude reporting, and a signal source for altitude alerting devices. The new altimeter marked the first usage of a brushless encoder in an altimeter. The Federal Aviation Administration proposed that automatic altitude reporting become mandatory for all aircraft operating above 10,000 feet in controlled airspace after January 1, 1973.

The new test equipment included a pressure transfer standard, air data calibrator, TTU-205 test set, altitude encoder tester, programmable pressure generator, and programmable high-power resistive load.

Some of the new test sets, such as the air data calibrator and the pressure transfer standard, contain Kollsman's new resonant frequency transducer, a solid-state, high-accuracy transducer. Tests showed the transducer to be insensitive to inclined attitudes including rotation, shock, vibration, and acceleration.

Kollsman spent 3 years in research and development to produce the transducer and was able to incorporate it in products with military and civilian application.

The licensing agreement with Plessey Company concerns Plessey's PV740 aircraft integrated data system, which meets proposed federal regulations ordering expanded flight data recording capabilities in commercial airplanes. The PV740 also records other flight and engine performance information for detailed analysis of the operation of the aircraft.

Kollsman developed late in 1969 a new precision corrected-altitude system for the executive jet field. Called Karen, the system combines corrected altitude, altitude reporting, and altitude alerting in a dual-channel instrument system with digital display. The system supplies corrections for altitude scale error, altitude reporting code, and the aircraft static system.

Kollsman's Apollo optical equipment was used on all the U.S. manned space flights in 1969. The Optical Unit Assembly, a combination sextant-telescope, was used in navigation of the Apollo 9, 10, 11, and 12 Command Modules. The Alignment Optical Telescope, built by Kollsman to update the Inertial Measurement Unit of the Lunar Modules, was used on the surface of the moon before the lift-off of the Apollo 11 and 12 Lunar Modules.

Kollsman star trackers were employed in the spacecraft attitude control system of the Orbiting Astronomical Observatory (OAO), which concluded a year of continuous operation on December 7, 1969. The star trackers are also employed in the Goddard Experiment Package, a Kollsman-built 38-inch reflecting telescope and spectrometer. The tele-

scope unit was delivered to the Goddard Space Flight Center, Greenbelt, Maryland, in 1969 and may be launched in another OAO in 1970.

Another major highlight of 1969 in the optical field was the first operational use of Kollsman's AN/USQ-28 Photo Mapping and Geodetic Survey System. The Air Force's Aerospace Cartographic and Geodetic Service deployed 2 RC-135A jets and personnel to Brazil in September to begin a 5-year mission to photograph the entire nation with the AN/USQ-28 system.

The heart of the 34-unit system is Kollsman's Geocon IV lens, the world's most accurate aerial lens and the first to be fully corrected for color photography. Kollsman supplied technical assistance and field support for the system in both the United States and Brazil.



Kollsman star trackers, 6 of which help position the Orbiting Astronomical Observatory, demonstrated their reliability by completing a year of operation aboard OAO-2. In photo, one of the trackers is checked out under clean-room conditions.

Kollsman's capabilities were applied in the areas of night-vision equipment and stabilized sights. Deliveries were made in 1969 of a tank periscope housing assembly, an optical alignment periscope for Polaris submarines, and a fire-control telescope for Marine howitzers; and production continued on naval range finders and a weapon sight for an anti-tank missile.

During the year, the Army began field tests of initial quantities of the Kollsman NODLR (Night Observation Device, Long Range), which permits infantrymen to detect targets through smoke or haze and in total darkness.

Kollsman's Delphic II data display system, originally developed for use by the Air Force in radar tracking operations in Alaska, was ordered by a

major New York bank to call up computer-stored economic data for presentation on large screens as 4-color charts. Another variation of the system was installed in November 1969 at the Navy's Barking Sands Underwater Range at Kauai, Hawaii, and was expected to be operational by the end of the year. The system can display the constantly changing trajectories of vehicles and weapons engaged in antisubmarine warfare exercises. The display is in 5 different colors over varied reference charts and background maps.

Kollsman added to its experience in the biomedical field in 1969, beginning development of a gravity-independent infusion device for the Air Force School of Aerospace Medicine at Brooks Air Force Base, San Antonio, Texas. The device is a pressurized flexible plastic container designed for use under battlefield conditions to supply wounded servicemen with needed infusions of blood, plasma, glucose, or other solutions. The device does not have to be held or placed above the wounded man.

LEAR SIEGLER, INC.

During fiscal 1969, Lear Siegler, Inc., continued its pattern of orderly growth by achieving record sales, earnings, and earnings per share. Total sales for the fiscal year ending June 30 were \$586,900,000, up 13 percent over the restated figures for the previous year. Increases of 16 percent in earnings and 15 percent in earnings per share were reported over the prior year's performance. The first-quarter report for the 3 months ending September 30, 1969, indicated a continuing trend.

Approximately \$370,000,000, or 63 percent, of LSI's total sales in fiscal 1969 were to various segments of the growing transportation industry. Commercial airlines, military and general aviation aircraft, helicopters, automobiles, trucks, buses, trains, submarines, spacecraft, and virtually every other means of travel relied to a significant degree on precision instruments and equipment produced by LSI.

Long a leader in military and aerospace avionics and ground-based equipment, LSI's penetration of the commercial aviation market continued through the year with a variety of new products from its divisions associated with the overall aerospace industry.

LSI AVIONICS GROUP

Astek Division

Headquartered at Armonk, New York, the Astek Division of LSI is a leading manufacturer of pressure-sensing and servoed aircraft instruments used for altitude, airspeed, and cabin-pressure control systems. In 1969, the division's products were used

on 64 of the world's airlines; the division supplied approximately 90 percent of the domestic and 85 percent of the world market for overspeed limit sensors.

In addition to producing overspeed limit sensors and digital altimeters for the Boeing 747, Astek Division received an award for a newly developed electronic clock and fault isolation panel for another of the new-generation jet transports, the McDonnell Douglas DC-10.

Called the Airborne Digital Time System, the new clock, which provides a new and better means of time-keeping for airline pilots, is accurate to one second in 200 hours. In addition to providing the pilot with a highly accurate digital display of time, elapsed time, and chronometer functions, the clock generates time signals for use in on-board airborne integrated data systems, flight recorders, and voice recorders.

Added to Astek's line of primary flight instruments in 1969 was a complete line of altimeters with self-contained encoders for automatic reporting of the aircraft's altitude to ground stations. Such digital altimeter-encoders provide the pilot with a continuous display of pressure altitude as well as digitized altitude reporting code.

Although the division's major manufacturing programs were directed toward the commercial and general aviation markets, military applications included such items as the command Mach airspeed indicator for the Navy A-7 light attack aircraft.

Astronics Division

Continuing its leadership in the field of aircraft automatic flight control systems, LSI's Astronics Division enhanced its position in 1969 through significant technical developments and its selection for important programs.

Located adjacent to Santa Monica Airport, Santa Monica, California, the division was developing advanced flight control systems for commercial as well as military aircraft. Two major systems development programs of the division, for the Lockheed TriStar multirange trijet transport and the Navy P-3C long-range patrol aircraft, continued during the year. In addition, the division started a 2-phase study program for NASA's Electronic Research Center to demonstrate improved all-weather landing system performance through the use of inertial navigation system inputs. Following an analytical study to determine relative performance improvements provided by such a system, it was planned to utilize a Federal Aviation Administration Convair 880 equipped with an LSI all-weather landing system to demonstrate the concept.

The division was also selected to provide an improved autopilot automatic approach coupler for a special squadron of Air Force C-135 aircraft. The new coupler will improve performance and allow

automatic coupled approaches under Category II weather conditions.

Continuing its leadership in the development of automatic flight controls for vertical takeoff and landing (VTOL) aircraft, the Astronics Division developed a flight path guidance system that will automatically fly the aircraft down a preselected flight path or profile to a precise landing point. The program was part of an Air Force study of low-visibility VTOL operations. An integral unit of the system is the flight path angle computer developed by the division. Providing the pilot with instantaneous flight path angle, vertical velocity, and angle-of-attack information, the instrument will be of value to pilots of conventional aircraft as well as VTOL craft.

Major continuing production programs at the division included dual flight control systems for the A-7 Corsair II light attack aircraft and flight control systems for the BQM-34 Firebee target drone.

Instrument Division

LSI's contributions to the historic conquest of the moon included 17 instruments manufactured by the Grand Rapids, Michigan-based Instrument Division of Lear Siegler, Inc. Aboard each Apollo Command Module are 2 LSI guidance and navigation computer displays and a Delta velocity display which informs the astronauts of changes in desired speed along the flight path. Fourteen instruments aboard the Lunar Module provide critical information during the descent to the moon and the takeoff. These instruments include attitude director indicators, which provide the astronauts with indications of the spacecraft's attitude in relation to the moon's surface, and instruments used during the critical Lunar Module/Command Module docking.

During the year, the Instrument Division delivered an experimental cockpit instrument panel which could have significant impact on future panel requirements of both military and commercial aircraft. Delivered to the Air Force for installation and evaluation aboard a T-39 trainer, the panel uses a unique all-electroluminescent lighting approach designed to provide an even distribution of instrument panel light. Utilization of the electroluminescent lighting techniques will, in addition to reducing light hot spots, eliminate color shifts that result from changes in lighting intensity.

Included in the major programs of the division were the production of attitude reference and bombing systems for the F-4 aircraft; attitude heading and reference systems for the CH-53 and CH-46 helicopters; and displays, gyros, and gyro systems for a wide range of military and commercial aircraft.

A 1969 addition to the aircraft using the division's products was the S-3A antisubmarine aircraft. The division was providing the S-3A with attitude heading reference systems and the interface for its

inertial navigation system. The attitude heading reference system, consisting of a gyro and computer-converter, is the backup for the carrier-aligned inertial navigation system. The inertial navigation interface system consists of a converter and navigation controller with interface for components of the navigation system and the craft's central computer.

LSI POWER EQUIPMENT GROUP

Power Equipment Division

In the field of electric generating equipment, the LSI Power Equipment Division achieved substantial advances during the year, accounting for over half of the DC generating systems market for commercial and military aircraft applications. The division, located in Maple Heights, Ohio, a suburb of Cleveland, also recorded significant progress in other markets which it serves. For example, during the year, the Power Equipment Division's development of motors for deep-submergence vehicles gained rapid recognition. These motors, through proprietary design characteristics, provide high performance with long life under the severe environment of aqua-space.

Contracts were received for these oil-filled DC motors, which are virtually insensitive to pressure and are to be used in the propulsion systems of 2 deep-submergence vehicles.

Contracts for electromechanical devices, another important area of the Power Equipment Division's activities, were received for Lockheed TriStar and McDonnell Douglas DC-10 applications. Four different applications on the DC-10 will use 15 actuators manufactured by Lear Siegler. One of the 2 applications for the TriStar is the cargo-door actuation system, consisting of a power unit, 2 torque tubes, and 2 outboard gearboxes.

Divisional development programs directed toward lighter-weight, longer-life aircraft electric power generating systems resulted in technical breakthroughs in both AC and DC generator systems. A new generation of AC generators combined with a constant-speed drive and known as an integrated drive (IDG) package makes an approximately 50 percent weight reduction possible. The division will build this type of electric generating system, including 90-KVA generators, generator control units, and bus bar protection panel current transformers and circuit breakers, for the new Lockheed TriStar. Electricity produced by such a system could supply the requirements of 120 average homes.

Another major LSI breakthrough, the development of a brushless DC starter-generator, was achieved during the year. Working in cooperation with RCA under an Air Force-funded program, the division developed power switches which perform the function of brushes and commutators used in conventional DC starter-generators, offering longer life and reduced maintenance for the unit.

The largest value engineering award ever given by the Army Aviation Systems Command was received by the LSI Power Equipment Division in 1969. The award was LSI's share of the savings realized by the Army through use of the division's brushless generators on the CH-47 Chinook helicopter. The new generators provided not only a reduction in unit price but also substantial savings in maintenance and spare parts costs.

Romec Division

One of the leading manufacturers of aerospace hydraulic and pneumatic systems, the Romec Division of LSI produces more lube pumps for jet engines and more fuel boost pumps for helicopters than all other manufacturers combined. The division, located in Elyria, Ohio, also produces a wide range of fluid-handling systems and related equipment for the aerospace and aviation industries.

Contributing to the success of the Apollo program, the division provided test point couplings for the Apollo and environmental control valves for the Lunar Module from the start of the respective programs. The self-sealing, quick-disconnect couplings are used in the pressurization of fuel tanks for checkout and operation of the Lunar Module.

During the year, Romec developed a system, with the U.S. Department of Health, Education, and Welfare, for the dissemination of Dichlorvos chemical in aircraft on international flights. The chemical disinfects the aircraft interior and thereby assists in preventing the spread of disease. The World Health Organization is adopting the LSI system for all new airliners to be used on international flights.

In addition to the division's products for the aerospace, defense, and general aviation markets, Romec was developing and manufacturing fluid-handling components for such new commercial aircraft as the Boeing 747 and supersonic transport, the Lockheed TriStar, and the McDonnell Douglas DC-10.

Transport Dynamics Division

A leader in the field of self-lubricated and metal-to-metal spherical, journal, and rod end bearings, Transport Dynamics manufactures bearings for major commercial and military aircraft as well as for missile and space programs. Primary applications for the division's bearings are related to landing gear, hydraulic actuators, thrust reversers, valves, manual flight controls, and other high-load, low-speed bearing surfaces.

During the year, Transport Dynamics supplied various types of bearings for a wide variety of applications including Boeing 707, 720, 727, 737, and 747 transports and CH-46 and CH-47 assault transport helicopters; McDonnell Douglas DC-8s, DC-9s, and DC-10s; and Lockheed TriStar commercial transports and C-141 and C-5 military transports.

SYSTEMS AND SERVICES GROUP

Cimron Division

LSI's Cimron Division, a pacesetter for sophisticated precision instruments, introduced an entirely new line of digital multimeters in 1969. Included in the line is the San Diego-based division's Model 3903 word generator. Marking a significant first in the industry, the new unit features push-button programming for the digital data simulators used for timing or controlling sequential tests on systems or components.

The division improved its position in the circuit board manufacturing equipment market with its patented Hydro-Squeegee solder-leveling machine. Achieving approximately 80 percent of the market, the automatic machine levels solder and rinses and dries printed circuit boards up to 2 feet square at a rate of 9 feet per minute.

Cimron also made a strong inroad into the fast-developing field of automatic check-out systems for aircraft. In addition to receiving a contract for the development of a new generation of digital multimeters for the Versatile Avionic Shop Test (VAST) program, the division was providing these meters for the Bendix 200 system and as analog to digital converters for systems used on the F-111, EA-6A, and F-104 aircraft.

Component Services Division

LSI's Components Services Division, headquartered in Harrisburg, Pennsylvania, also has facilities at Oklahoma City for instrument and equipment repair and overhaul services on a wide variety of airborne and ground-based systems and components. As one of the largest operations in the country engaged primarily in repair, overhaul, and associated services, the division's activities range from servicing of automatic flight control systems to small parts fabrication.

Although a service organization, the LSI division did develop a portable air data generator designed for testing aircraft static and pilot pressure systems and related instruments. Developed to support the division's altimeter exchange program, the unit meets or exceeds Federal Aviation Administration requirements.

Electronic Instrumentation Division

Through the development of a new common connector bussing technique which reduces present time-consuming electronic wiring practices, the Electronic Instrumentation Division added electronic components to its product line, which includes data acquisition and communication systems and ordnance devices.

During the year, the division carried on continuing programs with NASA, the Army, the Air Force,

and the Navy for telemetry equipment, closed-circuit television, artillery fuzes and booster assemblies, and optical proximity fuzes.

An interesting non-aerospace application of the division's high-precision spaceborne television camera was recorded during the year. Incorporated into an optical system of Kollmorgen Corporation, the LSI camera is used on a Sciaky electron-beam welding machine which is so large that it must be aimed by the television camera.

Hokanson Division

While established as a leader in ground-support air-conditioning equipment for commercial and military aircraft, missiles, and spacecraft, the Hokanson Division also established itself in the aircraft galley and interior furnishings field.

During the year, the division received a contract from United Air Lines for the design and manufacture of the galley units for the upper lounge of the Boeing 747. In a continuing program, the division was manufacturing galleys and interior equipment for the Air Force C-9A aeromedical transport.

Through its basic product line of mobile ground-support air-conditioning systems, the Hokanson Division was supplying equipment for 53 of the world's leading airlines. In addition, it was providing similar units for military aircraft. Included in this type of equipment were ground-support units that provide both electrical power and conditioned air to the electronics bays of aircraft during ground check-out.

During the year, the division provided unusual support to a major aircraft development program. To combat the desert's summer heat during flight tests of the Boeing 747 at Edwards Air Force Base, California, 2 LSI H-65 mobile truck-mounted air conditioners were used to maintain cabin comfort. Combined capacity of the 2 units was 120 tons of refrigeration with a delivered fresh-air flow of over 600 pounds per minute.

Management Services Division

The types of management and technical services offered by the Oklahoma City-based Management Services Division of LSI were increased substantially during the year by the addition of over 210,000 square feet of hangar facilities at Mobile, Alabama. Located at the former Brookley Air Force Base, the division's new facility, consisting of 2 hangars and a smaller utility building, will be used for fixed-base aircraft maintenance and modification operations and for light manufacturing support programs. Initial work at the facility involved rehabilitation of Navy S-2 twin-engine antisubmarine aircraft.

Since 1961, LSI has been a major participant in military programs for aircraft and aerospace systems maintenance. In 1969, the division was carrying out its third successive 3-year contract with the Air

Force for on-site service at some 25 air bases. This type of field-team aircraft and avionic service capability was also being utilized by the U.S. Army for aircraft maintenance and operations services in Southeast Asia and in the United States.

Early in 1969, the Management Services Division completed prototype engineering, kit manufacture, flight check-out, technical data package, and installation of AIMS and Loran systems in an F-101 fighter/reconnaissance aircraft. This installation was a first for the Air Force, and similar systems will be required for all military, civilian, and commercial aircraft in the future. AIMS is an acronym for Air traffic control radar beacon system, Identification friend or foe, Military equipment, Systems. By means of ground interrogation of airborne equipment, AIMS provides air traffic controllers with a fast, automatic means of determining an aircraft's position, identity, and, for the first time, altitude without pilot contact.

LOCKHEED AIRCRAFT CORPORATION

Lockheed Aircraft Corporation in 1969 passed significant development and production milestones in its new advanced-technology L-1011 TriStar jetliner, which marked the company's return to the front ranks of U.S. passenger airplane manufacturers. Lockheed also won the Navy's important S-3A carrier-based antisubmarine patrol plane competition, recorded major progress in several other government programs, and expanded a number of lines of commercial business.

The company began 1969 with a firm backlog of \$4.8 billion. Nearing year-end, it had an all-time-high backlog of \$5.2 billion, of which 50 percent was in commercial orders, chiefly for the L-1011.

Major technical achievements included step-by-step testing of 8 giant C-5 Galaxy heavy logistics transports, the world's largest airplanes; a series of land-based launches of the Poseidon submarine missile; and delivery of operational P-3C Orions, most advanced version of the Navy's land-based antisubmarine patrol plane.

Lockheed's overall areas of interest included—in addition to its traditional market in air vehicles and support—missile and propulsion systems; space systems and orbital vehicles; electronics ranging from communications to radar, control computers, and information systems; housing and construction; ground vehicles; shipbuilding; and overseas operations and investments.

Major assembly work on the L-1011 TriStar started in Burbank and at the new TriStar assembly plant in nearby Palmdale, California, and all major fabrication work was in production. Schedules called for mating of major fuselage sections in January 1970, with complete fuselage mating the following month and first flight late in the year.

The wide-bodied trijet is designed for the world's highest-density travel markets in the decade of the 1970s and beyond. It will carry from 250 to 345 passengers and can use intermediate-size airports. Its 3 Rolls-Royce RB.211 engines, embodying a 3-shaft principle, make improved use of fuel, reducing smoke and noise annoyance. Provisions for passenger comfort outdate previous concepts of airliner luxury.

Late in 1969, Lockheed announced a proposed long-range L-1011 TriStar commercial jetliner capable of serving 95 percent of the world's international route requirements. The new member of the TriStar family retains the basic configuration but will have more powerful Rolls-Royce engines, a larger wing, and a fuselage 40 inches longer. Its range with 260 passengers and 10,000 pounds of cargo will approach 6,000 miles.

In August, the Navy awarded a contract for its new S-3A carrier-based antisubmarine patrol plane to Lockheed in a teaming arrangement with LTV Aerospace Corporation and Sperry Rand Corporation. The compact aircraft will enter service in the 1970s, using an advanced computer-controlled avionic package, an extension of the sophisticated system developed by the Navy for Lockheed's land-based P-3C Orion.

S-3A crews, by using a computer for tactical calculations and routine functions, will be able to make correct antisubmarine warfare decisions at least 10 times more effectively. The S-3A and the P-3C will supplement each other and, together, will provide improved ocean surveillance all over the world. The initial contract, which will provide \$461,000,000 over a 5-year period, was for production of 6 planes, with an option to the Navy to procure 193 production models.

The eighth, and final, C-5 Galaxy logistics transport in the test series completed its first flight in November 1969 and began testing of its paradrop, ground-loading, and delivery systems. Four squadrons of the giant 728,000-pound aircraft were being built for the Military Airlift Command.

The test fleet by the end of October had made almost 300 flights, accumulating over 1,000 hours of flying time and compiling an impressive list of achievements. These included taking on 100,000 pounds of fuel in day and night refueling tests, operating at temperatures ranging from 125 degrees above to 65 degrees below zero, and taking off with an unofficial world record maximum gross weight of 798,200 pounds, 35 tons greater than in standard military operations.

Delivery to the Navy of operational P-3C Orion antisubmarine patrol planes took place on schedule in September. The computer-based A-NEW submarine detection system carried by the new, advanced Orions enables retrieval, transmission, and display of tactical data with unequalled speed and accuracy. About 100 P-3Cs were to be built under

the initial program; delivery rates reached 3 per month in 1969. First assignments were for the Atlantic fleet and assignments were to be made to the Pacific fleet in the mid-1970s.

Logistics transport activities included continued production of the C-130 Hercules and of its commercial derivative, the Lockheed 100, at a rate of 4 per month. The Air Force ordered 15 HC-130Ns, valued at \$33,000,000, for the Aerospace Rescue and Recovery Service, and the government of Iran signed a \$27,600,000 contract for 10 C-130Es. Lockheed at year-end had delivered nearly 1,100 commercial and military Hercules in about 40 versions. They were serving the Air Force, the Navy, the Coast Guard, and the governments of 17 foreign nations.

The number of commercial Hercules cargo craft in operation was raised to 29 when the Flying W Airways purchased 3 Dash 20 models with cargo holds 100 inches longer than the standard Lockheed 100. Flying W in turn leased the planes for oil exploration work in the Alaska North Slope area.

Late in the year, Lockheed announced a Dash 30 version of the Hercules which will increase the cargo compartment by 704 cubic feet, to a total of 6,000 cubic feet. The new version was scheduled to enter service, following Federal Aviation Administration certification, in November 1970; it was to replace the Dash 20 on the production line.

Also in the field of air cargo, the fully automated and mechanized Lockheed 500 cargo-loading simulator attracted wide attention among airlines, shippers, and airport operators. The system demonstrates the rapid loading capabilities being developed for this proposed commercial cargo derivative of the C-5 Galaxy. The Lockheed 500 could be the first civilian cargo aircraft to bring airfreight costs down into competition with surface transport.

The L-500 would carry a 160-ton load at jet speeds over a range of 2,550 nautical miles. It would use most world airports that handle existing jets. As an automobile hauler, it would have a capacity for 58 luxury models, 62 standard-size models, or well over 100 small foreign imports.

The Military Airlift Command in 1969 continued maximum utilization of its fleet of 14 squadrons of Lockheed C-141 StarLifters; the fleet has a capacity of 595,000,000 ton-miles per month. April marked the 25,000th C-141 flight to transit Elmendorf Air Force Base, Alaska, in the 6,000-mile route from the U.S. East Coast to Southeast Asia. Each aircraft carries an average of 50,000 pounds of equipment and supplies.

The Polaris/Poseidon program, one of the free world's major global deterrents and the largest program ever managed by Lockheed, highlighted activities in missiles and propulsion with the firing of the 12th Poseidon test vehicle from a launch pad at Cape Kennedy in November. Scheduled before year-end was another land-based firing and the first firing from the Navy's surface ship, USS *Observation*

Island. Poseidon has double the payload and accuracy of the Polaris A3, which it will succeed as the Navy's fleet ballistic missile. Launch-tube modification started during the year on the first of 31 nuclear submarines due to carry Poseidon. As many as 5 boats will be converted yearly until all are deployed in the mid-1970s. Work continued on modification kits for a fourth Polaris version and on updating of Polaris missiles, including repair, modification, and inventory management.

In August, United Kingdom crews successfully launched a Polaris demonstration and shakedown operations and test vehicle from the submarine HMS *Renown*.

Lockheed's launch escape rocket motors, fortunately not needed, served in the historic flights of Apollos 9, 10, 11, and 12. The Lockheed motors would loft the spacecraft away from danger in event of a booster malfunction during lift-off. Lockheed received a subcontract early in the year for 9 more sets of launch escape motors for use on later Apollo flights.

Another propulsion milestone was achieved in successful inflight firings of the Lockheed-powered solid-propellant short-range attack missile, SRAM, under development for the Air Force. A third highlight in this field was Lockheed's announcement of its tribrid rocket motor, capable of very high specific impulse.

The reliable workhorse of the Air Force and civilian space programs in 1969, as for many years past, was Lockheed's Agena booster and satellite, which has participated in more than half of all U.S. space launches since 1959. Its military uses are classified. Launches for the National Aeronautics and Space Administration were continuing.

In a NASA launch in April, Agena placed NASA's Nimbus 2 weather satellite, fourth in the Nimbus series, in circular earth orbit, 690 miles high. In another NASA launch in the spring, an Agena placed in earth orbit an Orbiting Geophysical Observatory, one of several launched in recent years in NASA's program to explore the earth's near-space environment. Another NASA task planned for Agena was the early 1970 launch of a mercury ion engine in the Space Electric Rocket Test (SERT) program to prove out the new power plant's usefulness for long space missions. Lockheed also designed, developed, and tested SERT's solar array deployment mechanism. In the spring of 1970, an Agena was to launch another Nimbus weather satellite.

In other space activities, Lockheed joined in a teaming arrangement with The Boeing Company to compete for a NASA award for study of a reusable, chemically fueled spacecraft that would fly between earth and low-earth orbit. The space shuttle will consist of a large vehicle to provide initial boost and of a smaller craft that will continue into orbit and perform space missions. Each vehicle, after completing its task, will fly back to an airplane-like landing.

With Boeing providing principal effort for the boost vehicle and main engine integration, Lockheed will lead the study effort on the orbital vehicle and integrated electronics. Tasks will be shared in systems engineering, systems test, and mission operations.

Electronics, a major Lockheed activity, showed significant growth in 1969. The new low-cost multi-applications computer (MAC 16), introduced late in 1968, found wide acceptance in a range of industrial uses, with orders exceeding \$1,000,000 for the first 9 months. In computer storage systems and components, weekly production of ferrite cores reached a record 20,000,000 units and work was advancing on Lockheed's plated wire memory systems.

On their journeys to Mars, NASA's Mariner 6, launched in February, and Mariner 7, launched in March, carried a Lockheed analog and digital tape recorder system. Lockheed's Model 417 portable tape recorder continued to win industrial applications, and production of Lockheed's fully automated oil computer registers remained at a high rate.

Development continued in advanced data recording systems for airlines and military fleets and sales of Lockheed Models 109-C and 109-D flight recorders, introduced as the industry's first recorders 11 years before, passed the 1,900 mark.

Lockheed maintained its 10-year leadership in gunfire control systems and at year-end anticipated a Navy award for production of its Mk 86 system, designed for the Navy. The Mk 86 is the most advanced naval gunfire control system in existence. The expected production award was to be the largest of its kind in Lockheed electronics activities. For the Army, Lockheed manufactured a forward area anti-aircraft radar, an integral part of the Vulcan air defense system.

At year-end, Lockheed was preparing to mark a milestone in its leading position in undersea systems with launch of the first of 2 deep-submergence rescue vehicles (DSRV) being manufactured for the Navy. The craft are designed to rescue crews of disabled submarines from depths as great as 5,000 feet and to be transportable by the Air Force in Lockheed C-141 jet transports. When commissioned, the DSRV and its associated system will be able to start rescue operations almost anywhere in the world within 24 hours. After being flown to a port near an accident, the DSRV will be carried piggyback on another submarine to the precise site at sea, where it will dive to the disabled sub, attach to its hatch, and take crewmen aboard, 24 at a time.

The *Deep Quest* research submarine, funded and built by Lockheed, won national notice early in the year when it successfully recovered, after other attempts failed, the flight recorders of 2 passenger airliners that went down in the ocean several miles off the southern California coast.

Studies progressed in another important undersea system program placed with Lockheed by the Navy, the deep submergence search vehicle (DSSV), which

is to be capable of descending 20,000 feet to locate and recover small objects. DSSV will be able to submerge with a 4-man crew for up to 40 hours.

Lockheed during 1969 maintained its position as a leading aircraft maintenance and modification company, performing reworks on C-130s, C-121s, C-135s, and other types of aircraft for special military missions; providing worldwide support of Air Force, Army, Navy, and NASA aircraft at domestic and overseas bases; and completing over 8,000 on-time turnaround service deliveries of commercial airliners at its Kennedy International Airport maintenance facility.

Lockheed continued as maintenance manager of the U.S. Air Force/German Air Force F-104 advanced fighter pilot training program at Luke Air Force Base, marking its 100,000th flight hour and graduating its 360th student on or ahead of schedule.

Significant progress was made in low-cost housing. At year-end, more than 1,200 houses, apartments, and schools utilizing Lockheed's patented Panel Lock housing systems had been built, were under construction, or were on order in the United States and abroad.

Highlighting Lockheed activity in land vehicles was the roll-out at midyear of the first of 3 Army test versions of Lockheed's Twister, followed a few months later by the other 2. All 3 began Army shakedown tests and evaluations for military applications. Like the original Twister, the Army versions have 2 bodies joined by a pivotal yoke that allows them to flex freely. Each body has 4 wheels powered by an engine in that body, providing the complete vehicle with 8-wheel drive and enabling it to maintain ground contact at all times. The vehicle's suspension and articulation improve traction for high-speed operation and protect the driver and the crew from the severe jolts of a cross-country run.

Another Lockheed land vehicle, the go-anywhere TerraStar amphibian, successfully passed rigorous Army tests. Lockheed built an auxiliary locomotion system for the Army's 105-millimeter howitzer using the TerraStar concept. The company also designed a civilian production model of TerraStar to meet the needs of mineral exploration and other firms for a sturdy vehicle that operates equally well on hard surfaces, mud, or swamplands and in open water.

Lockheed's JetStar, first of the corporate, or business, jets and still the only one with 4 engines, marked a milestone during the year when 9 of the planes passed the 5,000-hour mark of inflight service each. Eight of the 9 were in Air Force use, bearing the C-140 designation. The ninth was the Lockheed-owned corporate JetStar, based in the Midwest, which had the highest commercial utilization. Six of the C-140s were assigned to the Military Airlift Command and were based at Andrews Air Force Base, Washington, D.C., where they provided priority transportation for Presidential cabinet and staff members and other top government officials.

More than 137 JetStars were in service, including 2 used by a major airline for inflight training of pilots of large passenger transports, freeing the airliners for revenue service.

Lockheed made significant progress in its information systems work in 3 areas of specialization: systems for hospital records, aids for educational systems, and aid to state and local governments. A 15-hour course for junior and senior high school students, giving the students facts on drugs and placing them in roles as decision makers in a simulated narcotics crisis, won widespread use. The curriculum package includes a 3-hour color movie-animation segment produced for Lockheed by a major motion picture studio. Work was completed under several contracts calling for installation of systems for hospital business offices, culminating in a complete system that, for the first time, links business data with data for the doctor, nurse, pharmacy, dietary specialist, and patient. This system, in El Camino Hospital on the San Francisco peninsula, was to be fully operational early in 1970. Other work included cost-savings studies for several state and local governments.

Lockheed released details late in the year of a quiet observation airplane, the YO-3A, developed for the Army Aviation Systems Command. It is an outgrowth of the silent-flying Q-Star, which was designed, built, and tested by Lockheed before receiving the Army award. The YO-3A is powered by a 6-cylinder engine turning a 6-bladed wooden propeller. A large plastic canopy gives the 2-man crew excellent visibility. Adapted from the Schweizer SGS 2-32 sailplane, the 30-foot-long craft has an unusually wide wingspread of 57 feet and requires relatively little power to stay aloft on flights of long duration.

In the field of information storage and retrieval, the European Space Research Organization, a 10-nation technical body based in Paris, started use of a Lockheed-developed system using computer terminals for scientific searches through 500,000 technical references. Lockheed developed the system for NASA and 1969 marked the start of its use by 7 centers of the U.S. space agency. A total of 40 to 50 terminals eventually will link most of the major space facilities around the nation to the computer file, which includes research findings from a great variety of fields that bear on man's exploration of space. Design of the system was based on Dialog, an information retrieval computer language originated by Lockheed.

Lockheed's Seattle shipyard operations in 1969 included delivery to the Navy of the 300-ton *Plainview* research hydrofoil, built of aluminum and largest vessel of its type, and several conventional ship completions and overhauls. The DE-1057 *Rathburne*, first of 5 destroyer escorts of this class being built for the Navy, was launched in May. Keel for the second vessel was laid in January. The second of 7

landing platform docks being built passed its sea trials; a third was to be delivered by year-end.

One of the largest projects undertaken by Lockheed since it entered the heavy construction field in 1959 was the \$19,300,000 award in March from southern California's Metropolitan Water District. The work consists of a tunnel over 5 miles long, one of the final links in an extensive system to bring water from northern to southern California. In April, Lockheed won a \$6,000,000 award for construction of a dam in southwest Washington. Lockheed also completed in 1969, 4 months ahead of schedule, its part in the Belden power project for the Pacific Gas & Electric Company, driving 2 15-foot concrete-lined finished tunnels for a total length of 6.5 miles at the Feather River in northern California.

Although the Army terminated its letter contract for production of the AH-56A Cheyenne helicopter in 1969, Lockheed continued work under a research and development contract to verify the rigid-rotor compound helicopter concept, prove the value of the Cheyenne's advanced fire-control and armament system, and establish specifications for a production version.

A typical activity of Lockheed's group of international companies was the licensing of a Japanese manufacturer to build 46 Lockheed P-2J Neptunes for the Japan Air Defense; the first aircraft was delivered late in the year. Work continued on an extensive aircraft maintenance program for the Royal Saudi Arabian Air Force. Also in 1969, Lockheed provided aerospace research laboratories for the combined military services of the Republic of China (Taiwan). Other investments included electronics assembly operations in Hong Kong and manufacture of arc-welding equipment in Mexico, a finance company in Australia, a tin mine in Bolivia, and a manufacturer of aircraft, ships, and motorcycles in Italy. Lockheed maintained customer service and marketing representatives worldwide.

In August, Lockheed established a subsidiary, Lockheed Offshore Petroleum Services, Ltd., in Vancouver, British Columbia, to provide services to the world's offshore oil industry. Work began on a prototype system off the southern California coast that will be evaluated for capability to pump oil from water depths as great as 1,200 feet; late in the year, several oil companies agreed to join Lockheed in sharing costs of the tests. Economic feasibility of earlier methods is limited to about 400-foot depths. The Lockheed system is designed to make accessible vast new undersea oil reserves.

Management changes announced late in the year included the retirement of L. Eugene Root, who was succeeded as group vice president and president of Lockheed Missiles & Space Company by Stan W. Burriss. Executive Vice President M. Carl Haddon, retiring in January 1970, was to be succeeded by William B. Rieke. Year-end employment was 99,200.

LTV AEROSPACE CORPORATION

A SUBSIDIARY OF LING-TEMCO-VOUGHT, INC.

LTV Aerospace Corporation, one of the nation's largest producers of aviation and space hardware and systems, began a reorganization and announced creation of 3 publicly held subsidiary businesses in late 1969.

The company also continued its move into diversified fields, ranging from its nationally known aircraft/missile capability to adult education and training programs, commercial utility vehicles, educational television, publishing, recreational area operation, and other programs still under development.

The corporation, its operations reaching throughout most of the world, is headquartered in the LTV Tower in downtown Dallas, Texas. President and chief executive officer is Paul Thayer.

Under the reorganization plan announced in September and effected in December, Vought Aeronautics Corporation was formed from the Vought Aeronautics Division, becoming the largest subsidiary of LTV Aerospace. (Vought Helicopter Incorporated, formation of which was announced in 1969, was to operate as a wholly owned subsidiary of Vought Aeronautics Corporation.) Vought Aeronautics traces its history back 52 years through its predecessor company, Chance Vought Aircraft.

Synetics Incorporated was formed from existing elements of LTV Aerospace having common business interests: Missiles and Space Division; the division's newly created Kinetics International Division at Tyler, Texas; and Kentron Hawaii, Ltd., a wholly owned subsidiary.

LTV Education Systems, Inc., continued as a wholly owned subsidiary of LTV Aerospace, as it had been since it entered business in January 1969.

Additionally, LTV Aerospace Corporation entered into an agreement to purchase the Mt. Werner ski area at Steamboat Springs, Colorado, and announced plans to develop it into a leading year-round recreational area. The facility, located 160 miles northwest of Denver, will be operated as a division of LTV Aerospace.

The Vought Aeronautics A-7 Corsair II series of aircraft continued to prove its battleworthiness with the Navy in Vietnam during 1969, and later versions rolling from the assembly lines went into service with the Navy and the Air Force.

The first Air Force A-7D tactical fighter, a follow-on version of the A-7A and A-7B with a higher-thrust Allison/Rolls-Royce TF41 engine and a highly advanced avionics system, was delivered to the Tactical Air Command September 1. Production of the A-7B aircraft for the Navy was completed.

An even newer version in the series, the A-7E, was delivered to the Navy in 1969 and it successfully completed carrier-suitability trials in October aboard the USS *Independence*.

Each version of the Vought A-7 is capable of

carrying virtually every air-to-ground weapon in the Air Force/Navy arsenal. In addition, the A-7 can defend itself with air-to-air missiles and rapid-fire cannon. The A-7D and A-7E incorporate such advanced avionics as the head-up display, computerized weapon delivery and navigation systems, and forward-looking radar.

Accuracy in weapons delivery with the A-7 has been unparalleled. Vought expected to build some 1,600 A-7s before the program is completed.

Vought was officially notified by the Swiss government that the A-7 light attack aircraft was selected as one of 2 finalists in a competition to choose a new aircraft for the Swiss armed forces. The final winner was to be announced in 1970 with delivery to begin in 1973. The program was expected to reach \$300,000,000.

Vought Aeronautics continued to remanufacture 395 of its famed F-8 Crusader fighter series aircraft, modernizing the B, C, D, and E aircraft as well as the RF-8A.

Returning to the Grand Prairie, Texas, plant for remanufacture in 1969 was RF-8A No. 144608, a photographic model flown in 1957 by then Marine Major John H. Glenn, Jr., in setting several records for supersonic flight from Los Angeles to New York. The famous Crusader emerged as a new RF-8G and returned to the fleet.

The Vought F-8 Crusader remained the fastest single-engine Navy fighter in the world and continued making a mark for itself as a MiG killer. The F-8 retained its record, with more than half the Navy victories over MiGs in the Vietnam war. Crusader operational commitments extended well into the 1970s.

Vought also received a contract from the French Navy for 10 new wing structures to extend the service life of F-8E (FN) Crusaders built for France in 1964-65.

As a subcontractor to The Boeing Company, Vought Aeronautics was building the empennage and aft body section for the 747 transport. Under a similar arrangement, Vought began fabricating the horizontal stabilizers for the McDonnell Douglas DC-10. Vought also will build the aft body section for the Boeing SST.

The team of Vought and Lockheed-California was named winner August 1 in a competition to build the S-3A (formerly VSX) antisubmarine warfare aircraft for the Navy. Under the research and development contract, Lockheed will be prime contractor on the program and Vought will be responsible for the aircraft's carrier suitability.

Vought expected to build the wings, engine mount pods, aft fuselage system, landing gear, tail assemblies, and all control surfaces. The contract gave the Navy the option to procure 193 production models of the S-3A.

In July 1969, Vought Aeronautics entered into an agreement with Sud-Aviation of Paris to market and

service the Alouette II, the Alouette III, and the semirigid-rotor SA-341 helicopter through a new subsidiary, Vought Helicopter Incorporated.

The Alouette II is a 5-place, turbine-powered helicopter capable of carrying loads up to 1,700 pounds and of operating above 14,000 feet. The 7-place, turbine-powered Alouette III helicopter, capable of lifting useful loads of over 2,000 pounds, flies at speeds in excess of 130 miles an hour. It can hover above 20,000 feet. The new SA-341 features a semirigid main rotor and ducted fan in lieu of a tail rotor. It carries a useful load of over 1,700 pounds and flies at speeds above 160 miles an hour.

Vought Helicopter Incorporated immediately began assembly operations, with major components being flown in from France. At year-end, Vought's Alouette helicopters were being demonstrated to commercial operators in North America, including Canada and Alaska.

In other areas, Vought Aeronautics participated with General Electric in the development of a tracked air-cushion research vehicle for the U.S. Department of Transportation. The vehicle was being designed to travel on a thin cushion of air along a guideway at speeds up to 300 miles an hour in high-traffic-density areas between cities.

Synetics Incorporated, under the reorganization plan, was furnished a scope of activities extending from outer space to the ocean depths.

The Missiles and Space Division is composed of an ultramodern million-plus-square-foot manufacturing, laboratory, and headquarters complex at Dallas and a 2,000,000-square-foot Michigan Facility near Detroit.

In the space field, the division's 4-stage, solid-propellant Scout continued a successful string of launches for NASA, for agencies of the Department of Defense, and for a number of foreign nations, bringing to 67 the number of missions in the vehicle's 10-year history.

Included in the year's activities were the launchings of the third satellite for the 10-member European Space Research Organization and of Germany's first satellite, Azur. Continuing a performance growth program which enabled Scout to triple its payload capability in the decade of the sixties, the division had under development a larger Algol III first stage designed to increase the vehicle's payload capability by another 30 to 40 percent. In addition, a standard fifth stage was developed to make possible highly elliptical deep-space orbits and to extend the Scout's probe capabilities to the sun.

In the Apollo program, a unique company-developed space radiator system, which provides the proper temperature for the astronauts and their equipment inside the Command Module, operated flawlessly in the lunar missions, as it had in every flight since it was introduced on Apollo 7.

Man got his first closeup look at the moon's harsh surface through the division's Lunar Extravehicular

Visor Assembly helmet which provided optical protection and helped maintain thermal balance inside the space suit. The company's Space Environment Simulator provided thermal analyses and other data on the Apollo suit and the portable protective life-support system and contributed toward design of longer-duration surface systems of the future.

The lunar missions also made use of manned lunar landing and return studies conducted by the company at the outset of the Apollo program, and the astronauts drew on mission planning and training experiences in the division's Manned Aerospace Flight Simulator. The company also conducted spacecraft thermal analyses for all Apollo missions using company-developed computer routines and real-time monitoring by company personnel.

In missile activities, the division's Michigan Facility took the Army's Lance surface-to-surface missile a step nearer production with successful temperature-extreme environmental tests and successful firings of extended-range versions of the system. The highly mobile general-support weapon is the first Army missile to use prepackaged storable liquid propellants and a simplified inertial guidance and control system. It will permit the Army to direct accurate fire at long distances on such targets as enemy troop concentrations, supply depots, and transportation routes, quickly and accurately. Advanced testing was under way at White Sands Missile Range.

The Missiles and Space Division was also actively engaged in the fields of advanced defense systems, ducted rockets and ramjet systems, optical and other guidance systems, radar technology, and other advanced programs.

In the new products field, the division developed the unique ORBIS III traffic-monitoring device which can detect illegal speeds automatically around the clock. It records, in a single photograph, citation-type evidence such as the vehicle involved, license plate and driver, location, time and date, posted speed, and vehicle speed. It ignores vehicles within legal limits. The unit is designed in both permanently installed and mobile models. It can also be used for traffic evaluation and highway planning, marketing and recreation area surveys, border patrol surveillance, stolen car detection, and numerous other applications.

Continuing its expansion program, the division added 186,000 square feet to its headquarters facilities dedicated in 1968. Included were an additional shipping dock area, expanded paint facilities, and enlargement of the manufacturing warehouse area.

Kinetics International Division was established during the year, following a company decision to begin production of the KID multipurpose tractor-transporter surface vehicle and establishment of a 100,000-square-foot production site at Tyler, Texas. The small, 8-wheeled utility vehicle was extensively tested and demonstrated in Southeast Asia. There

its unique ability to cross extremely rugged terrain, to plow muddy rice paddies too soft even for water buffalo, and to swim canals and water barriers earned high praise from government officials, agriculture experts, and businessmen and resulted in sufficient orders to warrant production. A troop-support model called the MACV (Multipurpose Air-mobile Combat-support Vehicle) also was available to the military.

In addition to fulfilling overseas commitments, Kinetics planned to market the vehicle in the United States to industries operating in remote areas, to government agencies, and to farmers and sportsmen. The first pilot production model was scheduled to roll off the automated production line in December. The Tyler facility also will serve as headquarters for the development of other surface vehicles.

Kentron Hawaii, Ltd., continued to provide extensive services to U.S. government agencies and commercial corporations throughout the Pacific and Southeast Asia. The Honolulu-headquartered subsidiary maintained its position as the predominant technical contractor in the Pacific for support of national ranges. It also was a leading contractor in 1969 in the fields of telecommunications, logistics and base-support programs, engineering and technical support, electronic test equipment, calibration and repair, depot level maintenance, computer data services, analysis and management processing, technical training programs, and oceanology projects.

The versatile service organization continued its growth pattern in 1969 with the acquisition of American Asian International, Inc., a Saigon-based company engaged in architecture, engineering projects, and skills training in South Vietnam.

At the beginning of the year, LTV Aerospace formed a wholly owned subsidiary in a field far removed from military contracting: education. LTV Education Systems, Inc., entered business in January with a skills training and management development group and 3 commercial business colleges. By the end of the year, several other acquisitions had been completed and the college group had grown to 15 institutions in 3 southwestern states.

In September, Education Systems took a big step along the road toward broad diversification by acquiring a publishing company, an education-oriented electronics company, and a firm which builds student furniture.

The new publishing subsidiary issues a monthly teen-age magazine, *Metro Beat*, in the Dallas and Atlanta markets. Both are locally edited. The first Dallas issue appeared in November.

Aboussie Electronics is experienced in the design, installation, and programming of classroom television systems. The acquisition marked LTV ESI's entry into the field of programmed instruction and educational technology.

Guild Industries, the third acquired firm, is de-

signer and manufacturer of educational electronics enclosures, school study cubicles, and related student furniture. Guild sells its products throughout the United States and in 63 foreign countries.

LTV Aerospace began discussions in August for the possible sale of its interest in Computer Technology, Inc. The discussions were still continuing in November.

LTV ELECTROSYSTEMS, INC.

A SUBSIDIARY OF LING-TEMCO-VOUGHT, INC.

LTV Electrosystems, Inc., made significant advances in electronic systems development throughout 1969, strengthened its management structure and realigned its operating units, and added facilities and capabilities.

Further advances were made at the Memcor Division in developing lightweight, portable TACAN transponder beacon systems. In production for the Air Force was the AN/TRN-26, about one-fifth the size and weight of any previous system. It incorporates antennas, transponders, test-monitor-control, and auxiliary equipment. Each module in the system weighs under 100 pounds and can be transported by a 2-man crew. Introduced and demonstrated during the year was the AN/TRN-22, light enough and small enough to be carried by one man. Tested in conjunction with the British Royal Air Force, the unit was demonstrated in the London Daily Mail Transatlantic Air Race.

Memcor Division continued production of the AN/VRC-12 series of vehicle-mounted tactical radios for the Army under a multiyear procurement which reached a total of \$97,100,000 during the year. The AN/PRC-25 backpack radios were still in production at year-end and more than 83,000 of the lightweight modular FM radios had been delivered.

At the Garland Division, design and development of a mechanized mail-handling system for the U.S. Post Office Department promised major advances in speeding and simplifying the handling and sorting of mail. Utilizing some equipment already installed at key post offices and adding other equipment and special computer programs, machine sorting of up to 50,000 letters an hour appeared feasible. Work on the project was continuing under a \$3,200,000 contract from the Post Office Department.

Garland Division began delivery of AN/UYA-7 digital communication systems under a \$2,000,000 Air Force contract. Combining the proven advantages of digital transceiving equipment with Electrosystems-developed refinements—solid state compactness, automation, ease of operation, sophisticated package design—the system represents a major advance in digital communications technology.

Garland Division achieved a position of leadership in production of giant parabolic satellite communications antenna systems. In the last quarter of 1969, 4 100-foot-diameter dish antenna systems were in various stages of completion in Alaska, Spain, Guam, and Iran. Systems had been completed in Panama, Lebanon, Brazil, and Peru.

New technology in the field of automatic flight controls led to development of a fly-by-wire actuation system, Electro-RAM, at Garland Division's Arlington, Texas, facility. Replacing the manual and mechanical systems for controlling an aircraft in flight with direct electrical linkage between the pilot's controls and actuation devices, the system provides increased performance, better handling characteristics, and greater safety. Production continued on automatic controls for commercial airliners, including "feel" systems for the Boeing 727, 737, and 747 and the Lockheed L-1011.

Greenville Division developed and delivered to NASA a system for the earth resources survey installed in a C-130 transport. It included sensors which scan the electromagnetic spectrum from ultraviolet through infrared to superhigh frequency. The system also included closed-circuit TV, radiation thermometers, and other equipment linked to recorders and data handling devices and/or monitoring stations within the aircraft. With such aircraft, scientists can benefit mankind by discovering mineral sources, detecting crop diseases, finding fish, and checking on pollution.

The division demonstrated its 6.5-kilowatt airborne zoom light at the Paris Air Show and at various overseas points where simulated riots and disasters illustrated the value of using a helicopter-mounted light source. Airborne lighting systems produced at the division included a variety of arrangements of light banks, varying from the 6.5-kilowatt to a single-lamp 70-kilowatt system.

Greenville Division continued into the second year the procurement on IRAN of F/RF-101 aircraft at its Donaldson, South Carolina, plant and began production operations at its Roswell, New Mexico, plant on portable communications shelters, rework on B-52 bomber engine parts, and refitting commercial airliners.

Realignment of operating units included the sale of the Courter Operations (Boyer City, Michigan) of Memcor Division and the Continental Electronics Manufacturing Company, located in Dallas. Pickard & Burns Electronics Division at Waltham, Massachusetts, was established as a division of LTV Electrosystems. It had been operated previously as part of Continental Electronics. LTV Electrosystems also established a new division at Greenville, Texas, separate from the existing operations there. This division will specialize in heavy aircraft modification and maintenance for airlines and will be devoted exclusively to commercial operations.

Construction of new facilities continued at a swift

pace throughout the year at several facilities. A multisensor test facility, completed at the Greenville Division, provided the capability for accurate testing of a wide variety of sensors, antennas, and communication and avionics systems. A 64,000-square-foot engineering and administration building and a 32,500-square-foot addition to the main hangar were also completed.

A 48,000-square-foot addition doubled the size of the Memcor Division's Montek Operation in Salt Lake City. The Memcor Division increased its capability for production of backpack and vehicle-mounted tactical field radios with the completion of a 20,000-square-foot manufacturing building in Peru, Indiana.

A 60,000-square-foot manufacturing and administration building was completed at the Arlington, Texas, plant, adding considerably to the capability for production of automatic flight control systems for both military and commercial aircraft and of thrust vector controls for the Minuteman and Sprint missiles.

MARTIN MARIETTA CORPORATION

BALTIMORE DIVISION

Martin Marietta's Baltimore Division is a major aircraft modification and production center. During 1969, the Production Center moved into production phases of the Navy's ZAP, a hypervelocity solid-fuel rocket, and General Electric awarded the division a contract to build thrust reversers for the CF6 turbofan engine. The center was also manufacturing control surfaces for the McDonnell Douglas DC-10 and was providing tooling and some components for the Lockheed L-1011.

Several modification programs for both military and civilian users were being carried out by the Baltimore Division Modification Center. Military programs included work on the B-57 under the Tropic Moon project and side stick control kits for the F-104. Under contract to Texas Instruments, the center was engaged in AWADS (Adverse Weather Aerial Delivery System).

The Air Transport Association's collision avoidance system test and evaluation program was being conducted by the Modification Center. During the year, 3 collision avoidance systems were installed and tested for the association.

DENVER DIVISION

A major milestone for Martin Marietta in 1969 was the selection of the Denver Division as prime contractor for the Viking project. Viking is the space agency's unmanned exploration mission to land 2 scientific spacecraft on Mars in search of information relevant to life on the planet. Viking could also

provide clues to the creation and evolution of the solar system.

The contract designated Martin Marietta integrating contractor for the Viking project. It called for the Denver Division to design, build, and test the Viking landers and to develop, test, and integrate the life-seeking instruments and scientific experiments.

Two instrumented Viking spacecraft—each consisting of a lander and an orbiter—will begin a 200-day, 280,000,000-mile journey to Mars in 1975. They will be launched approximately 10 days apart by a Titan III/Centaur space booster.

In addition to the most important objective of seeking out evidence of biological activity on the planet's surface, Viking will be equipped to determine the atmospheric structure and composition of Mars, to transmit pictures of the Martian surface, and to determine surface composition.

Project management for Viking was assigned to NASA's Langley Research Center, Hampton, Virginia, under the overall direction of the Office of Space Science and Applications at NASA headquarters. The Jet Propulsion Laboratory, Pasadena, California, is responsible for the orbiter portion of the Viking spacecraft system and for tracking and data acquisition during the mission. The Titan III/Centaur launch vehicle to be used for Viking will be managed by NASA's Lewis Research Center, Cleveland.

Another significant advancement made by the Denver Division in the planetary exploration field was its selection by Jet Propulsion Laboratory to build the propulsion subsystem for 2 Mariner spacecraft designed for a scientific mission around Mars in 1971. The propulsion subsystem, unlike that flown on any previous spacecraft in the continuing series of Mariner planetary exploration missions, will have a multiple-start capability. The subsystem includes a liquid-fueled rocket engine which will provide the thrust to make the necessary midcourse trajectory corrections en route to Mars and to de-boost the spacecraft into Martian orbit. Additionally, slight changes in the orbits of the 2 spacecraft will occur upon command from earth.

Launch period for the Mariners will open in May 1971, with arrival at the planet in November 1971. The spacecraft will be in the 2,000-pound class, of which some 900 pounds will be used for propellants. The Mariners will conduct a scientific investigation of Mars for about 90 days.

The new space support building, most recent element in the division's space complex, became fully operational in October. The 6-story structure, with a capacity of 1,250 persons, will be the focal point for the final assembly of the Viking capsule lander system. The first 2 floors of the SSB offer a total of 54,000 square feet of superclean assembly area, the largest combined clean-room facility in the industry. A portion of the clean-room area was being used to

assemble the propulsion subassemblies for the Mars '71 spacecraft.

At midyear, construction began on a solar simulator to be incorporated into a 31-foot-diameter thermal vacuum chamber at the division's space center. Main components of the solar simulator are a 23-foot-diameter mirror and an array of 19 arc lamps of 20,000 watts each. The lamps are focused onto a special optical transmission system which beams the refracted light onto a giant mirror in the top of the large space chamber. The mirror, in turn, reflects a 16-foot-diameter beam of solar radiation adjusted optically to simulate the solar intensity that all vehicles will encounter in space.

The National Aeronautics and Space Administration's decision in mid-1969 to change the Apollo Applications Program (AAP) from a wet to a dry configuration called for major changes in the division's role as payload integrating contractor. The move from a space-outfitted orbiting workshop configuration to a ground-outfitted configuration required relocation of 28 experiments in the launch configuration and of the operating areas of 16 experiments.

A major milestone in the AAP effort was a contract add-on from Marshall Space Flight Center to develop the Multiple Docking Adapter (MDA) flight hardware for the orbiting workshop configuration. The division will initially develop an MDA mock-up locating various types of service equipment—life-support, electrical, and hydraulic systems—plus various experiments packages. The division will also be responsible for interface of the MDA with the Airlock Module and the Apollo Telescope Mount (ATM). The division was already under contract to provide the controls and displays console which will control the ATM. The console will be located in the MDA.

Primary objectives of the AAP are a concentrated study of the sun and the earth from earth orbit and of man in zero gravity. The ATM will accomplish the solar study with a series of 8 experiments; and an experiment housed in the MDA will look at the earth, utilizing a battery of 6 cameras to simultaneously photograph the earth in multispectral imagery. A total of approximately 50 experiments must be integrated into the AAP cluster.

Other advanced technological studies under way at the Denver Division included:

- Development of a manned maneuvering unit to provide both increased mobility for man in space and a basis for development of more sophisticated maneuvering units which might provide remote maneuvering capability for free-flying experiments modules functioning around a mother spacecraft.
- Preparation of an optical contamination experiment flight hardware to investigate the phenomena of surface contamination of optical surfaces exposed in space. A variety of optical surfaces will be precisely calibrated as to optical properties before the

AAP flight and returned to earth following the mission to aid in determination of the causes and possible solutions to the optical contamination problem.

- Development of Apollo Lunar Surface Drill flight hardware for a subsurface lunar geothermal experiment to be flown on Apollo 13. The lunar drill is used to emplace 2 heat-flow probes in the moon to transmit subsurface soil thermal characteristics back to earth. In addition, the drill is used to obtain a core of the subsurface lunar geology to be returned to earth for study.

- Studies of the techniques and technology of remote sensing equipment as applied to interpretation of both earth and planetary resources. To this end, the division in 1969 started work on a program to identify geological features that are observable from airborne systems. Once an area is overflown with sensors, the same area is examined by classical geological methods in order to zero out errors in the sensing exploration.

The meteoroid penetration detector development project, which began in 1967, was completed in 1969. The work centered on determining the feasibility of attaching meteoroid detectors to the exterior of the Saturn S-IVB stage and on developing a radiation-resistant thermal-control coating material for spacecraft.

Work under this project included the design, development, fabrication, and test of various types of detectors which could be used to provide data about the characteristics of the meteoroid environment and meteoroid penetration in space. The information is critical to the design of deep space manned and unmanned spacecraft.

The division's involvement in planetary exploration was also concentrated on 2 other fronts. One was a study to determine the feasibility of exploring Venus with an unmanned spacecraft designed to eject small instrument probes to the surface. The 6-month study focused on the number and types of probes, the entry locations, and the capabilities and technology development necessary for various entry systems best suited to achieve the scientific objectives of the 1979 Venus mission opportunity. The second involved in-house studies to identify the most promising unmanned missions to the outer planets such as Jupiter and for the grand tour of Jupiter, Saturn, Uranus, and Pluto.

Other advanced research and development and space-related studies under way at Denver included:

- An automatic component test station program to design a system for testing large scale array integrated circuits.

- A microfilm storage display system capable of containing the equivalent of 3,000 pages of paper documentation. The unit is an important element in on-board check-out systems for future spacecraft.

- In-tankage development studies of the storage and transfer of liquid methane for future spacecraft and supersonic transport aircraft.

- Investigations of the radiation environment affecting vehicles entering the planetary atmospheres of earth, Mars, Venus, and Jupiter.

- Development of a new attitude control system designed to reduce costs, increase reliability, and reduce weight.

- Development of a white pigment that has stable radiative properties in the ionizing and displacement-type radiation environments of near-earth and interplanetary space.

- Development of instrumentation to monitor the deployment and measure the profile accuracy of an orbiting low-frequency radio telescope (LOFT). This project, targeted toward the mid-1970s, was to result in a 1,500-meter radio telescope outside the earth's radiation belt.

Major production base of the division continued to be versions of the Titan III family of launch vehicles. Successful flight operations were conducted at Cape Kennedy, Florida, and Vandenberg Air Force Base, California, with launches of both the Titan IIIC and the Titan IIIB.

Development and fabrication of Titan IIID progressed as scheduled. In addition, plans were made to integrate the Titan IIID with the Centaur high-energy upper stage for planetary exploration missions. Launch stand modification and conversion began at Cape Kennedy and at Vandenberg Air Force Base to handle the Titan IIID/Centaur and the Titan IIID, respectively. At the same time, study on a space shuttle system proceeded, resulting in a proposed configuration and preliminary wind-tunnel tests of a scale model.

ORLANDO DIVISION

In 1969, Martin Marietta's Orlando Division continued work on 4 major tactical missile systems: the Army's Pershing, SAM-D, and Sprint and the Navy's Walleye. Work was concluded on the Army's Shillelagh antitank missile.

During the year, the division received a go-ahead from the Army to build 30 additional subscriber units and one retransmission unit for tests of the RADA tactical communication system. RADA is a mobile, wireless digital communication system that provides secure division-level field communications without central switchboards. The system was planned for deployment in the 1973-74 time period.

The Orlando Division continued to supply system components and logistic field support for the Navy's air-to-surface Bullpup missile system and for the Army's BIRDIE electronic fire-control system.

A 40-pound millimeter wave hardware experiment was completed and delivered to NASA for launch aboard the ATS-5 satellite, in synchronous orbit over the Pacific. The unit transmits and receives millimeter wave signals from ground stations located throughout the United States and Canada. The Orlando Division also continued its work for

NASA on the control signal processor, a critical flight component used on the Apollo/Saturn launch vehicle, and on gyro processors for the Apollo Telescope Mount program.

Development work continued on lasers for tactical application: illuminators, seekers, and target designation and missile guidance systems. Some of this equipment was already undergoing extensive military field test and evaluation; other systems were in development. Major emphasis was directed toward improving the efficiency, output, and adaptability of lasers for field use; one program of particular importance was aimed at developing eye-safe lasers for the military.

Another research program of considerable interest involved the application of "particle-reference" devices to inertial guidance equipment. These devices use a dust-size glass particle suspended in an electrical field to provide inertial reference for new types of accelerometers, gyroscopes, and gravity meters.



Martin Marietta's Orlando Division was conducting a research program involving the application of "particle reference" devices to inertial guidance equipment. These devices employ a tiny glass ball suspended in an electrical field to provide inertial reference for new types of accelerometers, gyroscopes, and gravity meters.

Improved ground-support equipment for the Pershing system was in full production in 1969. Included in the Pershing 1-A system, as the program is known, are several changes to the equipment used in counting down and launching the missile. The most visible change is the switch from tracked to wheeled vehicles for transporting firing units. Increased mobility and reliability, less vibration, lower

maintenance costs, and increased rate of fire result from the improvement program. Other major Pershing 1-A system advances are a new programmer test station, a fast-reacting erector-launcher, and a new battery control center to serve as a unit command post.

By year-end, some Pershing units had already been converted to the new PI-A system, replacing the original PI version mounted on track-laying vehicles. The older version had been deployed in Europe since 1964.

Annual practice test firings from off-range missile sites in southeastern Utah into White Sands Missile Range, New Mexico, continued. These exercises are designed to maintain troop proficiency in handling the 400-mile-range Pershing missile.

Development work on the Sprint antimissile missile, one of the major components of the Safeguard ballistic missile defense system, continued under a contract with Bell Telephone Laboratories. Flight testing continued at White Sands Missile Range, and later tests were scheduled for Kwajalein Atoll in the Pacific, where Sprint will be integrated with other elements of the Safeguard system.

Production continued on the Walleye glide bomb and on transmitting and launching equipment for the Bullpup air-to-surface missile. (Bullpup was operational with both Navy and Air Force fighter aircraft and with aircraft of the NATO nations. The Navy's Walleye, a highly accurate television-guided weapon with no propulsion, was operational with both Navy and Air Force fighter units.)

During the year, Martin Marietta announced plans to build a high-volume electronics production facility near Ocala, Florida. The plant was scheduled to be completed in early 1970.

MARTIN METALS

Martin Metals produces investment castings and is engaged in the research, development, and production of high-temperature superalloys. These alloys, many containing as many as 10 to 15 different elements, must withstand the 2,000 degree Fahrenheit temperatures and highly corrosive environments and pressures of advanced jet engines.

During 1969, MAR-M alloys were serving jet power requirements in vehicular, marine, and industrial power plants throughout the world and were being incorporated into experimental engines for future power needs.

Martin Metals' vacuum-melted investment cast turbine blades and vanes are in use in jet engines such as Pratt & Whitney Aircraft's JT3D. P&WA's JT9D engine has Martin Metals castings in the blades of the second, third, fourth, and sixth stages. Other engines containing Martin Metals parts included the Pratt & Whitney Aircraft JT12, J52, JT8D, TF30, and FT4 and the General Electric TF39.

During 1969, much of the technical effort was devoted to a Ductility Improvement Discovery (D.I.D.), a method whereby the somewhat limited ductility of present-day superalloys can be significantly increased with no loss in tensile and stress rupture strength. The increasing demand for higher-strength alloys has, over the years, resulted in a compromise in ductility. With Martin Metals' D.I.D., turbine components of many alloys can be used for a longer time before being retired for lack of ductility.

RESEARCH INSTITUTE FOR ADVANCED STUDIES

The Research Institute for Advanced Studies (RIAS) near Baltimore City performs basic research in solid-state physics, chemical physics, fluid sciences, structural mechanics, materials science, and biosciences. Its work is funded by Martin Marietta Corporation and by contracts with various U.S. government agencies, including the Air Force, the Army, the Navy, the Advanced Research Projects Agency, the Atomic Energy Commission, the Department of the Interior, and the National Aeronautics and Space Administration. The institute staff also provides consultation services to other divisions of Martin Marietta Corporation on contractual programs.

During 1969, RIAS had approximately 50 professional staff members; more than half of them held doctorates. This staff included scientists from many foreign countries as well as from the United States and was augmented by visitors from universities and other research centers who presented seminars or participated in regular RIAS research programs. Results of RIAS research are published in the leading science journals and in symposia papers.

The physics groups carried out research on metastable compounds, radiation damage, space thermal protective coatings, and electronic band structures and bonding in intermetallic compounds. Research into the physical mechanisms involved in the decomposition of high-energy crystals suggested techniques for modifying and controlling the decomposition rate of these compounds, some of which are used as explosives and solid rocket oxidizers in operational missile systems.

A Semiconductor Physics Department was formed in 1969 and work was begun in the area of optically active defects and dopants in wide band gap semiconductors, using methods of electron spin resonance and photoluminescence. These studies are relevant to performance of both optically and electrically generated light signal systems.

The fluid sciences group continued its programs in hypersonic blunt body aerodynamics, 3-dimensional laminar boundary layers, and low-speed lifting aerodynamics. Emphasis in these external aerodynamics programs was on those aspects peculiar to truly 3-dimensional flow.

This group also conducted studies of unsteady boundary layer transition, local disturbances in viscous flow and development of vorticity, launch vehicle structural stability (POGO), and radiative heat transfer from dynamic gases.

The RIAS materials science group continued its refractory carbide studies. Titanium carbide and vanadium carbide, and their alloys, were investigated in a combined theoretical and experimental program that encompasses electron microscopy, mechanical behavior, bonding, and ordered structural studies. This program is intended to provide structural materials with combined ductility and high-temperature strength surpassing any materials used today. The group also continued its work dealing with surface-sensitive environmental effects on material behavior of many structurally important metals, such as titanium, aluminum, and ionic non-metallic compounds. These materials may become embrittled and fracture under relatively low stresses in selected environments. Objectives included elucidation of the mechanism of this type of failure (stress corrosion), means for preventing embrittlement, and effects on deformation properties.

Studies were begun on metal-matrix composite materials. Factors basic to the behavior of fiber-reinforced metals and to dispersion strengthening with the very stable hard carbides were being investigated.

Under a NASA contract, the RIAS biosciences group continued research on an extraterrestrial life detection experiment. The technique rests on the detection, by mass spectrometry, of the enzyme-catalyzed exchange of oxygen-18 between water and labeled oxyanions. This exchange appears to be common to all forms of observed life.

The RIAS extraterrestrial experiment is heat sterilizable and makes minimal assumptions about the nutritional requirements of organisms that might be found on other planets. In 1969, this work concentrated on simplifying the detection procedure, increasing the number of applicable oxyanions, and continuing laboratory studies to verify the concept.

Work in photosynthesis—seeking a better understanding of the mechanism by which living plants convert light energy to chemical energy—provided considerable insight into the mechanisms and kinetics of the processes involved in the photooxidation of H₂O to produce O₂ evolution and reducing equivalents. The nature of the quantum processes involved and the requirement of a manganese-containing catalyst were revealed.

Chemosynthesis research centered on the cultivation of a hydrogen-oxidizing microorganism and studies of its potential contribution to a closed ecological system, such as a manned spacecraft on an extended voyage. Various energy sources were evaluated by the biosciences group and a system can now be defined.

McDONNELL DOUGLAS CORPORATION

During 1969, McDonnell Douglas Corporation, St. Louis, Missouri, worked on more than 20 separate product and service programs, each generating over \$10,000,000 in sales. Six generated over \$100,000,000.

The DC-10 program moved ahead with the receipt of additional orders for this trijetliner and the start of production and assembly. Orders and firm options for the new wide-bodied jet transport reached 201 with the announcement on October 14 that National Airlines had placed orders for 9, with options for 8 more. National was the 10th airline to select the DC-10.

Earlier in the year, Overseas National Airways purchased 3 DC-10F convertible passenger/cargo versions, with options for 3 more. This first order for the DC-10F was announced on June 17.

On June 7, 4 European carriers announced in Paris their decision to order the DC-10. KLM Royal Dutch Airlines, Scandinavian Airlines System, Swissair, and France's Union de Transports Aeriens placed orders for 14 Series 30 intercontinental versions, with options for an additional 22.

Other DC-10 customers included American Airlines, orders for 25 and options for 25; United Air Lines, 30 on order and 30 optioned; Northwest Orient Airlines, 14 ordered and 14 optioned; and Trans International Airlines, 2 on order and 2 on option.

The DC-10, a multirange advanced-technology jetliner designed to meet the expanding air transportation needs of the 1970s, was to be produced in 3 versions, each capable of accommodating up to 345 passengers.

The Series 10 is designed for service on domestic routes of 300 to 3,500 statute miles. The Series 20 and Series 30 are extended-range models for intercontinental operations. Maximum gross takeoff weight of the Series 10, with full payload, is 410,000 pounds. For the Series 20 and Series 30, it is 530,000 pounds.

Three high bypass ratio engines give the DC-10 a cruising speed of over 600 miles per hour. The General Electric CF6-6 engine, rated at 40,000 pounds of takeoff thrust, is the power plant for the Series 10. Power plant for the Series 20 is the Pratt & Whitney Aircraft JT9D-17 engine, producing 49,800 pounds of takeoff thrust. The Series 30 is equipped with the General Electric CF6-50A engine, generating 49,000 pounds of takeoff thrust.

Two of the engines are mounted conventionally on pylons under the wing, and the third is installed above the aft fuselage at the base of the vertical stabilizer. The engines are approximately 8 feet in diameter, nearly double the size of those on earlier commercial jets.

The first DC-10 manufacturing operations began on January 6, less than 9 months after the go-ahead

for the program. Chips flying from an automatic milling machine as it processed an 800-pound aluminum forging into a DC-10 windshield frame signaled this production milestone at the Douglas Aircraft Company's Torrance, California, facility.

Initial assembly operations started on June 23 at the McDonnell Douglas facility in Santa Monica, California, with the installation of a special gold-plated fastener as the first step in assembling a cockpit window frame.

The upper and lower halves of the first DC-10 production nose section were joined October 17 at Santa Monica, with the unit scheduled for subsequent transfer to Douglas at Long Beach, where final assembly of the big jet was to be performed.

During the year, the pace of DC-10 development accelerated at other McDonnell Douglas divisions and at the facilities of the hundreds of experienced, reliable subcontractors in the United States, Canada, and Europe.

In addition to the Douglas Aircraft Company at Long Beach and Torrance and the McDonnell Douglas Astronautics Company at Santa Monica, McDonnell Douglas divisions with major roles in the program were the McDonnell Aircraft Company, St. Louis, which designed and developed the wing and was producing certain control surface components, and the Douglas Aircraft Company of Canada, Ltd., a McDonnell Douglas subsidiary in Malton, Ontario, which was manufacturing the wing structure.

Other significant events in the DC-10 program during the year were the start of construction of 3 facilities in Long Beach for use in engineering, production, and flight training activities.

Work began in January on a 250,000-square-foot engineering development center capable of accommodating 3 DC-10s. The complex provides the company with a single integrated facility for flight, structural, and systems test programs; engineering development activities; and related technical research on large commercial aircraft. The structure is 300 feet long and 344 feet wide, with an attached 3-story laboratory and office building to house research and computer facilities.

Also under construction was a final assembly building 510 feet long and 480 feet wide, with a roof height of 94 feet. In the final stages of production, 6 DC-10s will be housed in this building. In addition to assembly operations, the structure will house a 4-story support area with space for stock rooms, offices, and administrative activities. A 20,000-square-foot center will be located on one floor for training airline personnel in the operation and maintenance of DC-10 systems. Initial assembly, including the joining of the wings and fuselage and the installation of major systems, will be performed in existing facilities at Long Beach.

In October, ground was broken for a 21,000-square-foot advanced flight training center which

McDonnell Douglas will lease from Flight Safety, Inc., for the training of DC-10 crews. This Douglas Flight Crew Training Center will house a \$2,600,000 DC-10 simulator with a 6-axis-of-motion capability. The simulator was built for Flight Safety by Conduccion Corporation, St. Charles, Missouri, a McDonnell Douglas subsidiary. The center will enable the company to consolidate all of its ground and flight training activities in connection with the DC-8 and DC-9 jet transport programs as well as the DC-10 program.

While moving ahead with the DC-10 program, McDonnell Douglas continued the steady production of its 4-engine DC-8 jetliner and its short- to medium-range DC-9 twin-jet. During the first 3 quarters of the year, the company delivered 67 DC-8s and 100 DC-9s. Through October 15, orders for a total of 617 DC-9s had been received, of which 529 had been delivered. DC-8 orders totaled 554, with 490 delivered.



McDonnell Douglas Corporation marked a milestone on May 27 with delivery of the 500th DC-9. By year-end, deliveries had topped the 530 mark and the company had orders for more than 600 of the twin-jets.

The DC-9, ordered by 42 airlines in Europe, Asia, Australia, South America, and North America, was in production in 3 versions: the Series 20, which carries up to 90 passengers in a 104-foot-long fuselage, for flights from very short runways; the Series 30, which carries 115 passengers in a 119-foot-long fuselage; and the Series 40, which accommodates up to 125 passengers in a 125-foot fuselage.

Three versions of the DC-8 Super Sixty series were in production: the Super 61 transcontinental jetliner, the Super 62 ultralong-range transport, and the Super 63 intercontinental model. The Super 61 and Super 63 carry up to 259 passengers in an all-coach configuration. Thirty-nine airlines had ordered the DC-8 by year-end.

On August 22, the company delivered its 1,000th commercial jet transport, a DC-8 Super 63F version.

The jetliner was delivered to Trans International Airlines just 9 days short of the 10th anniversary of the Federal Aviation Administration's certification of the DC-8 for commercial operation on August 31, 1959. Another milestone in the company's commercial aircraft history occurred on May 27, when the 500th DC-9, a sleek Series 30 model, was delivered to Allegheny Airlines.

In military aviation, the Douglas division of McDonnell Douglas delivered its first contingent of TA-4J trainers on June 6, turning over 7 of the new, 2-place advanced jets to the Naval Air Advanced Training Command. In September, Navy flight students inaugurated carrier qualifications with the TA-4J aboard the USS *Wasp* in the Gulf of Mexico.

The TA-4J is the newest trainer version in the bantamweight Skyhawk family which, in the attack bomber version, is being procured by the Navy in the improvement A-4M single-seat attack model for use by the Marine Corps. More than 2,300 Skyhawks of all versions have been produced by the company for carrier operations and for close air support missions. Skyhawk deliveries to the Navy during the year also included versions for use by Israel and New Zealand.

Production of the C-9A aeromedical airlift transport for the Military Airlift Command of the Air Force continued at Long Beach. By the end of the third quarter, 8 of these "flying hospital wards" had been delivered to transport sick or wounded military personnel on flights between medical facilities in the United States. Designated the Nightingale, the C-9A is a military version of the DC-9 Series 30 and will accommodate more than 40 ambulatory patients, 30 to 40 litter patients, or a combination of ambulatory and litter patients.

During 1969, the McDonnell Aircraft Company in St. Louis continued to upgrade, produce, and deliver F-4 Phantoms and by year-end had delivered more than 3,600.

On March 27, 1969, the Air Force Aeronautical Systems Division awarded McDonnell a contract to build 50 boron epoxy rudders for the Phantom, the largest quantity order ever issued for the production of boron composite structures. This award recognized McDonnell's leadership in the development of advanced structural materials required in the design of future fighter aircraft.

In July, McDonnell received a 3-year contract from the Air Force Flight Dynamics Laboratory to develop and test-fly a flight control system designed to be more maneuverable and less vulnerable to combat damage than present systems. Using an F-4 Phantom as a test vehicle, the company was to evaluate fly-by-wire control and integrated hydraulic actuator devices at each control surface for greater maneuverability and survivability in air-to-air combat. Electric signals, rather than rods or mechanical devices, relay the pilot's inputs to control surface actuators.

International use of the Phantom was extended when, in December 1968, West Germany announced that it would purchase 88 RF-4E reconnaissance aircraft and the U.S. Department of State announced that Israel would purchase a quantity of F-4Es. These purchases, like those of the United Kingdom, Iran, and Japan, were made through arrangement with the U.S. government.

A ceremony turning over 6 F-4D tactical fighters to the Republic of Korea Air Force was held on August 25 at Seoul. These were the first of a squadron of 18 being provided by the United States under the U.S. Military Assistance Program.

The year 1969 saw the Phantom establish another record. In May, British Royal Navy F-4K Phantoms broke the New York-to-London air speed record 3 times within a week in winning the London Daily Mail Transatlantic Air Race. The fastest time, take-off to touchdown, was 4 hours 46 minutes 57.6 seconds.

Also in 1969, the Phantom became the official aircraft of both of the world's 2 best-known flight demonstration teams, the U.S. Navy Blue Angels and the U.S. Air Force Thunderbirds. This marked the first time in the history of these precision flying units that both flew the same type of aircraft at the same time. It also represented their parallel transition to Mach 2 aircraft. The Blue Angels made their debut flying F-4Js at Yuma, Arizona, on March 15, and the Thunderbirds, flying F-4Es, appeared before President Nixon on June 4 at the Air Force Academy in Colorado.

McDonnell was active in other areas during the year. In March, a special team of McDonnell and American Airlines pilots and engineers began a 3-month STOL flight program using the Model 188 STOL transport, for which McDonnell holds a license agreement with Breguet Aviation of France. On April 16, a 40-flight-hour test program, flying in and out of city-center-to-city-center type STOL-ports, was inaugurated to evaluate STOL aircraft characteristics and 3 advanced navigational systems. Much of the evaluation flying was done in the St. Louis-Chicago area. This was the second Model 188 demonstration program with a major airline. Late in 1968, the company completed a joint project with Eastern Airlines, in which a Model 188 operated into New York, Washington, Boston, and Newark on routes paralleling the air shuttles in the Northeast Corridor.

The No. 1 project for McDonnell Aircraft Company during the year, however, was the Air Force F-15 tactical fighter contract. On December 31, 1968, McDonnell, which has been designing and building twin-engine jet fighter aircraft longer than any other company, was selected as a finalist for the contract definition phase of the competition, along with Fairchild Hiller Corporation and North American Rockwell Corporation. Throughout the year, top engineering, management, and production

personnel devoted their full time and energies to this important task.

In the space field, the highlight of McDonnell Douglas activities during 1969 was the major role the organization played in the successful manned Apollo missions. McDonnell Douglas Astronautics Company produced the S-IVB stage of the powerful Saturn rocket which propelled the Apollo 11 astronauts to their rendezvous with the moon and man's first walk on the lunar surface and which operated flawlessly on 3 other manned space missions in 1969.

As part of its work in the Apollo program, McDonnell Douglas shared in the lunar surface samples returned to earth by the Apollo 11 astronauts. Scientists at the company's space and planetary sciences laboratories in Santa Monica received about 1 ounce of assorted powder and rock chips for analysis to determine the luminescence, microphysical, microchemical, and adhesive characteristics of the material. McDonnell Douglas Astronautics Company was one of the few industrial firms in the nation to participate in the lunar sample analysis program.

During the year, the company received space contracts from the National Aeronautics and Space Administration for Saturn launch support services at the John F. Kennedy Space Center, and for work on the Saturn V workshop and its Airlock Module. One award was to modify an S-IVB stage for use as a workshop, scheduled for launch into earth orbit in 1972 as part of the Apollo Applications Program. Another was for continued development of the airlock which will serve as a passageway between Apollo spacecraft and the workshop and as the nerve center for all subsystem controls and monitoring. Airlock development was under way at company facilities in St. Louis.

A 3-man crew will inhabit the 10,000-cubic-foot interior of the S-IVB liquid-hydrogen tank for a scheduled 28 days during the first mission, and for 56 days during later missions. The S-IVB will be fully outfitted on the ground and will be launched, with an Apollo Telescope Mount attached, by a 2-stage Saturn V. The purpose of the workshop program is to conduct biomedical, astronomical, and other scientific programs.

During the year, the Astronautics Company delivered an 8-ton airlock to NASA's Marshall Space Flight Center for extensive ground testing there and subsequently at NASA's Manned Spacecraft Center to qualify it for use on the workshop mission. Work on modification of an S-IVB for use as the first Saturn V workshop was under way at the company's Space Systems Center in Huntington Beach, California.

Another major space project for NASA was a study of a future manned space station which could reach flight status in the mid-1970s. McDonnell Douglas was one of 2 industrial firms selected to

conduct the 11-month program definition studies. The Marshall Space Flight Center directs the company's effort in the preliminary design and planning of a 12-man space station which could be developed by 1975 for earth-orbital purposes. The project includes the conceptual design of a 50-man space base to be made up of specialized modules assembled in low-earth orbit in the late 1970s and early 1980s. Various concepts of advanced space shuttles, which would be capable of landing at precise locations and of being reused, were to be evaluated to identify the most economical means of supplying a large space base.

Launch vehicle projects at McDonnell Douglas included the continuing production of the Thor and Delta rockets for placing medium-weight satellites in earth and solar orbits.

Used extensively by the Air Force and NASA for 12 years, Thor recorded in August 1969 its 300th success as a space launch vehicle. Combined with a variety of upper stages, Thor at year-end had placed more U.S. satellites in orbit than all other boosters combined.

Thors were the first stages of the vehicles which orbited an advanced Nimbus weather satellite and the OGO-F spacecraft from the Western Test Range during the year. Aboard OGO-F was a company experiment designed to identify, count, and determine the energies of solar-charged particles emitted by the sun during solar cosmic ray events. Thor was also the booster stage of the Delta vehicles which orbited 2 Orbiting Solar Observatories, ISIS-A, 2 Intelsat communications satellites, Explorer 41 (IMP-7), BIOS 3, and the ESSA 9 weather satellite during 1969.

McDonnell Douglas Astronautics Company continued to produce the Long Tank Thor version at its facility in Santa Monica for launch by the Air Force from Vandenberg Air Force Base and by the National Aeronautics and Space Administration from both the Eastern and Western Test Ranges.

Upgrading of the Delta to increase its weight-to-orbit capability continued during the year. The new Delta Super Six launch vehicle, with 6 solid-propellant rockets clustered around the base of the first stage instead of the customary 3, was announced. The change adds 150,000 pounds of usable thrust to the 330,000 pounds the vehicle generates during lift-off. With this added lift-off power, the Delta Super Six is able to orbit more sophisticated applications satellites that require more and heavier equipment for such activities as earth resources scanning and infrared weather survey photography.

In the area of space research, McDonnell Douglas Astronautics Company received a NASA contract to conduct a 3-month test of a 4-man regenerative life-support system in the company's space station simulator at Huntington Beach in 1970. A crew of 4, confined in the simulator for the 90-day period—much like astronauts in a space station in orbit—

was to maintain the equipment, monitor its performance, and repair it if required. The goal of the experiment is to demonstrate the capability to operate the system with continuous regeneration of water and oxygen, without resupply, using an advanced waste-management subsystem. The new experiment follows a successful company test in 1968, during which 4 men spent 60 days in the simulator.

Other significant space research contracts awarded to McDonnell Douglas Astronautics in 1969 included a study, for NASA's Marshall Space Flight Center, of design concepts and development requirements for a nuclear rocket stage which could serve as an upper stage on a Saturn V launch vehicle. Two other firms received parallel awards. NASA also awarded the Astronautics Company a contract to study earth-orbital experiment requirements including manned space flight capabilities, space medicine and biology, space astronomy, space physics, communications and navigation, and earth resources survey.

In the missile field, McDonnell Douglas Astronautics Company continued its work on the Spartan long-range interceptor of the Safeguard ballistic missile defense system. The company is a major subcontractor to Bell Telephone Laboratories and Western Electric Company on this program. Work also continued on the Project Upstage experimental missile configuration under a contract awarded by the Advanced Research Projects Agency of the Department of Defense to design, develop, and flight-test the configuration.

Other missile and space programs included research in solar physics, materials, reentry, biotechnology, and electronics. One project was a study at the company's Astropower Laboratories to determine whether computer technology can be used to detect the onset of an epileptic seizure. This work was being done under contract from the Social and Rehabilitation Service of the U.S. Department of Health, Education, and Welfare. Other areas of Astropower research included pattern recognition, materials, and desalination of seawater.

At the company's Donald W. Douglas Laboratories, scientists and engineers were continuing development of 2 tiny atomic batteries, the ISOMITE and the BETACEL; of miniature engines which one day may power heart-assist devices; and of heat pipes for use in spacecraft cooling systems.

Major fields of research at the corporation's Douglas Advanced Research Laboratories include mathematical sciences, environmental sciences, life sciences, and materials sciences. During the year, international symposia on acoustical holography, lunar transients, and laser applications in the geosciences were held at the Huntington Beach facility of McDonnell Douglas Corporation.

Throughout the year, the corporation's McDonnell Automation Company division continued to expand its activities. In February, it expanded data

processing marketing services in its Denver regional office area with the addition of a Control Data Corporation 6400 computer. This unit permits businesses to use their own small computers to communicate, via telephone lines, directly with the 6400. In addition, the installation of a Conversational Inventory Management System in the company's Denver facilities makes it possible for large and small businesses to obtain inventory information within seconds by using a typewriter-like terminal in their own offices.

In March, at the company's St. Louis facilities, the most powerful computer available for commercial data processing became operational when an IBM System 360 Model 65/75 ASP system began transmitting data relayed to it from more than 3 dozen smaller computers and terminals located throughout the nation.

Other developments included entering, in July, into a cooperative effort with Atomic Power Development Inc. of Detroit to develop and market a wide range of nuclear fuel management computer programs for the electric utility industry. These programs will provide long-range consulting and engineer training to utilities that use the company's nuclear fuel management programs. In August, the company entered the microfilm processing field with a computerized microfilming service to help control the paper explosion generated by high-speed computer printers. In September, under contract to the Southern Pacific Company of San Francisco, the company announced the development of a computer system for use by the nation's railroads. This system will permit rapid route selection and clearance of unusually large or heavy loads.

During 1969, the corporation continued to develop its EROS collision avoidance system. On May 14, the first of 3 EROS II test units was made available to the Air Transport Association for a flight evaluation program. EROS II is the second generation of the system that has been operational on more than 14,000 F-4 Phantom test flights in the St. Louis area since October 1965. EROS II, which was designed to perform to specifications established by the Air Transport Association, was publicly demonstrated at Glenn L. Martin Airport, Baltimore, Maryland, on September 23 as part of a test program that began in June.

Finally, in 1969, as part of the JOBS program of the National Alliance of Businessmen, the corporation conducted, for the second successive summer, a 10-week summer training employment program for needy high school students in the St. Louis area. James S. McDonnell, chairman and chief executive officer, is a member of NAB's National Executive Board and chairman of the 10-state Region VII, dedicated to finding permanent jobs for the hardcore unemployed. In both St. Louis and Los Angeles, the corporation was working actively to aid the disadvantaged.

MENASCO MANUFACTURING COMPANY

Menasco observed its 35th anniversary of incorporation in 1969. Originally a manufacturer of aircraft engines, the company began production of aircraft landing gear in 1940 and in 1969 landing gear was Menasco's major product. During the year, Menasco retained its position as the largest volume producer of landing gear in the United States.

Menasco's experience and expertise in shock mitigation were recognized in 1969 in the award of 4 research and development contracts for military shock isolation. These were outgrowths of work previously done in designing and producing shock isolators for Polaris missiles and for Minuteman missile sites.

Two other spin-offs of Menasco's basic technology, for the transportation industry, reached final development in 1969. A railroad draft gear was accepted for production and sale by the Association of American Railroads and an automotive bumper shock mount system was successfully introduced.

Menasco invested a record \$4,003,000 in new plant and equipment for its 2 producing divisions, in Burbank, California, and Fort Worth, Texas. This completed a 4-year capital expansion program to provide the capability to design and produce any size or type of landing gear or shock isolator currently planned or projected.

Early in 1969, Menasco's \$87,500,000 contract with Lockheed for design and production of L-1011 TriStar main and nose landing gear was augmented with a contract for installation of wheels, brakes, and retraction actuators, giving Menasco system responsibility for the L-1011 landing gear, which is being produced by the Texas Division.

Menasco was selected by Grumman Aerospace Corporation to produce main and nose landing gear for the Gulfstream II jet transport, increasing Menasco's share of the corporate jet market.

Successful completion of a 14-month production program was realized when, early in 1969, the California Division made first delivery of bogie beams for the Lockheed C-5 jet transport ahead of schedule. This was followed by award of a \$14,000,000 follow-on contract for 69 additional shipsets of bogie beams, the major components of the landing gear for the giant plane.

In March, Menasco contracted with Electro Hydraulics Ltd. of Warrington, England, to produce hydraulic components for the L-1011 landing gear. In August, Menasco purchased a 49 percent interest in Jarry Precision Ltd. of Montreal, Canada, a manufacturer of numerical, hydraulic, and tracermatic controlled machine tools; aircraft and automotive stampings; and aircraft components.

During 1969, Menasco participated in the following programs: the Bell UH-1B helicopter; the Boeing B-52, 707, 720, 727, and 737 aircraft and CH-46A helicopter; the General Dynamics F-111A, FB-111, F-102, F-106, and B-58; the Grumman Gulfstream

II; the LTV A-7A and F-8U; the Lockheed L-1011 TriStar, C-5, C-130, C-141, P-3, and JetStar; and the McDonnell Douglas DC-9 and F-4K.

The backlog of orders for landing gear and related aerospace components was \$143,000,000 at the close of the first quarter of the 1970 fiscal year (September 30).

Financial results for the fiscal year ending June 30, 1969, made the year the second most successful in Menasco's history. Shipments were \$42,825,125, earnings were \$2,656,648, or \$1.60 per share on average shares outstanding, and corporate assets were \$31,333,000.

President Gerald J. Lynch activated an Automotive Products Division in August and appointed Vice President Arthur C. Haines, former Ford Motor Company executive, as general manager. Vice President John J. Paige, formerly corporate director of manufacturing, was appointed to succeed Haines as general manager of the California Division and Vice President Jay K. Palmer, formerly corporate director of sales, was named assistant general manager.

George H. Whitney, partner in the law firm Gibson, Dunn, and Crutcher, and Cyril C. Nigg, director of Sunshine Biscuits, Inc., were elected directors of Menasco, succeeding Herbert F. Sturdy, deceased, and Thomas J. Bannan, who had resigned.

Relations with organized labor in both Menasco plants remained excellent. In September, the Texas Division signed a contract with members of the International Association of Machinists and Aerospace Workers which will continue to September 1972.

NORTH AMERICAN ROCKWELL CORPORATION

Editor's Note: While the organizational terminology herein is accurate for calendar year 1969, the AEROSPACE YEAR BOOK was informed early in 1970 of a change in the North American Rockwell corporate structure. The Aerospace & Systems Group was eliminated and the 5 divisions formerly within the group report directly to the corporate executive vice president, effective January 1970.

North American Rockwell (NR) in 1969 was a major participant in man's greatest scientific achievement in history—putting a man on the moon. The famous spacecraft *Columbia* was an NR product.

In addition to building the Apollo Command and Service Modules, the company manufactured the massive second stage and the engines that powered all stages of the huge Saturn V launch vehicle. NR also built the ascent engine that lifted the Lunar Module from the moon's surface to begin the astronauts' return to earth.

The corporation consists of the Aerospace & Sys-

tems Group, headquartered in El Segundo, California, and the Commercial Products Group, based in Pittsburgh, Pennsylvania.

The 29th largest industrial corporation in the United States, NR in 1969 was engaged worldwide in 20 related engineering and manufacturing businesses. It had major strengths in research and development, aerospace and commercial products, and systems engineering, and a growing position in a number of the emerging industries. (Except for general aviation aircraft, all items covered here are products or programs of the Aerospace & Systems Group.)

In May, the board of directors created the new position of executive vice president and elected Robert Anderson to fill it. He had 20 years' experience with Chrysler Corporation, where his last position was vice president of product planning and development. Robert C. Wilson succeeded Anderson as vice president of the corporation and president of NR's Commercial Products Group. Wilson had been a vice president of General Electric Company, where he had served since 1941 in engineering, manufacturing, and marketing operations.

The board of directors also created a new corporate officer position: vice president, international. Elected to this post was A. B. Kight, who joined the corporation in March as vice president, international, for the Commercial Products Group. He previously was a vice president of Borg-Warner Corporation, where he had been in charge of international operations.

Within the Aerospace & Systems Group, the Rocketdyne and Atomics International divisions were brought within a new organization, the Power Systems Divisions. Named to head the Power Systems Divisions was Jay D. Wethe, group vice president of the Aerospace & Systems Group. Wethe previously was president of The Marquardt Corporation.

In the Commercial Products Group, the Aero Commander and Remmert Werner divisions were brought within the General Aviation Divisions, a newly created operating unit. President of the General Aviation Divisions is Richard N. Robinson, president of Aero Commander, which he will continue to head. Remmert Werner Division will continue to be directed by Frank P. Fleming, president.

This new division represents a concerted effort to broaden services to the fast-growing general aviation market and to marshal resources in that field under one efficient and flexible organization. The unification is expected to result in improved service to both present and future customers.

Since the early 1960s, NR had been serving as the principal contractor for NASA's Apollo program. The Space Division was responsible for the design and construction of the Apollo Command and Service Modules. In addition, the Space Division continued its work on the second stage (S-II) of the Saturn V launch vehicle. The Rocketdyne Division was responsible for the engines of all 3 Saturn V

stages, plus a number of smaller rocket engines used in the Apollo spacecraft. The Tulsa Division was responsible for the Adapter, the section of the spacecraft which houses the Lunar Module.

In 1969, the Apollo program conducted 4 successful manned space flights, 3 of them to the moon. Apollo 9, in March 1969, tested the Command Module *Gumdrop* and the Lunar Module *Spider* in a 241-hour earth-orbit mission. The Apollo 10 mission, in May, with astronauts Stafford, Young, and Cernan, included a descent to within 50,000 feet of the moon's surface. The Apollo 11 mission, which culminated in the landing of the first men on the moon, on July 20, 1969, was viewed firsthand by millions of persons throughout the world. The second lunar landing flight was Apollo 12 in November. On that mission, astronauts Conrad and Bean landed near Surveyor 3 on the Sea of Storms and recovered some Surveyor components while astronaut Gordon remained in lunar orbit aboard the spacecraft *Yankee Clipper*.



North American Rockwell contributed to the success of the Apollo program in a number of areas. The company's Space Division built the Command/Service Module spacecraft Columbia (shown), which flew on the first lunar landing mission, and the S-II second stage of the Saturn V launch vehicle. Rocketdyne Division provided propulsion systems for all 3 stages of Saturn V, and Tulsa Division was responsible for the Lunar Module Adapter.

Four Apollo Command and Service Modules were being modified for the Apollo Applications Program (AAP) flights, which were scheduled to begin in March 1972, and 5 spacecraft were being modified for the ALEM (Apollo Lunar Exploration Missions). AAP calls for 28-day missions of an orbiting workshop and ALEM involves more detailed, scientific studies of the moon.

The next big space effort, following Apollo, was expected to be the establishment, in the middle 1970s, of a large earth-orbiting space station. A related planned effort will be the development of a reusable shuttle vehicle to carry men and equipment into space.

During 1969, the Space Division established 2 organizations to prepare for these new programs. Both organizations were staffed by key management and engineering personnel from the Apollo and S-II programs. The organization headed by Robert Greer, former manager of the S-II program, was assigned the 11-month NASA space station study. The shuttle effort, involving several NASA and Air Force study contracts, was being performed by a new organization established at the Downey Facility. This effort was being managed by Dale Myers, former manager of the Apollo Command and Service Modules program.

Another space contract of importance was the 12-month program to design, construct, and check out a Flying Lunar Excursion Experimental Platform (FLEEP). The initial vehicle under contract was to be used as a research and simulation device.

In ocean systems, the *Beaver IV* deep submersible workboat completed its sea trials and was outfitted for mating with a sea-floor satellite station. The *Beaver* was the first American submarine to be fully certified by the American Bureau of Shipping.

A 200-ton prototype undersea oil production station was to be completed early in 1970 and immediately undergo a dry land check-out and test.

As the nation's principal designer and builder of large liquid rocket engines, the company has supplied propulsion for several of the nation's large ballistic missiles and for more than 900 U.S. military and civilian space launches. In the first 9 months of 1969, company-produced engines were used in 27 successful space vehicle launches.

Generating 1,522,000 pounds of thrust, the F-1 is the most powerful liquid-propellant rocket engine in the free world. It is clustered in a group of 5 to provide 7,610,000 pounds of thrust, or 160,000,000 horsepower, for the first stage of the Saturn V launch vehicle. The F-1 was in regular production for the Apollo/Saturn V program.

With the initial Saturn V boost already provided by the F-1s in the first stage, the second stage is powered by 5 J-2 engines and the third stage by a single J-2. Generating up to 230,000 pounds of thrust each, they achieve high efficiency by using liquid hydrogen as fuel. The J-2 engines, the nation's largest operational liquid hydrogen engines, were also in production.

Eight H-1 engines, generating 200,000 pounds of thrust each, provided the first-stage power for the Apollo/Saturn IB flights.

During the year, the company's plant at McGregor, Texas, delivered solid-propellant rocket motors under accelerated schedules for the Sparrow,

Phoenix, and Shrike missiles, and provided gas generators for the Navy's Tartar and Terrier missiles and the Army's Shillelagh missile.

Rocketdyne was responsible for the Apollo Lunar Module ascent engine which boosts astronauts off the moon and back to the orbiting Apollo Command Module during the lunar landing missions.

The division's jet engine components operation made deliveries on afterburners for aircraft jet engines during the year.

At the Los Angeles Division, flights of both the 2,000-mile-an-hour NB-70 experimental air vehicle and the hypersonic X-15 rocket research aircraft were completed under flight research programs administered by NASA.

Utilizing the facilities of its expanded Structural Machining Center, the division carried out a wide range of subcontracts. Work included wings for the Bell HueyCobra helicopter, horizontal stabilizers for the McDonnell Douglas DC-9 commercial transport, and tooling for such aircraft as the Boeing 747 jumbo jet transport.

A new addition to the center's equipment was a Froriep Spheromill, the largest piece of metalworking equipment ever purchased by the division. Shipment of the numerically controlled vertical turning and boring machine from Germany began late in 1969. The 5-axis machine weighs over 200 tons and is able to turn, bore, mill, and drill large complex components up to 43 feet in diameter. It can handle jobs weighing up to 70 tons.

Two significant research contracts awarded the division during the year were to develop and produce for the Air Force boron epoxy wing skin which will be tested on an F-100 Super Sabre, and to design and fabricate for NASA a new type of airfoil, the supercritical wing, to be mounted on a modified version of the F-8 Crusader.

The durable F-100 Super Sabre fighter-bomber, rolled out by the Los Angeles Division in 1953, was performing vital service for the United States in Southeast Asia. The company produced a wide range of F-100 modification kits for the Air Force under a program for further extending the service life of this nation's first operational supersonic airplane.

Production of the Sabreliner business jet in the 10-passenger Series 60 model continued during the year. Announcement was made that the aircraft would have nonstop transcontinental range with the installation in future aircraft of the new ATF 3 bypass engine being developed by The Garrett Corporation. The engine, in the 4,000-pound-thrust class, was to be designed for retrofit to all Series 60 airplanes.

Sabreliners passed a total of 1,500,000 flight hours as the more than 325 planes operated by the Air Force, the Navy, and civilian organizations continued in operation.

A new use for the versatile airplane was an-

nounced in October when a modified Sabreliner was delivered to the National Center for Atmospheric Research (NCAR). NCAR was to use the airplane for investigation into jet stream dynamics and turbulence, upper troposphere and lower stratosphere air movements, cloud physics, and atmospheric electricity. Modification included installation of a long nose boom with special sampling probes, a sonde and chaff pod under the fuselage, a large nose radome, and special fuselage doors and punting points for research equipment.

Six Series 40 Sabreliners were delivered to the FAA under a lease agreement. Five of them were in service as airway checkers and one was being used as a pilot trainer.

During 1969, the Columbus Division produced 3 different types of aircraft under Navy contracts.

The division completed delivery of the 271 OV-10A Bronco light armed reconnaissance aircraft under the Department of Defense contract administered by the Navy. An order for 18 of the aircraft was received from the Republic of West Germany, which intended to utilize the multimission airplane in a target-tow configuration.

Aircraft already delivered were seeing combat service in South Vietnam with units of the Air Force, the Marine Corps, and the Navy. During its first year in Southeast Asia, the versatile aircraft amassed over 52,000 flight hours and compiled an enviable record for dependability, survivability, and efficiency while fulfilling such varied roles as armed reconnaissance, forward air control, and helicopter escort.

The OV-10 also attracted considerable interest among other foreign nations, including Japan and Australia.

Production of the RA-5C Vigilante tactical reconnaissance aircraft continued for the Navy. Those in production feature improved sensor systems and uprated General Electric J79 jet engines providing improved performance to reconnaissance squadrons deployed aboard all attack carriers of the Navy.

The last T-2B Buckeye twin-jet Navy trainer was delivered to the Naval Air Training Command and delivery of the T-2C version of the dependable trainer was begun. The T-2C features General Electric J85 jet engines which offer a slight performance improvement. However, availability and economy were the primary reasons for changing power plants.

Columbus Division also delivered the 321st, and last, T-28D modification. The program of modification and rehabilitation of the venerable T-28A trainers to the D configuration had been conducted for over 7 years.

Development continued on the Navy's Condor missile. Condor features a television guidance system that will provide Navy attack aircraft with a standoff capability. Several unpowered flights were conducted during the year, along with a series of successful ground test firings of a solid rocket motor

developed with company funds at NR's McGregor, Texas, facility.

Tulsa Division continued production of the Saturn S-II second stage flight hardware, Apollo spacecraft Lunar Module Adapters, primary structures for the Apollo Service Module, and instrument units.

The division has program management for the Air Force's WS-131B Hound Dog weapon system and was managing a fleet IRAN program to insure the reliability of the system.

The Tulsa Division was a major subcontractor on The Boeing Company's 747 superjet, producing the lower center fuselage section, a keystone in the giant aircraft's structure, and the fixed wing leading edges.

The Tulsa Division offered the largest, most complete composite bonding installation within the company, specializing in honeycomb and metal-to-metal bonding. The division's plastic and bonding facilities can fabricate the largest composite structures that the industry might require in the foreseeable future. Huge bonding ovens and autoclaves provide a total square foot bonding volume unsurpassed in industry.

Testing of the S8DR, prototype nuclear reactor developed by the company's Atomics International Division, demonstrated the suitability of the SNAP (Systems for Nuclear Auxiliary Power) compact reactor concept for both space and terrestrial environments. Such reactors can provide a reliable, long-life source of power for earth satellite communication and observation systems, manned space vehicles, orbiting space stations, and manned bases on the moon or Mars, and for such terrestrial uses as hardened missile bases and undersea bases. The S8DR is designed to produce 600 thermal kilowatts and to operate for 10,000 hours in a space vacuum. The program was being conducted by AI for the U.S. Atomic Energy Commission.

The nation's most complete aerospace electronics center in one geographic location is in Anaheim, California, where the company's Autonetics Division complex covers 267 acres. Here, more than 3,000,000 square feet of facilities are devoted to research, design, development, test, and fabrication of electronic products.

In 1969, Autonetics began production on the Minuteman III intercontinental ballistic missile program. The division was associate prime contractor for Minuteman III guidance and control equipment and responsible for 99 percent of the missile's electronics.

The nation's most advanced all-digital computer-controlled avionic systems for the Air Force's new FB-111A strategic bomber were flight-tested, and F-111D advanced tactical fighter-bomber production systems were delivered.

Avionic systems for 75 FB-111As were in production. First production models of the aircraft were

delivered to the Strategic Air Command in September 1969. F-111D system development tests and production continued for 96 aircraft. Both versions use microelectronic circuitry to improve performance while reducing size and weight and increasing reliability.

Modification continued on Ship's Inertial Navigation Systems (SINS), which were guiding the U.S. nuclear-powered submarine fleet armed with Polaris and Poseidon ballistic missiles. SINS continually update the submarine's exact position; the extreme navigation accuracy of SINS enables a submarine to launch its missiles while submerged. Nearly all U.S. and British submarines armed with Polaris missiles are equipped with Autonetics' SINS. The new Poseidon missile and modified SINS will be aboard 31 of the 41 vessels in the nuclear fleet.

Maintenance and repair of inertial navigators continued for the Hound Dog air-to-surface nuclear missile carried by the B-52 strategic bomber.

Autonetics, the world's largest producer of military airborne digital computers, has produced more than 4,000 airborne computers. In production in 1969 were the Minuteman III computer and a navigation computer for the F-111 program. Aircraft and launch computers for the Short-Range Attack Missile (SRAM) and the Condor missile were under development and test.

Along with the F-111D attack radar, Autonetics was producing the radar-equipped navigation system for the Navy RA-5C Vigilante tactical reconnaissance aircraft manufactured by the Columbus Division. Columbus also was working on associated carrier-based intelligence systems for use with the RA-5C.

Autonetics was updating the series of radars for the NATO F-104 aircraft and the U.S. Air Force F-105 aircraft. Additionally, prototypes of an improved radar for the Italian Air Force F-104 aircraft were built. Research on advanced radars such as electronic phased-array models was continuing.

The division began production of advanced metal oxide semiconductors/large-scale integrated (MOS/LSI) circuits in 1969 for use in the Hayakawa Electric Company's new 3-pound desk-top calculator. The contract for these devices was the largest order for MOS/LSI in the history of the industry. Autonetics was also manufacturing and delivering MOS/LSI devices for use in the entertainment and passenger service multiplexing systems installed in the Boeing 747 and was manufacturing other advanced circuitry for the commercial market.

The division developed MOS and silicon-on-sapphire circuits for applications in such growing fields as computers, calculators, and the conversion, processing, and transmission of digital data. Other applications include MOS/LSI circuit use in electronic musical instruments.

Advanced research and development of microelectronic circuitry and materials for microwave

application were being pushed vigorously. This technology represented important breakthroughs, with promise for advanced radars and other microwave equipment.

In other areas, Autonetics was manufacturing electronic support equipment for the Apollo spacecraft and Saturn automatic check-out equipment for aircraft and missiles, was developing and producing antisubmarine warfare equipment, and was pursuing research and development of advanced lasers, optical star trackers, and infrared sensors.

The division was conducting advanced, government-funded avionics studies for new aircraft programs including the B-1A strategic aircraft and the F-15 advanced tactical fighter for the Air Force.

Construction began in October 1968 on a new 1,000,000-square-foot electronics center on a 92-acre site, part of the company's 1,300 acres at Laguna Niguel, California. It was to be the world's largest single electronics engineering and manufacturing facility under one roof. Initial occupancy was scheduled for mid-1970 for manufacturing, engineering, and support operations for computers.

In 1969, the Aero Commander Division, with headquarters in Bethany, Oklahoma, manufactured 7 models of private and business aircraft ranging from personal and agricultural airplanes to piston and turboprop twin-engine executive aircraft.

Remmert Werner Division, with headquarters in St. Louis, Missouri, operates a number of fixed bases for general aviation airplanes across the country and is the worldwide distributor of North American Rockwell's twin-jet business aircraft, the Sabreliner.

NORTHROP CORPORATION

Growth in aircraft, communications, and electronics paced Northrop Corporation to another year of record sales, earnings, and backlog in fiscal year 1969. During the decade of the sixties, Northrop sales more than doubled and earnings nearly tripled. Equally significant was growth in the numbers of customers and markets. Some 45 percent of the company's sales in fiscal 1969 were to purchasers other than the U.S. military services.

Military aircraft continued to be an important influence on Northrop's plans for future growth. An improved version of the F-5 tactical fighter, incorporating increased thrust engines and aerodynamic and avionics changes, was proposed. The F-5 continued to be the most widely deployed supersonic aircraft in the free world and more than 1,000 were under contract at year-end. Of this number, 290 were licensed for production outside the United States.

Northrop joined North American Rockwell in bidding on the F-15 high-performance fighter planned for the Air Force. The company also was one of 4

which completed funded studies for analysis and preliminary design for a new close-support aircraft known as the A-X, needed to provide support for troops in the battlefield.

Taking advantage of the considerable experience gained in the successful T-38 jet trainer program, Northrop was conducting a long-term study of U.S. Air Force pilot training requirements for the 1975-90 time period. Eleven hundred Northrop T-38s had gone into service by year-end to train U.S. and German Air Force pilots.

Northrop was in its third year of participation in the Boeing 747 program and in 1969 delivered the equivalent of 35 shipsets of the 150-foot-long passenger section. Seventy-one shipsets were scheduled for delivery in 1970. Northrop was working under a contract in excess of \$500,000,000 covering the first 201 aircraft.



Northrop Corporation was conducting advanced research toward development of production techniques for the application of boron and graphite composites to future aircraft. In photo, technician unrolls a sheet of boron composite material.

Communications interests included radio, television, telephone, and telegraph, whether by satellite, cable, microwave, or troposcatter systems. In 1969, a Northrop subsidiary, Page Communications Engineers, Inc., completed new earth stations for satellite communications in Iran and Lebanon. In Greece, Page was designing and installing a complete nationwide television and radio broadcasting system which will link Greece to most western Euro-

pean capitals. Another subsidiary, The Hallicrafters Company, introduced several new models of transceivers, including a single sideband communication system for use in the United States and abroad.

Electronics, like aircraft, is an area in which Northrop has established itself not only as a producer of major subsystems but also as a prime system contractor. Navigation programs in 1969 included both shipboard and airborne receivers for the Navy Omega system, a network of very-low-frequency transmitters which eventually will provide the first worldwide all-weather system. Northrop continued to produce the versatile inertial-Doppler navigation system for the Air Force/Lockheed C-5.

Northrop continued to be one of the leading suppliers of military special-purpose computers, concentrating on a growing requirement for computers that can operate reliably in difficult environments. In addition to computers for its own navigation and guidance systems, Northrop was providing digital computers for the C-5 malfunction detection system.

Northrop was selected in 1969 to develop a system to be used by all U.S. military services for rapid collection and transmission of air reconnaissance information. Called the Joint Services Inflight Data Transmission System (JIFDATS), the program is managed for the Department of Defense by the Navy. Sensors—such as cameras, infrared, and radar—installed in reconnaissance aircraft will collect data for electronic transmission to surface terminals where the data will be displayed as a photo-type image.

The company was combining its computer technology with its extensive activity in automatic test equipment (ATE). Northrop ATE is in use aboard U.S. nuclear submarines and destroyer escorts to monitor the readiness of Polaris and Poseidon missiles and electronic systems. By adding a special-purpose digital computer, advanced ATE will be able to monitor up to 50 different ship's systems continuously.

Another kind of monitoring equipment was being produced by Northrop for use on aircraft. Flight safety systems which provide recorded voice warning messages to pilots about aircraft malfunctions were being used by U.S. Army helicopters and German Air Force F-104G Starfighters, among others. Some versions include maintenance and crash recorders.

The Hallicrafters Company, one of the leading suppliers of military electronic countermeasures equipment, won a number of significant contracts in 1969. The Northrop subsidiary developed an infrared countermeasures system which led to the first production contract ever awarded in this area by the U.S. government. One of the new countermeasures programs uses an advanced cross field amplifier tube developed by Warnecke Electron Tubes, Inc., a Northrop affiliate.

In an example of the technological strengths that

can be woven from Northrop's 3 primary areas of interest—aircraft, communications, and electronics—the company was pursuing worldwide requirements for modern aviation ground systems. In Iran, Northrop brought together multinational industrial organizations to bid on an integrated air traffic control system and was investigating the need for a new international airport in Teheran. In 1969, the company was named systems manager for the planning and construction of a new jet-age airport in Puerto Rico. Extensive air transportation studies on requirements from 1970 to the twenty-first century were conducted under contract by Northrop in a number of countries, including Chile, Peru, Ethiopia, and Indonesia.

Northrop's contributions to Apollo 11's lunar mission reflected an uncommon diversity of technologies throughout the company. The company probably is best known for its development of the Apollo parachute landing system which worked flawlessly on all manned missions. Also important to Apollo are a company-developed gyroscopic package in the Saturn V booster; electronic sensors in the launch escape system; the large-screen real-time display system used by mission control at Cape Kennedy to monitor launch progress; UHF communications equipment linking Cape Kennedy to downrange tracking stations; inertial navigation systems and marine star tracking equipment aboard Apollo range ships; a biomedical recording unit used aboard the recovery ship *Hornet* to measure the physiological effects of the mission on the Apollo 11 crew; and the Lunar Receiving Laboratory at Houston's Manned Spacecraft Center, designed and operated by a joint-venture company formed by Northrop and Brown & Root, Inc.

PAC GROUP

During 1969, a new name was introduced to identify the 4 aviation-related subsidiaries of Purex Corporation, Ltd. Pacific Airmotive Corporation, Aircraft Turbine Service, Inc., and R. J. Enstrom Corporation were operated as the PAC Group from Pacific Airmotive headquarters in Burbank, California. The year was one of expansion and growth for each of the group's divisions as they continued to play their vital roles in supporting and supplying the airline and general aviation industries.

The Pacific Airmotive Engine Division in Burbank broadened and strengthened its airline jet engine maintenance programs and, by the end of the year, had complete capabilities in repair, process, and test of a wide spectrum of jet engines extending from the PT6 turboprop to the giant JT9D, which powers the Boeing 747 and some versions of the McDonnell Douglas DC-10.



PAC Group's Pacific Airmotive Engine Division completed and put into operation a new test cell capable of accommodating engines up to 100,000 pounds thrust.

Completion of a new \$2,000,000 big-engine test cell represented a highlight of the year for the division. It was the first test cell capable of accommodating the JT9D to be completed and in operation, other than the manufacturer's. It was designed to handle existing jets, the RB.211 engines in support of the L-1011 flight-test program, and other engines with as high as 100,000 pounds thrust.

The first phase of the division's major facilities expansion program was completed in 1969 with a resulting 25 percent increase in shop area. Major machine tool acquisitions completed during the year included 2 Everite electrolytic grinders and a solid-state Charmilles electron discharge machine. Total refurbishment of plating facilities and reorganization of plant layout and shop flow continued the productivity improvement plan initiated several years ago. The phase-out of piston engine maintenance at the Burbank facility was completed during 1969 to permit full concentration on airline jet engine programs at that location.

The division continued its computerized parts monitoring and engine records programs which, together with inflight monitoring, constituted the PATCO (Pacific Airmotive Turbine Control) program. With this program, PAC established technical support for propulsion systems reliability programs approved by the Federal Aviation Administration during 1969 for Flying Tiger Line, Air West, Wien Consolidated Airlines, and Purdue Airlines, and by the Canadian Department of Transportation for Wardair Canada.

PAC's advances in facilities expansion and technical support capabilities in 1969 resulted in the signing of new exclusive engine service contracts. American Airlines contracted with the division for JT9D engine maintenance on its fleet of 747s; Flying Tiger Line, for JT3D-7 engine support; Air West, Wien Consolidated Airlines, and Purdue Air-

lines, for JT8D support; and a number of commuter airlines, for PT6 support. Long-term engine service contracts also were signed or extended with Hawaiian Airlines and Alaska Airlines (JT8D), with Wardair Canada (JT3 and JT8), and with Dow Chemical for its industrial GG4 engine.

The PAC Group's Airwork Service Division in Millville continued to be the only U.S. overhaul agency authorized by the manufacturers to overhaul every major turbine engine in operation on business and commuter aircraft. In 1969, the division received authorization from Rolls-Royce to overhaul the Turbomeca AZ14/16, power plant for the Handley Page Jetstream.

In February, the division added a JT12 field maintenance and troubleshooting school to its series of turbine engine classes offered to chief mechanics and maintenance supervisors. A torquemeter test kit for the Beech King Air was developed and marketed by the division. An employee, Allen Weisbein, won the State of New Jersey Award in the FAA's Sixth Annual Aviation Mechanic Safety Award Program for his development of a simple computer that solves a complex Dart engine adjustment problem.

A program was launched to establish select fixed-base operators throughout the United States as Airwork authorized turbine engine service centers to enable aircraft operators away from their home bases to utilize the services of well-equipped and experienced engine maintenance organizations.

The Airwork turbine engine control program was developed for commuter air carriers. The program, a complete PT6 engine support package, includes a monitoring system using the movement of easily plotted engine parameters to provide advance warning of potential malfunctions. The program was initiated with Altair Airlines in October.

A new hangar was opened on Millville Airport to provide fly-in engine support services. Emergency engine rental and exchange requirements were met for customers by air delivery, beginning in late 1969.

In July, the Aircraft & Engineering Division on Hollywood-Burbank Airport delivered the 170th Convair 580, completing the conversion program under its contract to the Allison Division of General Motors Corporation.

The division's aircraft sales activities for the Fan Jet Falcon, the Handley Page Jetstream, the Learjet, the DC-6B, and the Tradewind continued during the year. Another major element of the division's business, post-factory completion of corporate aircraft, increased substantially in 1969. Aircraft receiving post-factory installations included the Boeing 737, the DC-9, the Gulfstream II, the Fokker F-28, the Falcon, and the Handley Page 137. The latter received certification, and initial deliveries were made to corporate operators. Strong emphasis was placed on service work for airline and corporate customers which operate 707, 727, and 737 aircraft, in addition to smaller jet and reciprocating aircraft.

The R. J. Enstrom Corporation continued to expand manufacturing capabilities to provide for the production of 100 helicopters per year by the end of 1969. The piston-powered F-28A helicopter proved highly successful in government agency applications and was used by the New Jersey State Police, the City of Pasadena Police Department, and the Illinois and Michigan conservation departments.

The first demonstrator model of the new turbine-engine T-28 helicopter was completed in November, with introduction scheduled for January 1970 at the Helicopter Association of America convention in Las Vegas. Enstrom ordered the Garrett-AiResearch TSE 36-1 turbine engine to power this new machine, which was to be available in May 1970.

The year 1969 marked the first full calendar year in which the Aviation Products Divisions of Airwork and Pacific Airmotive operated as one organization. The division supported all major airlines in the United States, most foreign carriers, and the general aviation industry from 17 stocking warehouses in key domestic centers, plus international branches in Paris and Hong Kong.

The number of manufacturers represented by the division, a distributor of major aviation product lines, increased to more than 150 companies. The Chicago branches of Airwork and Pacific Airmotive were merged into a single operation with warehouse and offices at Elk Grove Village, Illinois.

With wide customer acceptance of the 400 series, Cessna multi-engine aircraft sales established a new record in 1969 for the Light Aircraft Distributors Division. Sales were primarily in the corporate operator field, with the pressurized 421A model the top seller in the series.

Introduction of the new Cessna Aerobat 150 generated increased interest in the learn-to-fly models as Cessna Aircraft Company, through its distributor organizations, offered a complete acrobatic training curriculum to dealers.

In 1969, assistance from aircraft manufacturers and distributors stimulated another giant leap forward for Air Age Education programs in high schools and colleges. Donations of 2 new Cessna 150 commuters were again made by the Light Aircraft Distributors Division to a high school and a junior college as an award for outstanding progress in aviation education.

The year was one of rapid expansion for the Aircraft Turbine Service Division, the overhaul and repair facility for auxiliary power unit gas turbine engines and related components. The operations of its associate company, Jet Turbine Service of Farmingdale, New York, were absorbed, sales increased approximately 30 percent over the previous year, and a program to increase the division's facilities and capabilities was initiated.

A new pneumatic air supply system, designed to increase production and accommodate future projects in support of the new wide-bodied jets and

supersonic commercial aircraft, was installed at the division's Long Island plant.

New licensing arrangements were completed with Pan American Business Jets and Avions Marcel Dassault for overhaul of equipment on board the Fan Jet Falcon, including units manufactured by Zenith, Le Bozec et Gautier, and Bronzvia. In conjunction with the Falcon overhaul program, technical services and support of the Microturbo gas turbine auxiliary power unit were expanded.

PHILCO-FORD CORPORATION

AERONUTRONIC DIVISION

The year 1969 was one of significant accomplishment for Philco-Ford Corporation's Aeronutronic Division of Newport Beach, California.

In an era of reduced government funding, the division continued to garner its share of contract awards and maintain a substantial backlog of military business in its major program areas of tactical missile systems, air defense systems, airborne weapon systems and stabilized fire-control systems, propulsion products, high-strength protective armor, radar, and reconnaissance and intelligence systems.

Largest single contract awarded in 1969 was for continued production of the Army's Shillelagh guided missile, the highest production volume guided missile ever produced in U.S. history. It is a fully guided tactical antitank missile system designed and developed by Aeronutronic under contract to the Army Missile Command, Redstone Arsenal, Alabama. In production since 1966, Shillelagh has been operational since 1967. During 1969, the missile system was deployed with additional Army units in the United States and overseas.

Production on the Shillelagh continued at the Army Missile Plant operated by Aeronutronic at Lawndale, California. The division was also producing the tank-mounted guidance and control equipment at the Lawndale plant.

As an extension of its tactical weapon systems development work, Aeronutronic continued to carry out studies and developments of sight-line stabilization equipment and its integration into advanced new military systems, to increase the combat effectiveness of high-speed aircraft.

Second largest funding to Aeronutronic in 1969 was on the Chaparral air defense system, one of 2 major systems selected by the Army to provide field commanders with low-altitude air defense as part of newly organized air defense battalions. Representing the fourth-buy production award on the system, the contract called for continued production of guided missile fire units and weapon system test equipment. Chaparral is an infrared heat-seeking missile-firing system mounted on an XM-730 tracked vehicle to meet Army requirements for a forward

area air defense system. The Chaparral system consists of launch and control assembly, vehicle, and missiles.

During 1969, Chaparral completed a highly successful test and evaluation program at the Army's Tropical Test Center in Panama, and the Army announced the successful testing of the system under simulated nuclear blast conditions in Canada. In the latter program, carried out at Suffield, Alberta, Canada, the Chaparral vehicle was located less than 2,000 feet from "ground zero" during the massive explosion of 1,000,000 pounds of TNT. Chaparral was still in a "go" firing condition following the massive blast.

Contracts for lesser amounts for engineering services and continued research on the Chaparral system were also awarded to Aeronutronic in 1969.

At midyear, the division received a contract to design and build a Chaparral gunner simulator/evaluator to train "missileers" and improve their efficiency. The training units were to be delivered in 1970.

Aeronutronic continued production in 1969 of the XM140 automatic weapon for defense use on helicopters. During the year, the XM140 automatic cannon entered the Engineering Test/Service Test phase in its advanced development cycle. The test program spanned approximately 6 months and included the firing of about 60,000 rounds of 30-millimeter ammunition. Test-bed for the XM140 during the extensive test program was an XM30 armament subsystem mounted on a UH-1C helicopter, with 2 automatic guns mounted in 2 remotely located, power-operated turrets.

Aeronutronic was also under contract to both the Air Force and the Army for the development of advanced caseless ammunition weapon systems. During 1969, Aeronutronic was one of 2 contractors competing under contract for the advanced automatic caseless ammunition cannon for the F-15 aircraft. Aeronutronic's entry, called HIPAC, will be capable of firing 6,000 25-millimeter rounds per minute.

A side-looking airborne radar designed and built by Aeronutronic was used by the Coast Guard in a special project carried out during the year in the Northwest Passage in connection with the SS *Manhattan* ice-breaking tanker. The side-looking radar, aboard a Coast Guard aircraft which flew with the *Manhattan*, was used for mapping ice and for testing the radar's potential as a valuable operational tool in Arctic shipping.

The NASA Earth Resources Program was using an Aeronutronic DPD-2 radar aboard P-3V and C-130 aircraft which were being flown worldwide to gather geological data, with excellent results.

Aeronutronic, the developer and producer of the ground-to-air Chaparral air defense system, entered the field of highly maneuverable short-range missiles for air defense and air-to-air combat. Philco-

Ford was prime contractor to the Air Force on the AIM-9E guided missile program. This is an advanced version of the AIM-9B (Sidewinder 1A), resulting from a modification to the missile's infrared guidance and control unit. The AIM-9E provides improvements in air-to-air missile capability against highly maneuvering targets. The modified guidance and control unit was in volume production and Aeronutronic expected to be in production of an improved version of the AIM-9E in 1970.

In the missile controls field, Aeronutronic continued its established position as a developer and supplier of high-quality, high-performance hot-gas control subsystems for Army, Air Force, and Navy guided missiles. The hot-gas jet reaction control valves are used for roll control and additional control functions during missile flight. Additional follow-on production contracts for these control valves were awarded to the division in 1969.

In the fall of 1969, Aeronutronic was one of 2 contractors selected by the Army Missile Command for test and evaluation of the revolutionary low-cost Ballistic Aerial Target System (BATS). The Aeronutronic version was designated LOCAT, a trademark of Philco-Ford Corporation. Under the terms of the contract, Aeronutronic was to build 40 LOCAT (Low-Cost Aerial Target) missiles to be flown and tested by the Army. The contract included an option for production of large quantities of the aerial targets. The expendable 15-foot-long, 200-pound LOCAT target was developed by Aeronutronic to train air defense gun and guided missile crews against low-altitude enemy aircraft.

Aeronutronic continued production on a lightweight, highly effective, dual-property steel armor which provides excellent multiple-hit protection for helicopters and small boats. The Aeronutronic-developed armor plate is an adaptation of a patented Ford Motor Company process for producing ultra-high-strength steel. The steel, designated by the trademark AUSFORM, is used on helicopters, fixed-wing aircraft, small boats, and other vehicles for which minimum weight and thickness are required for maximum ballistic protection against armor-piercing and ball-type projectiles.

Aeronutronic was also involved in significant influence fuze business. During 1969, first-phase production contracts were awarded Aeronutronic on the Navy's Standard ARM fuze and on the Air Force's general-purpose bomb fuze. Both programs have significant production potential.

To provide a base of advanced technology for present business areas and current projects, and to develop new business areas, Aeronutronic continued to maintain an extensive applied research laboratory at its Newport Beach, California, headquarters site. The laboratory was conducting a broad program of diversified research in the fields of physics, chemistry and the biosciences, and materials and processes. Projects included research on

nondestructive testing of metals, including commercial aircraft components to insure passenger safety, and on water desalination and purification.

At year-end, Aeronutronic employment was approximately 4,000.

PIPER AIRCRAFT CORPORATION

Demand for Piper's 2 heavy twins—the 6-place Aztec and the 6- to 9-place Navajo—increased during 1969. The 2 models were being used in ever-increasing numbers around the world for all types of business flying, corporate aircraft fleets, airline and commuter services, cargo hauling, and mail delivery.

Nine Navajos were purchased by Aeronaves de Mexico, an airline based in Mexico City. This represented a record sale of that model to one concern. A mass delivery of 5 Navajos was made to the Argentine Army, the largest single delivery of that model.

In the single-engine category, Piper's Cherokee Arrow, first introduced in 1967, continued to be the fastest-selling single-engine retractable-gear aircraft on the market. The Arrow's unique fail-safe gear extension system has established a precedent in general aviation safety.

The largest delivery of single-engine aircraft, 20 Cherokee 140Bs, was made to the Oxford Air Training School, Oxford, England, the largest school of its kind in Europe. The University of Illinois also purchased 10 Cherokee 140s for its flight training program. The Airline Training Center of Pacific Southwest Airlines, San Diego, California, continued to be one of the largest users of Piper products, training airline pilots with 13 Aztecs and 21 Cherokee Arrows, along with Boeing 727 jets.

October marked the end of the first year of Piper's Flite Center program, an entirely new concept designed to standardize flight training and to develop new pilots. The program reduced by almost 13 hours the time needed for the average student to gain his private pilot license.

During the summer of 1969, Piper initiated a computer service that allows a customer or plane owner to estimate business, commuter, or corporate aircraft operating costs, using individual data which he himself supplies. The direct-line telephone-computer service accomplishes in minutes what previously took days.

Early in the year, Piper introduced the single-engine Comanche 260C with tiger shark nose cowling. The new, longer cowling design increased performance and minimized engine sound. In October and November, the 1970 Cherokee line was introduced at Vero Beach, Florida.

The Piper product line was being sold and serviced domestically by 410 dealers, and international markets were being covered by 140 other dealers in

90 countries. The fast-growing foreign markets represented almost 25 percent of Piper's total dollar volume.

An assembly program was established in Bogota by the Colombian government for assembly of the Pawnee agricultural plane. Manufactured at Lock Haven, Pawnees were being delivered in kit form and assembled by Colombian labor. Similar delivery and assembly work was being performed on Piper Cherokees.

Geographically speaking, Piper Aircraft became a part of the map of Pennsylvania. Piper, Pennsylvania, officially marks Piper's facilities and a U.S. post office in an area formerly known as Quehanna, 19 miles northeast of Clearfield, Pennsylvania. The name was approved by the U.S. Department of the Interior's Board on Geographic Names. The facilities include 2 factories and the post office.

As part of Piper's role in the nationwide "Discover Flying" campaign, a \$200,000 advertising campaign was launched in 400 newspapers in the United States and Canada during May. Over 1,500 lines of advertising were placed in local newspapers in virtually every Piper dealer's area. Piper Flite Centers also were brought into the campaign, which featured an introductory \$88 Flying Start Course consisting of ground indoctrination and 4 flight lessons.

Employment at Piper's 4 plant sites remained constant for much of the year with 556 employed at the Piper, Pennsylvania, plant; 2,200 at Lock Haven; 102 at Renovo, Pennsylvania; and 1,568 at Piper's Cherokee plant and Research and Development Center at Vero Beach, Florida—for a total of 4,426.

In March, 88-year-old William T. Piper, Sr., founder of the corporation, announced his retirement as chairman of the board of directors. He was named honorary chairman of the board and director emeritus of the company.

PNEUMO DYNAMICS CORPORATION

In April 1969, Pneumo Dynamics suffered a grievous loss in the untimely death of its president, Sam S. Mullin, who had served as president and chief executive officer of Pneumo Dynamics and its predecessor company for over 23 years. He was principally responsible for the substantial growth and expansion of Pneumo during the decade of the sixties.

To succeed him as chief executive officer, the board of directors elected his close and long-time business associate, Gerard A. Fulham, who was named to the new position of chairman of the board. Fulham was formerly senior vice president. Other top-level changes included the promotion of Executive Vice President John J. Brogan to president, of Senior Vice President James A. Wood to executive vice president, of Vice President Robert A. Hoagland to senior vice president, and of Secretary Rob-

ert J. Asman to vice president-corporate affairs, and the appointment of Glenn D. Babbitt, formerly general manager of Pneumo's Cleveland Pneumatic subsidiary, to the new position of group vice president-aerospace.

As in prior years, the production of aircraft landing gears at Cleveland Pneumatic and of flight control systems and components at Pneumo's National Water Lift division accounted for the major portion of Pneumo Dynamics' business. Sales of Pneumo Dynamics Corporation and its consolidated subsidiaries reached a new high, surpassing the previous year's record of \$142,900,000 and producing a substantial increase in earnings.

CLEVELAND PNEUMATIC

In 1969, Cleveland Pneumatic (CP), Pneumo's aircraft landing gear subsidiary, recorded the highest level of sales in its 75-year history, and its 43 years in the landing gear business. This was its second successive year of record-breaking sales. Although CP continued during the year to be a major supplier of landing gear for military aircraft, the preponderance of its deliveries was for commercial aircraft, attributable principally to the impact of the Boeing 747 landing gear program.

In September, Executive Vice President Robert H. Wehrenberg was named general manager of Cleveland Pneumatic. He continued to be directly responsible for CP's multimillion-dollar 747 landing gear program, but additionally he assumed overall responsibility for all other areas of Cleveland Pneumatic's operations.

In 1969, Cleveland Pneumatic completed the facility activation of its new "big gear" complex. This \$20,000,000 expansion of production, engineering, and test facilities, begun in February 1967, constituted the largest single expansion of capacity by the landing gear industry since World War II, and increased Cleveland Pneumatic's floor space by 50 percent.

Modernization emphasis at CP at year-end was being concentrated on the main plant. An individual machine tool utilization study was undertaken, with attendant relocations for more efficient operation. Retrofit was accomplished on profile milling machines to allow numerical-control operation. In addition, CP modernized control systems on multi-axis equipment, retrofitted a large flash butt welder to an electronic feedback control, and modified its main plant heat-treat facility with the installation and controls of both exothermic and endothermic gas generators.

Extensive manufacturing development studies were undertaken in the fields of electrochem milling, trepanning, cold-work machining, and cutting-tool geometry applications.

During 1969, delivery of gears to all customers was brought to a completely on-schedule basis.



Pneumo Dynamics Corporation's Cleveland Pneumatic completed work on its \$20,000,000 "big gear" complex. One of many new facilities is this drop test tower being used for check-out of Boeing 747 wing gears.

Production on the commercial side of Cleveland Pneumatic's aircraft business included landing gears and components for the McDonnell Douglas DC-8 and DC-9 and for the Boeing 707 transport (all versions), 737, and 747. Delivery of commercial gears or spares continued for the Convair 880 and 990, for the Grumman Gulfstream II, and for United Air Lines' Sud-Aviation Caravelle fleet.

In the area of military aircraft, Cleveland Pneumatic supplied landing gears or components for the Boeing KC-135, B-52, and CH-46A; the Grumman A-6A, EA-6B, and TC-4C; the Fairchild Hiller C-123; the Kaman HH-43B and HU-2K-1; the Lockheed C-41; the LTV F-8D and F-8E; the McDonnell Douglas C-124, C-133, F-4, and RB-66; and the North American Rockwell F-100, OV-10A, T-2C, and T-2J.

NATIONAL WATER LIFT

In 1969, National Water Lift (NWL), adjusting to a lower volume of business occasioned by the dearth of new military aircraft programs, consolidated its Grand Rapids, Michigan, and Palm Beach, Florida, operations into the Kalamazoo, Michigan, main plant. Another facility, at El Segundo, California, maintained production on space applications, including components for the highly successful Apollo program. NWL was producing 35 valves and controls for the Apollo Command and Service Modules.

Production of aircraft primary flight controls and components for the Boeing 727, 737, and 747 and

the McDonnell Douglas DC-9 continued, as did production of flight controls for the Lockheed C-130 Hercules, the McDonnell Douglas F-4, and various other aircraft. Initial deliveries of the inboard and outboard aileron and rudder servo systems for the Lockheed TriStar were made during the year. Also, design of series input servo actuators and spoiler actuators for the Navy's new F-14A was initiated.

In the field of ASW aircraft, NWL was proposing on the primary flight controls for the Lockheed S-3A and was working closely with potential contractors on the F-15 fighter competition.

Aircraft engine controls production continued at NWL and high-temperature engine components were being supplied for various models of General Electric's J79, J85/15, TF39, and CF6 and for Pratt & Whitney Aircraft's TF30. Advanced design of high-temperature titanium actuators continued for General Electric's SST engine.

The year 1969 also marked delivery of the first preproduction units on the complete flight control package for Hughes Aircraft's Maverick missile.

Advanced ordnance suspension systems development and production for tracked vehicles contributed to the division's diversification during the year. Research and development of turret stabilization systems and fire-control systems added to NWL's expanding technical know-how in overall advanced ordnance vehicles of the future.

RCA

DEFENSE ELECTRONIC PRODUCTS

RCA in 1969 retained its position as one of the larger and more broadly based enterprises devoted primarily to electronic science and technology. The company continued to pioneer in many areas of electronics, communications, and space sciences, from microminiaturized electronic components to large space surveillance systems. The Defense Electronic Products (DEP) organization of RCA consisted in 1969 of 5 semiautonomous operating divisions; staff engineering, personnel, manufacturing, marketing, and finance groups; and a staff planning and systems development function. This structure creates an efficient combination of skills, facilities, and resources.

Defense Engineering

Defense Engineering, Moorestown, New Jersey, is a staff organization that supports the 5 operating divisions with engineering resources and is the center for DEP-wide technical coordination. Defense Engineering comprises 3 highly skilled operating activities reporting to the chief defense engineer. They are Advanced Technology Laboratories, Central Engineering, and Defense Microelectronics.

Working closely with the RCA David Sarnoff Research Center, these activities perform tasks for various DEP divisions and, in highly selected areas, engage in techniques contracts for the government. These areas of contact help assure an awareness of the latest results from basic research, a realistic understanding of the government's needs, and effective communications with Defense Electronic Products divisions.

Advanced Technology Laboratories, Camden, New Jersey, and Burlington, Massachusetts, is a techniques and new systems oriented group with the function of pursuing applied research and advanced engineering in areas of future systems interest to the government. ATL's activities typically cover a large number of technical disciplines and require a mixture of physicists, electrical and mechanical engineers, and computer specialists.

Advanced Technology Laboratories' efforts are very creative and necessitate continuous contact with military technical customers, the DEP products groups, and the RCA Laboratories.

Programs include development of LSI/hybrid equipment technology, design automation for complex digital equipment, use of lasers in tactical and high-density recording applications, pattern recognition using parallel organized computers for such applications as speech recognition and radar data classification, solid-state microwave techniques (therms management and cooling techniques), and sophisticated electromechanical and electrooptical systems for a variety of applications.

ATL developed under a NASA contract a pulsed optical radar that can track and measure range to a cooperative target. The unit can locate and track its target at a range to 700 meters with a range accuracy of plus or minus 1 meter and a position accuracy of plus or minus .04 degree azimuth or elevation. The laser unit was developed to automatically and continuously monitor the position of an astronaut as he moves about the lunar surface. The system will also keep a TV camera trained on the astronaut as he explores the moon.

An optical radar was ideal for this task since it did not require the large, complex antenna system and target reflector required by conventional RF radars. The gallium-arsenide injection laser, together with a small retroreflector target and a silicon photodiode receiver, provided a compact, rugged tracking and ranging system with high accuracy and low power consumption (approximately 7 watts).

ATL was also developing a Vuilleumier-cycle refrigerator to handle a heat load of 5 watts at a temperature of approximately 77 degrees Kelvin with a thermal power input of less than 250 watts. During 1969, the Thermodynamics Group analytically showed the thermodynamic soundness of Vuilleumier-cycle refrigeration, developed optimizing procedures for VM system design, and demonstrated

the feasibility of building hardware. A laboratory breadboard performed all the functions of the thermal compression cycle. This breadboard achieved a temperature of 105 degrees Kelvin in its early testing phases. Company-funded programs were to continue in this area through 1971. Long-range work was to be directed toward the development of high-reliability systems and totally thermally-actuated engines.



RCA's Defense Electronic Products developed under NASA contract a laser tracking and ranging unit capable of continuously monitoring the position of an astronaut as he moves about the lunar surface.

Central Engineering, Camden, New Jersey, is responsible for applying the capabilities of new technology to manufacturing processes to produce reliable defense and aerospace systems. Its objectives are to contribute to reduced cost and improved performance by promoting a more common usage of known materials, parts, design techniques, and processes; to provide specialty skills and costly facilities which are uneconomical to duplicate in each DEP division; to develop new or improved techniques and processes for current and future manufacturing needs; and to provide critical standards technique consulting services to all DEP divisions.

The Defense Microelectronics activity, Camden and Somerville, New Jersey, was established to pioneer microelectronics development within RCA Defense Electronic Products. In addition, the activity both participates in and provides technical guid-

ance to microelectronics programs undertaken by each division of DEP. In 1969, Defense Microelectronics continued to specialize in the design and development of critical high-performance circuits and circuit and sensor arrays required to integrate RCA's key electronic equipments. This work included thick and thin film hybrids; IC, MSI, and LSI monolithic arrays including PMOS, CMOS, and bipolar devices; and electrooptic sensors and microwave microelectronics.

Plans and Systems Development

Plans and Systems Development (PSD), Moorestown, New Jersey, is the DEP staff organization responsible for the overall DEP planning and the development of system concepts responsive to government needs. PSD comprises 3 activities: Plans, Systems Development, and Systems Methodology and Support.

Major systems programs worked on by PSD in 1969 included infantry combat electronic systems; integrated communication, navigation, and identification; satellite navigation and traffic control; electronic countermeasure techniques for satellite survivability; and classified satellite systems. In addition, systems formulations and analyses were performed in ground tactical systems, satellite systems, sub-HF systems, communication/navigation systems, and early-warning systems.

The Plans activity establishes overall DEP objectives, leads and coordinates planning efforts of the 5 DEP divisions, integrates divisional plans into a total DEP plan, and determines compatibility of this total plan with the plans of DoD, NASA, and other government agencies. Upon identification of the areas of major change or growth resulting from new operational concepts and emerging technologies, the areas offering greatest potential are selected. A new business development plan for each area selected is then prepared. Areas within the specialization of specific divisions are assigned to those divisions.

Areas which require advanced systems skills or are of multidivisional systems interest are assigned to the System Development activity, where highly qualified scientists and engineers develop the new programs. These senior personnel concentrate their efforts in the fields of operations research, operations analysis, and concept development in systems areas of major interest to DEP. They develop the system concepts, lead DEP multidivisional efforts in major programs, and provide a cadre of trained personnel for divisional support in systems development.

The Systems Methodology and Support activity provides the following service to all DEP organizations: system simulation and evaluation, human factors and information systems engineering, and program management coordination including management and data processing services.

Aerospace Systems Division

The Aerospace Systems Division, Burlington, Massachusetts, provides specialized electronic systems and subsystems for manned space flight, military/aerospace computing systems, automated test equipment, command and control systems, and tactical products employing data processing, electrooptics, and radar.

In 1969, ASD was under contract to the Army for several automated test equipment (ATE) programs. The Land Combat Support System (LCSS) includes all studies, investigations, design engineering, fabrication, and production of test equipment to provide complete field maintenance capability for the TOW, Lance, and Shillelagh missile systems. Depot Installed Maintenance Automatic Test Equipment (DIMATE), developed for the Army Electronics Command, has proved the capability of automated test systems to troubleshoot complete assemblies of Army electronic systems in only 25 percent of the time required by conventional test systems.

ASD built for the Air Force the AN/TSW-7 air traffic control towers, which are air transportable and completely equipped with all necessary communications for use at tactical airfields. The AN/TSW-7 has 3 controller's positions. It can be unloaded from an Air Force transport at a forward airfield, set up on integral jacks, and in full operation shortly after arrival.

ASD was also active in developing process control systems. One of these, Automatic Process Test Equipment, was delivered to the Electronic Components Division of RCA and at year-end was in operation testing color television picture tubes. This type of equipment was being considered for use in manufacturing plants by large companies such as Lockheed and Martin Marietta.

The AN/APN-155 low-level altimeter, developed by ASD under contract for McDonnell Douglas Corporation and qualified for use in the F-4 high-performance jet aircraft, has been a highly successful solid-state equipment since being placed into production in 1956. Its excellent acceptance has resulted in follow-on orders for additional units.

A second-generation altimeter, the AN/APN-194, was designed and tested at ASD. Featuring hybrid integrated circuitry and a solid-state C-band transmitter, the receiver/transmitter weighs only 4 pounds, approximately 30 percent of the APN-155.

ASD was heavily involved in electrooptical systems research, development, and production. This included laser designators, range finders, and illuminators; low-light-level TV; high-resolution TV; special applications of image devices to point source detection; and combinations of these systems.

ASD was awarded several contracts by the Army for design, fabrication, and testing of laser range finders for man-portable use and for tank and other vehicle applications. Also, a study was completed

for the Army on using a laser in a helicopter for obstacle detection. The Integrated Observation Device, produced for the Army, incorporates an ASD-designed laser range finder with night-vision viewing devices.

Other division activities included participation in an Army flight-test program involving a laser used as a weapons guidance device, delivery to the Air Force of laser range finders and communicators, and systems studies of large integrated laser electro-optic systems.

The division performed a laser design concept study for the Navy in which a high-energy, short-pulse laser system employing frustrated total internal reflection isolators was investigated. The study resulted in a high-power missile-tracking laser system. Under contract to the Naval Air Development Center, ASD developed a blue-green laser transmitter unit for underwater use.

TV devices being produced by ASD included low-light-level camera systems utilizing almost all classes of low-light-level image tubes, among them I-SEC, I²V, isocon, image orthicon, and silicon intensifier tubes. A unique pulse gating circuit permits operating these cameras in combination with pulsed illuminators. In addition, ASD was developing for the Air Force a high-resolution camera system which uses a return beam vidicon as the image pickup tube. Further, the division was conducting system analysis involving utilization of these devices in many different military applications.

ASD was performing additional development work for the Air Force on the AN/FSR-2 optical surveillance tracking system to further refine this satellite detection system, part of the SPADATS system.

ASD was engaged in developing for the Air Force and the Army devices and systems employing miniature mosaics of infrared sensitive cells with as many as 128 rows of 128 cells each. Applications include mortar flash detection and aircraft tail warning systems.

The division completed development of a highly sophisticated general-purpose aerospace computer, VIC (Variable Instruction Computer). This computer was incorporated into the Post-Attack Command and Control/Airborne Data Automation (PACCS/ADA) system which was being flown by the Strategic Air Command to demonstrate the feasibility of automating the present airborne command post functions now performed manually by the EC-135C "Looking-Glass" aircraft. The entire system was integrated by ASD and delivered to the Air Force.

In addition, a study was completed for the Air Force Electronic Systems Division which defines the system configuration for an advanced airborne command post for the future. A sophisticated airborne multiprocessor system, the Model 215 computer, was designed and will be built at ASD for application to this and similar systems.

In the area of electronic warfare and advanced multifunction radar systems, ASD was engaged, under Air Force Avionics Laboratory contracts, in exploiting recent technological advances in integrated microcircuits by applying them to the design of an electronic warfare system and to the development of hardware. ASD delivered a Target Homing and Warning System (THAWS) to the Navy to provide integrated sensing, control, and display of electronic warfare functions on board advanced Navy aircraft.

ASD was developing several classified Navy and Air Force electronic warfare systems and components for airborne applications. In general, these involved the exploitation of very recent technological advances and the definition of future research in this area. A pulse-Doppler miniature radar for detection of missiles was being built at ASD under an Air Force contract. This will provide missile attack warning on board aircraft. A high-power jammer, utilizing the latest advances in the state of the art, was also being developed for airborne applications under contract to the Air Force.

ASD was also a major developer of electronic guidance and communication systems for the Lunar Module (LM) under contract to Grumman Aerospace Corporation. The RCA rendezvous radar/transponder system provides moon-landing astronauts with critical range, direction, and velocity of the Lunar Module relative to the Command/Service Modules to enable the Lunar Module to find the basic spacecraft in lunar orbit after leaving the moon's surface. The Lunar Module's landing radar gives continuous measurements of altitude and velocity relative to the lunar surface during the final phases of descent and landing.

ASD also built the LM Attitude Translation and Control Assembly (ATCA) and the Descent Engine Control Assembly (DECA). ATCA provides the timing and sequencing signals for firing the jets for attitude and translation control, as well as the automatic trim signals for the gimbaled descent engine. DECA controls the Lunar Module's descent engine throughout the power descent to the moon, turning the engine on and off and controlling the intensity and direction of its thrust.

In addition to the actual Lunar Module hardware, ASD developed a large complex of ground-test equipment to support development of the LM electronic and communication systems.

Astro-Electronics Division

The Astro-Electronics Division, Princeton, New Jersey, is known also as the RCA Space Center. It has an unexcelled reputation for design and fabrication of long-life unmanned spacecraft and spacecraft systems. This division is a leader in the development of operational and scientific satellites and of lunar and interplanetary space systems and subsystems.

Spacecraft built by AED include Tiros (Television Infrared Observation Satellites) weather satellites, the SERT (Space Electric Rocket Test) space platform, ESSA operational weather satellites, Relay communications satellites, and Navy Navigation Satellites, as well as many classified spacecraft.

Nineteen Tiros satellites and Tiros Operational System (TOS) satellites were designed and built by RCA from 1960 through 1969. Ten Tiros satellites were built for NASA's Goddard Space Flight Center.

Nine ESSA operational weather satellites, built by AED for NASA and the Environmental Science Services Administration, were successfully placed in orbit from 1966 through 1969. The ESSA 1 and 2 weather satellites were the world's first global operational satellite system. The ESSA 1 satellite carried 2 .5-inch vidicon cameras. Automatic Picture Transmission (APT) cameras aboard ESSA 2, as well as ESSA 3, 5, 7, and 9, are equipped with RCA Advanced Vidicon Cameras (AVCS). Except for ESSA 3, retired, pictures from these spacecraft are sent to command and data acquisition stations in the United States for use in global weather forecasts.

AED was under contract to NASA's Goddard Space Flight Center to design and develop the next generation of weather satellites, known as the Improved Tiros Operational Satellite System (ITOS). The first spacecraft, Tiros M, was scheduled for 1969 launch.

The division also supplied major subsystems for the Nimbus weather satellites. This program, with NASA's Goddard Space Flight Center acting as manager and prime contractor, is concerned with experimental weather sensing and measurement systems. AED has been responsible for a major part of Nimbus program hardware, providing television, power and data storage subsystems, and video ground station equipment.

AED was building the Navy Navigation Satellites, first developed by the Applied Physics Laboratory of Johns Hopkins University. The first launch of an RCA-produced Navigation Satellite was March 1, 1968.

AED also made contributions to the Apollo program. A miniature, lightweight television camera built by AED provided live television pictures of the astronauts during the Apollo 7 and 8 space missions. The 4.5-pound camera was the first space-qualified camera to make extensive use of integrated circuits. The division also built several TV scan-converters for use with Apollo cameras and performed studies and subsystem testing for RCA's portion of the Lunar Module.

Development and study activities of the division during 1969 covered a wide variety of spacecraft and spacecraft systems. These included unmanned earth resources satellites, data relay satellites, low-altitude satellites, galactic Jupiter probe, broadcast satellites, ultrahigh-resolution television sensors, in-

frared sensors, line scan sensors, dielectric tape cameras, advanced data storage and processing systems for spacecraft, spacecraft stabilization systems, spacecraft antennas, solar and other power supplies, and system requirements for future space missions.

Collection and processing of scientific data from spacecraft continued to be an important activity at AED. Specialized ground stations and ground-station equipment were designed and built for earth orbit and lunar space missions. In addition, new techniques in ground data handling were under investigation to meet the requirements for earth resources observation missions. Among these was the use of lasers for reproducing electronic images derived from sensors working in the visible and near-IR portions of the spectrum on high-definition film. A laser beam image reproducer and soft copy display were built in support of the ground-station requirements.

For the future, AED was directing increased attention to developing those spacecraft and space systems which return practical benefits to the world. Continued development and improvement in earth-orbiting satellites were planned with new technology that will lead to greater scientific knowledge of the earth, the planets, and the stars. In this regard, AED was teamed with the Martin Marietta Corporation on the NASA Viking program for the unmanned Mars landing mission.

AED also was active in oceanography. The division developed a Station-Keeping and Mobile Platform (SKAMP) which is an automated unmanned sailing craft capable of performing a number of important scientific data gathering tasks. The second-generation SKAMP prototype was scheduled to undergo open ocean testing in late 1969.

Defense Communications Systems Division

Principal facilities of the Defense Communications Systems Division (DCSD) are in Camden, New Jersey. Total resources include a complete engineering organization capable of effective project management as well as comprehensive systems and product engineering through all phases of design, development, and manufacture.

DCSD headquarters in Camden, employing engineers, scientists, technicians, and manufacturing and administrative personnel, is a fully integrated design, development, and fabrication facility devoted to handling a wide variety of defense and space electronics work. Specialized engineering laboratories and areas of technical competence are applied to aerospace and tactical communications, trunking and switching systems, recording equipment, command and control communications, advanced communications technology, and communications systems. A fully equipped hybrid microelectronics laboratory is centrally located to support the engineering groups in advanced product design.

DCSD's Camden manufacturing plant has several unique production facilities for space age electronics. Among the most important is the DCSD White Room, utilized for the production of ultrareliable electronic equipment for such programs as Minuteman. The facility consists of a 20,000-square-foot area in which temperature and humidity are rigidly controlled and dust content is maintained at an extremely low level.

DCSD is responsible for numerous large-scale military programs involving diverse skills and capabilities. Management competence has been proved both in planning and scheduling and in the judicious combination of engineering and specialized facilities to produce, implement, and maintain fully integrated communication systems. A salient example of production competence was the delivery of more than 3,000 racks of equipment for the Minuteman Sensitive Command Network and Support Information Network. This prime equipment and associated spares were delivered on or ahead of schedule.

In 1969, the division had programs for the design, development, and production of communications for numerous government applications including communications techniques investigation and conceptual studies. This large and diversified area encompassed the development and production of communications transmission and terminal equipment, plus systems for submarine, shipboard, manpack, vehicular, fixed-plant, aircraft, missile, space-ground, and space vehicle applications.

DCSD projects in the field of tactical military communications included AN/PRC-25 and AN/PRC-77 FM manpack walkie-talkie radio sets, AN/ARC-144 ultrareliable UHF radio sets for aircraft, AN/ARC-142 high-frequency and AN/ARC-143 ultrahigh-frequency transceivers for antisubmarine warfare aircraft, AN/TRC-97 tactical communications equipment, and AN/UCC-5 multiplex carrier equipment.

Digital communications and switching systems were also an important part of the DCSD product line. Four major programs under development or in production at year-end were the Ships Interior Communications System (ICS), the Minuteman Sensitive Command Network (SCN), the Autodin System Improvement Program (ASIP), and the Integrated Circuit/Message Switch (ICMS).

Major space communication programs in which the division participated included the development of tactical satellite communications terminals, Apollo Command Module VHF communications, the communication subsystem for the Apollo Lunar Module, and the Extravehicular Communications System (EVCS) which permits astronauts to explore the lunar surface while maintaining communications with each other and with mission controllers on earth.

Wide-band recording equipment produced by the

division incorporates the latest in recorder technology and includes equipment such as the PT-501 series of video recorders as well as continuous video recorders.

The division has considerable experience in major communication systems, involving study, synthesis, design, development, production, and operational support. Under study at year-end were an integrated communications control system that will simplify operation of airborne radios, and Mallard system studies for creating advanced communications for field military units of the mid- and late 1970s.

Missile & Surface Radar Division

From 1957, when the first precision monopulse tracking radar, the XX-1, was installed at Patrick Air Force Base, until year-end 1969, the Missile & Surface Radar Division, Moorestown, New Jersey, had designed and produced a family of 71 radars of ever-increasing sophistication and capability. They are installed at locations around the globe, both on land and on ships at sea.

The standard RCA FPS-16 and its transportable version, the MPS-25, are precision C-band instrumentation radars standardized for the Air Force, the Army, the Navy, and NASA. Both are ideally suited for assuring range safety and for tracking rockets, missiles, nose cones, boosters, tankage assemblies, instrument packages, debris, earth-orbiting satellites, and space vehicles.

The FPQ-6 instrumentation radar and its air-transportable version, the TPQ-18, represent a major forward stride in the detection, acquisition, and precise continuous measurement of the position of missiles and space vehicles in flight.

M&SRD developed a high-performance tactical radar, the UPS-1, for use by the Marine Corps, the Air Force, the Army, and the Navy. It is packaged in lightweight units, suitable for transportation and operation in the assault phase of amphibious operations.

Another advanced tactical control system under development at M&SRD was the TPQ-27, which will direct tactical aircraft to targets with high precision by use of ground-based precision tracking radar, command control systems, and data links.

Under the Apollo Reentry Ships Program, M&SRD developed the first precision tracking radar to use integrated circuits for all essential electronic functions. Known as CAPRI, this instrument has the general capability of the FPS-16 radar except that the user has a number of options in the pedestal and antenna subsystems. The resultant savings in space, weight, and power make it easily adaptable for installation on board ship, in a trailer, or in small one-story buildings.

The division was designing and developing advanced over-the-horizon radars for the armed forces.

The first major real-time ground-support system

for space missions to use integrated circuits was installed on the Air Force's Eastern Test Range by M&SRD. It consists of 4 ground stations—at Antigua, Ascension, and Grand Bahama islands and Pretoria, South Africa—and a control station on Cape Kennedy. Also deployed are shipborne stations which enable flight scientists to select and call up various telemetry data from space vehicles while the vehicles are in flight down the Eastern Test Range.

M&SRD developed the first truly lightweight hand-held radar for use by combat infantrymen to detect moving targets and direct small-arms fire in all weather and visibility conditions. It weighs as little as 2 pounds in its lightest version and can detect man-sized targets at ranges up to 1,500 meters, defining range within a few meters and angle within a few degrees. A communication mode is also provided, enabling 2 units to set up a secure voice link. The RCA hand-held tactical radar is an all-solid-state system using the latest in integrated circuits and miniature electronics.

Following a far-reaching evaluation of existing equipment for Navy air defense, RCA was chosen by the Navy to perform studies for an Advanced Surface Missile System (ASMS). As head of a team which comprises Bendix, Raytheon, and Gibbs and Cox, RCA developed a design of a system for fleet air defense in the 1970s.

M&SRD developed an erectable antenna to boost, if necessary, voice, TV, and telemetry signals beamed by astronauts from the moon's surface to earth. The antenna is packed as a cylinder only 39 inches long and 10 inches in diameter, but it can be erected on the lunar surface into a 10-foot parabolic antenna. Its contours are within the very fine tolerances needed to direct a beam of energy efficiently from the moon to the earth.

One of M&SRD's newest capabilities is high-volume production of precision complex multilayer printed circuits. A completely mechanized printed circuit manufacturing facility with 25,000 square feet and employing 125 production personnel began operations in early 1968. It produces some of the most complex precision printed circuits—ranging up to 22 layers in construction—for some of the largest electronics firms in the world.

Electromagnetic and Aviation Systems Division

The Electromagnetic and Aviation Systems Division has 3 facilities: Huntsville, Alabama; West Los Angeles, California; and Van Nuys, California, headquarters for the division.

The Huntsville facility is concerned with field service and depot support, primarily for the Saturn ground computer check-out system.

The Aviation Equipment Department, located in West Los Angeles, designs and builds commercial and general aviation airborne weather radar systems, distance measuring equipments, transponders,

and navigation/communication systems. A large percentage of weather radars in use by commercial airlines, as well as general aviation radars, are built by the Aviation Equipment Department.

The Van Nuys facility designs and builds electronic warfare systems; ordnance systems; military and commercial display/memory systems, or intelligence data systems; and military aviation products and systems, a counterpart of the commercial work in the Aviation Equipment Department. The Van Nuys facility has been a leader in the development and manufacture of special-purpose computers, random access memory systems, display systems, electronic warfare equipment, and secure communication systems since 1960.

In electronic warfare, the division was making a significant contribution to the nation's defense effort, including techniques and equipments for deceiving and neutralizing electromagnetic threats. The Electronic Warfare group, a major developer and supplier of countermeasure equipments to the Department of Defense, at year-end was engaged in engineering and manufacturing programs for electronic warfare components and complete systems.

EASD was designing, developing, and manufacturing ordnance products, especially fuzing assemblies for mortars, rockets, and bombs. An extensive independent research and development program was conducted on radio proximity and optical fuzing techniques.

The division was producing Mark 25 monitor assemblies and Mark 26 safing devices under contract to the Navy. In addition, it was under contract to Harry Diamond Laboratories to design and develop the XM588 near-surface burst fuze.

The division's major developments in military information systems were card and drum random access mass memories, video data display systems, and the Saturn ground computer system.

The division developed 2 generations of card memories, the Model 3488 and the Spectra 70/568. These mass memories are among the largest and most economical on the market, in terms of cost per bit. In progress were the design and development of third-generation random access memories which will provide faster time and greater capacity at lower cost per bit.

The random access drum memory systems broke the bit-per-volume barrier in drum memories. This drum memory, a development of the division's independent research and development program, was being produced for use in the Tactical Fire Direction System (TACFIRE) program. Another drum memory system was being produced for commercial data processing applications.

The division developed and manufactured several different types of commercial and military display systems, including the Spectra 70/752 video data terminal, the 70/750 modular video data system, check-out and launch control displays, Tactical In-

formation Processing and Interpretation (TIPI) displays, and Airborne Data Automation (ADA).

RCA and EASD for several years have been a major supplier of aviation equipment products to commercial airlines and to general aviation. Among the equipments that the division markets are distance-measuring equipments, weather radars, IFF transponders, navigation equipment, traffic direction and control equipment, and airborne display/memory systems. The division entered the military market with the intention of combining its experience in commercial aviation systems with its military technological capabilities. In 1969, the division was awarded a major contract from the Army for avionic signal conditioning equipment of the type used for aircraft integrated data systems.

ROHR CORPORATION

In 1969, Rohr Corporation continued its momentum as a primary supplier of jet engine pods with delivery of more than 2,100 aircraft power plant systems.

The company took an important step forward early in the year when it joined with Grumman Aerospace Corporation as an associate contractor on the F-14 supersonic air superiority fighter aircraft. The F-14 will give Rohr a major position in the fighter power plant business for the first time. As an associate contractor, Rohr will build the 14-foot-long engine inlet ducts and will design and build the aft nacelle structures, which measure 16 feet long.

Good progress was made in meeting the power plant schedule for the McDonnell Douglas DC-10, a 3-engine jetliner that will enter airline service in 1971. The first shipset of production engine pods was to be delivered to McDonnell Douglas early in 1970.



Rohr Corporation delivered more than 2,100 power plant pods during 1969. In photo, a night test of a jet engine.

During 1969, the Boeing 747 program at Rohr moved from the development stage into full production. Rohr was building the aircraft's power plant assemblies and pylons. The company was also supplying the engine pods and pylons for Lockheed's C-5 Galaxy.

Rohr also planned to continue development work on power plant assemblies for the 2 supersonic transport prototypes.

A new Rohr-designed thrust reverser for the Boeing 737 twin-jet was developed during the year. The target-type high-performance thrust reverser, which stops the aircraft 23 percent faster than the original unit, was being retrofitted on 737s in service.

During 1969, Rohr was participating in 17 aircraft programs with 8 airframe and engine builders. Deliveries continued for many successful and long-running programs such as the McDonnell Douglas stretched DC-8 and DC-9; the Boeing 707 and 727; the Lockheed P-3 Orion, C-130 Hercules, and Jet-Star business jet; the Grumman Gulfstream II; and the North American Rockwell Sabreliner.

In a major move designed to strengthen and reshape the company's participation in non-aircraft markets, Rohr announced in May the formation of an Industrial Systems Group. All operations involving antennas, automove systems, mass rapid transit vehicles, and marine products were brought together in the new organization.

Under a \$66,700,000 contract with the San Francisco Bay Area Rapid Transit District, Rohr was to design and build 250 mass rapid transit cars over a 3-year period. The first BART car was to be delivered in mid-1970.

Rohr entered the automated materials-handling market with the establishment of an Automove Systems Division. The action is the result of the company's very favorable experience with its automove storage facility which has been in operation at Rohr's Chula Vista, California, plant since 1967. Automove is an automated system of material handling, storage, and control of parts and tools. It is controlled by a real-time peripheral computer which is interfaced with a larger computer. Shortly after the formation of the new materials-handling division, Rohr received a contract to build a system at Norfolk, Virginia, which will use 3 computer-controlled stacker cranes to move stock in and out of 6,240 storage locations.

The company's antenna business continued at a healthy pace with the delivery of 300 microwave antennas which are used in telephone-television transmissions. A communications satellite antenna with a 100-foot reflector dish was erected in Morocco, and a similar structure was under construction for installation in Greece.

The company's marine products business was expanding at a promising rate. During the year, 23 major marine products, including 40-foot workboats,

a 65-foot yacht, and 85-foot warping tugs, were either completed or under construction.

Rohr's research and engineering programs produced several significant breakthroughs in materials and thermal technology. A new Rohr proprietary bonding process, called liquid interface diffusion, or LID, may open the way to more efficient processing of lightweight titanium structures. Research on jet engine sound suppression resulted in the development of sound-suppressing panels which are structural parts of the aircraft's engine nacelle. During the year, the Federal Aviation Administration awarded Rohr a contract to study and evaluate several possible methods to suppress jet engine sound on commercial aircraft. The one-year study will provide the FAA with technical and economic data which will be used to set acceptable levels of jet engine sound.

The company's Space Products Division continued to build motor cases, insulation, and nozzle assemblies for Titan III rocket boosters, with delivery to begin in 1970.

Plant facilities were expanded by over 266,000 square feet, bringing the total factory and office area at all Rohr locations to over 3,000,000 square feet. During the next year, facilities were to be expanded by over 230,000 square feet.

The favorable trend at Rohr toward greater manpower efficiency continued as employment fell from 12,308 to 11,206, while corporate sales advanced to a new high of \$266,000,000. New labor agreements at all 4 company facilities were negotiated during 1969.

SINGER-GENERAL PRECISION, INC.

SUBSIDIARY OF THE SINGER COMPANY

When General Precision Equipment Corporation merged with The Singer Company, a new subsidiary was formed to include Kearfott Division, Librascope Division, Link Division, and Tele-Signal Corporation. In the latter part of 1968, consistent with the Singer philosophy of establishing group functions, each serving in general a common marketplace, the divisions of Singer-General Precision, Inc., were assigned as follows: Kearfott and Librascope were combined with The Strong Electric Corporation and General Precision Systems, Ltd., London (GPE subsidiaries) and 2 elements of The Singer Company, HRB Singer, Inc., State College, Pennsylvania, and the Instrument Division, Bridgeport, Connecticut, to form the Defense and Space Systems Group. Link Division was combined with Graflex and other GPE subsidiaries to form the Education and Training Products Group, and Tele-Signal was assigned to the Office Equipment Group. Other group organizations within Singer include North Atlantic Consumer Products Group, Home

Furnishings Group, Industrial Products Group, International Group, and Metering and Controls Group.

Primary emphasis in this description is given to the Defense and Space Systems divisions, Kearfott, Librascope, Instrumentation, HRB Singer, Strong, and General Precision Systems, Ltd.; to Link Division; and to Tele-Signal Corporation.

As a member of the \$1.7 billion Singer family, the company in 1969 was a major producer of electronic, electromechanical, optical, and other precision-made products for the military services, the government, and industry. The company has won worldwide recognition for achievements in Doppler, stellar, and inertial navigation and guidance; analog and digital computation; simulation and training; weapons control; and analog and digital communications. Its product line in 1969 ranged from large ground-based computerized systems and simulators and airborne digital computers to tiny gyroscopes and instruments used in interplanetary space vehicles. Virtually every major aircraft, missile, space vehicle, and antisubmarine warfare vessel in operation or under development was using a Singer product. The company's products and services were being made available in international markets through direct sales from the United States, joint operations with affiliated companies, and licensing of major overseas companies to produce and market the products. This flexible operation allows the company to support the U.S. government's overseas sales program.

DEFENSE AND SPACE SYSTEMS GROUP

Kearfott Division

Several major equipment contracts for navigation, guidance, and airborne data processing that were received during the 2-year period ending in 1968 reached major milestones in 1969 when, having completed their development and preproduction phases, they became full production items. Among these items were Doppler-inertial systems for the Navy P-3C aircraft and the Navy/Air Force A-7D/E.

Other applications for Kearfott's inertial equipment under contract were for the SRAM missile and the F-105 T-Stick II program. An inertial measurement unit for Collins Radio Company, to be used in commercial and business aviation, was also under contract. The first commercial aircraft application was the Lockheed L-1011 TriStar; selection of the Collins INS-60 system for this application was announced by Lockheed-California Company in 1969. Doppler systems were also being produced by Kearfott for the FB-111 strategic bomber and the C-5 Galaxy transport.

Concurrent with the activities in the navigation system field, Kearfott instituted a program of advanced digital computer developments with the objective of establishing a family of digital machines

having the inherent modular accommodation and growth capability for the airborne navigation, fire-control, and weapon delivery requirements of the 1970s.

In 1969, Kearfott Division was shipping production quantities of its advanced microelectronic analog-digital converters and its control and display panels for the advanced avionic system being integrated by North American Rockwell's Autonetics Division for the FB-111 strategic bomber. Other versions of the control and display panels and of the analog-digital converters were delivered to the Autonetics Division for incorporation into the advanced avionic system for the F-111D tactical fighter-bomber. By the end of 1969, Kearfott was scheduled to produce similar equipment for use aboard the F-111F version.

Other conversion equipment produced by Kearfott was being shipped to IBM Federal Systems Division to be integrated with the IBM 4 Pi computer into the avionic system for the A-7D/E.

The flights of the Apollo spacecraft in 1968 and 1969, including the moon landing missions, featured a variety of Kearfott-produced equipment, such as an orbital rate drive electronics assembly used to convert the Apollo's inertial attitude references into real earth and real moon coordinates for the astronauts' attitude indicators. This device is unique in that the front panel uses lunar white electroluminescence for illuminating the characters of the controls on the display control panel. Two other electroluminescent displays were aboard, one to indicate helium temperature and pressure, and one to indicate propellant quantity aboard.

Significant advances continued in the field of advanced electronic detection equipment. The Kearfott guidance system for SRAM successfully achieved its first major milestone when it guided the missile during the first powered flights of SRAM. The missile, released from a B-52H over the White Sands Missile Range, successfully passed all test objectives on 2 consecutive flights, one in July and the other in October 1969.

The main plants of Kearfott Division are located in New Jersey; other facilities are in New York, Ohio, North Carolina, and California.

Librascope Division

Librascope is composed of the Systems Division and Products Division. For over 20 years, Librascope has been a leading designer and supplier of shipborne antisubmarine warfare weapon control systems for the Navy. Deliveries were made during the year on the Subroc (submarine-borne rocket) weapon control system and the Mk 48 torpedo weapon control system, and development continued for the production of improvements to the ASW weapon control system for the SSN and FBM submarines. In addition, Librascope was supplying the

Navy with data gathering systems designed for various missions, some of them classified.

In anticipation of Navy and ship system requirements, Librascope expanded its capabilities in underwater acoustics and associative signal processing to provide improvements to existing sonar systems.

In the underwater acoustics area, additional orders were received for digital oceanographic data acquisition systems. These systems provide, from aboard a ship, extremely accurate and rapid sensing of the ocean's environmental parameters: temperature, depth, sound velocity, salinity, current velocity, and direction.

Airborne optical systems continued active with additional contracts and deliveries of the XM27 sight system for the Army's light observation helicopter program.

The Librascope L-193 head-up display, a servoed cockpit display system that continuously superimposes flight information and commands in bright colors against the background sky seen by a pilot, was installed in a jet aircraft by the Federal Aviation Administration and a major airline. Other major carriers showed a decided interest in the display.

A 1969 Librascope development in airborne optics was the L-2C display, a head-up display system used by pilots to control their aircraft's glide angle during a landing approach. The L-2C display enables a pilot to land precisely on a selected touchdown point of the runway, with no overshooting or undershooting landing problems.

Librascope's Big-Screen Viewer, developed for the Department of Defense, is a night viewing device designed to provide vision under ambient lighting down to starlight conditions. Customer acceptance was excellent; follow-on orders were received.

The Laserchrome display system is a new concept for the display of dynamic information in a real-time large-screen format. The device operates as a selective access display, capable of interfacing with both digital and analog data systems. It can formulate a variety of alphanumeric symbols as well as vectors and tracers by utilizing a built-in character generator. The system provides a convenient high-performance display for information such as alphanumeric data, strip chart recording, or X-Y plotting in a large-screen format.

Systems Division was also producing other sophisticated optical systems and instrumentation such as pilot sights for jet aircraft, photonavigational viewfinders for reconnaissance aircraft, large-screen military intelligence display systems, and automatic 70-millimeter copy camera systems.

Products Division was designing and manufacturing various-size disc-memory systems for military, industrial, aerospace, and other computer manufacturers; and encoders, integrators, flow computers, mechanical computing components, and other products for computing, data processing, and communication systems.

The Products Division announced a new small-size and low-priced commercial 500,000-bit disc-memory system in 1969. Known as the Model L107-8-4, it is an extension of the present Model L508 which was designed for military application. The Model L107-8-4 provides inexpensive, high-performance storage for a wide variety of commercial data processing requirements. Typical applications are for small computers and calculators, automatic test and check-out systems, process controllers, and buffer or display systems, and as an extension of core memory.

In cooperation with another systems manufacturer, Librascope made shipments of its L516M militarized disc-memory system. The memory systems are an integral part of naval shipboard information centers.

In the area of control and conversion devices, Librascope developed and was in production on the first completely field-serviceable contact shaft encoders on the market. The encoders are readily and easily serviced for extended life without removal from the equipment in which they are installed. These single-stage encoders are available with 8, 9, or 10 bits of absolute binary resolution and with 1,000 counts of 8421 BCD code per turn of shaft. The encoders feature nonambiguous output without the need for external circuitry.

Located in Glendale, California, Librascope employed at year-end approximately 1,400 people and occupied nearly 385,000 square feet of plant area.

The Strong Electric Corporation

The Strong operation, located in Toledo, Ohio, continued to specialize in the design and manufacture of light source equipment for the entertainment and graphic arts industries, solar radiation simulators for environmental testing of space vehicles, and are imaging furnaces for research at high temperatures.



High-intensity lights produced by The Singer Company's Strong Electric division illuminate Launch Complex 39 as Apollo 11 undergoes prelaunch check-out.

Strong was also involved in the production of equipment for the Department of Defense. Among the military products produced during the year were airborne carbon-arc searchlight systems for use by naval patrol aircraft for antisubmarine warfare and 30-inch-diameter searchlight systems, featuring a 20-kilowatt xenon light source, for use by the night vision section of the Army for battlefield illumination. These lights could also be modified, with infrared filters, for anti-infiltration operations.

A major application for the xenon searchlight systems was the battery of 50 searchlights, using the 20-kilowatt xenon source, which provided ground illumination for fueling, final check-out, and launching of all Apollo flights starting with the Apollo 9 launch. These high-intensity light sources provided adequate lighting for the color photographic documentation of the entire launch proceedings at Launch Complex 39, Kennedy Space Center.

HRB Singer, Inc.

HRB Singer, Inc., located in State College, Pennsylvania, with additional facilities in Reston, Virginia, and Rome, New York, was engaged primarily in studies and development of hardware for reconnaissance, surveillance, and intelligence.

Primary emphasis of the division in 1969 was on the evolution of generation techniques and equipment operating in all portions of the spectrum including the visible, infrared, and electromagnetic portions.

Instrumentation Division

With headquarters in Bridgeport, Connecticut, and plants in New Jersey and California, the Instrumentation Division continued as one of the recognized leaders in the design and production of precise electrical and electronic measurement, test, and laboratory standards instrumentation.

During the year, the division acquired Alfred Electronics, Inc., of Palo Alto, California. With this acquisition, it became a leading supplier of advanced swept microwave instrumentation and components.

The Bridgeport operation introduced the first solid-state wide-band signal generator available to the industry. This instrument has the capability of computer interface and features wide-band capability.

The division's Gertch operation in Los Angeles, California, developed a series of solid-state analog-to-digital conversion instruments with unmatched characteristics, and its Ballantine operation in Boonton, New Jersey, developed a new wide-band digital measuring system for applications requiring measurement of voltages over a wide frequency range and where digital interface is considered mandatory.

General Precision Systems, Ltd.

General Precision Systems, Ltd., located in London, England, was involved primarily with studies and development of software relating to problems of traffic control above, on, and around major international airports. The division recently completed a detailed study of the Hong Kong Airport complex and was engaged in a similar study of the Montreal, Canada, airport.

EDUCATION AND TRAINING PRODUCTS GROUP

Link Division

At the Link Division, the 1969 emphasis was on continued simulation of military aircraft, commercial aircraft, and space missions, and on the equally important automobile driver simulators. These systems duplicate on the ground, and in a safe environment, the events that occur in actual flight or on the road.

Link's famous "Blue Box" of World War II has been succeeded by highly sophisticated digital computerized simulators for the Apollo lunar missions and for the new high-speed military and commercial jet aircraft. During the year, Link produced a substantial number of simulators including those for the DC-9, the 707, the 727, the 747, the stretched DC-8, and other aircraft. New orders were received from commercial airlines for additional simulators for these aircraft and for the L-1011 jet transport.

A new visual system for flight simulator training in day and night takeoffs and landings in all types of weather was also developed. This system, called VAMP (Variable Anamorphic Motion Picture), utilizes a 70-millimeter color movie of perfect aircraft landings. Through the use of a unique optical system and a computer-drive servo system, VAMP faithfully presents the out-the-window scene as viewed by the pilot as he makes his landing. His variances from a perfect landing are immediately evident as the picture changes perspective relative to his position. Picture quality is maintained at all altitudes and the film itself can be treated to add fog of varying densities to simulate various weather conditions. The VAMP system was purchased by several commercial airlines and was used with a weapon systems trainer that Link built for the military.

The company also produced a substantial number of simulators for various military aircraft including the F-4, the F-111, the P-3, and the A-7.

The company's contribution to the general aviation field included the development of the Link GAT-1, the first in a series of low-cost general aviation trainers. The GAT-1 trainer was designed specifically for use by fixed-base operators, high schools, and colleges. GAT-2, the second in the series, was in production. GAT-2 is designed for use in multi-engine pilot training.

NASA's astronauts took their first "flight" to the moon long before their actual blast-off from Cape Kennedy. The Command and Lunar Module mission simulators permitted them to take the trip safely, and with remarkable realism, many times—without ever leaving the ground.

The Advanced Products Operations developed a growing business in information storage and retrieval devices and was supplying high-accuracy precision measurement equipment used in mapping operations and in determining missile flight characteristics. Other Advanced Products equipment was used by NASA to produce lunar and Mars photographs and by the U.S. Weather Bureau to reproduce data acquired by spacecraft for meteorological observation.

Link Ordnance attained new prominence in the fields of systems analysis and explosive systems and in the production of sophisticated electroordnance components. A number of components were employed in the Saturn and in the Apollo Lunar Module and Command/Service Modules; they were but a few of the many Link systems used throughout the ordnance, missile, and aerospace industries.

Link Information Sciences, a computer applications organization, was providing an array of software services to the military services and other government agencies as well as to education institutions, industries, and businesses. The new division was offering skills required for effective problem solution in areas concerning systems research and development, mathematical analysis, computer systems and applications programming, and facility management.

The Link Commercial Products Operations was selling and servicing the new Link driving simulator, widely used in the Allstate Good Driver Trainer Program. It was also producing other educational products such as the computer-oriented electronic learning systems. Link's Transportation Products Operation was producing a complete line of traffic control devices.

OFFICE EQUIPMENT GROUP

Tele-Signal Corporation

Tele-Signal is an engineering-oriented, highly skilled electronics development and manufacturing firm. Its capabilities include applications, original design, development and production engineering, and practical design for prototype and long-run, large-quantity production of both component units and complete systems for all phases of voice frequency telecommunications transmission including telephone; telegraph; data transmission; timing recovery; data modems; and remote supervisory control, monitoring, and telemetering. Tele-Signal serves worldwide markets, either through company-owned and -staffed offices or through engineering sales representatives.

The expanded Data Systems Division, headquartered in a separate facility on Long Island, provides a total system management for major communications programs. Services offered by this division include planning and erection of plant facilities as well as design, manufacture, installation, personnel training, and in-the-field maintenance and service.

Tele-Signal was founded in 1957 to produce fully transistorized solid-state voice frequency telecommunication and data systems and modular equipment for use by common carriers, the military services, private communication systems, and public utilities for transmission over wire lines, radio, and satellite relay media.

Products that Tele-Signal produced in 1969 for its domestic and international markets included modular transmission apparatus and systems that provide for many simultaneous telephone, telegraph, and/or data information signals over single transmission circuits; speech privacy systems; encoding and decoding systems for remote selection, monitoring, alarm reporting, control, and metering—used by public utilities distributing water, gas, petroleum, and power as well as by sewage treatment plants; timing recovery systems; signal conditioning apparatus; and specialized test and measuring equipment.

During the year, Tele-Signal entered the satellite market by providing switching and signaling equipment to operate with the Intelsat 4 satellite.

At year-end, Tele-Signal had more than 650 engineering, production, and administrative personnel. It occupied over 100,000 square feet in several plants located in the heart of Long Island, close to the source of ample production personnel and materials and to rapid transportation facilities.

SOLAR DIVISION OF INTERNATIONAL HARVESTER COMPANY

The 1969 year was marked for the Solar Division of International Harvester Company by the development of a new approach in diffusion bonding of titanium, a broadening of component work on the new generation of passenger jet aircraft, and continued production of advanced materials and components for space vehicles. The division saw an ever-increasing utilization of its gas turbine engines in industrial applications around the world and a continuation and potential extension of their use in auxiliary power units for helicopters and business jets. Solar introduced a new industrial gas turbine in 1969 to complement its range of engines. In the government area, a Solar-developed gas turbine-powered generator system completed rigorous Air Force qualification testing.

Solar developed a new approach to diffusion bonding of titanium, referred to as Continuous

Seam Diffusion Bonding. The process moved from the research laboratory and at year-end was in operation as a production process.

Simple airframe flight hardware was fabricated, and evaluation of the process continued with aerospace prime manufacturers for more complex structures. Research continued on the process to apply it to other materials. Programs were proposed to the government to scale up the process and obtain additional design data.

Added to the continuing requirements for Pratt & Whitney Aircraft TF30, J52, JT4, and JT3 components were substantial orders for JT9 felt metal seals.

General Electric Company placed orders for major SST engine (GE4) components and TF34 details. New fabrication and processing techniques were developed in order to supply the large, complicated thrust reverse frame for the SST engine.

Continued requirements for the McDonnell Douglas F-4 slotted leading edge and the boundary layer control ducting made that contract one of the longest-running production efforts in the history of the company.



A Solar technician sprays coating on a beryllium container for the SNAP-27 nuclear auxiliary power system first used on Apollo 12. Solar manufactures the containers at San Diego.

In Solar Research Laboratories, work continued in the fields of composite materials, high-temperature sensors, titanium joining and forming methods, and high-temperature plastics; and in fundamental investigations into the mechanisms of particle erosion and hot corrosion of materials in a gas turbine environment.

Solar continued its contribution to NASA's Apollo program, providing the Saturn V launch vehicle ducting for fuel, pressurization, and hydraulic systems; bimetallic joints for engine controls; and coolant manifolds. For the Lunar and Command Modules, it provides main communication antenna structures.

Always a leader in the fabrication of difficult materials, Solar extended the list to include production of beryllium components for use in precision mirrors, solar arrays, and satellite structures.

Solar has been for many years a leader in the manufacture of industrial bellows and expansion joints. In 1969, it introduced a new line of hinge and gimbal expansion joints to provide for both angularity and offset in high-pressure pipeline linkage without end-thrust.

Deliveries of the 100-horsepower Titan series radial-flow gas turbine continued at a high rate during the year for application in auxiliary power units in various military transport helicopters: the Navy CH-46 and CH-53, the Army CH-47 and CH-54, and the Air Force HH-53.

Preproduction tests were satisfactorily completed and the manufacture of production articles started on the 30- and 60-kilowatt, 400-cycle, precise-power gas turbine generator sets to be used in the Air Force 407L tactical communication system. Titan series engines serve as the prime movers.

A new bleed-air version of the Titan turbine neared the end of its development and test phase and was to go into early prototype production for installation and continuing development testing in auxiliary power units in a series of business jets and smaller airliners.

Twelve 750-kilowatt generator sets, powered by the Saturn 1,100-horsepower gas turbine, were delivered for installation in an Air Force facility in California. This was the largest single installation of Saturn engine-powered generator sets; the sets constitute a portion of the facility's total energy system.

Solar gas turbines found increasing industrial applications in 1969. They were driving natural gas compressor sets, continuous-duty and standby generators, liquid pumps, and a variety of heavy-duty industrial equipment, as well as propelling high-speed boats and off-highway hauling trucks. The growing offshore petroleum activity and new oil discoveries in Alaska were especially bountiful areas.

A new industrial engine—the 3,000-horsepower Centaur gas turbine—was introduced in 1969 and at year-end was in service in the field, complementing Solar's range of engines which stretch from 3,000 down to 25 horsepower.

SPERRY RAND CORPORATION

SPERRY FLIGHT SYSTEMS DIVISION

Research, development, and production in the fields of flight instrument systems, compass systems, attitude reference systems, and automatic flight control systems continued as the prime activity of Sperry Flight Systems Division.

SPERRY GYROSCOPE DIVISION

Among accomplishments by Sperry in 1969 was selection of the division to produce the automatic flight control system for the Boeing supersonic transport. This will be the first commercial flight control system to use digital general-purpose computers.

Sperry was also selected to produce the standard navigation instruments and air data instruments, plus a number of specialized electronic systems, for the McDonnell Douglas DC-10 and the Lockheed L-1011. Air data instruments and some of the additional electronic systems on these aircraft represented new fields of activity for Sperry. Analog air data instruments were to be produced for the L-1011, and digital air data instruments for the DC-10. Sperry was also to produce vertical gyros and directional gyrocompass systems for both aircraft and a special compass coupler usable with inertial navigation systems for the DC-10.

For the L-1011, Sperry was to produce air data computers. For the DC-10, the division was to produce the autothrottle and speed command system, the elevator load feel and flap limiter system, and a new type of engine-thrust indicator and its associated computer.

Sperry's integrated autopilot and flight director system on the Boeing 747 successfully underwent flight tests, leading to extensive airline service scheduled for 1970. During the year, additional airlines ordered Sperry flight instruments for use on their 747s.

In 1969, Sperry introduced a totally new instrument system for commuter airlines and business aircraft. The system, called STARS (Sperry Three-Axis Reference System), is a 3-axis attitude and heading reference system with flight director and outputs for autopilot operation.

Sperry-designed equipment gained increasing acceptance in the growing Japanese aircraft industry during the year, with 2 of the industry's latest aircraft, the YS-11 turboprop airliner and the new CX military jet transport, scheduled to use Sperry-designed flight directors, compass systems, and flight instruments. The equipment was to be produced under license by Tokyo Keiki Seizosho (TKS).

Sperry's double-redundant 3-axis stability augmentation system used in the Air Force X-24A lifting-body research vehicle underwent successful flight test at Edwards Air Force Base.

Category II certification was obtained in 1969 for the Grumman Gulfstream II corporate jet transport, equipped with Sperry flight instruments and compass systems as well as with the Sperry autopilot which is standard on the aircraft. Sperry's autothrottle was also certified for this aircraft and the division was selected to supply autopilots, plus advanced air data computer systems and high-accuracy compass systems, for the next year's production run of the aircraft.

During 1969, Sperry Rand's Sperry Gyroscope Division delivered to the Navy 3 modernized Terrier missile fire-control systems and the first of 4 pilot production systems for an advanced surface-ship sonar. Progress continued in research and development in the fields of sonar, ASW systems, shipboard and space inertial navigation systems, radar techniques, and electrooptical technology. Modernization of the first transportable Loran-D radio navigation transmitter complex for tactical deployment was completed.

At year-end, 20 DLG-class Navy frigates were programmed for outfitting with the improved Mark 76 Terrier fire-control system being modernized by Sperry. Three of the systems were delivered and 7 others were undergoing modernization. The improved system has increased performance, serviceability, and reliability and is able to accommodate the new Standard missile.

Work continued on fixed-site and mobile electronically scanned radar systems which employ a computer to control the radar beam from a fixed antenna. Earlier work on this new breed of radar was embodied in Sperry Gyroscope's HAPDAR (Hard Point Demonstration Array Radar), in operation at White Sands Missile Range, New Mexico. During the year, additional funding was received for development of an experimental phased-array antenna which was expected to aid in the development of new phased-array tracking radar systems.

For future shipboard radar needs, Sperry engineering teams were at work in advanced technologies including sophisticated transmitter wave forms, digital signal processing techniques, and antenna systems.

In the field of antisubmarine warfare, Sperry delivered the first of 4 pilot production systems for an advanced surface-ship sonar. The system, in which extensive use of microcircuits was made, was expected to advance the Navy's antisubmarine warfare capability significantly. The first system was being installed aboard a Navy destroyer for at-sea evaluation in 1970.

During the year, Sperry was awarded a contract to define a new submarine sonar suit for nuclear-powered attack submarines. Other study contracts were received for sonar exploratory and advanced development. The company also was funding additional research in the related fields of sonar equipment, fire control, countermeasures, and overall antisubmarine warfare systems.

A contract was awarded to Sperry in 1969 for 15 Ship's Inertial Navigation Systems (SINS) to be installed on the SSN 637-class attack submarines and the attack carrier (CVA) ships. This equipment is used for precision navigation aboard both vehicles. In addition, Sperry received a contract to develop the carrier segments of the Carrier Aircraft Inertial

Navigation System (CAINS). This system provides the basic inertial reference by remote control for aligning carrier aircraft (S-3A) prior to launching.

The division received authorization for study programs for improving the performance of ship-board inertial navigation systems. With company-sponsored funding, an Advanced Automatic Inertial Navigation System that is expected to replace the existing SINS product line was under development. The Marine Aided Inertial Navigation System (MAINS) was being developed for general ship-board navigation requirements. This system should meet the requirements for the majority of hull types for the decade of the 1970s.

Sperry's Attitude Reference Unit (ARU) for the Spartan antimissile missile had an exceptionally good record during Spartan missile evaluation flight testing.

Sperry's Pulse Integrated Pendulous Accelerometer (PIPA) had outstanding success during the Apollo missions performed in 1969.

Sperry began modernization of the transportable Loran-D transmitter complex for tactical and operational evaluation purposes. At Eglin Air Force Base in 1968, this complex successfully demonstrated, for the first time, the tactical advantages of a mobile Loran-D chain in the field. Development of LAWDS (Loran-Inertial Aided Weapon Delivery System) for jet fighter aircraft continued during 1969 in order to satisfy the growing Air Force need for an all-weather attack capability. The Sperry Loran Manpack completed successful testing by the U.S. Navy in the United States and Vietnam.

Electro-Optics engineers at Sperry Gyroscope Division were continuing development of products based on advanced electrooptical technology. Improved high power density, gallium arsenide laser diode arrays were placed on the market. Sperry applied these components to both beacons and optical radars, including a tactical cloud-base height measurement device. The ring laser gyroscope, pioneered by Sperry, was being incorporated in a strapdown 3-axis inertial measurement unit suitable for aircraft, tactical missile, and space use. This development promised dramatic improvements in life and reliability relative to comparable platforms using conventional gyroscopes. Sperry laser technology resulted in a self-contained alignment laser designed for field use. Infrared detection and tracking sensors were receiving increased emphasis for flash location, measurement, and homing guidance applications.

SPERRY MICROWAVE ELECTRONICS DIVISION

Major aerospace production at the Sperry Microwave Electronics Division in 1969 continued to include semiautomatic check-out equipment for flight-line and depot maintenance programs of A-7, F-111, B-52, and B-58 aircraft radars. The equipments are designed to meet the maintainability and turn-

around-time standards necessary for maximum aircraft utilization.

Major new efforts included the development of 4 building blocks—C-band and X-band frequency synthesizers, the frequency time interval meter, and an interface test fixture—for the Navy's VAST (Versatile Avionics System Tester) program.

For the A-7 program, the division developed and began delivery of a new test set to perform end-to-end analysis of the Doppler navigational radar. Through the use of a portable anechoic chamber contoured to the aircraft skin, measurements are made on the antenna and radome, as well as on the system. Significantly, this is the first custom flight-line tester designed with microwave integrated circuits which reduce size and weight, improve reliability, and simplify logistics.

Production of card, module, and component testers for the Navy's SINS program and development of general-purpose digital testers circuit cards represented a major step toward the improvement of maintenance programming. This type of check-out equipment was expected to become even more significant as prime equipments become more complex and are further miniaturized with LSI techniques.

Several standard radar test sets, including the AN/UPM-6, the AN/UPM-14, and the AN/UPM-29, were also being produced by Sperry Microwave.

SPERRY SYSTEMS MANAGEMENT DIVISION

The mission of the Sperry Systems Management Division, as the name implies, is the design, development, and integration of complex systems, from design conception through manufacture, delivery, and long-term support. The division's 1969 activities encompassed submarine systems, deep ocean systems, avionics, surface-ship systems, and civil and industrial systems.

SSMD marked a major milestone in integrated avionics technology with delivery of the prototype of ILAAS, an advanced weapon delivery and navigation system for attack aircraft, to the Naval Air Systems Command. The system, which was in flight test at year-end, can deliver all types of air-to-ground ordnance with pinpoint accuracy while providing the pilot complete flexibility in maneuvering and evasive tactics.

As navigation subsystem manager, the division continued to supply technical support to the Navy's Polaris and Poseidon fleet ballistic missile programs. The technical concepts for achieving the greatly increased accuracy of the Poseidon navigation subsystem were verified at sea. In addition, the first pilot production equipments of this navigation subsystem, including the Univac-manufactured CP-890/UYK computer and CB-2342/UYK converter, were delivered ahead of target schedule.

Activity in ocean systems and marine sciences was broadened. Although interested primarily in inte-

grated instrument systems for deep-submergence vehicles, the division was conducting systems work in vehicle propulsion, deep diving work systems, vehicle systems, and the marine sciences. The vehicle systems activities included bathyscaphs, nuclear research, undersea search and rescue, submersible transport, and industrial submersible work systems.

Efforts in the marine sciences were directed at ocean instrumentation systems such as the National Data Buoy System, integrated ship control, collision avoidance and navigation systems for commercial shipping, and diver support systems.

The division expanded its activities into the civil and industrial area with the award of a contract from the U.S. Bureau of Public Roads for the development of an automated traffic control system. Other commercial and industrial problem areas of the complexity and proportion to require a systems management approach were being investigated. These included medical and hospital systems, transportation systems, waste management systems, and law enforcement systems.

The division's expanded business interests in 1969 were reflected in the growth of its work force and facilities. SSMD manpower showed a 14 percent increase during the year and at year-end stood at about 1,750 people. An additional 10,000 square feet of space was being added to the division's Great Neck, New York, facilities, which already totaled about 100,000 square feet. Another 100,000 square feet of plant space, which housed SSMD's Polaris and Poseidon groups, was located in Syosset, New York.

UNIVAC DIVISION

Sperry Rand Corporation's Univac Division continued to expand during 1969 and a significant portion of the expansion was in aerospace-related activity.

Univac's Federal Systems Division, St. Paul, Minnesota, was awarded \$50,000,000 in Federal Aviation Administration contracts for Automated Radar Terminal Systems (ARTS-III), which are to be installed at 62 high-density terminal areas within the next 4 years. The systems will display aircraft identity and altitude and other pertinent flight information, adjacent to the existing position display on flight controller consoles.

Airline reservation systems continued to be a prime area for Univac Data Processing Division business. Scandinavian Airlines System announced installation of a third \$2,500,000 UNIVAC 494 system at its computer center in Copenhagen. Other airlines using or installing UNIVAC computers included BEA, Northwest, Air Canada, Iberia, Air France, Eastern, and United.

In related activity, Telex Corporation was replacing 2 UNIVAC 492 computers at its Fairfield, Connecticut, plant with 2 UNIVAC 494s which will

be used in a complete reservation service for all elements of the travel industry including agents, hotels, and car rental firms.

In defense-oriented activity, the Federal Systems Division was supplying the airborne computers and programs for the S-3A carrier-based antisubmarine warfare twin-fanjet aircraft which will replace the S-2. The computers were being developed for Lockheed-California Company, prime contractor. They accept and process data from airborne sensors and display the data on video screens for viewing by members of the 4-man crew.

The division was also producing microelectronic computers for the Navy's land-based antisubmarine aircraft, the P-3C, under a \$13,600,000 contract, and it received a \$16,700,000 contract to design and develop weapons system computers for the Minuteman integrated command and control system.

The Army's Safeguard System Evaluation Agency (SAFSEA) announced it was using a UNIVAC 1108 computer complex at White Sands to evaluate critical aspects of the ballistic missile defense system. The 1108 complex uses Univac's EXEC 8 software.



Sperry Rand's Univac Division delivered a UNIVAC 1557/1558 Graphic Display Subsystem to the Army's Safeguard System Evaluation Agency (SAFSEA). Tied into a UNIVAC 1108 computer, the subsystem is used to display information needed in evaluating critical aspects of the Safeguard ballistic missile defense system.

In space activity, NASA's Marshall Space Flight Center accepted a \$12,000,000 UNIVAC 1108 multiprocessing computer system, which integrates operations of the entire center. Called "the most complex third-generation computing system in existence," the system includes 3 1108 processors and about 80 input-output terminals in laboratories and management offices. During Apollo launches, the 1108 complex converts data from the Saturn rocket into engineering formats which are displayed on television-like screens at the center. UNIVAC 1230 computers are the chief data processors at each tracking sta-

tion in NASA's global communication network supporting Apollo missions. UNIVAC 494s at Goddard Space Flight Center and at the Manned Spacecraft Center route a continuous torrent of information to and from the astronauts.

The Air Force Global Weather Central, Offutt Air Force Base, Nebraska, accepted a system composed of 4 1108s for processing weather data from thousands of reporting stations throughout the world. The computers assist Air Force weathermen in preparing forecasts for virtually any spot on the globe.

Univac's commercial activity expanded at even a faster pace. Orders and installations included a wide variety of fields, from corporate management information systems to stock quotation systems; hospital records; crime information networks linking local offices with central computers; and school grading, scheduling, and inventory systems. Expansion overseas was particularly dynamic.

During 1969, Univac announced its new 1106 computer, an extension to the 1100 series. Also unveiled were 2 new additions to the 9000 series, the UNIVAC 9200-II and UNIVAC 9300-II, both offering increased capability over earlier models.

The Federal Systems Division announced plans for a 350,000-square-foot manufacturing and engineering facility in Egan Township, Minnesota, with construction to begin in the spring of 1970.

At Univac World Headquarters in Blue Bell, outside of Philadelphia, 5 new buildings were leased during 1969. Called the "campus complex," they total about 100,000 square feet of space. The Data Processing Division leased an additional 143,000 square feet of space in Roseville, Minnesota. Univac's employment reached about 35,000, including production activity in the former Sperry-Utah facilities in Salt Lake City; in Bristol, Tennessee; in Utica, New York; and in Roseville.

VICKERS DIVISION

During 1969, Sperry Rand Corporation's Vickers Division continued in high production a number of aerospace programs. In the military area, which was highly volatile because of uncertainty as to the degree of continuing effort in Vietnam, major production continued for the McDonnell Douglas F-4 fighter and for a variety of helicopters. Another continuing program was Vickers turret drives for combat vehicles. Phasing into production were power supplies and hot-gas relief valves associated with the directional control system of the first 2 stages of the new strategic missile, Minuteman III.

Commercial interest centered on the new large-capacity jet transports, for which Vickers had extensive contracts. Production of hydraulics for the Boeing 747 began in 1969, followed by units for the Lockheed L-1011, which utilizes Vickers hydraulics exclusively, and for the McDonnell Douglas DC-10. The division won a number of contracts dur-

ing the year in the small turbine engine market with the Vickers fuel pump. A new type of nose wheel steering system for the Beechcraft 99 commuter aircraft was successfully tested toward the end of the year.

SUNDSTRAND AEROSPACE GROUP SUNDSTRAND CORPORATION

The Sundstrand Aerospace Group continued in 1969 as an internationally prominent supplier of components and systems for aerospace, undersea, and terrestrial applications. Sundstrand Aviation, Sundstrand Datanetics, Inc., United Control Corporation, and Howard Foundry Company form the Sundstrand Aerospace Group of Sundstrand Corporation.

Bruce F. Olson continued his duties as chairman of the board of the Sundstrand Corporation, as did Louis H. Schuette as vice chairman of the board and James W. Ethington as president. Evans W. Erickson remained as vice president of the Sundstrand Aerospace Group. Frank R. Cordon was appointed vice president and general manager of Sundstrand Aviation. Cordon, formerly vice president of marketing, was a 12-year veteran with Sundstrand.

SUNDSTRAND AVIATION DIVISION

Sundstrand Aviation Division, headquartered in Rockford, Illinois, expanded its position as a leading supplier of aerospace components and systems with important additions to its product line in 1969. While the constant-speed drive (CSD) remained the primary product, Sundstrand Aviation was also manufacturing accessory drive systems, controlled speed motors, auxiliary power systems, and aircraft actuation systems. In addition, the Sundstrand Aviation product line included missile power units, underwater propulsion and power systems, and electrical power generating systems for space application.

The Sundstrand constant-speed drive converts the variable shaft speed of the aircraft's jet engine into a constant output speed to drive the aircraft's AC generators. Sundstrand has produced more than 65,000 constant-speed drives with an accumulated flight time of over 125,000,000 hours.

The Sundstrand integrated drive generator (IDG) is the latest state-of-the-art CSD advancement. The IDG combines a customer-proven axial gear differential (AGD) CSD with an advanced-design oil spray cooled generator. A major difference between the IDG and the conventional CSD/generator combination is a unique interface design which permits the IDG drive to circulate oil through the generator section.

Major new contracts for the year included the IDG and the controlled speed motor (CSM) for the F-14 and the leading edge slat actuation system for

the L-1011. The Sundstrand IDG will supply the primary AC electrical power for the F-14, and the Sundstrand controlled speed motor of the half-head design will be used in the emergency electrical generating system. Sundstrand was selected as systems manager for both electrical systems on board the F-14. The Sundstrand leading edge slat actuation system joined the previously selected Sundstrand IDG on board the L-1011. The leading edge slat actuation system provides aerodynamic configuration control of the aircraft, allowing the L-1011 to take off and land on shorter runways and at lower speeds. Sundstrand was selected system manager for this actuation system.

Sundstrand was active in many fields other than aircraft systems during 1969. Sundstrand Aviation was serving as system manager of the complete propulsion system for an advanced antisubmarine warfare torpedo. Involvement included tankage, the fuel delivery system, the recovery system, and subsystems for cooling, lubrication, and hydraulic actuations. System and component testing was conducted in Sundstrand Aviation's Turbine Systems Research Laboratory, a 20,000-square-foot complex equipped for the research, development, and production testing of advanced hot-gas turbomachinery systems.

Sundstrand Aviation was also producing missile power units (MPU) for an advanced-design fleet ballistic missile. MPUs are hot-gas turbine-powered units which provide either hydraulic power for thrust vector control or electrical power for on-board electrical systems, or a combination of both.

Continuing programs of research and development were conducted on other products, including a hydraulic steer system for military vehicles and organic Rankine cycle systems. Organic Rankine cycle systems are gas turbine driven power conversion units. The turbine is powered by a heat vaporized organic working fluid in a closed loop. The systems can function unattended in remote areas for long periods of time. Sundstrand Aviation was also developing an on-site, natural gas fueled, total energy version of the system for the American Gas Association.

UNITED CONTROL CORPORATION

United Control Corporation, Redmond, Washington, a subsidiary of the Sundstrand Corporation, continued to specialize in the design and manufacture of electronic equipment for aerospace applications. Products in 1969 included aircraft stall warning computers, electronically servoed angle of attack sensors, windshield temperature controllers, and thermal switches.

United Control products were selected for several major aircraft programs during 1969, including the Boeing 747, the McDonnell Douglas DC-10, the Lockheed L-1011, and the Grumman F-14A and

Gulfstream II. The 747 will use the United Control stall warning computer, stateroom temperature control system, and truck steering unit. The stall warning and prevention computer constantly monitors the attitude of the aircraft, warns the pilot of an impending stall, and, if desired, prevents the stall. The United Control stateroom temperature control system automatically maintains the desired temperature in the stateroom area. The United Control truck steering unit electrically positions the landing gear body trucks when the nose gear is turned during taxiing.

United Control products selected for the L-1011 include a variety of thermal switches, an angle of attack sensor, and servoed accelerometers for use in the automatic flight control system. The thermal switches monitor and control temperatures in a variety of aircraft systems.

The DC-10 will use a United Control angle of attack sensor and a windshield temperature control system. The angle of attack sensor provides angle of attack inputs to such flight control avionics as stall warning computers, go-around computers, speed command inputs, cockpit angle of attack displays, and autothrottle computers.

United Control was selected to design and develop the approach power compensation system for the Navy/Grumman F-14A. The system includes the electronic computer, actuators, and servoed accelerometers and provides fly-by-wire throttle control to power-assist the pilot's manual and automatic throttle control for cruise, approach, and landing.

Grumman selected the United Control windshield temperature control system for the Gulfstream II.

In addition to new contracts, United Control received several major follow-on orders, including the major subsystems of the C-141 all-weather landing system. United Control subsystems included the rotation/go-around computers, autothrottle systems, test programmer, and logic computers and accelerometers. The all-weather landing system provides the C-141 with Category II landing capability.

SUNDSTRAND DATANETICS, INC.

Sundstrand Datanetics, Inc., formerly the Recorder Group of United Control Corporation, continued as a recognized leader in the design and manufacture of flight data and cockpit voice recorders, airborne audio entertainment and announcement systems, automatic terminal announcement systems, and magnetic recording head assemblies.

Datanetics equipment was chosen by many of the world's major airlines during 1969. Airborne entertainment systems were selected by Trans World, United, Pan American, Alitalia, Northwest, Western, National, Japan, China, Braniff, and Lufthansa airlines. Specialized applications included Air Force One and the Playboy DC-9.

Datanetics automatic terminal announcing sys-

tems were selected for the BOAC terminal at John F. Kennedy International Airport in New York and for the Alitalia terminal at Fumicino Airport in Rome. These systems provide automatic, multilingual announcements.

Datanetics flight data recorders provide indestructible digital and analog recording of flight information. Airlines selecting Datanetics flight data recorders during 1969 included Austrian, Lufthansa, Alitalia, American, Braniff, Iberian, CIA Mexicana, Icelandic, Japan, Southern Airways, Britannia, and Aer Turas.

Digital flight data recorders were selected by McDonnell Douglas Corporation, American Airlines, and United Air Lines.

The Federal Aviation Administration selected Datanetics cockpit voice recorders and flight data recorders.

HOWARD FOUNDRY COMPANY

Howard Foundry, located in Chicago, Illinois, continued to produce metal castings of ductile and gray irons, manufactured by a variety of casting methods and used by the aerospace, heavy equipment, and ordnance industries.

TELEDYNE CONTINENTAL AVIATION AND ENGINEERING

Government contracts for production of Continental Aviation and Engineering J69 and J100 series of turbojet engines and spare parts, for related overhaul and retrofit, and for component improvement programs accounted for the major portion of new business received during 1969.

Production orders were increased for J69-T-29, J69-T-41A, YJ69-T-406, and J100-CA-100 turbojet engines powering Teledyne Ryan Aeronautical tri-service subsonic and supersonic Firebee jet targets. These engines range in power from 1,700 to 2,700 pounds thrust. While drone engines are normally military qualified for 18 hours of operation, the time between overhauls of the J100-CA-100 was increased to 90 hours.

The 1,920-pound-thrust YJ69-T-406 turbojet, developed for supersonic application in the Navy BQM-34E and the Air Force BQM-34F drones, successfully completed its flight-test program. The BQM-34E drone demonstrated 1.1 Mach number at sea level and 1.5 Mach number at 60,000 feet.

Also included were orders for the 1,025-pound-thrust J69-T-25 turbojet, powering Cessna's T-37 twin-jet military trainer aircraft. Described as the lowest cost jet aircraft in the Air Force inventory from the standpoint of both initial cost and operating expense, the T-37 boasted an almost unheard of mission reliability of 98 percent. Over 7,000,000

hours had been logged in the trainer without a single fatality attributed to engine failure. An outstanding accomplishment for the year 1969 was the accumulation by the J69-T-25 turbojet engine of over 1,000,000 flying hours in the USAF Air Training Command. The T-37 was also serving as the primary flight trainer for Brazil, Peru, and other South American countries, where additional engine flight time was logged.

Continental Aviation and Engineering was continuing the design and development of an advanced turbine engine gas generator for the Air Force. In addition, goals were established for a company-financed turbine engine program, and components were being prepared for testing.

A significant milestone was reached in September 1969 when the Toledo, Ohio, facility surpassed the 9,000 turbine engine mark since production began in 1954.

The table that follows specifies the thrust range and fuel consumption of engines in production at year-end 1969.

Military Designation	Maximum Rated Thrust (Pounds)	Specific Fuel Consumption (Pounds/pound thrust/hour)
J69-T-25	1,025	1.14
J69-T-29	1,700	1.10
J69-T-41A	1,920	1.10
YJ69-T-406	1,920	1.11
J100-CA-100	2,700	1.10

Manufacture of turbine engine spare parts was continued at the Neosho, Missouri, facility along with additional turbine engine overhaul contracts on the J69 engine series and MA-1A starter carts.

In 1969, Continental Aviation and Engineering became a Teledyne company, devoted exclusively to the design, development, and manufacture of turbine engine power.

TELEDYNE CONTINENTAL MOTORS

Demand for Continental aircraft engines and spare parts increased in 1969 with Continental Motors again supplying a large portion of the total number of engines delivered to the general aviation industry.

Continental's major customers in the general aviation field were Cessna Aircraft Company and Beech Aircraft Corporation. Continental Motors was also powering models of aircraft built by numerous other companies throughout the world including Beagle Aircraft Ltd., Boelkow Entwicklungen, Britten-Norman Ltd., Reims Aviation, and Sud-Aviation. These aircraft covered a wide range of uses, from single-seat agricultural models to aircraft used for commuter airlines, personal transportation, cargo

transport, corporate and private travel, and similar activities.

The demand for Continental's 375-horsepower geared turbocharged GT520-D engine, utilized in Cessna's pressurized Model 421 introduced in 1967, and for the company's 300-horsepower TSIO-520-E, installed in Cessna's Model 401 and Model 402 aircraft, was significant. Also noteworthy was the demand during 1969 for Continental's IO-520-C engine that powers the twin-engine Beechcraft Baron.

Continental-powered Cessna and Beech general aviation type aircraft continued to serve American armed forces for forward air control missions, pilot training programs, aerial supply, photoreconnaissance, and other purposes. Typical were the military versions of the Cessna Super Skymaster, designated by the military as the O-2 series, and the T-41 series, basically Cessna's Model 172.

Continental Motors' zero-time remanufactured aircraft engine program, under which owners of Continental-powered aircraft can exchange their original engine for a like model factory-remanufactured power plant that has been restored to new engine standards, also made a significant contribution to total business volume. Work conducted under this remanufactured engine program was accomplished at Continental's Mobile, Alabama, facility.

Continental Motors' successful licensing agreement with Rolls-Royce of Crewe, England, was in its ninth year. Under this arrangement, Rolls-Royce manufactures and sells certain Continental aircraft engines used by airplane producers in Europe and elsewhere in the Eastern Hemisphere.

Continental's extensive aircraft engine design and development program continued during the year. One particularly significant new program was expected to provide aircraft engines featuring a substantial improvement in weight-to-horsepower ratio.

Rolls-Royce, in conjunction with Continental, introduced a new Rolls-Royce/Continental engine, the O-240. Based on the O-200 engine design, the O-240 provides 30 percent more horsepower with only a 12 percent increase in weight.

TELEDYNE RYAN AERONAUTICAL

Editor's Note: At year-end 1969, Ryan Aeronautical Company became Teledyne Ryan Aeronautical.

Product highlights of the year 1969 for Ryan Aeronautical Company were the first production order for the Ryan Firebee II supersonic aerial jet target; the first manned landings on the moon, with assists by Ryan landing radar; and award of the Doppler radar system for the Navy S-3A ASW patrol aircraft.

Major business event of the year was the acquisi-

tion of Ryan by Teledyne, Inc., in January. Robert C. Jackson, formerly president of Ryan Aeronautical Company, became chairman of the board and chief executive officer. Succeeding Jackson as president was Frank Gard Jameson, formerly executive vice president. L. M. Limbach became executive vice president. T. Claude Ryan, founder of the Ryan organization in 1922, and chief executive since incorporation of the company in 1931, continued to maintain his office at company headquarters and continued in an active role in the firm's aerospace affairs as a director.

Ryan was awarded a \$12,500,000 Navy contract to produce the advanced Firebee II (BQM-34E). The fixed-price letter contract has a ceiling of \$25,000,000. Ryan developed and flight-tested the high-performance Firebee II under contract to the Naval Air Systems Command. The new target was undergoing Navy mission evaluation flights at the Naval Missile Center, Point Mugu, California, prior to fleet deployment. Initial deliveries of Firebee II were scheduled for early 1971. The 1,000-mile-per-hour pilotless drones will fly operational target missions for both surface-to-air and air-to-air missile firings.

Firebee II is capable of flying at Mach 1.1 at sea level, Mach 1.8 at 45,000 feet, and Mach 1.5 at 60,000 feet. It is designed to meet increased military requirements for high-performance aerial targets. Firebee II is an advanced version of Ryan's veteran BQM-34A subsonic Firebee I, of which more than 4,000 have been delivered to the Army, the Navy, and the Air Force.

For the Surveyor program, Ryan developed a new radar technology. Ryan radars helped soft-land 5 of the survivable robot spacecraft on the moon.

In 1969, improved, man-rated Ryan radars, built under subcontract to RCA, were helping Apollo astronauts make safe, controlled descents to the lunar surface in the first manned landings. The systems measure altitude and velocity as the spacecraft descend, feeding these measurements into guidance computers which automatically control the descent engines.

Ryan's moon landing radar performed sooner than expected in guiding Apollo 11 astronauts Neil Armstrong and Edwin Aldrin in their descent to the Sea of Tranquility in the *Eagle* Lunar Module, July 20, 1969. Scheduled to acquire return signals from the moon at 39,500 feet, the sensitive system locked on at an altitude of 44,000 feet instead, giving the astronauts' guidance computers an important update on the *Eagle's* altitude and rate of descent. Velocity signal acquisition came at an altitude of 28,000 feet, a mark also about 5,000 feet higher than planned. Radar analysts said this demonstrated the high reflectivity of the moon's seas and the sensitivity of the radar's receivers.

When Armstrong determined that his automatic descent path would carry *Eagle* into a football-field-size crater, he took manual control to fly over it but

still relied on the Ryan radar for indications of forward speed, altitude, and rate of descent.

The role of the landing radar had been increased for Apollo 11. First guidance update had been revised from 25,000 feet to 39,500, and velocity acquisition had been revised from 18,500 feet to 23,200. This enlarged role came about because the system performed beyond expectations during Apollo 10 in May 1969, when the *Snoopy* Lunar Module swept past the moon. The radar first acquired at 82,800 feet and measured the low point of the pass at 47,000 feet.



Under subcontract to RCA, Teledyne Ryan Aeronautical produced landing radars for the Apollo Lunar Module.

Radar ground-velocity sensing equipment for the new Navy/Lockheed S-3A will be produced by Ryan Electronic and Space Systems under a contract announced in October by Lockheed-California Company. The contract calls for design, development, qualification, and production. Ryan's radar is a modification of the Ryan AN/APN-193 Doppler navigation set. Improvements include automatic land-sea bias, a microwave stripline receiver, micro-electronic packaging, and a 1,000-hour reliability. The S-3A GVS radar will also feature a solid-state transmitter and a planar-array antenna that mounts flush with the contour of the aircraft fuselage.

Ryan also provides Firebee target service operations for the armed forces at bases in the United States and overseas. Contract extensions of these services for 1969-70 amounted to over \$6,500,000.

In September, a new flight record in survivability

of remote-controlled aerial targets was set at Tyndall. Three subsonic Firebees soared into the air at one-hour intervals on the 38th flight for each, breaking the former record of 37 flights by a jet drone target.

The many missions flown by these 3 targets represented a big dollar saving, according to the Air Force. The 3 drones had flown a total of 114 missions, representing a cost of approximately \$300 per flight.

Fast and elusive, Ryan Firebees have been used at Tyndall since 1958 as prime targets for Aerospace Defense Command and Tactical Air Command fighter-interceptor pilots. The targets fly at over 600 miles per hour at 50,000 feet and provide an evaluation both of the efficiency of air-to-air missiles and of a pilot's firing skill. Firebees are augmented with various systems which prevent direct hits by heat-seeking and radar-controlled missiles. Instead, electronic and mechanical devices record near-miss distances. Recovery is commanded automatically when a hit occurs in flight. A self-contained parachute system lowers the target to recovery areas on water or land.

Meanwhile, at the world's largest Army Air Defense Center, Fort Bliss, Texas, Ryan Firebee aerial jet targets flew more than 6,000 banner tow presentations in a period of 14 months in support of an accelerated antiaircraft automatic weapons training program.

Operating at the Army's Dona Ana Range nearby in New Mexico, Firebees made more than 500 target flights in 4 months. The variable-speed remote-control target averages 14 presentations per flight. A maximum of 18 presentations per flight is reached in many instances. Flying at speeds ranging from 300 to approximately 500 knots, the Firebees present a 2-foot by 12-foot banner tow target to the Army's powerful 3,000 round-per-minute Vulcan 20-millimeter guns.

Hundreds of Army antiaircraft trainees have been processed through the Dona Ana Facility since the advent of the Firebee as a low-altitude high-speed threat target. Reusability of the target is the key to highly economical training at Dona Ana. Firebees have flown an average of 58 flights between losses, reducing the cost per presentation to a low of less than \$700. Mission reliability reached 93.96 percent during the 14-month period.

The Army's hard-hitting Chaparral missile, introduced into the operational inventory in 1969, also was busy tangling with the versatile Ryan Firebee/Towbee aerial target system. Unmanned subsonic Firebees, trailing the infrared Towbee targets from their wing tips, made multiple presentations for the heat-seeking Chaparral missiles at McGregor Range, New Mexico, part of the Army Air Defense Center.

Since the beginning of the Ryan target operation at the range in 1964, 633 flights had been made by the Firebee for a total of 1,294 Firebee/Towbee

presentations by year-end 1969. A cumulative mission reliability over the 5-year period reached an all-time high of 93.76 percent.

At McGregor, Firebee target operations were supporting Hawk missile battery annual service practices, indoctrination and training firings of the shoulder-operated Redeye heat-seeking missile, and Nike missile firings.

Also continuing during 1969 was the advanced flight testing at NASA's Ames Research Center of the Ryan-built XV-5B fan-in-wing Vertifan aircraft. The XV-5B was delivered to NASA in mid-1968 following a \$1,000,000 renovation and modification program. Ryan originally developed the XV-5A for the Army.

Production continued on the Ryan AN/APN-182 Doppler radar set and supporting test equipment. This high-accuracy hover-control radar was being installed in the Navy/Sikorsky SH-3D ASW helicopters. The radar controls the automatic descent and hover maneuver required in ASW operations while the helicopter makes soundings with its acoustical sonar device.

Under a new contract with Hughes Aircraft Company, ground-support equipment for the Navy's Phoenix missile will include portions designed and built by Ryan Electronic and Space Systems. Ryan will furnish ground-support equipment items and supporting software for use in Phase III development of the Phoenix. The contract calls for the design, product development, fabrication, assembly, acceptance testing, and delivery of 3 equipment groups of development model equipment.

Ryan also delivered 3 infrared wave-height sensors to the Naval Oceanographic Office for use in a development effort in automated sea state prediction in the South China Sea. The sea state prediction model is part of the environmental forecasting program under joint development by the Navy Weather Research Facility and the Naval Oceanographic Office.

The sensor transmits and receives infrared radiation to produce an accurate profile of ocean surface movement. With ship motion compensation, wave heights and wave distribution can be charted from the measurements. Advance warning of storm fronts can also be determined.

The first all-solid-state electronically steered phased-array antenna system was delivered by Ryan in May 1969 to NASA's Manned Spacecraft Center, Houston, Texas. The 16-module array is called the Ryan Combined Acquisition and Tracking Radar (CAT radar). It is an antenna prototype of a radar sensor applicable to space rendezvous and docking maneuvers. Ryan microwave engineers believed the CAT radar to be the first all-solid-state phased-array antenna system delivered to a government agency. Other phased-array designs either use traveling wave tubes, and are not all-solid-state, or are still under development.

The small, 1- by 1- by 3-inch modules permit conformal "wraparound" mounting of the antenna on a satellite or spacecraft. It features a Ryan-patented technique using step-recovery diodes to shift the phase of the microwave beam, steering it rapidly over a 120-degree field of view (plus or minus 60 degrees in both azimuth and elevation). The CAT is a "non-cooperative" radar, acquiring and tracking without need of a cooperating transponder on the target vehicle. In addition to rendezvous, it could assist in tracking space debris.

In a related area, a test model of an advanced missile-seeking radar was being designed and built by Ryan under a developmental contract awarded by the Naval Ordnance Systems Command. The radar will be an improvement in electronically steered missile-seeker antennas. Small antenna modules will be mounted conformally on the nose cone of a slender prototype missile. The test model will be solid-state, semiactive.

In another application of Ryan's remote-control technology, the company developed a unique system for remote-control operation of minesweeping jeeps. During 1969, an initial number of these vehicles received combat environment evaluation. Results were promising.

Ryan's AN/ASN-95 automatic homing and guidance set also received combat zone evaluation, with an Army/Air Force parawing delivery system. Good results were achieved in these tests also.

Ryan completed manufacture of 29 titanium-aluminum alloy descent engine chambers for use in Apollo Lunar Module vehicles, under contract to the Systems Group of TRW Inc. The chambers were produced in follow-on orders that began in early 1965 and brought to 101 the total number of units delivered.

Ryan's early experimentation with titanium began in 1951; it has since been directed toward metal component structures demanding light weight and possessing characteristics to withstand extreme elevated temperatures. Ryan became one of the first companies in the United States to form this metal successfully by the drop-hammer process. The company subsequently produced exhaust system shrouds for helicopters and became the nation's largest producer of finished titanium engine pods and pylons for DC-8 aircraft.

THIOKOL CHEMICAL CORPORATION

Presentation of the coveted Department of Defense Craftsmanship Award to Thiokol's Huntsville Division "in recognition of sustained excellence of performance and outstanding improvements" highlighted a year of advances in rocket propulsion technology. Thiokol was the third contractor in the nation to receive the award, the highest given in

DoD's Zero Defects program. The award is based on outstanding performance in establishing, developing, and sustaining a quality program over a long period. To qualify, a contractor must first have received the Participation Award, which the Huntsville Division earned in 1967, and the Achievement Award, which was attained in 1968.

Thiokol's Zero Defects program, which operates under the name "Quality Thinking," was established in 1962 and has continued on a concentrated basis since that time. The Huntsville Division develops and produces solid-propellant motors for the military services, the National Aeronautics and Space Administration, and other government agencies as well as for industrial contractors.

The Wasatch Division received 2 contracts from the Air Force to produce Bomarc motors, reviving an active program of several years ago. Work involves loading the motors with solid propellant. Bomarc is a supersonic, ground-to-air interceptor missile providing air defense for the United States and Canada.

The Huntsville Division's solid-propellant Maverick motor performed successfully in its first flight test, on September 19. The first air-launched test of the air-to-ground vehicle was conducted at the Air Force Flight Test Center, Edwards Air Force Base, California. Launched from an F-4 Phantom II, the test was unguided, but the model possessed the aerodynamic and mass characteristics of the ultimate operational missile. The operational version will be guided by television and is designed to attack small, hard tactical targets such as tanks and sealed fortifications. The Maverick missile is under development for the Air Force by Hughes Aircraft Company.

Thiokol rang up several milestones in motor performance during 1969. The 500th flight of a Huntsville Division-produced Castor I helped launch an Athena vehicle from Green River, Utah, on September 9. In addition to Athena, Castor I has powered Little Joe, Scout, Blue Scout, Jr., and others. Castor IV, the newest and largest member of the Castor motor family, successfully passed static tests during preproduction qualification at Thiokol's Huntsville Division.

Four Aerospace Group general managers were named vice presidents by Thiokol's board of directors. All of the new officers are general managers of major company divisions and are continuing in those capacities. They are John H. Goodloe, Huntsville Division general manager; H. Griffith Jones, general manager of the Elkton Division, Elkton, Maryland; Ray A. McElvogue, general manager of the Longhorn Division, Marshall, Texas; and James M. Stone, general manager of the Wasatch Division, Brigham City, Utah.

The year marked Thiokol Chemical Corporation's 28th year of progress in rocket propulsion and associated technologies.

TRW INC.

The aerospace activities of TRW Inc. continued to grow dramatically during the year. In space, TRW launched 10 spacecraft during 1969, 5 of them in a period of 15 days. Three of the spacecraft, Pioneer E, TETR-3, and Intelsat 3 (F-5), did not achieve proper orbit because of malfunctions of their launch vehicles.

The first 2 Intelsat 3 launches of the year (F-3 and F-4) completed the first global communications satellite system for public use. The sixth launch in the series (F-6) placed a second satellite over the Atlantic to accommodate the greater communications traffic there. Two more Intelsat 3s were ordered by the Communications Satellite Corporation.

A single launch on May 23 placed 2 Vela nuclear test detection satellites and the OV5-5 piggyback research satellite in orbit. This was the fifth Vela launch and the 28th TRW-built piggyback satellite delivered to the launch pad.

The sixth, and final, Orbiting Geophysical Observatory (OGO) was launched on June 5. OGOs have returned more scientific data from space than any other spacecraft. TRW proposed an adaptation of OGO for NASA's Earth Resources Technology Satellite program, and, late in the year, the company received a contract from the Air Force to design and develop 6 satellites for Phase II of the Defense Satellite Communications System. These synchronous-orbit communications satellites will provide the Department of Defense with versatile, worldwide communications.



Technicians of TRW Inc. check over a unit of the company's hydrazine propulsion system, which performed flawlessly on the 1969 Mars flights of Mariners 6 and 7.

As the major U.S. subcontractor for Canada's Tel-sat domestic communications satellite, TRW will have responsibilities for the structure, positioning and orientation, attitude control, apogee motor, solar array, and thermal design of the RCA Ltd. spacecraft.

Late in the year, NASA entered into negotiations with TRW for the construction of Pioneer F and G spacecraft, which will conduct the first explorations of Jupiter.

TRW's activities in advanced propulsion systems for space continued to result in new technological achievements. The Lunar Module descent engine, the first throttleable rocket motor developed, was successfully test-flown on 4 Apollo missions, and its performance on Apollos 11 and 12 permitted man's first landings on the lunar surface. A TRW-built hydrazine propulsion system was employed for mid-course maneuvers of Mariners 6 and 7 en route to Mars, and the Big Ben low-cost engine concept, originally developed with company research and development funds, was demonstrated at Edwards Air Force Base and was under Air Force contract.

TRW penetrated a new and promising nuclear technology frontier by winning a contract to design and develop a radioisotope thermoelectric generator (RTG) for Atomic Energy Commission use on the Navy's advanced Transit Navigation Satellite.

A joint venture, entered into with Commonwealth Oil Refining Company, was an interesting example of a spin-off from the nation's space program. The HYSTL Development Company will produce the HYSTL resins which were invented by TRW for use in ablative rocket thrust chambers. They show promise for a wide variety of commercial applications as a high-performance thermosetting plastic resin. In addition, TRW placed on the market a polyimide laminating varnish evolved from propulsion-related research in new polymer systems.

During the year, TRW's Systems Group moved a major portion of its electronic systems personnel into one of the most up-to-date and efficient facilities in the United States specifically designed for research, development, test, manufacture, and integration of electronic hardware.

The design of the facility evolved after a year of planning which included review and analysis of all major facilities of this type in the United States. Situated in the new 500,000-square-foot complex are scientists, engineers, technicians, and supporting personnel working in the areas of microelectronics, communications, data systems, countermeasures, ground systems, and electronic hardware manufacture. A unique feature of the complex is the close integration of supporting functions with their respective engineering, test, and production centers. This co-location is making a material contribution to improved program costs, schedules, and technical effectiveness.

Under additional NASA and Air Force funding

received during the quarter ending August 1969, the Electronics Systems Division continued to develop experimental avionic hardware for use with proposed navigational satellites. A new worldwide navigational satellite system was envisioned to meet commercial requirements for an air traffic control system and military requirements for tactical navigation. TRW was actively developing hardware which will be employed by virtually all military aircraft, commercial aircraft, and naval vessels following development of such a system. The large market generated by these users presents an important potential growth area for the TRW Systems Group.

Successfully demonstrating its ability to function as an "understudy" during routine operating conditions, TRW's AGS, or Abort Guidance System, operated as a navigational reference during the Apollo 11 and 12 missions to provide astronauts with a new level of confidence in all of the navigation systems aboard the Lunar Module. The AGS is the backup guidance system which parallels the primary guidance system aboard the Lunar Module and permits astronauts to take over control for a safe return to the Command Module.

Other electronic participation in the Apollo program included the addition of special circuitry to permit color TV operations from the Lunar Module and on the moon's surface. The subsystem, located at the Manned Spacecraft Center, eliminates voice and telemetry information from the composite signal returned to earth from the Lunar Module and allows the use of a faster scanning system to transmit color signals.

Another unique contribution to the safety of the Apollo program was the Lear processor. This contribution of combined electronic circuitry and advanced computer techniques gives astronauts the opportunity to determine reliably which of the systems—Primary Guidance Navigation and Control System, Abort Guidance System, or Manned Space Flight Network—is supplying the most accurate information during descent and ascent.

The Systems Group's Microelectronics Center developed many products and processes required for the group's highly advanced programs. One of the major TRW microelectronic efforts was in developing large-scale integration (LSI) processes which permit the economical fabrication of very complex circuits on single semiconductor substrates. This technique bypasses the dicing, packaging, and re-connecting of integrated circuits, a major improvement which saves time and money and adds reliability to the finished product. TRW's Metal Oxide Silicon (MOS) LSI techniques will result in the packing of more than 1,000 transistors in an area .2 inch square.

High-speed digital equipment developed with company funds by TRW's Microelectronics Center will make possible a communications link capable

of transmitting digital signals with the high quality of TV signals. The center was also perfecting high-speed analog-to-digital converters with a capacity ranging from 100 to 600 megabits, far in excess of speeds offered by any other equipment. Applications are extremely broad in infrared, video, radar, and similar high-frequency analog sources.

Microelectronics technology developed by Systems Group scientists and engineers helped perfect the supervisory control system of International Controls Corporation, a wholly owned subsidiary of TRW's Mission Manufacturing Company. ICC's unit permits the operation of an oil field, gas field, or pipeline from considerable distances; the electronic portion of the command and control system, which permits the operator to turn up or off or otherwise regulate production, involves a digital computer with TRW-designed and manufactured micro-electronic circuitry.

Another example of TRW's ability to use technology generated in one part of the company for the benefit of another, involves the digital hardware equipment of Credit Data Corporation, in which TRW has a major investment. Microminiaturized equipment for CDC's Credit Card Rejector system, which electronically converts a credit card identification number to a central computer over television lines, was one of the products developed by TRW's Electronic Data Systems Laboratory.

On January 1, 1969, TRW formed a new division, the Software and Information Systems Division, reflecting TRW's increased role and interest in the computer software industry. The division, headquartered in Redondo Beach, California, has major operations in Houston and in Washington, D.C. It employs 1,700 persons; more than 1,000 of that number are systems analysts, engineers, and programmers. Its dollar volume of work placed it among the top 5 computer organizations in the United States.

The new division was formed through the consolidation of TRW's Analytical Research Operations and Software and Computing Center, formerly part of Systems Laboratories, a division that was subsequently dissolved.

The division's contractual work in space and defense systems included mission trajectory support to NASA for the Apollo program and guidance and control support to the Air Force for the Advanced Ballistic Reentry Systems program.

The division was providing generalized management information systems to the commercial software market. Its software services included mathematical modeling, simulation, interactive graphics, data processing, systems analysis, and development of advanced applications software. Its multimillion-dollar inventory of more than 20 modern computers included the CDC 6000 series, the IBM 360, and the UNIVAC 1108.

TRW's Civil Systems Center deepened its commitment to the solution of urgent civil problems

during 1969, with contracts in the areas of high-speed ground transportation, urban traffic control, urban planning, air and water pollution, and medical systems.

The newly established Canadian Systems/TRW Ltd. in Toronto, Canada, was at work on a contract to plan the development of a 3,000-acre parcel of government-owned land west of Toronto, in one of the fastest-growing regions of Canada. The TRW effort was part of an 800-square-mile planning program undertaken by the federal and municipal governments in the area. TRW was using its Civil Systems resources to manage the project for the Ontario Housing Corporation, owner of the parcel. Similar master planning activities were being performed for the city of Fresno and for the Southern California Association of Governments.

The Civil Systems Center at TRW had U.S. Department of Transportation contracts to study high-speed ground transportation systems for access to the new Miami International Airport. Work was also being done for the Dade County Port Authority on improved bus systems at the Miami airport and for the Tampa Bay Regional Planning Council on improved transportation systems for Tampa's regional planning effort. Other contracts at TRW included high-speed ground transportation studies for the Northeast Corridor and for access to John F. Kennedy International Airport in New York.

In urban traffic control, TRW was planning a demonstration system to control traffic at about 100 intersections in Los Angeles County, using sensors and computers to monitor and regulate automobile traffic. This work was similar to the assistance TRW was providing the U.S. Bureau of Public Roads in developing a pilot traffic control system in Washington, D.C.

A contract was awarded for the functional integration of a new Walter Reed General Hospital, using advanced concepts, developed by TRW for the Army Surgeon General's office, for hospital communications, special-care units, materials handling, automatic data processing, and educational systems. The work will assure that the hospital will not be outgrown by advancing states of the medical arts and that information systems will keep pace with projected hospital growth.

In other civil areas, TRW was working on improved health and safety and increased production in coal mines, development of an expanded national air pollution control program, and disposal of solid wastes. The company received a contract from the Coordinating Research Council to conduct a program covering effectiveness of inspection and maintenance procedures for minimizing exhaust emissions in automobiles.

TRW maintained steady production schedules of parts for aircraft and related industries. At the same time, development work was under way on components for engines of the 1970s. Volume produc-

tion of precision-forged fan blades was under way for the Pratt & Whitney Aircraft JT9D engine for the Boeing 747 jetliner. While the 747 will provide substantial orders over several years, it was expected that advances in forge capability resulting from this program would be applicable to other superjets.

The company received its first follow-on order to supply 3 stages of turbine blades and vanes for the Rolls-Royce RB.211 engine being built for the Lockheed L-1011. Demand for this type aircraft was expected to total 1,000. TRW also won contracts to produce components for General Electric's TF34 turbofan engine, which will power the VFX anti-submarine aircraft, and for GE's CF6, which will drive the McDonnell Douglas DC-10.

Volume production on the giant fan blade, turbine blades, and nozzle guide vanes began in 1969 and was expected to continue to build up in 1970 and 1971. In addition, development orders were received for the CF6-50, a growth version of the CF6 for use on long-range DC-10 aircraft. Fan blades, compressor rotor blades, turbine nozzle guide vanes, and turbine blades continued in production on GE's TF39 for the C-5 transport.

TRW was also penetrating the fast-growing general aviation market, with contracts covering parts for Garrett-AiResearch's ATF 3 and TFE 731 engines and United Aircraft of Canada's JTF 15 engine for use on small jet aircraft serving feeder airlines and corporations. Examples of aircraft using these new-generation engines are North American Rockwell's new Sabreliner, Gates Learjet's Learjet 25, and Cessna's Citation.

Turbine parts for the demonstration power plants in contention for the Air Force B-1A bomber design were shipped in 1969.

Two major aircraft, the C-5 Galaxy and the 747, were using TRW pumps. After shipping 16 preproduction main engine fuel pump units for the JT9D, TRW received a sizable production order. The first 747s in the air carried these pumps. The C-5, which began flight testing in 1968, carries 12 TRW dual-element booster pumps in its wings and fuselage.

Production began on coated airfoils for use in the newer jet engines which must withstand increasingly higher temperature environments. The TRW coating substantially reduces blade corrosion and oxidation. The company was developing sophisticated manufacturing methods for the fabrication of both plastic and metal composite jet engine blades and vanes for 2 major engine companies. Prototype quantities of these blades and vanes provide TRW with the opportunity to implement process development techniques which could result in cost reductions and improved product reliability.

The company received its fifth fiscal year contract award for production of propulsion systems for the Navy's advanced MK 46 torpedo. This award is a multiyear contract, with delivery of the first year's

units scheduled for 1970. These systems continued to perform well during in-water tests.

In metallurgical research, the company achieved directional grain growth in castings. The improved thermal and structural characteristics of such castings were expected to permit upgrading of jet engine performance. TRW researchers continued work under an Air Force contract to develop superalloy investment castings containing both heavy and ultrathin walls to replace weldments in next-generation jet engines. The goal is to produce castings up to 4 feet in diameter with walls as thin as .04 inch for stationary engine parts. The parts could include compressor housings, diffuser cases, and turbine hubs. Such castings would weigh up to 350 pounds after gates and risers are removed. Tolerances will be close enough that machining will be required only where surfaces mate.

Intensive study continued on the application of high-integrity investment castings in industrial gas turbines. Experimental vane segments for the Westinghouse W-251 turbine engine were produced. Other possibilities included castings for heavy-duty (more than 1,000 horsepower) turbine applications, aircraft engine conversions to stationary power plants, and turbines for truck and off-the-road equipment.

TWIN INDUSTRIES CORPORATION

DIVISION OF WHEELABRATOR CORPORATION

Twin Industries' continuing modernization and expansion program had an effect on 1969 performance: more effective utilization of manpower was possible as a result of the installation of new equipment and improved methods.

In June 1969, 3-year contracts were successfully negotiated with the representative unions without a work stoppage, thereby enabling production to remain at a constant level throughout the year.

Late in the year, Twin Industries acquired government-owned machinery and equipment with a replacement value of over \$2,000,000. The company further increased chemical milling and bonding capabilities as well as substantially improving the material-handling system, and office and manufacturing areas were improved through acquisition and rearrangement.

At year-end, a total of 1,800 KC-135 and Boeing 707 empennage units had been manufactured and delivered to the customer. This program was initiated in 1956 and has continued uninterrupted. Work also continued on the F-111 and on the Grumman Gulfstream II executive aircraft.

Contracts under which deliveries were made included electric equipment consoles for the Raytheon Company and 747 window panels and F-5 units for Northrop. Other manufacturing efforts included leading edge units and splitters for the Lockheed

C-5 Galaxy and floor panels and ceiling panels, built on a direct contract with The Boeing Company, for the 747. Work also continued on strategic spare units for the leading and trailing edges of the Lockheed C-141 and on assemblies for the LTV F-8 Crusader.

J. Douglas Fast was named general manager during the last quarter of the year. Armed with an excellent backlog record and a high level of employment, the company looked forward to perpetuating a tradition of airframe manufacturing excellence.

UNITED AIRCRAFT CORPORATION

United Aircraft Corporation maintained its position of leadership in 1969 as a designer and manufacturer of aerospace products and took a pivotal part in man's landing on the moon.

The company's product line embraced jet aircraft and rocket engines, helicopters, space systems, jet aircraft controls, propellers, airborne radar, electronic devices, and others.

United's JT9D turbofan, an advanced-technology engine built by its Pratt & Whitney Aircraft division, powered the new Boeing 747 superjet on its maiden flight early in the year and through a rigorous flight-test program.

The 747 was flying with environmental controls made by Hamilton Standard division to keep atmospheric conditions within the cabin at safe and comfortable levels for those aboard.

Sikorsky Aircraft division made the first commercial delivery—for service on Alaska's oil-rich North Slope—of its S-64 Skycrane®, a heavy-lift helicopter capable of transporting a variety of bulky loads externally.

In space, United Aircraft recorded real achievements during 1969. It took particular pride in the contributions of 3 of its divisions to the Apollo 11 lunar landing mission.

Throughout the flight, Powercell® units, or fuel cells, made by Pratt & Whitney Aircraft generated all the electrical power required to run equipment aboard the Apollo Command Module. While astronauts Neil Armstrong and Edwin Aldrin were in the Lunar Module, they were kept alive by an environmental control system designed and built by Hamilton Standard. That division also provided the portable life-support systems, worn as backpacks, on which the 2 astronauts depended for their life-sustaining needs as they walked on the surface of the moon. At the end of the mission, the 3 Apollo 11 astronauts were picked up after splashdown by a helicopter built by Sikorsky Aircraft division.

United also had a role in the year's 2 Mariner missions, in which the spacecraft flew by Mars, sending back 200 pictures of the "red planet." Two Pratt & Whitney Aircraft RL10 rockets provided

propulsion for the upper stage of each of the Atlas/Centaur launch vehicles that sent the Mariners on their way.

While flight remained United's primary area of interest, inventive application of its flight-related skills continued to foster diversification into non-aeronautical fields. Such projects included gas turbine engines harnessed for tasks on land and sea, composite materials of high strength in relation to weight, clinical apparatus brought forth through a blend of medicine and aerospace engineering, and fuel cells to provide electrical power for undersea and commercial use.

United Aircraft was carrying out product design, development, and manufacture through 6 divisions. Because each has its own product lines and technical interest, detailed activities of the corporation for 1969 are reported separately in the following columns under the names of each. The divisions are Pratt & Whitney Aircraft, gas turbine engines for aeronautical, marine, and industrial applications, rocket engines, and fuel cell power plants; Hamilton Standard, jet aircraft controls, space and life support systems, biomedical equipment, propellers, electronics; Sikorsky Aircraft, helicopters, surface transportation systems; Norden, airborne radar and avionics equipment; United Technology Center, rocket propulsion, fluid-conveyance pipe; Electronic Components, microelectronic products.

PRATT & WHITNEY AIRCRAFT DIVISION OF UNITED AIRCRAFT CORPORATION

In September 1969, Pratt & Whitney Aircraft commercial gas turbine engines passed the 100,000,000-hour mark of accumulated flight time. At that time, engines were in use or on order by 130 airlines throughout the world.

The year 1969 also saw the beginning of full-scale production of the 43,500-pound-thrust JT9D turbofan, power plant for the Boeing 747 superjet and the McDonnell Douglas DC-10 Series 20 trijet. The JT9D was certificated by the Federal Aviation Administration in May to enter commercial service. By the end of October, more than 1,200 JT9Ds had been ordered. Production engine deliveries from P&WA's new, large engine assembly plant in Middletown, Connecticut, began in April. By mid-October, 73 production engines had been shipped.

Prior to commencement of production engine deliveries, P&WA had shipped 24 prototype engines. In addition, 12 JT9Ds were in use in the engine development program conducted in P&WA's East Hartford facilities and utilizing a leased Air Force B-52 which began operating as a flying test-bed in June 1968. By mid-October, the engine development program had accumulated in excess of 6,400 hours, including 220 hours in 57 flights of the B-52. The Boeing 747 flight-test program began in February, following roll-out of the aircraft in December 1968.

In flights of the 747, the JT9D showed significant improvement in the level and quality of engine noise over the largest earlier commercial engines, despite being more than twice as powerful. These flights also demonstrated that the JT9D does not emit visible smoke during takeoff, in flight, or while landing. Improved fuel consumption of more than 20 percent over earlier engines is another significant feature of the JT9D.

During 1969, the 5,000th JT8D engine was delivered. This widely used 14,000- to 15,000-pound-thrust turbofan powers the Boeing 727 and 737, the McDonnell Douglas DC-9, and the Sud-Aviation Super Caravelle. It was also selected to power the Dassault Mercure transport. An afterburning version is used in the Swedish Air Force Mach 2.5 Viggen fighter. In another military application, the JT8D will power the Nihon Aeroplane Manufacturing Company of Japan XC-1A transport.

The Federal Aviation Administration-approved service evaluation program for the JT8D reduced smoke combustion chamber developed by P&WA had accumulated over 90,000 hours by mid-October. The high time set of chambers had been run over 3,000 hours. The program, in which 5 U.S. and 3 European airlines participated, began in August 1968. The new combustion chamber, which markedly reduces smoke from the JT8D, performed excellently with no adverse effects on engine operation or fuel consumption. In October, P&WA was studying plans to put the combustion chambers into full production.

The JT3D turbofan, with up to 19,000 pounds of thrust, continued to perform satisfactorily as the power plant for most Boeing 707 and 720 and McDonnell Douglas DC-8 series aircraft. In March, a milestone in civil aviation was marked with the shipment of a JT3D that was the 12,000th commercial jet engine delivered by Pratt & Whitney Aircraft.

The P&WA 3,300-pound-thrust JT12 turbofan continued to perform satisfactorily on the 4-engine Lockheed JetStar and the twin-engine North American Rockwell Sabreliner. A free-turbine version, the JFTD12, is the power plant for the Sikorsky S-64 Skycrane helicopter. The engine saw widespread use in military service and expanded use in commercial heavy-lift helicopters in 1969. The most advanced version of the JFTD12 engine is capable of developing up to 4,800 shaft horsepower.

In the military field, the Pratt & Whitney Aircraft TF30, the world's first afterburning turbofan, which is in the 20,000-pound-thrust class, was selected to power the Navy/Grumman F-14A fighter. The engine is also the power plant for the Air Force F-111. Both planes are swing-wing twin-jets with supersonic capability. By mid-October, the engine had accumulated over 45,000 hours in nearly 20,000 F-111 flights.

A non-afterburning TF30 powers the Navy A-7A Corsair II subsonic multipurpose attack plane built

by LTV Aerospace Corporation. Another version of the TF30, the TF306 developed by SNECMA of France, is used in 2 versions—the IIIG and the F2—of the single-engine Dassault Mirage aircraft.

Other major military gas turbine engines include the TF33 turbofan (up to 21,000 pounds of thrust) for the Lockheed C-141A StarLifter, the Boeing B-52H, and versions of the Boeing C-135; the J52 turbojet (up to 9,300 pounds of thrust) for the McDonnell Douglas A-4 Skyhawk and the Grumman A-6 Intruder; the J57 turbojet (up to 18,500 pounds of thrust) for the Douglas A-3 Skywarrior, the LTV Aerospace F-8 Crusader, the North American Rockwell F-100 Super Sabre, the McDonnell Douglas F-101 Voodoo, the General Dynamics/Convair F-102 Delta Dagger, and versions of the Boeing B-52 Stratofortress; and the J75 turbojet (up to 26,500 pounds of thrust) for the Republic Aviation F-105 Thunderchief, the General Dynamics/Convair F-106 Delta Dart, and the Lockheed U-2.

The J58 turbojet, which is in the 30,000-pound-thrust class, is the power plant for the only operational aircraft in the world capable of cruising at Mach 3. The twin-engine Air Force SR-71 reconnaissance and YF-12A interceptor aircraft, both designed and built by Lockheed, have accumulated many hundreds of hours at Mach 3, flying at altitudes above 80,000 feet. The YF-12A set 9 world speed records.

The Air Force was operating 3 special versions of the Boeing 707: the VC-137A, powered by 4 JT3s, and the VC-137B and C, powered by 4 JT3Ds. These aircraft are Presidential transports, designated Air Force One when the President is aboard.

Significant progress was achieved at P&WA during the year in advancing weight-saving composite materials technology for aircraft engines. In January, the division successfully operated a JT8D turbofan engine utilizing a first-stage fan equipped entirely with boron-aluminum composite blades. They represented a 40 percent weight saving over conventional titanium blades and required no part-span shrouds for stiffening. In June, P&WA received the largest aero propulsion hardware contract involving advanced composite materials ever awarded by the Air Force Materials Laboratory. Under the \$4,700,000 contract, made in conjunction with the Air Force Aero Propulsion Laboratory at Wright-Patterson Air Force Base, Ohio, P&WA will design, fabricate, and test 2 stages of fan blades, a fan disc, and an intermediate case for an advanced composite engine. Composite materials used in the program will include boron-aluminum, boron polymer, graphite polymer, and other materials.

The division was also conducting an intensive program to investigate possible uses of composite materials in high bypass ratio engines such as the JT9D. Included in this program are cases, fan blades and vanes, and other components.

At Pratt & Whitney Aircraft's Florida Research

and Development Center near West Palm Beach, development of a high-performance turbofan engine for the proposed Air Force F-15 and Navy F-14B fighters entered the test phase. The Air Force engine, designated the F100, and the Navy version, the F401, have the same basic core, but are being individually tailored to meet different mission requirements of the 2 services. Pratt & Whitney Aircraft's F-15/F-14B engines utilize advanced concepts from the ATECG, AMSA, and lift/cruise programs, as well as the division's experience with other augmented turbofan engines and the Mach 3-plus J58 turbojet. F100/F401 performance details are classified.

The Florida facility continued to develop a powerful new reusable rocket engine under contract with the Air Force Rocket Propulsion Laboratory. Using liquid hydrogen and liquid oxygen propellants, the XLR129 will produce up to 250,000 pounds of thrust. The engine achieves its tremendous power through a high-pressure technique, and it has a 2-position nozzle that will enable it to perform well on both near-earth and deep-space missions. Tests of a full-scale thrust chamber proved the XLR129's staged combustion design in which hydrogen fuel is ignited in a preburner chamber before it passes into the main combustion chamber. Thrust of the XLR129 can be varied over a wide range.

Work also continued in Florida on an advanced-technology turboshaft engine, the 1,500-horsepower ST9. This new lightweight engine was being built and tested in a demonstrator program sponsored by the Army Aviation Materiel Laboratories for possible applications in V/STOL aircraft, including helicopters. The ST9 offers improved performance over earlier turboshaft engines and has a simple, rugged design that permits rapid diagnostic inspection, easy replacement of components, and a minimum number of special maintenance tools. Three standard tools, a screwdriver and 2 wrenches, are required for field maintenance.

Product improvement continued at Florida on the J58 afterburning turbojet engine.

The Florida center also supported launch activities in connection with the 15,000-pound-thrust liquid hydrogen/liquid oxygen RL10 rocket engine. Twin RL10 engines power the upper stage of the National Aeronautics and Space Administration's Atlas/Centaur space launch vehicle. In 1969, this versatile high-energy booster launched 2 Mariner spacecraft to the planet Mars and placed an Applications Technology Satellite in orbit around the earth. By year-end 1969, 72 RL10 engines had flown in the U.S. space program without a single failure.

Pratt & Whitney Aircraft's participation in the expanding market for non-aviation uses of gas turbine engines continued to grow significantly during 1969. This market is handled by Pratt & Whitney Aircraft's Turbo-Power and Marine Department,

formed in 1959. The engines utilized are the GG3, GG4, and GG12—modified versions of the JT3, JT4, and JT12 aircraft engines—which develop between 3,300 and 18,500 pounds of thrust. When connected to a free turbine manufactured by Pratt & Whitney Aircraft, the units are designated FT3, FT4, and FT12 gas turbines. The most widely used version is the FT4, capable of generating up to 30,000 shaft horsepower.

Among major installations ordered during 1969 was a 15-unit industrial gas turbine system using GG4s and FT4s as prime movers for oil field pressurization and processing and for electrical power requirements of an oil field operation deep in the Sahara Desert. Another foreign order for equipment, received from Mexico, called for a 15,000-kilowatt Mobile Power Pac electric station.

New major marine installations included an order for FT4s to power 4 30,000-ton-displacement general cargo ships under construction in West Germany; these ships are the first of their kind to use gas turbine engines for primary propulsion. Also, the U.S. Coast Guard ordered 2 more *Hamilton*-class high-endurance oceangoing cutters equipped with Pratt & Whitney Aircraft marine gas turbines for speeds above 20 knots, bringing the total to 11, including 9 in Coast Guard service. A U.S. Maritime Administration 100-ton air-cushion surface ship, to be built by Bell Aerospace, will be capable of 90-knot speeds and will be powered by 3 FT12s capable of developing 4,500 shaft horsepower each. The roll-on, roll-off cargo ship *Admiral William F. Callaghan* completed over 200,000 miles at sea in service between the U.S. East Coast and Europe. The vessel has cruise speed capability in excess of 25 knots. Other marine applications include boost power for 2 Royal Danish Navy frigates, 4 Royal Canadian Navy destroyers, and a hydrofoil ship.

By the end of October, more than 120 Pratt & Whitney Aircraft-powered gas turbine installations, capable of producing over 4,000,000 kilowatts, were in service with electric utilities. In the natural gas transmission field, Pratt & Whitney Aircraft gas turbines had accumulated about 1,000,000 in-service hours as prime movers for pipelines.

Pratt & Whitney Aircraft was conducting one of the nation's largest fuel cell research and development programs. Three 2.2-kilowatt Powercel 3A-2s operated successfully in the Apollo moon landing program, providing the on-board electrical needs of the Command and Service Modules. With the completion of the Apollo 11 mission, these Powercels had accumulated over 3,000 hours of operation.

In mid-October, a marine Powercel, operating independently in 50 feet of water on the ocean floor off the Florida coast, successfully provided all the electrical power needs of a 4-man undersea habitat. It was the first time a fuel cell had been used for commercial work under the sea. In another marine fuel cell program, P&WA was awarded a contract

in February to perform design studies for an undersea fuel cell power system capable of supplying 60 kilowatts for a 35-hour mission of a Deep Submergence and Small Object Recovery Vessel (DSSV) operating at depths to 20,000 feet. Upon completion of the design studies, the division submitted a competitive bid to build the power system.

The gas industry TARGET program, in which P&WA was teamed with 28 major gas utilities across the nation, neared completion during 1969 of 3 years of work in the first phase of a long-range effort to develop a natural gas fuel cell for businesses, apartment and office buildings, and homes. Technical feasibility of such a fuel cell was demonstrated during the Phase I TARGET period and plans were being laid as the year ended for the next phase of the program.

HAMILTON STANDARD DIVISION OF UNITED AIRCRAFT CORPORATION

Flawless performance of the portable life-support systems astronauts Neil A. Armstrong and Edwin E. Aldrin, Jr., wore during their 2-hour extravehicular activity on the lunar surface July 20 highlighted activities at Hamilton Standard in 1969, the division's 50th anniversary year.

The backpack was one of 9 different pieces of equipment Hamilton Standard developed for man's first moon landing. Other major equipment systems included the strapdown inertial measuring unit for the Lunar Module's (LM) abort guidance system and the environmental control system for the LM. Division-built equipment was used also on the Apollo 9, 10, and 12 missions.

The year saw the United Aircraft division broaden its life-support capabilities for space stations. A contract was received from NASA to develop and build a prototype system designed to support a multiman crew on a resupply basis. McDonnell Douglas and North American Rockwell selected the division to define life-support requirements for the space station studies conducted for NASA.

Development of advanced propellers increased markedly as Hamilton Standard began work on a 26-foot demonstration propeller for V/STOL tilt-wing transports under an Air Force contract. The propeller will have lightweight blades and a cyclic-pitch mechanism designed to give pilots direct attitude control of the aircraft during vertical flight and transition to forward flight. Hamilton Standard also began building advanced propellers, 23 feet in diameter, for the West German VC-400 tilt-wing aircraft. In the meantime, propellers were in quantity production for such turboprops as the Lockheed C-130 cargo carrier and the P-3 antisubmarine patrol plane.

Production of fuel controls continued for a variety of General Electric, Lycoming, and Pratt & Whitney Aircraft jet engines. Hamilton Standard

also worked closely with all 3 engine makers in the development of new controls for advanced-technology engines. These advanced controls, lighter and more refined in their control characteristics, employ digital electronics as well as hydromechanical methods for fuel-metering tasks.

A contract was received from Boeing to develop and supply pressure ratio sensors for the air inlets of the supersonic transport. Production of air inlet control systems for the General Dynamics F-111 continued. Grumman selected Hamilton Standard to supply wing-sweep actuator systems for the Navy F-14 carrier-based fighter.



A Hamilton Standard technician puts an ultrathin boron filament from a production run through a tensile test. The filament, the reinforcement element in new composite structures, has an ultimate tensile strength of 400,000 pounds per square inch.

The division produced a variety of equipment for the Boeing 747 jetliner, which made its first flight early in the year. Manufactured were environmental control systems as well as engine fuel controls, starters, and engine pressure ratio transmitters. Development progressed on the integrated pneumatic system being supplied for the Lockheed L-1011 jetliner. This system consists of the environmental controls, auxiliary power unit, and engine starters. Cessna Aircraft selected Hamilton Standard to supply air-conditioning systems for its new twin-turbofan Citation business jet.

In electronics, 3 computerized airborne integrated data systems were delivered for flight evaluation by

KLM-Royal Dutch Airlines, Scandinavian Airlines System, Swissair, and Union de Transports Aeriens. The new system employs a digital computer to analyze and selectively record flight data for monitoring and maintaining aircraft systems. A contract was received from Trans World Airlines to produce pressure ratio limit computers for its Boeing 747s.

Production of electron-beam welders continued for mass production, aerospace, and nuclear fuel companies. Engineering work concentrated on bringing forth new high-speed equipment for welding tubing and gas transmission pipelines.

Numerous orders for boron filament, Borsic®-aluminum tape, and related products were received from many companies working on the development and application of composite structures to airframe and jet engine components. By year-end, production capacity of high-strength, lightweight filaments reached 10,000 pounds per annum.

In the biomedical field, multichannel and single-channel patient-monitoring systems were sold to scores of hospitals and medical centers. An advanced Telamedic II® system, which transmits and records electrocardiogram data by telephone, was introduced. Research work continued in circulatory assist and artificial heart programs funded by the National Heart Institute.

Airport runway lights, jet engine diagnostic test systems, and computerized test equipment were produced for ground-support applications. In newer product areas, Hamilton Standard continued development work on advanced guidance and control systems and on digital data equipment.

SIKORSKY AIRCRAFT

DIVISION OF UNITED AIRCRAFT CORPORATION

Sikorsky Aircraft continued in 1969 to produce large and medium helicopters for military and commercial use through its air transportation systems section. Research centered on advanced vertical takeoff and landing (VTOL) aircraft.

Progress was reported in development of the TurboTrain and of a turbine-powered gunboat by Sikorsky's surface transportation systems section. TurboTrains offered regular passenger service between Montreal and Toronto and between Boston and New York. The gunboat began Navy tests.

Sikorsky's S-65, S-64, and S-61 helicopters were improved by more powerful engines and other physical changes that bettered speed, hot weather, altitude, and lifting performances. Engineering studies covered a wide range of VTOL aircraft, augmented in some cases by flight tests.

The S-65, newest and largest of Sikorsky's production helicopters, continued to demonstrate its versatility. The CH-53D, the Marine Corps version, and the CH-53C and HH-53C, Air Force configurations, were delivered for the first time as improved models of the CH-53A and HH-53B.

Two S-65A-2 helicopters were accepted by the West German government in 1969 as military transports. They represented the first of a 135-helicopter order to be built under a U.S.-German co-production program. S-65C-2 helicopters were ordered by the Austrian government as search and rescue vehicles.

The S-64 flying crane helicopter was presented in a growth version. CH-54Bs, improved models of the Army CH-54A, were delivered for the first time in 1969. The CH-54B can lift and carry 12.5-ton payloads, as compared with 10 tons for the CH-54A.

S-61 models, in a number of configurations, were delivered to military stations in the United States and abroad. The SH-3D, a growth version of the SH-3A, was delivered to the Navy as an antisubmarine warfare helicopter and search and rescue vehicle. The SH-3D was used dramatically to pick up American astronauts at the end of the Apollo 10 and 11 moon shots. Air Force HH-3E helicopters were used at Cape Kennedy at all Apollo landings. The Coast Guard's HH-3F, an S-61 model with highly sophisticated navigational and rescue equipment, flew its first missions from a number of Coast Guard bases. SH-3Ds were produced by Sikorsky for the Brazilian Navy, by Westland Aircraft Company (a Sikorsky licensee) for the British Navy, and by Gruppo Fratelli Agusta (another licensee) for the Italian Navy.

Commercially, Sikorsky's S-64E Skycrane was used for the first time, carrying oil rig parts and supplies over the tundra of Alaska's North Slope. S-64Es were used in a number of construction, petroleum, and utility projects. S-61N and S-61L helicopters, improved over earlier S-61 models, were delivered to operators such as Greenlandair in Greenland, Elivie in Italy, Helikopter Service in Norway, KLM Noordzee Helikopters in Holland, Brunei Shell in Brunei, Okanagan Helicopters in Canada, and Los Angeles Airways in the United States.

Research went far beyond flight simulator and computers. The S-61F, an experimental compound, was flown in a dozen variations. Boron-fiber glass tail rotor blades were tested on a company S-61R helicopter. An SH-3A helicopter was fitted with a 6-bladed main rotor and a 10-bladed tail rotor in an experiment aimed at reducing noise levels. Sikorsky's advancing blade concept (ABC), with twin rotor systems on a common axis, was fabricated and readied for wind-tunnel tests.

Engineering study included a number of projects. The S-65-200 and S-65-300 compounds reached final design stages. The S-65-200 is a 3-engine, 86-passenger commercial vehicle; the S-65-300 is a military carrier. The S-64B, a flying crane with an 18-ton load capacity, reached the preproduction stage, and studies continued on heavy-lift helicopters with even greater lifting ability. The S-64F, an improved S-64E, was readied for production.

The concept of a telescoping rotor blade was devised for possible use on a number of different aircraft. New materials, such as boron and beryllium, were tested for weight-saving and strength-giving characteristics. Safety, speed, maneuverability, maintenance, strength, noise, lift—all were considered in the drive for improvement.

Studies extended beyond the aircraft themselves. Sikorsky engineers mapped traffic routes and terminals for future intercity air service. Their forecasts indicated the need for more, larger, and faster VTOL aircraft in the 1970s and 1980s. Sikorsky was preparing to meet that need.

NORDEN
DIVISION OF UNITED AIRCRAFT CORPORATION

Norden registered gains during 1969 in its principal areas of interest in the avionics field.

Production continued throughout the year on search and track radar systems for the Navy/Grumman A-6A Intruder attack aircraft, which for years has performed all-weather missions in the Far East. Late in the year, Norden was awarded a contract from Grumman Aerospace Corporation to develop a new radar system for the A-6E, an advanced A-6 aircraft. The new radars will replace the A-6A radars and will provide a great increase in reliability without eliminating any of the performance features of the A-6A radars. Eventually, the new A-6E radars will be retrofitted to all fleet-operational A-6A aircraft.

Deliveries of multimode radar systems were made to Lockheed-Georgia Company for installation on the Air Force C-5 transport. Flight testing of the radar system was made in both C-141 and C-5 aircraft. The Norden radar provides more capability than any other operating airborne radar system, enabling the C-5 to achieve accurate landings or airdrops, day or night, in adverse weather, without any help from ground aids.

In the cockpit display field, Norden began deliveries of integrated display systems to the Autometrics Division of North American Rockwell Corporation, for installation in the Air Force/General Dynamics F-111D fighter-bomber. Flight testing of the system advanced during the year. The IDS provides, on cathode ray tube and head-up displays, all vital navigation, mapping, and target information, permitting precision all-weather operation of the high-performance F-111D.

During the year, the Navy completed testing of the integrated helicopter avionic system for which Norden provided radar and cockpit displays. The testing was carried out with the IHAS system installed in a Marine Corps/Sikorsky CH-53A helicopter. The system, designed for both helicopter and vertical takeoff and landing aircraft, enables precise self-controlled navigation and automatic terrain following under all weather conditions. At

year's end, Norden was developing a similar system for use in the Air Force/Sikorsky HH-53 rescue helicopter.

Development progressed on new cockpit display equipment designed especially for commercial aircraft. Norden's electronic attitude director indicator (EADI) was successfully flight-tested in a Boeing flying test-bed during the year, and was also tested in a McDonnell Douglas Corporation DC-10 simulator, as part of a continuing program to achieve the maximum configuration for airline use. The EADI integrates in one cockpit display all critical command and performance information. By mode switching, different combinations of instrument readings can be obtained for various phases of flight.

UNITED TECHNOLOGY CENTER
DIVISION OF UNITED AIRCRAFT CORPORATION

Completion of the flight-test program of the world's largest operational solid-propellant rockets with a perfect record and the ground testing of a newer and more powerful version of these motors highlighted a year of aerospace progress at United Technology Center.

Produced by UTC at its California rocket production center, the massive, segmented, 120-inch-diameter solid rockets operated flawlessly as the lift-off stage of the Air Force Titan IIIC space vehicle during all 13 test launches. Assembled in a 5-segment version for the Titan IIIC's booster system and used in pairs, the rockets are fired simultaneously to give the vehicle a total lift-off thrust of approximately 2,500,000 pounds.

The final launch in the test program, conducted at Cape Kennedy in May, boosted 5 satellites, including 2 Vela nuclear detection spacecraft, into their orbits. Earlier, in February, the 12th launch of the Titan IIIC carried the military's largest communications satellite into orbit. During the entire test-flight program, which began in 1965, the solid boosters successfully launched more than 50 satellites.

A 7-segment motor was statically test-fired in April at UTC. Producing a record 1,400,000 pounds of thrust, the test was the first for the powerful new rocket which had been planned for use in pairs as the lift-off stage of the Titan IIIM launch system, a program canceled by DoD. However, several more test firings will be carried out by UTC to flight-qualify certain new components and sub-assemblies as improvements for the Titan IIIC launch stage.

UTC's FW-4 solid-propellant upper-stage rocket, first flown in 1965, had by year-end placed 42 satellites in precise orbits; 5 flights were made in 1969 aboard the Air Force's Atlas F booster rocket and NASA's Delta and Scout launch vehicles.

Under contract to NASA, UTC began a program

to design, fabricate, and test-fire a high-performance hybrid rocket engine specifically suited for upper-stage applications. Possible uses include up-rating of the Delta and Atlas/Centaur launch vehicles. Under another contract with NASA, UTC continued its design support work for advanced hybrid rocket propulsion systems for a family of high-energy upper-stage rockets for future unmanned space missions.

UTC was awarded a contract from Beech Aircraft Corporation to static test the first full-scale hybrid rocket engine for the operational Sandpiper target missile. Under the program, UTC was conducting several firings of the hybrid engine to evaluate its performance and measure its infrared emission.

The company started development of a more powerful solid-propellant first stage for NASA's Scout space launch vehicle. Under a contract awarded to UTC by LTV Aerospace Corporation's Missiles and Space Division, prime vehicle contractor for Scout, both development and qualification static firings will be carried out during the 18-month program. Thirty feet tall and 45 inches in diameter, the new UTC rocket motor, called Algol III, will permit an increase of 40 to 45 percent in Scout's payload weight.

A unique missile to loft meteorological data-seeking instruments into the atmosphere to gather information about weather and climatic conditions was being developed by UTC for the Navy's Pacific Missile Range. The 10-foot-long missile carries its payload in an aerodynamically designed dart nested in an internally stored insulated canister, a technique which gives the vehicle its name, Kangaroo. Launched from a simple rail launcher, Kangaroo will utilize a solid-propellant motor for initial boost and a novel gas pressure device to propel the dart from inside the missile to unusually high altitudes.

A program to demonstrate germ-free solid-propellant rocket propulsion systems for planetary landing vehicles was being carried out for NASA's Langley Research Center. UTC will build and static test-fire several subscale flight-configuration solid-propellant rockets after subjecting them to a rigorous heat sterilization program that will meet NASA requirements for space vehicle decontamination. The contract was awarded to UTC after the successful completion of a 3-year company-funded research program to demonstrate an advanced propellant that would provide the required physical and ballistic properties necessary for heat sterilization.

A twofold program to establish new metal manufacturing processes for rocket hardware components of tactical weapons was being carried out for the Army Missile Command. The first step, successfully completed, demonstrated that shear spinning of advanced steel alloys can produce a rocket casing of light weight and high strength. The second step involves a casting process to fabricate nozzles

and motor cases that could be used for tactical weapons.

UTC was conducting a program to evaluate several low-cost nozzle insulation materials capable of withstanding the high temperatures encountered in rocket exhausts and the erosive effects of highly reactive fluids used in steering systems for large solid-propellant rockets. The program was one of several sponsored by NASA to evaluate inexpensive steering systems for very large solid rockets being considered for a variety of launch applications.

A simple, inexpensive device to prevent engine flameout in tactical rockets from liquid fuel or oxidizer starvation was successfully demonstrated for the Naval Air Systems Command. The device, a lightweight aluminum-spun cylinder for liquids, is forced to collapse in a controlled manner so as to mechanically expel its contents and literally force them into a rocket's combustion chamber, thereby maintaining the flow of propellant.

A one-of-a-kind, miniature ballistic test-firing range, capable of accelerating and measuring the supersonic velocities of particles 100 times smaller than a grain of sand, was developed for work being carried out for the Army's Research Office. Data obtained from repeated firings were enabling UTC propulsion experts to study performance losses caused by particles produced during combustion of metalized solid propellant and expelled through the nozzles of rockets.

A program to explore the production of sound from fire was being carried out for the Air Force Office of Scientific Research by UTC. The contract was awarded following the company's discovery that flames could accept electrical impulses and reproduce them as audible sounds with the clarity of a high-fidelity loudspeaker. The technique may prove useful as a means of introducing sound into the combustion chambers of rockets to assess combustion stability or as a device to take sound recordings of combustion itself.

Completion of a multimillion-dollar complex to manufacture metal products ranging in size from small machined parts to large rocket motor cases was announced in February. The new plant has a variety of metal forming and machining equipment for manufacturing as well as a facility to do chemical milling work.

UTC continued to manufacture and sell a wide variety of its Techite® pipe for fluid-conveyance systems. Techite is a by-product of UTC's work in the research and development of glass fiber rocket motor cases. In August, the company announced that Materiais de Construcao M.D.R. Company of Rio de Janeiro, Brazil, had been licensed to manufacture and market Techite in that country. Licenses were also granted to Johns-Manville Corporation for the United States and Canada and Hoeganaes Company for Sweden and other Scandinavian countries.

ELECTRONIC COMPONENTS
DIVISION OF UNITED AIRCRAFT CORPORATION

The Electronic Components Division completed its second year of operation as United Aircraft's microelectronics center. The division's line of discrete semiconductor devices, hybrid microcircuits, and integrated circuits increased its concentration on the communications and control field.

Discrete semiconductor achievements were highlighted by the introduction of hermetically sealed, high-frequency, high-power transistors for service in severe environments. The division expanded its position as a prime supplier of transistor chips to the computer industry and to other semiconductor and hybrid circuit manufacturers. The standard discrete device line was expanded to meet new applications in mobile and fixed-base communication systems and equipment as well as in high-frequency/high-power aerospace communication, guidance and control, and telemetry systems.

Custom-designed hybrid microcircuits for similar applications included microminiature voltage controlled oscillators, low-level differential amplifiers, video amplifiers, digital interface circuits, and functional blocks. Production of medium scale integration (MSI) components utilizing the multilayer technique was expanded. MSIs in production included as many as 30 multifunction integrated circuits on a 1-inch-square substrate. These components were in use in digital engine indicator and fuel control systems. The division continued with the production of single-layer, multilayer, and stacked hybrid microcircuit components for a number of military and aerospace applications.

The division's integrated circuit product line was expanded with the introduction of several new devices. A second family of transistor/transistor/logic (TTL) integrated circuits was placed in production during the year. These devices perform the complex gate and memory functions in high-speed commercial and military computers. A high-power voltage logic integrated circuit was introduced for use in commercial aircraft control systems. The 28-volt devices are designed to perform electronic reasoning to insure safe operation of the aircraft. Typical functions include control sequencing, control monitoring, situation monitoring, warning control, indication control, and system control. Custom-designed monolithic integrated circuits were developed and produced by the division for several applications.

UNITED AIRCRAFT RESEARCH LABORATORIES

United Aircraft Research Laboratories contributed advances in such diverse technologies as propulsion, lasers, metallurgy, and electronics during 1969 in its role as United Aircraft's central research organization.

Basic and applied research programs to broaden

United Aircraft's technical base and to explore areas of potential products for the corporation continued to be of prime importance to the research laboratories.

In United Aircraft's traditional area of interest, flight propulsion, the laboratories' scientists and engineers began advanced development of a low-volume ramjet propulsion system for missile applications. Activities included the refinement of an existing ramjet engine design and the testing of components.

Other propulsion activities included programs on hydrocarbon-fueled supersonic combustion ramjets for both cruise vehicle and missile applications, on advanced gas turbine engines, and on determining the feasibility of a gaseous core nuclear rocket engine concept for future space flight.

United Aircraft Research Laboratories reported several significant events in laser research during 1969, including advances in the generation and detection of high-power, ultrashort laser pulses applicable to such fields as radar and ranging, communications, controlled thermonuclear studies, optical information processing, and high-speed photography.

In the field of advanced materials, researchers worked to produce new composite reinforcement filaments with improved properties and high temperature stability. Studies included continued evaluation of Borsic-aluminum interaction, investigation of low-cost substrates for boron filament production, studies of graphite yarn and monofilament production techniques, and an extensive program to develop advanced fibers such as alumina and silicon carbide.

The laboratories continued a comprehensive research and development program in development of high-temperature alloys for gas turbine applications, using a patented process of unidirectional solidification of eutectic alloys. Other studies were carried out using metal matrix composites fabricated from such reinforcements as Borsic and sapphire fibers in aluminum, titanium, and other metals.

The laboratories also provided such technical support to the United Aircraft divisions as a central computer laboratory with 3 UNIVAC 1108 digital computers, and engineering test facilities including several wind tunnels.

In a move reflecting the corporation's growing interest in systems engineering and analysis, researchers worked on a study of mineral deposits in Long Island Sound for the state of Connecticut and undertook an air pollution control study for the U.S. Department of Health, Education, and Welfare.

In other programs, the laboratories continued work in fluid mechanics, physical chemistry, low-temperature physics, solid-state electronics, and plasma physics.

UNIVERSAL OIL PRODUCTS COMPANY

Universal Oil Products Company marked 1969 with vigorous expansion in a broad range of industries. In the airline and aerospace fields, the company's growth was highlighted by enlargement of the Aerotherm and REF Dynamics division plants, introduction of a new generation of inflight and ground-support service equipment for tomorrow's larger and faster aircraft, and continuing acceptance by the industry of seats by Aerotherm and food service equipment by REF Dynamics and its Mace unit.

UOP continued as a leader in the development of processes for the manufacture of high-octane gasoline and high-quality jet fuel meeting military specifications. Among these processes are Platforming, Fluid Catalytic Cracking, Isomax, HF Alkylation, Unifining, and Mercox. Other processes developed in UOP's Des Plaines, Illinois, research laboratories are used to produce components for the manufacture of plastics and synthetic rubbers with aircraft and aerospace applications.

Early in 1969, the UOP Process Division advanced its position of leadership in the petroleum refining and petrochemical industries with the introduction of Parex, a continuous process for extracting pure para-xylene, and Olex, a specific adsorption process for the recovery of normal olefins and mixtures with normal paraffins.

Indicative of UOP's growing international activity was the agreement announced in September whereby Nikki-Universal Co., Ltd., assumes the process licensing activities in the Far East for UOP and Japan Gasoline Company. Nikki is a joint-venture company of UOP and Japan Gasoline. UOP's global expansion was also enhanced by the consolidation within the UOP Fragrances Division of flavor and fragrances units operating in 11 countries; by the purchase of Esencias, Fragrancias y Productos Aromaticos, S.A., a Mexican maker of aroma chemicals and perfume compounds; by the purchase of Bisterfeld & Stolting, a well-established West German manufacturer of industrial laminated sheets, rods, and tubing; and by the acquisition of a contract for the evaluation of nickel deposits on the Philippine island of Palawan by UOP's subsidiary Calumet & Hecla Corporation.

Other UOP developments included the acquisition of Ehrhart & Associates, Inc., a well-regarded West Coast engineering and construction firm active in the design and construction of chemical and petrochemical process units; the start of construction on a copper-clad laminates plant in Franklin, Indiana, by the company's Norplex Division; and the initiation of the third phase of equipment and plant expansion at Wolverine Tube Division plants in Decatur, Alabama, and Detroit, Michigan. Wolverine is one of the world's leading producers of copper and brass tubing for the refrigeration and

air-conditioning industry, of zirconium alloy tubing for nuclear power plants, of copper and copper-zinc alloy tubing for plumbing and heating applications, of nickel-copper alloy tubing for desalination plants, and of titanium alloy and commercial grades of zirconium tubing for the chemical industry.

Toward the end of 1969, UOP was nearing the completion of a Materials Science Laboratory designed to establish the company as a leading center for in-depth studies of ceramics, polymers, rubber, reinforced plastics, and other materials. Significant growth was also recorded by divisions of the company which are engaged in air and water management, metal fabrication, chemicals, plant construction, and ground transportation equipment.

UOP AEROTHERM AND REF DYNAMICS DIVISIONS

UOP's activities in the aerospace industry achieved significant prominence in the creation of all-time-high backlogs for the UOP Aerotherm and REF Dynamics divisions.

In February, contracts were signed in a gold-pen ceremony with United Air Lines whereby UOP would supply Aerotherm first-class and tourist seats for United's fleets of Boeing 747 and McDonnell Douglas DC-10 aircraft. This represented the largest single seating award in the history of commercial aviation. Initial orders amounted to \$11,300,000 with options estimated at \$7,800,000.

Northwest Orient Airlines also announced selection of Aerotherm first-class and tourist seats and of REF Dynamics complete inflight feeding systems equipment for its fleet of DC-10 aircraft. Aerotherm seats had previously been selected for Northwest's 747s.

Over \$2,200,000 in contracts was awarded to REF Dynamics by McDonnell Douglas Corporation for the upper-deck forward service centers, aft coffee bars, and aft stowage units for DC-10 aircraft. REF also received substantial contracts to provide inflight food service equipment for the Boeing 747 fleets of Aer Lingus and Japan Air Lines. The Boeing Company placed orders with REF to design and manufacture coffee brewers, refrigerators, and freezers for the 747s. Other significant orders received in 1969 included contracts to REF Dynamics to supply Boeing 707 baggage units for Pan American, to modify Boeing 727 galleys for Braniff, and to build movie screens for the Boeing 747 for the In-Flight Motion Picture Company.

Additional follow-on orders to REF from Grumman Aerospace Corporation for pylons and platforms continued; in 1969, REF shipped the 1,500th A-6A pylon to Grumman.

Other Aerotherm Division contracts received were from Air Canada for first-class seats for its Boeing 747s and from Philippine Air Lines, which

standardized its BAC One-Eleven and DC-8-63 fleets with Zephyr II seats. Follow-on orders were received from British Aircraft Corporation for BAC One-Eleven and VC-10 crew seats. In 1969, the first sets of Pan American's Boeing 747 seats were delivered, and troop seats and crew galleys for the C-5 were delivered to Lockheed-Georgia Company.

Facility expansions were highlighted by the construction of a new plant for REF Dynamics in Melville, Long Island. REF's new plant will consist of 120,000 square feet of floor space. It consolidates the REF production facilities from 4 separate locations under one roof. An additional 44,000-square-foot addition to the Aerotherm plant in Bantam, Connecticut, was opened in early March.

In January, headquarters of the UOP Transportation Equipment Group were moved to Evanston, Illinois, where E. C. Walter assumed leadership of the group as vice president and general manager. The Transportation Equipment Group consists of the UOP Aerotherm Division at Bantam, manufacturers of commercial and military aircraft passenger seats, crew seats, lounges, aerostretchers and cargo pallets, and containers; the UOP Bostrom Division, Milwaukee and Cudahy, Wisconsin, manufacturers of truck, tractor, automotive, and heavy-duty ground transportation equipment seating; the UOP Amalga Division, Menominee Falls, Wisconsin, creators and fabricators of filament-wound fiber glass tubular products; the REF Dynamics Division, Mineola, New York, and the division's Mace unit, Jacksonville, Florida, manufacturers of inflight food service equipment including galleys, auxiliary units, bars, carts, ovens, brewers, refrigerators, and freezers, and of ground-support test stands and airframe assemblies. The Transportation Equipment Group also includes the UOP Bostrom U.K. manufacturing facilities in Northampton, England, and Bostrom S.A. in Nevelles, Belgium.

Several staff assignments were announced during the year in addition to Mr. Walter's appointment as general manager of the Transportation Equipment Group. Among the changes were the appointment of Daniel S. Karp to head up UOP aerospace activities in Europe and the consolidation of marketing for the Aerotherm and REF Dynamics divisions under James R. Funderburk, vice president of marketing. At Aerotherm, Norman D. Folling was appointed vice president-engineering and M. J. Dodd vice president-research. In addition, aerospace activities were expanded with the creation of the UOP Transportation Equipment S.A. in Nevelles, Belgium, where Aerotherm and REF Dynamics products will be manufactured for United Kingdom and European markets. It was expected that the facilities would be in operation by early 1970.

New products introduced in 1969 included a new line of REF serving carts, called Skycarts, representing an increased emphasis on the Mace unit's capability in providing a broad range of galley inserts

for commercial airlines. Of significant importance was the introduction of a new self-skinning foam process, the result of developments between the Aerotherm and REF Dynamics divisions. First production products of this new achievement were used on Pan American's Boeing 747 tourist passenger seats.

UOP INSTRUMENTS DIVISION

The UOP Instruments Division continued growth in the nuclear instruments department where large contracts were received from General Electric's Apparatus Operation for nuclear plant instrumentation for nuclear-powered destroyers.

The Instruments Division's aerospace department experienced growth specifically in subsystems-type work. A newly developed oil-quantity measuring system for DC-8 aircraft successfully completed a 1,400-hour flight test and production was started on a 25 shipset requirement. A similar system was being supplied as a fuel-quantity measuring device. This system accurately detects total parameters and displays the reading.

Additional developments in a hydraulic leak detection system expanded the division's capabilities in the area of sophisticated equipment. Development of a new oxygen regulator and refill valve for the DC-10 and completion of the development of a Navy fire rescue oxygen system opened new areas of involvement for the Instruments Division. The oxygen regulator and refill valve were being supplied to McDonnell Douglas, and the fire rescue oxygen system was under test and evaluation with the Navy.

New and repeat orders from McDonnell Douglas, National Water Lift, Boeing, Bell Helicopter, Ling-Temco-Vought, and Westinghouse contributed to a solid rate of growth for the division.

WESTINGHOUSE ELECTRIC CORPORATION

WESTINGHOUSE DEFENSE AND SPACE CENTER

One of the outstanding Westinghouse systems achievements in 1969 was development of the television camera used to take the first pictures of man on the moon. Developed by the aerospace division of Westinghouse Defense and Space Center for NASA's Manned Spacecraft Center in Houston, the camera was first used on Apollo 9. Later, during the Apollo 11 mission, it sent back to home television viewers and scientists visual coverage of man's first step on the moon.

A subsequent outgrowth in Apollo camera systems was a second Westinghouse-built lunar TV, a color camera for use on Apollos 10 and 11. The color camera was carried in the Apollo Command Module to televise astronaut activity en route to and

from moon orbit. The much smaller, black and white camera was used to televise the moment astronaut Neil Armstrong first set foot on the moon and the subsequent activities that Armstrong and astronaut Edwin E. Aldrin, Jr., undertook on the lunar surface.

Westinghouse also built the tiny companion TV monitor that allowed astronauts to see the exact scene that the color camera sent back to earth.

In military sensor technology, a milestone in advanced electrooptical systems was reached with successful flight of the B-57G aircraft. This was the first time that low-light-level TV, FLIR (Forward-Looking Infrared), moving target indication radar, and a laser ranger had been integrated with a digital computer for precision system performance. It was also the first time the Air Force had ever let a significant contract to an avionics company for complete modification for airborne weapons systems. Development of a B-52 electrovisual system using a low-light-level TV camera was initiated in 1969 by Westinghouse for the Air Force.

Man-portable lasers, rangers, and illuminators were developed and deployed with improved performance. Typical designs called for lightweight, compact, rugged equipment for use by mobile forces. These high-performance lasers were for ground and air application to provide continuous illumination and ranging for targeting purposes.

Westinghouse continued to rush production of operational airborne radar for the military. The AN/APQ-120 was built to equip the Air Force F-4E aircraft. The Navy F-4J was supplied with the pulse-Doppler AN/AWG-10 radar. Both radars were capable of controlling and operating with the Sparrow missile.

An advanced version of the digital AN/AWG-10 radar fire-control equipment was being flight-tested in preparation for use in Navy aircraft.

From 1960 through 1969, Westinghouse supplied more than 3,800 radar systems which were deployed and tested in combat. At year-end, the company was developing an F-15 fighter feasibility radar for the Air Force.

As a prime contractor to the Air Force for airborne electronic countermeasures, Westinghouse developed and produced an external equipment multipurpose airborne pod, a truly universal design adaptable to most aircraft and missions. It is a basic package available for carrying a wide variety of avionic and physical countermeasures.

Based on Westinghouse pioneering in molecular integrated circuits, countermeasure systems were available with broader performance capabilities than ever before. A circuit that 5 years earlier consisted of 2,100 discrete components was in production in a molecular circuit assembly occupying 15 cubic inches. Size and weight were reduced so that internal or pod configurations can be achieved with minimum airframe modification. Through extensive

use of molecular electronics, greater mean time between failures resulted, maximizing aircraft availability and cost effectiveness.

Other developments in airborne and space electronics were gravity-gradient booms for satellites, a lunar surface drill, airborne early-warning and control radar, and side-looking radar reconnaissance equipment for Army and geological surveys.

ASTRONUCLEAR/UNDERSEAS DIVISIONS

Following a 1968 reorganization, the Astronuclear Laboratory and the Underseas Division operated in 1969 under a single management headed by Dr. W. E. Johnson, vice president and formerly general manager of the Astronuclear Laboratory.

The Underseas Division in 1969 consisted of 3 main components:

- The Ocean Research and Engineering Center near Annapolis, Maryland, which continued activities in ocean research, life-support systems, design and operation of undersea research submersibles, sonar, and advanced studies in the recovery of ocean resources.

- Sanford Marine Services, Inc., a wholly owned subsidiary, Morgan City, Louisiana, which continued to provide diving, salvage, and other services to the marine, petroleum, and construction industries and to a variety of other customers.

- The missile launching and handling department, responsible for developing and providing launching capability for the Navy's fleet ballistic missiles, Polaris and Poseidon.

By year-end, the highly successful submersible Deepstar-4000 had made more than 500 dives. Nearing completion was a new submersible, Deepstar-2000, similar in general design to the Deepstar-4000. To be used in research and as a test-bed for prototype instrumentation, the craft is 20 feet long and 7 feet wide and is capable of carrying 2 scientists and a pilot to depths of at least 2,000 feet. It can operate for as long as 8 hours at a maximum cruising speed of 3 knots. Assigned to the company's Ocean Research Laboratory at San Diego, California, Deepstar-2000 was to be ready for operations in early 1970.

The Underseas Division was also working on a 20,000-foot-depth submersible, the deepest-diving privately owned submersible. The vehicle, capable of reaching 98 percent of the world's ocean floor, will be the third member of the Westinghouse Deepstar family.

"We expect to complete the Deepstar-20,000 by late 1970," Dr. G. F. Mechlin, Underseas Division general manager, said. "There is an obvious need to explore and work at great depths in the ocean. We've been planning a 20,000-foot submersible for a long time. For several reasons, we feel that we can now go ahead with the project. Our development programs in hull materials, flotation materials,

and buoyant structural materials are quite far along. Also, the market for deep-diving submersible services seems to be developing." The submersible will be able to transport 3 men and instruments or equipment to a depth of 20,000 feet for 16 hours of work.

The Westinghouse Ocean Research and Engineering Center formed an ocean sciences group that concentrates the center's oceanographic capabilities. The new group was to further develop the center's relationships with industrial oceanographic laboratories, education institutions, and government agencies, and undertake research and studies for and with those organizations.

Formed as part of the center's engineering department, the new group was involved with work in ocean physics, electrochemistry, physical chemistry, underwater acoustic and sound propagation and measurement, fluid dynamics, underwater energy transmission, mathematical analysis, and analytical simulation of ocean properties and parameters.

A new Westinghouse sonar and manipulator system was tested in a special testing pool at the Ocean Research and Engineering Center. The 15-foot-deep pool in the new laboratory is used in research on a wide variety of undersea equipment. The sonar was the Westinghouse ocean-bottom scanning sonar used to produce photo-like images of the ocean bottom at any depth. It is towed by a surface ship so that it travels at a preset depth above the ocean floor. In this way, it is able to survey large areas of the bottom relatively fast. Westinghouse sonar systems similar to this unit have been used to locate the wreckage of an airliner in Lake Michigan, to survey the wreckage of an offshore oil platform downed by a hurricane, to locate the fault scarp of an earthquake off the coast of Alaska, and to perform in other underwater search and survey projects. The manipulator system was to be used aboard the DSRV submersible.

A new barge was serving the offshore oil industry in the Gulf of Mexico. Called *Ranger*, it is a pipeline and derrick barge for use in laying and repair of pipe, salvage, construction, and all kinds of diving service. It was built and was being operated by Sanford Marine Services, Inc. Because of its size and capability, the *Ranger* can be used for smaller jobs at less cost than most available barges. It has a 50-ton diesel crane.

Astronuclear operations in 1969 were highlighted by successful completion of the testing of an experimental nuclear rocket engine, called XE, at the Nuclear Rocket Development Station, Jackass Flats, Nevada. Completion of the test series was a major step in the joint AEC/NASA program to develop a nuclear rocket. Tests of the XE engine began in March and continued through August.

During this period, 28 engine start-ups were suc-

cessfully completed and the engine was operated at various thrust levels for a cumulative test time of 3 hours 48 minutes, of which 3.5 minutes were at full thrust of about 55,000 pounds. The engine was tested in Engine Stand No. 1, a unique test facility which allows the engine to fire downward under simulated altitude conditions.

The XE test program explored a wide variety of operating modes and different pressure and temperature conditions. It included automatic start-ups using bootstrap techniques which do not require external sources of energy and multiple restarts and throttling. The XE test again demonstrated the stability of nuclear rocket engine performance and validated the design and operation of the test stand facility.

The XE engine runs included a series of successful technology tests over several years. Based upon this experience and the vast amount of information obtained, the design and development of a flight-rated 75,000-pound-thrust nuclear rocket engine called NERVA was being initiated. A nuclear rocket engine produces thrust by exhausting, at high velocity, hydrogen which has been heated to a high temperature by a reactor.

The XE engine was designed and developed by Aerojet-General Corporation and Westinghouse Electric Corporation, the industrial contractor team responsible for the development of the nuclear rocket engine. Overall management of the nuclear rocket program is the responsibility of the joint AEC/NASA Space Nuclear Propulsion Office in Germantown, Maryland.

Continuing development of new components brought thermoelectric power generation systems closer to the practical application stage. The Astronuclear Laboratory completed the design and fabrication of a terrestrial power system, SNAP-23, and an isotope-fueled prototype of this 60-watt unit was under test. Additional units of several other power ratings will be fabricated and eventually field-tested. These Sr-90-fueled units are especially adaptable to remote or severe environments for such applications as remote weather or seismic stations, intelligence data acquisition systems, microwave repeater stations, and command and control systems.

Another program of interest to "larger" power users was development activity leading to the demonstration of a large Co-60-fueled heat source. The prototype heat source, which is designed to be mated to a wide variety of conversion cycles, will produce 31 kilowatts (thermal); however, variations in the design will permit construction of units providing a wide range of thermal capacity. When coupled with conversion systems (dynamic or static), such systems will be capable of producing electrical power for remote applications over a range of power levels from 1 to 15 kwe.



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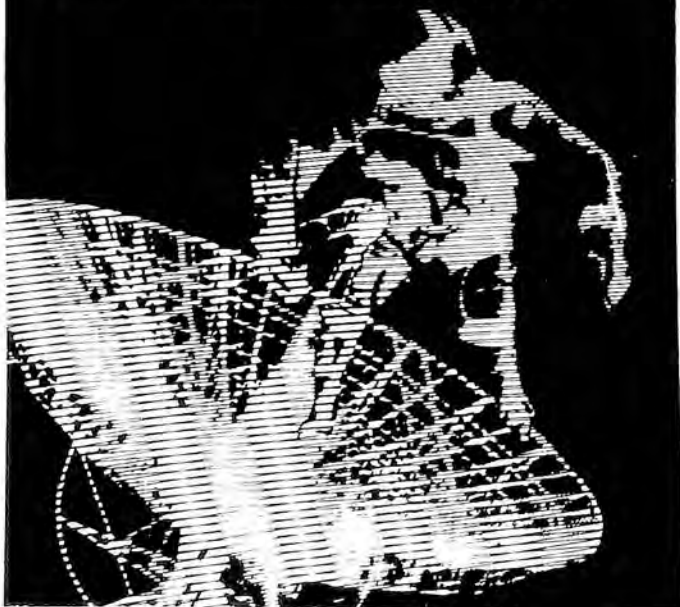


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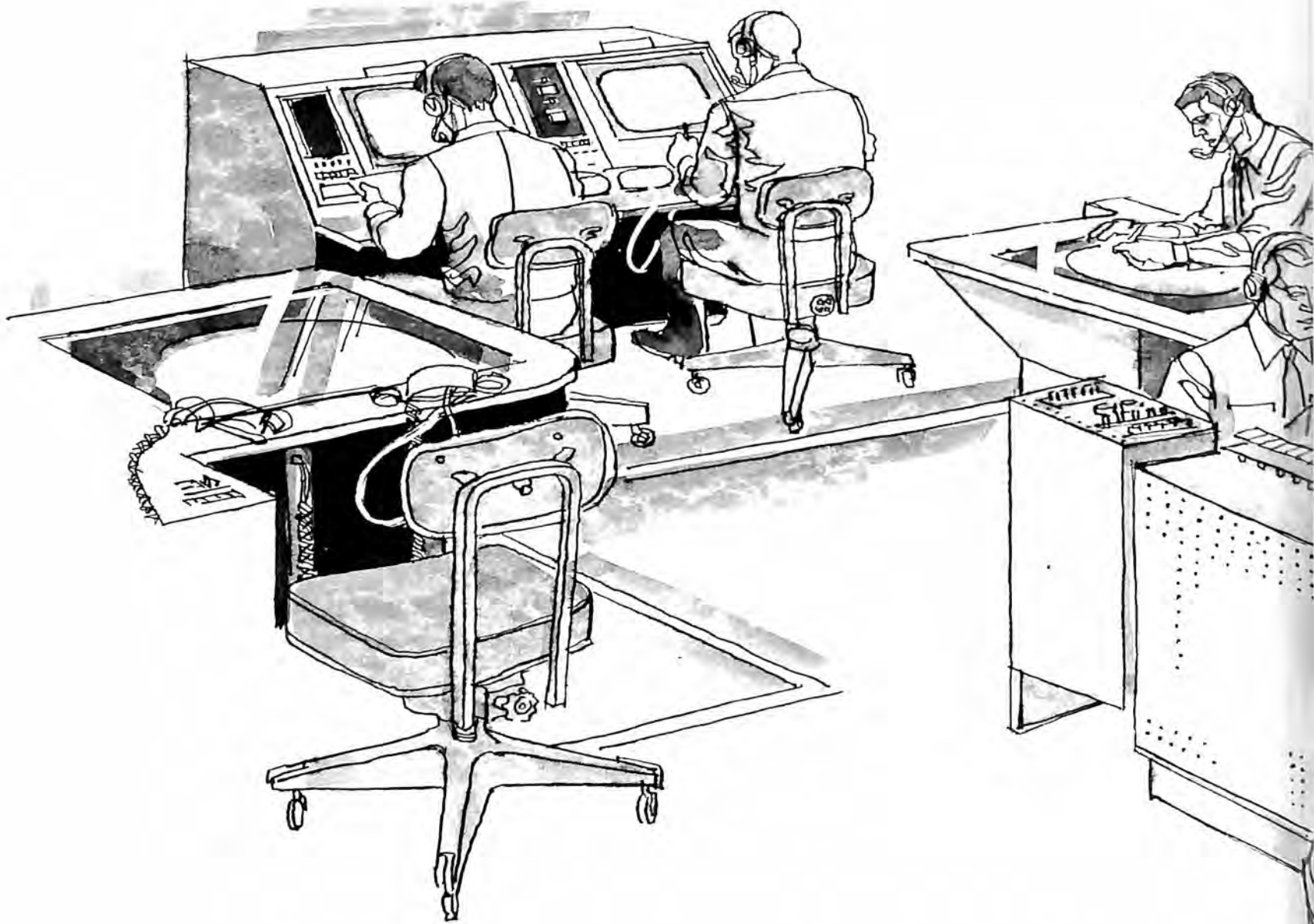
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Government Research and Development



During the fiscal year 1970, ending June 30, 1970, government funding of all types of research and development was expected to run slightly over \$15 billion, a decline from the previous year's level. By far the major portion of the funding was to be allocated to aerospace programs, although a direct dollar breakdown was not available. The enormous range of government research and development programs

precludes even a catalog listing herein, but this section contains the highlights of 1969 in those agencies primarily concerned with aerospace research and development, or with non-aerospace programs in which aerospace firms were participating. Additional detail on unclassified projects may be found in the individual company résumés in the Aerospace Industry Section and in the Reference Section.

ATOMIC ENERGY COMMISSION

Overall uses of nuclear energy, such as extensive applications of radioisotopes and radiation and continued work in the field of peaceful nuclear explosives, made further advances in 1969.

But the year was perhaps most historic for the uses of nuclear power in space. Experiments left on the moon by Apollo 12 astronauts were powered solely by nuclear power, the Apollo 11 crew left a radioisotopic heater on the moon, and outstanding progress was made in nuclear rocket propulsion.

While the Atomic Energy Commission took a first positive step toward the development of a fast breeder reactor, new orders for nuclear power plants by utilities showed a marked downswing during the year.

Apollo 11 astronauts placed an AEC-developed radioisotope heater on the moon. The isotopic device, fueled by plutonium-238, was built into the seismometer which sent lunar seismic readings back to earthbound scientists. The heater system, consisting of 2 canisters containing a total of about 2.4 ounces of radioactive plutonium-238 dioxide, kept the electronic instrumentation above minus 65 degrees Fahrenheit. Lower temperatures would damage the recorder. Lunar night readings drop as low as minus 250 degrees Fahrenheit.

Plutonium was also the power source for the surgically implantable cardiac pacemaker under development. Three successful implants were performed on dogs at the National Heart Institute, National Institutes of Health. Clinical studies were to follow extensive laboratory and animal test programs. Studies were under way to prepare isotopic heat sources that would result in the minimum radiation dose to a patient.

Several isotopic projects were under way in the environmental and pollution control field. Isotopic tracers and related techniques were being used to detect and measure pollutants. AEC's Brookhaven National Laboratory was using analysis of variations of sulfur-32/sulfur-34 ratios in stack gas to study the source, quantities, and meteorological distribution of sulfur dioxide emitted to the atmosphere from plants burning fossil fuel.

Washington State University developed a technique for attaching an iridium salt to wood fibers to study stream pollution problems in the pulp and paper industry. Waste discharged from plants is sampled and analyzed by neutron activation analysis to determine sources of pollution from paper plants.

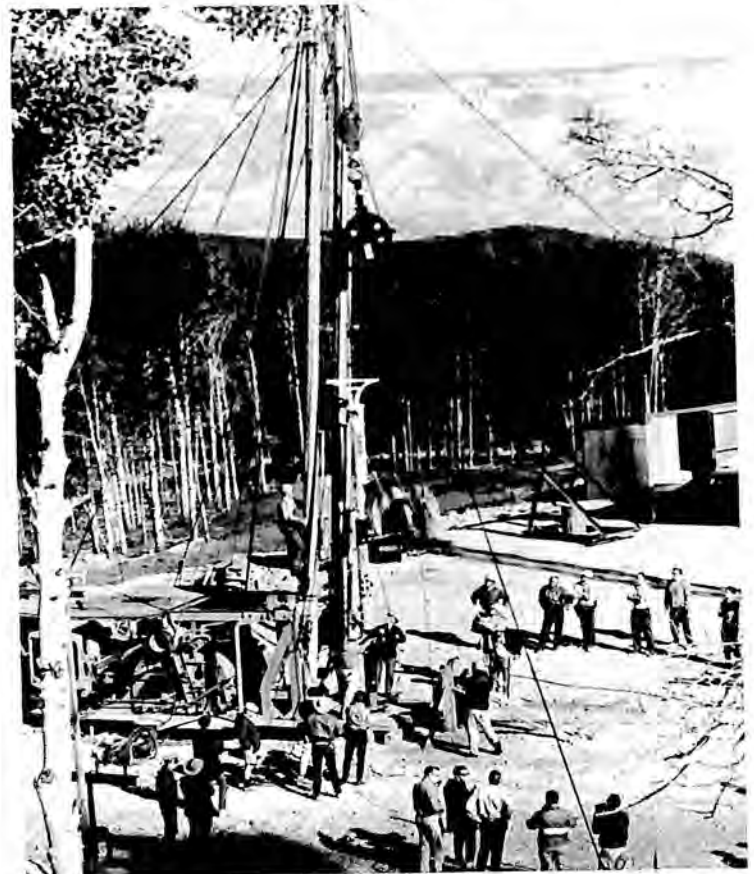
Nuclear activation analysis of characteristic trace elements in oil slicks was being evaluated as an aid in apprehension and conviction of shippers who pollute waterways with oil discharges. Radiation treatment of sewage was under joint study with the Federal Water Pollution Control Administration as a means of enhancing sludge settling rates.

On December 8, 1968, Project Schooner, the third

in a series of nuclear excavation experiments in support of the Atlantic-Pacific Interoceanic Canal Study Commission's program, was conducted at the AEC's Nevada test site. The 35-kiloton explosion excavated a crater in hard rock, about 852 feet in diameter and 208 feet deep. The explosive was emplaced at a depth of 355 feet below the surface of the ground. Schooner provided information on cratering effects from an explosion at a yield rate on an order of magnitude greater than previous experiments in hard rock and demonstrated the effects of a greater moisture content in the rock on crater parameters.

The second in a series of joint government/industry experiments to study the technical and economic feasibility of using contained underground nuclear explosions to enhance the recovery of natural gas was well under way at the end of 1969. The nuclear detonation portion of Project Rulison was conducted on September 10 at a site about 40 miles northeast of Grand Junction, Colorado. Rulison is a joint effort of the AEC, the Department of the Interior, Austral Oil Company, Inc., of Houston, and CER Geonuclear Corporation of Las Vegas, Nevada, acting as program manager.

The 40-kiloton nuclear explosion took place 8,442 feet below the surface of the ground.



The Atomic Energy Commission's Project Rulison 40-kiloton nuclear device is lowered into its 8,442-foot-deep emplacement hole near Grand Junction, Colorado. The September 10 detonation was the second in a series of government/industry experiments to study the feasibility of recovering natural gas by means of controlled underground nuclear explosions.

At year-end, the project participants were planning to begin in the spring of 1970 reentry drilling into the chimney of broken rock believed formed by the explosion so that they could obtain samples of the gas and start production testing. The gas samples were to be analyzed to determine the quality of the gas from a radioactivity standpoint. On October 1, it was announced that continuous post-shot observations made at the surface of the Rulison emplacement hole indicated that the nuclear explosion did release natural gas from the tight Mesa Verde formation.

Production testing of the Project Gasbuggy emplacement hole well continued during 1969. Project Gasbuggy, the first joint experiment to study nuclear stimulation of tight gas-bearing rock formations, is a joint effort of the AEC, the Department of the Interior, and El Paso Natural Gas Company. The nuclear detonation, involving a 20-kiloton explosive, was conducted on December 10, 1967, at a site near Farmington, New Mexico. As of October 6, 1969, cumulative production of gas from the emplacement hole well was 255,000,000 cubic feet. This compared with 80,000,000 cubic feet of gas produced from a nearby conventional well over a 10-year period.

The United States and Russia met in Vienna April 14–16 for technical discussions on peaceful uses of nuclear explosions. The U.S. delegation was headed by AEC Commissioner Gerald F. Tape, later president of Associated Universities, Inc. For the first time, the Soviet Union stated publicly that it has a peaceful nuclear explosives program and that it would be prepared to supply services as part of its obligation under Article V of the Non-Proliferation Treaty. Both delegations agreed that "... underground nuclear explosions may be successfully used in the not so far off future to stimulate oil and gas production and to create underground cavities ..." and that "... it may also be technically feasible to use them in earth-moving work for the construction of water reservoirs in arid areas, to dig canals, and in removing the upper layer in surface mining, etc." The 2 parties also agreed that additional talks in the future would be useful.

Legislation was introduced in Congress in January which would amend the Atomic Energy Act to permit the Atomic Energy Commission to enter into contracts to provide peaceful nuclear explosion services for commercial purposes. Under existing authority, the commission is limited to providing a nuclear explosion service for research and development, including demonstration projects that further AEC programmatic interests. The legislation recognizes industrial interest in the progress made to date in developing peaceful applications of nuclear explosions, and it takes into account Article V of the Non-Proliferation Treaty which provides that a commercial nuclear explosion service may be provided to non-nuclear weapon states party to the treaty.

The Atomic Energy Commission supported 4 research projects in the massive Barbados Oceanographic and Meteorological Experiment (BOMEX) which took place during 1969. BOMEX was an interagency effort to study the interaction between sea and air which helps to create large-scale weather patterns. AEC projects were conducted by Battelle Northwest, Argonne National Laboratory, Stanford Research Institute, and Lamont Geological Laboratory of Columbia University.

The Battelle Northwest project was concerned with studying the transfer of particles from the stratosphere to the ocean, called the air-to-sea exchange, and the subsequent mixing of the material in the ocean. The Lamont project, on the other hand, was concerned with the movement of material from the ocean depths upward and into the air. The Argonne National Laboratory measured atmospheric behavior at the ocean surface using highly sophisticated Argonne-developed instruments to record wind velocity, small rapid air fluctuations, and temperature. The Stanford Research Institute used a laser-radar device, called LIDAR, to examine the distribution of the minute particles which make up haze and fog. Data from the AEC projects will be incorporated in the BOMEX results and will also help the AEC to more surely and accurately predict the deposition and mixing of radioactive particles over the ocean under a variety of weather conditions.

A major step toward the development of a fast breeder nuclear power plant—one that provides heat for the generation of electricity and at the same time produces more fuel than it uses—was taken when an invitation was issued by the AEC to industry for proposals to conduct the first phase: definition of the technical and economic risks of the total project and determination as to whether there are bases for a cooperative arrangement for construction and operation of a plant. Proposals from Atomics International, General Electric, and Westinghouse were being reviewed at year's end.

While the government was progressing on the development of nuclear power, industry was recording a different record. Utilities that had been considering nuclear power plants were returning to coal- or oil-fired plants because nuclear plants were taking too long to build. Nuclear plant orders, which reached a peak of 31 in 1967, dropped to 17 in 1968 and to 6 as of mid-November 1969. Several reasons accounted for the downswing. The major reactor builders found they could not meet promised delivery dates; they did not have the necessary capacity and skilled labor. The boom in the construction industry delayed construction of non-nuclear components. Increased capital costs of skilled labor and equipment meant higher interest charges and, in some cases, eliminated the financial advantage from the lower operating costs of nuclear plants.

Concern over the safety of nuclear power plants was expressed by segments of the public interested in protecting the environment and waterways from pollution, in the aesthetics of the surroundings of proposed plant sites, and in eliminating dangers of radioactive discharges from plants. In the face of mounting opposition, the AEC continued to emphasize that in its reviews of a proposed nuclear power plant it considers the health and safety of the public paramount and only after it assures itself that the plant can be built and operated safely will it grant the necessary permits.

During the year, utilities placed orders for 6 plants with a total capacity of about 6,000,000 kilowatts. As of the end of the year, there were 15 operable nuclear power plants, 49 being built, 31 planned for which reactors had been ordered, and 9 planned for which reactors had not been ordered, representing a total of 80,500,000 kilowatts. Applications for construction permits were pending for 24 plants. During the year, the AEC granted 7 construction permits and 3 operating licenses.

A preliminary feasibility study by the Department of the Interior, the AEC, and the state of Utah concluded that the Great Salt Lake Basin offers a unique opportunity for the simultaneous production of desalted water, power, and steam to help fulfill the future demands of cities and industry in the Great Salt Lake area. As a result of the study, Utah will consider desalting as a potential source of a future water supply.

Another desalting study, by the United States, Mexico, and the International Atomic Energy Agency, indicated that large dual-purpose nuclear electric power and desalting plants are a promising means for producing large quantities of fresh water and power to meet the growing requirements of arid areas in the southwestern region of the United States and the northwestern region of Mexico.

During the spring and summer, the AEC implanted 3 compact 10-watt nuclear power generators in the Pacific Ocean off the coast of San Clemente Island for long-term testing. The successful operation of the generators should help fill a critical need in ocean exploration. They are designed to provide uninterrupted electrical power for 5 years or longer. In many remote locations where frequent maintenance, refueling, or battery recharging or replacement is difficult or expensive, compact radioisotope power sources promise operational and economic advantages over conventional power sources.

The world's first nuclear-powered deep submergence research and ocean engineering vehicle was launched early in the year at Groton, Connecticut. The submarine, designated NR-1, was developed jointly by the Navy and the AEC. The increased endurance made possible by nuclear power, and the technology gained by its development, will provide the basis for development of future nuclear-powered oceanographic research vehicles of still greater ver-

satility and depth capability. The 140-foot NR-1 has a crew of 5 and 2 scientists. It is able to move at maximum speed for periods of time limited only by the amount of food and other supplies it carries. It will perform detailed studies and mapping of the ocean bottom, temperature, and currents for military, commercial, and scientific uses.

By year-end, Congress had authorized 110 nuclear-powered submarines, including the NR-1, and 9 nuclear-powered surface ships. Of these, 87 submarines and 4 surface ships had been placed in operation. They had steamed over 14,530,000 miles without ever having to abort a mission because of reactor plant failure.

The year was a historic one for nuclear power in space. The experiments left by the Apollo 12 astronauts on the moon as part of the second lunar landing were being powered solely by nuclear power. The power source, a radioisotopic thermoelectric generator fueled with plutonium-238, represents the first use of nuclear electric power on the moon. The generator has no moving parts and will provide 63 watts of power for at least a year.

Earlier in the year, a radioisotopic heater, part of a passive seismometer experiment package, was placed on the moon by the Apollo 11 astronauts. The heater keeps the seismometer from freezing during the lunar night.

April saw the first civilian use of atomic energy in space with the launch of NASA's Nimbus 3 weather satellite, which carries 2 nuclear generators as supplementary power to solar cells. This combined power was resulting in the acquisition of data of such significance that it was characterized as "unprecedented" by the scientific community.

A radioisotope generator was making history by beginning its ninth year in orbit on a navigational satellite. The grapefruit-size atomic battery, launched in 1961, had operated 3 years beyond its 5-year design life by year-end 1969. Developed by the AEC, the 2.7-watt generator was supplementing power from solar cells on the oldest operating navigational satellite.

Another source of space power—a compact nuclear reactor with potential uses on a moon base and in orbiting space stations—began operating at design power in a land-based test at an AEC laboratory near Los Angeles. The reactor was producing 600 thermal kilowatts at 1,300 degrees Fahrenheit. It was being considered for space missions because of its potentially high reliability, small size, and long life (2 to 5 years) without need for refueling or maintenance.

Outstanding progress was noted in the development of a nuclear rocket. Testing of an experimental nuclear rocket engine at the Nuclear Rocket Development Station, Nevada, began in March and continued through August. During this period, 28 engine start-ups were successfully completed for a cumulative time of 3 hours 48 minutes.

On December 1, 1968, ground was broken for the first permanent building at the Atomic Energy Commission's National Accelerator Laboratory near Chicago. When completed, the laboratory will be the home of the world's highest-energy proton accelerator. The facility will cost approximately \$250,000,000 plus outlays for experimental equipment; the 200-billion electron volt (Bev) accelerator was scheduled to produce its first particle beam in 1972. The first of the laboratory's permanent buildings will house a linear accelerator, or Linac, which will serve as part of the 200-Bev accelerator. The Linac will serve to give the protons a boost in energy that will take them to 200,000,000 electron volts, one-thousandth of their ultimate energy in the NAL accelerator system.

The positive discovery of 2 isotopes of element 104 was reported on April 15 by scientists in the Lawrence Radiation Laboratory at Berkeley, operated for the Atomic Energy Commission by the University of California. The 2 isotopes are 104-257 and 104-259. The scientists believed, too, that they had discovered 104-258; they indicated, however, that the evidence was less certain. At the same time, Berkeley researchers said that after repeated attempts they had been unable to observe the isotope 104-260, the discovery of which was reported by a group of Russian scientists in 1964. The Lawrence Radiation Laboratory discoveries were made by bombarding a target in the heavy ion linear accelerator (HILAC).

On October 13, the first successful operation of the world's largest bubble chamber was recorded at the Atomic Energy Commission's Argonne National Laboratory near Chicago. The bubble chamber contains 6,400 gallons of liquid hydrogen. Since cosmic ray particles are much too small and travel too fast to be observed directly, the tiny lines of bubbles resulting from the passage of cosmic ray particles through the liquid hydrogen are photographed. These lines of bubbles (called "tracks") are studied to determine the properties of the high-energy particles. The 12-foot bubble chamber project was begun some 5 years earlier, at a time when the largest bubble chamber in operation had a length of 80 inches and a volume of about 1 cubic yard. The new Argonne vessel is 12 feet in diameter and 7 feet tall with a volume of about 26 cubic yards.

Earlier in the year, the world's largest superconducting magnet—to be operated in conjunction with the 12-foot bubble chamber—was completed and successfully tested at Argonne. Following the January tests, it was announced that the magnet was expected to operate at about one-tenth the cost of an equivalent conventional magnet.

On October 2, 1969, the Atomic Energy Commission safely conducted an underground nuclear calibration test of about 1 megaton in yield at Amchitka Island, Alaska. Data from the test were being ana-

lyzed at year-end and no determination had been made regarding further testing on the island. As of November 26, 1969, the AEC had announced 22 underground nuclear weapons-related tests during the year at the Nevada test site.

President Nixon appointed 2 new members to the Atomic Energy Commission in 1969. He named Dr. Theos J. Thompson to fill out the unexpired term of Dr. Gerald F. Tape; Dr. Thompson had been professor of nuclear engineering and director of the Massachusetts Institute of Technology Nuclear Reactor Facility since 1958. His nomination was confirmed on June 12. The President also named Dr. Clarence E. Larson, whose nomination was approved by the Senate on August 8. At the time of his appointment, Dr. Larson was president of the Nuclear Division, Union Carbide Corporation, Oak Ridge, Tennessee.

At year-end, the AEC commissioners and the expiration dates of their terms were as follows: Dr. Glenn T. Seaborg, chairman, June 30, 1970; Theos J. Thompson, June 30, 1971; Wilfrid E. Johnson, June 30, 1972; James T. Ramey, June 30, 1973; and Clarence E. Larson, June 30, 1974.

DEPARTMENT OF DEFENSE

At year-end, differing Senate and House versions of the defense appropriations bill were still being resolved in conference, but it appeared that Department of Defense funding (new obligational authority) for research, development, test, and evaluation for the fiscal year 1970 would be pegged near \$7.3 billion. The Senate version of the bill called for \$7.38 billion, the House version for \$7.197 billion. Even the larger figure would represent a substantial drop from the \$7.6 billion for fiscal year 1969.

As in previous years, the Air Force was to get the largest share of research and development funds, about \$3 billion (Senate \$3.06 billion, House \$3.057 billion). The Navy's allocation was \$2.193 billion in the Senate, \$2.04 billion in the House. The Army share was \$1.6 billion in the Senate, \$1.57 billion in the House.

Also included in the DoD budget was an allocation of slightly less than \$500,000,000 for programs of the Advanced Research Projects Agency. Primary aerospace project in this category was Defender, a broad program of research and exploratory development in the field of ballistic missile defense, penetration aids, and defense against satellites.

Highlights of the major Department of Defense research and development programs under way during calendar year 1969 are contained in the following résumés for the Air Force, the Army, and the Navy.

AIR FORCE

Research and development programs of the Air Force Systems Command in 1969 were directed toward a proper balance between providing "fixes" for the limited war requirements of operational commanders in Southeast Asia, development and acquisition of the next generation of weapons and systems, and pushing the state of the art for the advancement of technology in the future.

This encompassed scientific and technical work in many areas, from microcircuitry to missiles and bombers, from advanced fiber composite materials to air superiority fighters, from computers to command and control networks, from space foods to space satellites.

To create these new systems, weapons, and items of aerospace equipment at acceptable costs, in the face of heavy schedules and in the environment of rapidly changing technology, General James Ferguson, AFSC commander, at Andrews AFB, Maryland, directed the activities of divisions, centers, ranges, and laboratories at 300 installations around the globe.

AFSC's estimated budget for fiscal year 1970 was \$7.78 billion, which represented 29.4 percent of the total budget for the Air Force. Funds managed by the command totaled \$15.9 billion, and the command's facilities were valued at about \$2.5 billion. AFSC supervised about 1,300 projects and tasks, more than half of which were for limited war.

Two new management organizations were activated at the Aeronautical Systems Division at Wright-Patterson AFB, Ohio, during the year. One, the Directorate of Precision Weapon Delivery, nicknamed the "Hit the Target" office, was designed to conceive and analyze new approaches to providing techniques, equipment, subsystems, and weapons "to hit and destroy tactical targets 24 hours a day under all environmental conditions."

The other was the Air Mobility Division, which must grapple with the fact that the Air Force might not always be able to rely on prepared and equipped overseas bases in fulfilling its responsibilities. To accomplish this mission, the division was expanding on the "bare-base" concept, under which USAF combat forces would be able to fly anywhere in the world to sites that might have no facilities other than a runway, parking space, and a water supply; set up essential equipment; and be ready to conduct combat operations within hours.

In July, General Ferguson announced several changes in the program management of the F-15 air superiority fighter. The system program director at Wright-Patterson AFB will report directly to the AFSC commander, and the F-15 program monitoring responsibility was transferred from the Pentagon to AFSC headquarters under an assistant to the commander for F-15.

Several management improvement programs were

instituted or expanded, including SMAP (Systems Management Analysis Project) and C/SCSC (Cost Schedule Control Systems Criteria). SMAP is an effort to improve and condense the printed directives guiding Air Force Systems Program Offices (SPO). C/SCSC is a plan to achieve cohesive Air Force/contractor management control systems, utilizing a single integrated internal cost and schedule control system for the contractor which will serve his management needs and those of the government. In April, General Electric Re-entry Systems of Philadelphia, Pennsylvania, became the first aerospace contractor to reach operational achievement of C/SCSC.

Many of the advanced systems and end products under development in Systems Command laboratories or in production during 1969 would have been regarded as little more than science fiction fantasy only a few years earlier.

Air-cushion landing gears were being flight-tested over macadam, concrete, tall grass, snow, water-filled ditches, and wet sand.

A 12-pound manpack transceiver for ground-to-air voice communications was developed to replace a 41-pound set.

In rapid response to a Southeast Asia requirement for an "instant" helicopter landing zone, AFSC developed "Combat Trap" procedures that are used to blast out suitable areas with 10,000- and 15,000-pound bombs.

A new television camera tube was developed for use in low-light-level operations which will allow pinpoint target acquisition, identification, tracking, and weapons delivery.

By using conventional aircraft control surfaces and appropriate feedback signals, a system called LAMS (Load Alleviation and Mode Stabilization) demonstrated the capability of flight control technology to alleviate gust and maneuvering loads and to damp structural oscillations. This system may increase the fatigue life of B-52s and similar aircraft from 70 to 100 percent.

For maximum assistance to the B-1 aircraft program, formerly known as Advanced Manned Strategic Aircraft (AMSA), AFSC's Air Force Flight Dynamics Laboratory surveyed all of its programs to determine which could be applicable. Thirty-two efforts were identified as sources of technology directly applicable to the planned configuration of the aircraft. Thirty of these efforts were "bought" by the B-1 Systems Engineering Office to the extent of including descriptions of each in an addendum to the statement of work.

The Air Force Human Resources Laboratory developed a series of nondecision job performance aids for electronics technicians, allowing high school students to resolve troubleshooting problems and make detailed repairs to complicated electronic gear after only 12 hours of training.

Tests of an airborne audiovisual recording system

that should improve pilot training procedures by giving immediate performance evaluations were under way. TV recording and playback techniques are used.

A rapidly deployable lightweight antenna mast was developed for use in Southeast Asia. The 100-foot, 166-pound mast can be erected by 5 men in less than 45 minutes, without tools.

An improved reinforcing fiber produced for use in structural plastic composites is 50 percent higher in elasticity and 35 percent higher in tensile strength than commercially available graphite fiber.

A number of aircrew rescue and recovery projects were under way. One involved a V-type parawing, self-rescue model which may enable a crewman of a disabled aircraft to use his ejection seat to fly away from enemy territory.

Another idea would assure a pilot that he will not collide with his seat during ejection from an aircraft. A lifeline, a 50-foot nylon cord, is attached to the cockpit floor and to the bottom of the seat. When the crewman ejects, the tethered seat is pulled away from him when the line reaches its 50-foot limit.

An electronic helicopter-to-ground locating system, capable of finding and rescuing downed crewmen by day or night in all kinds of weather, was successfully demonstrated. Signals transmitted by a pocket-size radio, carried by all aircrewmen, are received through a series of antennas mounted beneath a rescue helicopter. The new system can position the helicopter directly over the man to be rescued, even when he is hidden by dense foliage.

Clothing that will not burn or melt in air at high temperatures was developed from a new polymeric fiber, polybenzimidazole, which can be knit or woven into fabrics, webbings, tapes, ribbon, or sewing thread.

A new jet engine that is half the length and one-fifth the volume of similar previously developed engines in the same thrust class was under development.

A low-cost asbestos fiber suitable for use in composites was developed which may prove valuable for use in missiles and other applications. Boron composites were also being used in landing gear assemblies at considerable weight savings.

Since laboratory efforts are the key to future capabilities, AFSC was conducting research in supersonic and hypersonic speed regimes. It was seeking better high-temperature, high-strength materials; investigating new aircraft structures and aerodynamic shapes; improving control systems and making propulsion systems more efficient; and improving aircraft survivability and weapon accuracy. Space, computers, high-lift devices, microelectronics, laser technology, exotic materials and composites, component reliability, human performance factors—all were receiving the attention of Systems Command scientists and administrators.

Apollo crews, using Saturn launch vehicles, were

supported by facilities at the Air Force Eastern Test Range, Patrick AFB, Florida, and both the Eastern Test Range and the Western Test Range provided communications, weather information, and a complete complement of instrumentation ships on station in the Atlantic and Pacific oceans. An Air Force C-135 aircraft equipped with the Airborne Lightweight Optical Tracking System (ALOTS) filmed the launches of Apollos 9 through 11 plus the splashdown of Apollo 11. Several EC-135N aircraft, the Apollo Range Instrumented Aircraft (ARIA), were deployed from Patrick AFB to provide S-band tracking, voice relay, and both S-band and UHF telemetry for Apollo missions.

The experimental satellite, TACSAT 1, largest and heaviest communications satellite launched in the free world, was boosted into a synchronous equatorial orbit by the Air Force's Titan IIIC space booster at the Eastern Test Range in February. The giant satellite was designed to provide the nation's armed forces with a capability to communicate on a worldwide basis with ships, aircraft, and foot soldiers using receiving antennas varying in size down to 1 foot in diameter.

The final launch in the Titan IIIC research and development program was accomplished on May 23 with the orbiting of 2 improved Vela satellites at the Eastern Test Range. These satellites, the fifth pair launched by the Air Force, were designed to monitor nuclear detonations as much as 100,000,000 miles or more into outer space, at the same time scanning through earth's atmosphere for similar activity. Additionally, the Vela's provide detection of solar flares and other similar hazards that could affect manned space programs.

Use of the high-speed track at the Air Force Missile Development Center (AFMDC) was made to test such missiles as SRAM, Standard ARM, and Maverick. Flight tests, impact tests, and guidance system tests were also made or planned.

In its continuing investigations of biological responses to aerospace environments, the USAF School of Aerospace Medicine made studies of the course of experimental influenza in mice at different altitudes and with varying degrees of oxygen. The studies showed that subnormal oxygen levels seemed to increase resistance to influenza, while increased susceptibility was demonstrated under 99 percent oxygen conditions.

The School of Aerospace Medicine conducted 2 experiments for NASA to determine the ultraviolet protection afforded the eyes by the Apollo helmet and visor system. As a result of tests using primates, the school determined that an extravehicular activity mission requiring an astronaut to face the sun would exceed the threshold limitation for photokeratitis in 78 minutes. Hence, the school recommended that these missions be limited to a maximum of 60 minutes, leaving an 18-minute safety margin.

The fifth C-5 Galaxy off the assembly line of

Lockheed-Georgia Company at Marietta, Georgia, went to the Armament Development and Test Center's (ADTC) climatic hangar at Eglin AFB, Florida, for 14 weeks of environmental testing at temperatures ranging from minus 65 degrees to plus 125 degrees Fahrenheit, in the world's largest environmental chamber. This was the first portion of a 13-month all-weather testing program. The second Galaxy made the first cross-country flight for any C-5 in May, when it was flown to the Air Force Flight Test Center at Edwards AFB, California, for 6 months of combined Category I and Category II testing. On June 15, it set a world record when it became airborne at a total gross weight of 762,000 pounds.

ADTC received its first F-111A in April for an extensive weapons carriage and clearance test program called Seek Eagle. The tests proved that the aircraft is capable of carrying a variety of weapons and weapon configurations. The various combinations will be used by the Tactical Air Command's growing fleet of F-111s.

The only remaining XB-70 aircraft made its last flight February 4 from Edwards AFB to Wright-Patterson AFB, Ohio, where it was on display at the Air Force Museum. Likewise, the No. 1 X-15 research airplane, first flown June 8, 1959, was airlifted on May 9 to the Smithsonian Institution in Washington, D.C., where it was being displayed with other historic aircraft.

On May 5, the X-24 lifting-body research vehicle made its first free flight, over the desert at Edwards AFB, after being dropped from its B-52 mother ship, the same B-52 that air-launched the X-15 on its test flights. The X-24 is a flatiron-shaped vehicle with angled vertical fins on each side and one on the center line.

Among tests under way in the wind tunnels at Arnold Engineering Development Center, Tennessee, was a program to determine the feasibility of reducing the severity of sonic booms generated by high-performance aircraft, without degrading aircraft performance. In another program, hundreds of tests were made on separation of stores from tactical aircraft to help insure that the stores will follow the proper trajectory and not collide with the parent aircraft following release. Stores include bombs, missiles, fuel tanks, gun pods, and flare pods.

The newest Air Force solar observatory began operating in January at Ramey AFB, Puerto Rico, following installation and testing by the Electronic Systems Division. The telescope system permits simultaneous observation, remote television monitoring, and photographic recording by an electrically programmed camera, aiding in the prediction of effects of major solar events.

A hands-off radio was developed for use by paramedics, who often operate in the noisy environment of helicopters. It uses bone conduction to pick up and emit sound, leaving the paramedic's hands free

and enabling the paramedic to perform emergency first aid or to defend himself. The microphone and antenna are sewn into a special mesh cap that fits under the helmet worn by pararescuemen.

The first improved Back-Up Interceptor Control (BUIC III) facility was turned over to the Aerospace Defense Command at Fort Fisher, North Carolina. The high-speed computerized control center will furnish air defense commanders with real-time information on any airborne threat to North America.



At Arnold Engineering Development Center, the Air Force's Systems Command was studying the feasibility of reducing sonic boom severity without losing aircraft performance.

Several air traffic control systems were under development or testing. One involved a prototype tactical air control tower capable of converting an unattended airstrip into a high-capacity airfield within one hour. It can be transported by cargo aircraft, ship, truck, or helicopter. Another, Project Seek Dawn, was installed in Southeast Asia to monitor and direct tactical air operations in combat, using high-speed computers to process flight plans and to check aircraft by radar tracking.

The first automatic telephone switch of the 490L Overseas Autovon system was turned over to the Air Training Command at Sheppard AFB, Texas, in March. When completed, the system will automate existing manual facilities and link 2,000 military bases throughout the world.

A modern communications network in Japan, the Kanto Plain Communications System installed for the use of U.S. military forces in the Tokyo area, was dedicated. It is designed to interface with existing military communications systems such as Autovon and Autodin.

Compass Link, a revolutionary system for relaying high-quality photographs by satellite from operational areas to Washington, D.C., was disclosed in June. The system's equipment converts aerial photographs into electronic signals at a ground terminal

in Southeast Asia. They are sent to a satellite which receives and retransmits the data to another ground terminal in Washington.

Future astronauts may be able to talk their way from one spacecraft to another if experiments which were being conducted by AFSC scientists are successful. They were working on a voice-actuated control system for astronaut maneuvering units. It was hoped that the machine would respond to 14 voice commands—words such as stop, back, right, open, or down—freeing the astronaut's hands for other work.

The 2 largest X-ray machines ever built were dedicated at the Air Force Special Weapons Center, Kirtland AFB, New Mexico, on January 28. They were being used to study the effects of gamma radiation produced by nuclear explosions on electronic equipment.

In November, USAF Headquarters presented the Space and Missile Systems Organization (SAMSO), Los Angeles AFS, California, the Outstanding Management Improvement Program Award for "an outstanding cost reduction program." The unit had a validated savings of over \$68,000,000.

ARMY

During 1969, the Army continued its research and development effort on the Lockheed AH-56A weapons helicopter. A production contract announced earlier was canceled, but the weapons helicopter remained the Army's highest priority aircraft system and the Army intended to procure the AH-56A when technical difficulties are solved.

In other research and development on aircraft, the Army initiated preliminary efforts on development of the Heavy Lift Helicopter (HLH); the Utility Tactical Transport Aircraft System (UTTAS), destined to replace the workhorse Huey helicopter in logistics operations; and the Manned Aerial Vehicle for Surveillance (MAVS), slated as eventual replacement for the veteran Grumman OV-1 Mohawk. On these programs, the Army was stressing increased maintainability and reliability, reduced vulnerability, and improved crashworthiness, in addition to mission performance.

In a major propulsion research program, the 1,500-shaft-horsepower demonstrator gas turbine engine project was experiencing singular success. Test engines were demonstrating markedly reduced weight and substantially improved specific fuel consumption.

During 1969, the Army was developing its second "quiet aircraft." After highly successful trials of the Lockheed QT-2 in Vietnam, the quiet aircraft program was continuing with flight tests of Lockheed's YO-3A.

In the major area of missile development, the

antiballistic missile (ABM), the concept was re-oriented to defense of the nation's retaliatory capability, the silo-based ICBMs, and a number of improvements were achieved. The ABM system, originally called Sentinel, was renamed Safeguard. Like its predecessor, Safeguard includes 2 missile systems, a long-range weapon (Spartan, built by Western Electric Company in association with Bell Telephone Laboratories and McDonnell Douglas Astronautics Company) and a lower-altitude, high-acceleration interceptor (Sprint, Western Electric/Bell/Martin Marietta); a battery of sophisticated radars; and a system of ground computers to perform the myriad calculations necessary for tracking and interception.

In line with a Presidential requirement to incorporate the latest state-of-the-art improvements into the Safeguard system as deployment decisions are made, based on threat expansion, major advanced developments were achieved in interceptor and radar designs.

An improved third stage for the Spartan interceptor provides higher performance at longer ranges with greater accuracy, permitting multimission capability to maintain tempo on the evolving threat.

A flight program was to be performed to demonstrate greatly improved axial and lateral maneuver capability under precise laser gyro control, utilizing a unique aerodynamic lifting body which achieves control forces without the typical control vanes or wings. The aim of this project is to provide an evolutionary successor to the endo-atmospheric Sprint interceptor.



Although an earlier-announced production program was canceled, the Army continued its research and development effort on the Lockheed AH-56A and the weapons helicopter remained the service's highest priority aircraft system.

Two new multifrequency research radars, Altair and Alcor, were put into operation at Kwajalein to perform the necessary discrimination and radar research to develop advanced capabilities for the Safeguard radars. These radars include the capabil-

ity for real-time threat and penetration aid complex discrimination diagnostics using flexible waveforms with extremely wide bandwidth. Associated with the radar system was a program of flight testing of ICBM target and reentry research vehicles. In this program, a standard ICBM booster was being used to place multiple targets in position to simulate many possible threat combinations, including various-shaped reentry vehicles, some with extensive on-board research instrumentation.

In other missile research and development programs, work continued on the SAM-D (Surface-to-Air Missile Development). SAM-D will be an air defense system for use in both battlefield and continental defense against high-performance aircraft and short-range missiles.

Support equipment for the Lance missile, a surface-to-surface weapon designed to provide greater fire support to Army field divisions, went into production while the missile system itself continued in engineering development. Test firings continued at White Sands Missile Range.

Testing of the Chaparral, a Navy-developed Sidewinder IC modified for surface-to-air use, was essentially completed. First tactical units entered the Army's inventory early in 1969.

The 20-millimeter Vulcan self-propelled and towed air defense gun, developed as a companion to Chaparral, also completed its major test program and entered the active inventory.

The portable Forward Area Alerting Radar (FAAR), designed to provide early warning to Chaparral, Vulcan, and Redeye teams, continued to undergo test and evaluation.

NAVY

In the past 50 years, the rapid growth of aerospace technology has assisted the Navy in the acquisition of an air arm long enough and strong enough to reach nearly any part of the globe by way of the highly mobile carrier strike forces. Building such naval air power is the responsibility of the Naval Air Systems Command. The command manages the development, production, and technical support of all Navy and Marine Corps air weapon systems and has full life-cycle responsibility for every air weapon system the Navy develops and uses. The full impact of the concept of this "cradle-to-grave" responsibility is apparent at the time for delivery of an air weapon system to the fleet. Delivery of the operational system to the fleet, however, is a milestone of progress in the command's life-cycle responsibility rather than an end. It marks the beginning of fleet technical support activities provided by the command throughout the entire history of its use in the Navy.

To accomplish the task of development, produc-

tion, and technical support of air weapon systems, the Naval Air Systems Command was maintaining during 1969 a worldwide organization supporting the activities of more than 130,000 persons engaged in air systems work. The command was supporting research laboratories at various locations in the United States. Additionally, it was performing maintenance, overhaul, and rework on air weapon systems at 7 major aviation rework facilities.

To meet the challenge of the 1970s, the Naval Air Systems Command embarked in 1969 on 2 vital aircraft programs destined to give the Navy a new dimension in air superiority. Prime contractors were selected to begin development of a new supersonic fighter and of an antisubmarine warfare aircraft. Both aircraft were scheduled for fleet introduction in 1973.

Grumman Aerospace Corporation was selected to develop and produce the F-14, which will replace the F-4 Phantom II. Known previously as the VFX, the F-14 will be a variable-sweep-wing aircraft with a tandem seating arrangement and will offer an appreciable increase in performance over the F-4. The twin-tailed F-14 will have an all-weather capability for delivery of the Phoenix, Sparrow, and Sidewinder missiles using the AN/AWG-9 weapons control system. It will also have an air-to-ground attack capability and a modern air-to-air high-performance gun. First flight of the F-14 was planned for early 1971.

Lockheed Aircraft Corporation was picked to begin work on the Navy's newest antisubmarine warfare aircraft, the S-3A, which will replace the S-2 Tracker, a twin reciprocating engine plane which has been in service for over 15 years. The new aircraft will be powered by 2 high bypass turbofan engines and will be capable of speeds and ranges twice that of the S-2. These turbofan engines will operate at a specific fuel consumption rate 25 to 30 percent below that of operational turbojet engines. The savings in SFC will correspondingly increase on-station time and allow a higher maximum speed capability in comparison to present ASW aircraft.

The use of an advanced avionic system, designed around a general-purpose digital computer, will substantially increase the 4-man crew's ability to perform its mission. The computerized system will be able to analyze underwater sounds and other sources of tactical information and present data on television-like displays for interpretation by the operators. Additionally, automation of routine aircrew functions will give the crew more time to analyze the sensor data, enabling it to make more effective tactical decisions. Like the F-14, first flight of the S-3A was expected to be in 1971.

The F-14 and the S-3A will eventually join forces with another new weapon system, which entered the fleet in 1969. The P-3C Orion, the Navy's newest land-based antisubmarine weapon system, pro-

vides the fleet with a search and detection capability never before available in airborne antisubmarine warfare. The new aircraft is the product of a multi-million-dollar research and development program which had its beginnings in 1960. The P-3C ushers in a new era in antisubmarine warfare techniques and equipment which will provide the Navy with an advanced weapon system to more effectively detect, classify, localize, and attack undersea targets through the use of automatic data processing equipment.

First deliveries of the P-3C Orion took place in May and June 1969. This antisubmarine patrol plane gives the Navy outstanding potential. Nearly everything in the modernized Orion operates in conjunction with the ASQ-114, a miniaturized digital computer. The computer takes over routine communication functions, assists the navigator by maintaining continuous dead reckoning position, and provides steering information to the pilot. The computer receives inputs from all ASW sensors, stores these data, and feeds them to the tactical displays as needed. It even tests itself and makes diagnostic analyses whenever failures occur.

The first fleet P-3C was accepted by Patrol Squadron 30, the Atlantic Fleet replacement training squadron, in June. VP-30 will use this airplane, and others like it, for transition training of men from other squadrons scheduled to receive the P-3C. The new Orion commenced service acceptance trials by the Board of Inspection and Survey at the Naval Air Station, Patuxent River, Maryland, in early October.

Naval Air Systems Command was continuing its program to modify the E-2A Hawkeye early-warning aircraft. Under a 1968 contract with Grumman Aerospace Corporation, all E-2As were to be provided with an improved general-purpose Litton computer. The improved system will provide greater tactical flexibility through its increased memory capacity, programmable microminiaturized construction, and increased maintainability and reliability. Formerly known as the Mod AX, the modified aircraft will be designated E-2B. First prototype was delivered to Naval Missile Center, Point Mugu, California, in June 1969 for operational development. First fleet delivery was scheduled for January 1970.

The follow-on to the E-2B airborne early-warning/command and control vehicle is the E-2C, under development at year-end. The tactical necessity for a detection-reporting system with near-land/overland capability resulted in development of the APS-111 radar. The new radar, successfully demonstrated in mid-1967, greatly improves the operational capability of the Airborne Tactical Data System over earlier "blue-water" limitations. The E-2C makes extensive use of microminiaturization and state-of-the-art improvements which will improve reliability and maintainability of the weapons system. Flight test

of the first prototype was scheduled for April 1971 with production delivery commencing in October 1972. Service acceptance trials will begin in March 1973.

Throughout the year, North American Rockwell Corporation's OV-10A Bronco was proving its versatility as a lightweight armed reconnaissance aircraft while operating under the austere combat conditions of Southeast Asia. Numerous research and development tasks were initiated and were in various stages of completion to improve existing aircraft systems, to develop new associated weaponry, and to more fully evaluate and extend the performance capabilities of the Bronco.



The North American Rockwell OV-10 Bronco was the subject of several Navy research and development projects aimed at increasing the Bronco's performance or at development of new systems and weaponry.

A contract was awarded North American Rockwell Corporation for the development of a retro-launcher and 106-millimeter recoilless rifle system which will increase the target marking and illumination capability of the Bronco while adding considerable offensive power. Ground tests were under way at Naval Weapons Facility, China Lake, California, on this project, and combined efforts were being made by NWF and Weapons Service Test at Patuxent River for the development and testing of a lightweight gun pod to increase the integral firepower of the OV-10A. A smoke screen capability was developed and was under evaluation, and tests were simultaneously progressing at Patuxent River to insure OV-10A compatibility with the use of MK-12 smoke tanks.

A continuing program at Patuxent River, being carried out to evaluate the technical aspects of Bronco performance, included a hot-day/high-altitude performance study, a spin characteristic project, a rough terrain capability study, a STOL performance study, carrier suitability tests aboard LPH-4 type ships, and the development of a damaged aircraft helolift doctrine.

A comparative study for the development of a water-injection system versus an increased shaft horsepower engine for the Bronco was under way. The purchase by the Federal Republic of Germany of 18 OV-10B aircraft, and interest shown by other foreign countries in acquiring the Bronco, were indicative of the high esteem that this aircraft has earned.

In April 1969, the first of new production RA-5C aircraft were delivered. These aircraft incorporated J79-GE-10 engines, a widened inlet duct, and leading edge wing root fillet. The changes greatly improved the handling characteristics of the aircraft in landing and takeoff configurations. Carrier suitability tests were conducted by NATC Patuxent River in July aboard the USS *Independence* and no difficulties were encountered.

A major avionics modification was made to the EA-3B which greatly expanded the capability and flexibility of this aircraft. The EA-3B is a passive electronic countermeasure version of the A-3B twin-engine sweptwing bomber which first entered active service in 1956. Except for 4 A-3B aircraft, all basic bomber aircraft had been converted to KA-3B tanker or EKA-3B tanker/ECM aircraft. Other versions in active service included the RA-3B photo version and the TA-3B training version used for training bombardier/navigators.

During 1969, a contract was awarded to McDonnell Douglas Corporation for production of a new Skyhawk, the A-4M. This model was scheduled for delivery to the fleet in early 1971; it offered significant improvement over earlier versions. New features include a larger-thrust engine, self-contained starter, drag chute, increased ammunition capacity, and larger canopy.

Production also commenced on the TA-4J trainer model, which was delivered to the Naval Air Advanced Training Command in June 1969. This Skyhawk trainer will replace the aging TF-9 Cougars and will become the first operational jet that student naval aviators fly.

Development of the A-6A continued during 1969. A proposed advanced version of this all-weather attack airplane features a solid-state microcircuit core memory computer and a simultaneous multi-mode high-resolution radar system. Development of a video recorder system for A-6 radar and sensor imagery recording commenced in 1969.

The EA-6B tactical jamming system completed a highly successful year of development, with 4 pre-production aircraft delivered by the end of 1969. Fleet suitability trials were scheduled to begin at mid-1970. A derivative of the A-6A, the EA-6B is a 4-place all-weather twin-turbojet electronic warfare aircraft designed for carrier and advance-base operation. Featuring a highly advanced electronic system, the EA-6B will be capable of tactical electronic surveillance and countermeasures in support of fleet strike aircraft. The heart of the weapons

system is a central data processing computer which will assist the crew in dealing effectively with dense electronic environments.

First fleet delivery of the A-7E took place in July 1969. Improvements of the A-7E over the A-7A and A-7B include more advanced radar, navigation, and weapons systems. The aircraft is equipped with an Allison TF41-A-2 engine and a General Electric M61A1 "Gatling gun."

In 1967, a requirement was issued for a heavy-lift crane helicopter. In 1969, the Naval Air Systems Command responded to the requirement with a plan for an 18-ton crane. The crane helicopter will be utilized by the Navy and the Marine Corps in ship and shore operations to retrieve dud aircraft, move large logistic loads, and increase general logistic mobility. The crane will be fleet-available 2 to 3 years from program approval and will be deployable by C-5, ship-compatible, and self-retrievable. The crane will give the naval service an increase in vertical lift capability from 8 tons to 18 tons and will give the logistic mobility required to support the operating forces in a 1970-80 environment.

A prototype of the AH-1J was unveiled at the Bell Helicopter plant, Fort Worth, Texas, in October. The AH-1J is a tandem 2-seated armed tactical helicopter procured for the Marine Corps. The AH-1J is powered by a twin-turboshaft R400-CP-400 engine capable of 1,800 shaft horsepower flat rated to 1,100 shaft horsepower with availability of 1,250 shaft horsepower for takeoff and 5-minute limit. The AH-1J has 2-bladed main and tail rotors and fixed skid landing gear. A significant firepower capability is achieved by the installation of a 20-millimeter cannon swivel chin turret. The cannon is a 3-barrel modified lightweight M-61 manufactured by General Electric Company. Gross weight of the AH-1J is 10,000 pounds; empty weight is 6,442 pounds. A total of 49 AH-1Js had been ordered by year-end, with production delivery scheduled for June 1970. BIS trials (Board of Inspection and Survey) were scheduled for June-August 1970.

In 1968, the Navy approved a program to modify a number of UH-2C Seasprites to the armed search and rescue configuration (HH-2C). The purpose was to provide a combat SAR helicopter with increased survivability over the UH-2A being flown from destroyers in the Tonkin Gulf. Changes to the basic UH-2C include armor plate, a TAT-102 turret with a single 7.62-millimeter minigun, dual wheels, an uprated transmission, and a fourth tail rotor blade. The airframe contractor, Kaman Corporation, completed development testing on the HH-2C in May 1969. Navy evaluation took place at the contractor's plant in Bloomfield, Connecticut, in June, and service acceptance tests began at the Naval Air Test Center, Patuxent River, Maryland, in September 1969. Fleet delivery was expected in early 1970.

The Naval Air Systems Command approved action in 1968 to convert 12 SH-3A helicopters to a combat

SAR configuration. This configuration includes removal of the sonar equipment with associated wiring and provides for incorporation of lightweight armor, dual Emerson TAT-102C turret system with the General Electric 7.62-millimeter miniguns, deck-edge inflight refueling capability, external fuel tanks, improved self-sealing internal fuel cells, increased capacity fuel dump system, cargo deck with additional troop seating, T58-GE-SF engines, and other minor structural and electrical modifications. The model designation of HH-3A was approved for this configuration. A contract with Sikorsky Aircraft Division of United Aircraft Corporation, Bridgeport, Connecticut, provided for a prototype installation and 11 additional kits for installation during progressive aircraft rework at the Naval Air Repair Facility, Quonset Point, Rhode Island. Contractor tests of the prototype aircraft and installation were completed in October 1969 and the aircraft were readied for transfer to the Naval Air Test Center, Patuxent River, Maryland, for instrumentation and Navy evaluation. The Navy evaluation was to be completed by May 1, 1970, with first fleet deliveries scheduled for July 1970.

The Bell X-22A, a dual-tandem tilting duct research V/STOL aircraft, completed its contractor flight demonstration program in April 1969 with an MPE (Military Preliminary Evaluation) of the 3-mode VSS (Variable Stability System). The Naval Air Systems Command was seeking interest from the Air Force, NASA, Army, and FAA for a jointly funded long-term research program using the X-22A VSS capability to explore stability and control requirements for a wide range of V/STOL aircraft; to determine flying quality criteria, displays, and control systems for V/STOL; and to culminate in realistic military/agency detail specifications for future V/STOL type aircraft.

In February, a requirement for the LAMPS (Light Airborne Multipurpose System) was issued. The Naval Air Systems Command, with assists from the Naval Air Development Center, Johnsville, the Naval Avionics Facility, Indianapolis, and industry, published a proposed technical approach in September and this was forwarded to the Chief of Naval Operations in November. A specific operational requirement was due early in 1970.

Concurrently with the concept formulation efforts, a test-bed feasibility program was being conducted at the Naval Air Development Center, Johnsville, under Naval Air Systems Command management. This program was utilizing a Kaman NUH-2C as a test-bed aircraft and existing avionic equipments to probe the feasibility of a sophisticated system for operation from ocean escorts and destroyers.

The primary armament of Naval Air Systems Command's new aircraft, the F-14, will be the Sparrow III air-to-air missile. The newest member of the Sparrow family is the AIM-7F, a solid-state successor to its vacuum tube predecessors. The ad-

vanced Sparrow has materially increased operational capabilities in range, altitude, and maximum launch velocity. Most significant, however, is the quantum jump the missile promises in overall reliability. Plans called for utilization of the missile in an AUR (All Up Round) configuration which will delete the requirement for organizational and intermediate-level on-board maintenance. Fleet delivery of the Sparrow AIM-7F was scheduled for early 1971.

The first units of the Sidewinder AIM-9G were delivered to the fleet in early 1969. In the AIM-9G, the Sidewinder Expanded Acquisition Mode (SEAM) modification is used in conjunction with the aircraft SEAM equipment as an aid in detecting the presence of, acquiring, and tracking infrared targets. The SEAM system provides headslaving of the AIM-9G missile to airborne intercept radars. The AIM-9G is configured to be interchangeable with the AIM-9D in aircraft loading so that both missiles can be used aboard aircraft not equipped with SEAM.

Testing of prototype Sidewinder AIM-9H air-to-air guided missiles was completed in 1969. The AIM-9H incorporates a solid-state electronics section and SEAM in the guidance control unit instead of the conventional electronics section of the AIM-9D/G. Pilot production was scheduled to begin in November 1970. The solid-state version was expected to increase tracking rate, reliability, and producibility of the missile and should decrease the cost.

The Phoenix missile firing program continued in 1969. From the inception of the firing program in 1966 to November 1969, 18 of the 24 missile launches were successful (passing less than 25 feet from the target). Completion of the Phoenix research and development phase was expected by mid-January 1970.

Standard ARM missiles continued in production during 1969 with both the Navy and the Air Force continuing their test programs with Standard ARM qualified aircraft. Research and development work continued.

A specific operational requirement was issued for the development of an antiship weapon called Harpoon. Plans were formulated for the conduct of a formal contract definition effort on this system.

Condor, an electrooptically guided air-to-surface weapon, was successfully tested in an unpowered configuration. Steps were taken by the development contractor, North American Rockwell Corporation, to terminate efforts to develop a prepackaged liquid-propellant motor for the missile and to initiate development of a solid-propellant motor instead. Development effort on the new motor proceeded satisfactorily.

Early in 1969, the technical and operational evaluation of the MQM-74A target was successfully completed at the Pacific Missile Range, Point Mugu,

California. Designed and developed for the Naval Air Systems Command by Northrop-Ventura, the MQM-74A is a midwing jet-powered vehicle required to provide an improved performance replacement for the MQM-36A in Navy and Marine anti-air weapons training missions.

First operational capability for training use was established at the Marine range at Twentynine Palms, California, in February 1969. Operations from ground launch sites on San Clemente Island, California, and Dam Neck, Virginia, commenced in the summer of 1969 in support of fleet training. Future MQM-74A employment includes ship-based launching for operations at sea.

A program to develop automatic formation drone control capability for such targets as the BQM-34A and the QT-33A was being pursued by the Naval Air Systems Command. This system, which is required for certain essential weapon evaluation tests, was being developed by Control Data Corporation. The design contract was the culmination of development work which had been carried on for several years at the Naval Weapons Center, China Lake. Employing equipment from these early development efforts, the Naval Weapons Center successfully demonstrated in May 1969 closed-loop, fully automatic control of 2 targets (QF-9J master and BQM-34A slave) in formation on 3 test runs of approximately 2 minutes each.

During 1969, under Project TRIM, the Navy successfully demonstrated the feasibility of incorporating electrooptical sensors into a high-performance aircraft for detecting non-radar significant targets at night. This effort was completed by Grumman Aerospace Corporation in January 1969 after an extensive flight-test program. The test program utilized a nonstandard, nondeployable A-6A aircraft with electrooptical sensors installed in outer wing pods, flying against both real-world and calibrated test targets.

Based on the results of the A-6 TRIM feasibility program, a concurrent development/production contract was executed with Grumman Aerospace Corporation to install/integrate this class of electrooptical sensors into 12 new production A-6As, redesignated A-6Cs. The first flight of the prototype A-6C was completed in late August 1969, with scheduled delivery of the first 2 A-6Cs to the Navy in November 1969 for Navy technical and operational evaluation. The TRIM program represented the first Navy application of this class of night sensors to high-performance attack aircraft.

A calibrated electrooptical test range was completed at the Naval Air Test Center in June 1969 using Naval Air Systems Command Project TRIM funding. The test range is located at the Naval Electronics Systems Test and Evaluation Facility (NESTEF), Webster Field, Maryland, and consists of a newly constructed TV-IR resolution target and 4 standard military 3-bar photographic resolution

targets. This target complex is the first fully instrumented test range designed specifically for quantitative flight test/evaluation of electrooptical sensors.

In September 1969, Westinghouse Aerospace Division was awarded a contract to modify a government-furnished NP-2H aircraft to adapt it for use as a multisensor/weapons system test vehicle in support of Project TRIM development efforts. The NP-2H airframe will provide a nose fairing in which various electrooptical sensors may be mounted for a side-by-side comparison of performance, with interchangeable windows to permit the testing of both visible and infrared type sensors. The multisensor test vehicle was scheduled for completion during the summer of 1970.

In order to enhance the performance of low-light-level television systems under extremely low light levels (10^{-4} foot candles or less), the Navy's TRIM program was investigating the use of a covert pulsed laser illumination system using gallium arsenide diodes. Using a pulsed illuminator system, it is possible to augment the natural scene illumination and to range gate the receiver to view a volume of space around the target, rather than the entire atmosphere, thus eliminating illuminator backscattering and scattering effects due to fog or smoke between the target and the receiver. During the fall of 1969, RCA was awarded a contract to provide a covert target illuminator, to be delivered for test in the TRIM multisensor test vehicle during the summer of 1970.

Under Project TRIM funding and direction, a Forward Looking Infrared (FLIR) image enhancement unit was built at Naval Weapons Center (NWC), China Lake, to assess the feasibility of applying signal processing techniques to improve the quality of the IR imagery obtained from conventional FLIR systems. The most promising technique considered involved the utilization of the second spatial derivative. This second derivative image is added to the normal image video and has the effect of enhancing the edges of the various objects within the field of view. This image enhancement unit was incorporated by Hughes Aircraft Company into the TRIM AD FLIR feasibility system under a contract from Naval Air Systems Command in March 1969 and the modified system was delivered to NWC, China Lake, in August 1969 for subsequent evaluation. The enhanced FLIR unit was to be flight-tested using a high-performance aircraft such as an A-6 and was to be flown against both calibrated target ranges and representative real-world targets early in 1970. The results of the flight tests will determine the applicability of incorporating this image enhancement technique to existing and future triservice FLIR systems.

The Naval Air Systems Command completed flight test and evaluation of the HAS (Hover Augmentation System) in an RH-3A and a Marine CH-46A helicopter. The HAS system, developed by the

Sperry Flight Systems Division, enhances the hovering capability of a helicopter with operational improvement during typical hovering tasks such as sonar dips in an ASW mission, ground and sea rescue of troops, and handling various sling loads. Significant reduction of pilot effort with greatly increased positioning accuracy highlighted the final flight-test report from the Naval Air Test Center, Patuxent River, Maryland. HAS system concepts may have particular application for helicopter search and rescue missions and will be reflected in the automatic stabilization specifications where applicable.

The Naval Air Systems Command completed exploratory tests of a rotary hydraulic aircraft-arresting system that shows considerable promise for replacing the Mark 7 Mod 3 linear hydraulic system in future aircraft carriers. The proposed system consists of 2 rotary turbine energy absorption units coupled to contoured drums (programmed drums) for arresting cable storage. The drum contours tend to maintain rotor revolutions per minute during the period of aircraft deceleration, thereby maintaining the level of energy absorption.

The Naval Air Systems Command, in recognizing the need for improved flight control system designs for future advanced aircraft, requested competitive proposals for research and development of a concept in which aircraft control is accomplished with no external moving surfaces (NEMS). Honeywell Inc. was selected to perform the design and development work on the NEMS.

The year saw advances along a number of fronts in the Naval Air Systems Command materials program. Illustrative of these was the development of a new high-strength aluminum heavy forging and plate alloy, designated NAVAIR-3, under contract with Aluminum Company of America. This new alloy has improved combined strength and stress corrosion resistance over any other aluminum alloy available. In addition, it has much lower quench sensitivity during heat treatment than 7075 aluminum alloy and therefore can be heat treated in larger sections without loss of strength.

During the year, the Naval Air Systems Command completed a field evaluation of barrier film coated bearings on selected short-lived aircraft avionics units. The barrier coating technique uses the application of a nonwetting, thin chemical coating to the exterior ball bearing surfaces to prevent lubricant loss by spreading. In the evaluation of 6 different types of items previously characterized by high failure rates, no unit malfunctioned as a result of bearing or lubricant failure. Twofold to fourfold increases in service life had been achieved at the time the tests were discontinued. In addition to increased reliability, the technique offers significant potential for cost savings.

Major developments occurred during 1969 in the AWCLS (All-Weather Carrier Landing System). At

the Naval Air Test Center, Patuxent River, a new APC (Approach Power Compensator) was developed for the F-4J. This new APC is good for both manual and AWCLS (fully automatic) landings, whereas the previous system was unsatisfactory for both. A significant item in 1969 was the certification of USS *Saratoga* for the fully automatic AWCLS landings.

A radar augmentor was also developed, a Ka-to X-band cross-band airborne radar augmentor for the AN/SPN-42 (landing control center for AWCLS). This development was necessary to provide point source tracking and 4-nautical-mile tracking in 10 millimeters of rain per hour. Range in rain has been one of the big problems in providing an all-weather landing capability.

Investigations were conducted into the feasibility of going to a phased-array antenna for the AN/SPN-42. This would increase the traffic-handling capability from 2 airplanes to 4 simultaneously and would also provide for viewing other traffic in the area at the same time.

In October 1969, the Naval Air Systems Command awarded a contract to Northrop Corporation for the engineering development of the Joint Services Inflight Data Transmission System (JIFDATS). The development and subsequent procurement of JIFDATS was being managed by the JIFDATS project manager within the Naval Air Systems Command. The system was being developed to provide the Army, the Navy, the Air Force, and the Marine Corps with the capability of transmitting tactical reconnaissance and surveillance data from airborne sensors to surface terminals with minimum time lapse, thus providing current tactical intelligence.

In a long-range effort to halt the proliferation of special-purpose avionic test equipment, the Naval Air Systems Command was introducing the general-purpose VAST (Versatile Avionic Shop Test) system to the fleet. The VAST program objectives are to replace the varieties of unique special support equipment with a cost effective and technically superior standard test system. Primary advantages will be reductions in avionic shop space requirements, in numbers of highly skilled avionics technicians through simplification of best techniques, and in avionic turnaround time.

In support of this program, the Naval Air Systems Command had under limited production procurement 2 generations of VAST systems. The VAST system designated AN/USM-335(V) was to be installed in short airfield tactical support vans to support Marine Corps helicopters. This system was to test the self-contained navigation system portion of the Integrated Helicopter Avionics System (IHAS) program. The AN/USM-335(V) system can be expanded to support the automatic flight control system and the short range station keeping portions of the IHAS program. Test and evaluation of this VAST system was to commence early in 1970.

The AN/USM-247 VAST is a second-generation development incorporating state-of-the-art improvements and utilization of microelectronic components. It was to be installed in attack and antisubmarine warfare aircraft carriers and selected shore stations for avionic testing at the intermediate or depot maintenance levels.

Plans called for AN/USM-247 VAST support of the A-7E, E-2C, F-14A, and S-3A aircraft. As other avionic equipment or weapon systems are introduced, test stations will be configured to meet the new testing requirements.

In 1969, the Navy made significant progress in applying space technology to aircraft communications and navigation and to space science. Communication from aircraft to other elements of the fleet and to shore activities by means of communication satellites was accomplished. Considerable effort was being applied to user equipment which will give this capability to naval aircraft including small strike aircraft. Similar efforts were being made to develop user equipment which will give naval aircraft the capability to use the Navy Navigation Satellite system. Initial efforts were concentrated on using the received signals to update aircraft inertial systems. Longer-range efforts were concerned primarily with direct aircraft navigation by satellite based on a new ranging concept.

Solar radiation monitoring of the sun by satellite continued to be performed by the Solrad 9 satellite launched on March 5, 1968, with the objective of scientific observation of the sun as a key to understanding the sun-induced natural phenomena in the near-earth environment. In addition to its normal functions, the Solrad 9 satellite was used to support the manned lunar flights of the Apollo 8 and 10 missions and the manned lunar landing flights of Apollos 11 and 12. The satellite was a key element in the system established to provide warning of radiation hazards which might affect the Apollo astronauts.

Equipment for the reception of cloud cover pictures from weather satellites and cloud cover pictures and other meteorological data from the Advanced Technology Satellites was developed by the Naval Avionics Facility, Indianapolis. Design was based on a previous model developed by the Naval Electronics Laboratory, San Diego. Evaluation was conducted during the fall of 1968. The evaluation was successful and the equipment, designated AN/SMQ-6(V), was accepted for service use. Several carriers operating in Southeast Asia were provided with the equipment in 1969.

Research and technology programs of the Naval Air Systems Command gained considerable momentum under a new organization introduced in 1966. In that year, responsibility for the planning and management of research and technology effort was assigned to a separate operating group under an assistant chief for research and technology.

A far-reaching program of advanced concepts

studies and advanced development projects was under way to provide a basis for the planning and development of future systems. Work continued on projects leading to advanced aircraft systems for attack, anti-air, command/control, antisubmarine warfare, amphibious support, and operational support applications. Studies and advanced development projects were conducted on air-to-air and air-to-surface missile concepts employing propulsion and guidance concepts exploiting the latest advances in technology. To provide a tool for the development and test of advanced concepts for aviation systems aboard ship, plans were developed for use of a decommissioned 40,000-ton aircraft carrier as a test-bed.

Research, exploratory development, and advanced development programs designed to provide a sound integrated technological base for future system and subsystem development were conducted during the year.

Interim results of a research program on mercury cadmium telluride infrared detectors showed promise. This research is based on the use of a novel epitaxial deposition technique which is designed to prevent a buildup of contaminants in the deposition chamber. While the new detectors are competitive with similar detectors in sensitivity, they have a response time of less than 50 nanoseconds. This response time is substantially better than similar developmental type mercury cadmium telluride detectors and represents a major step forward in its use for detecting laser signals.

Newly developed laser holographic techniques will allow the development of a greatly improved method of storing, retrieving, and assembling navigational maps for aircraft. It is anticipated that this system will effect a tremendous saving in storage space and time in originating and assembling a mission map. A contract was executed for the initiation of development of a horizontal display system using the laser holographic technique.

In an effort to counter the stress corrosion problems inherent in high-strength aluminum alloys used in naval aircraft, a research and development program in materials developed a series of heat treatments which render the most common aluminum alloy (7075) essentially immune to stress corrosion; organic coatings capable of withstanding the attacks of synthetic fluids which have damaged previous coatings; insulation practices for troublesome steel fasteners; and inspection techniques for discovering hidden corrosion cracks.

Until recently, there was a serious deficiency, from a design standpoint, in operational environmental data for helicopters. A specially designed flight-load recorder was developed and installed in combat helicopters and, as a result, service conditions under extremes of operational severity were being recorded. This effort affords structural designers an opportunity to gain an insight into com-

bat needs for structural safety and reliability. A warning instrument for pilots was being developed with the objective of preventing the onset of rotor blade stall and associated highest load occurrences.

Design of inlets, flap junctions, etc., for modern aircraft and missiles results in many cases in highly curved surfaces. In order to obtain a design for efficient airflow, it is necessary to understand the effect of such large longitudinal surface curvature on the behavior of a thick turbulent boundary layer. By starting with the equations of motion and proceeding in a systematic manner, Naval Ordnance Laboratory scientists derived the compressible turbulent boundary layer equations for flow over curved surfaces, equations not previously available. By use of these equations, an analytical investigation of the effect of longitudinal surface curvature on the behavior of an incompressible turbulent boundary layer in an adverse pressure gradient large enough to produce separation was made.

To preclude premature, expensive, and time-consuming jet engine removals for inspection purposes, a sonic approach to component malfunction detection was investigated and deemed feasible. A sonic analyzer to identify and locate engine component degradation or failure was developed and adapted for analysis of 2 engines. This instrument, capable of "listening" to more than 150 discrete moving parts within the engine, operating at idle speed, was expected to permit complete engine condition analysis within a period of 15 minutes.

The development of solid-state electric power switching and control devices, such as silicon controlled rectifiers, power transistors, and diodes, combined with the development of multiplexing techniques, provides the basis for the complete redesign of future aircraft electric systems. Exploratory development work effort completed during the year proved the feasibility of obtaining an advanced electrical system which will offer attractive operational advantages.

The ability of a pilot to obtain the highest level of performance from his aircraft under day/night low-visibility conditions is directly affected by the cockpit instrumentation provided to him. The Integrated Modular Instrumentation System was being considered as a development of new display technologies, to obtain the required instrumentation. This system is built around 5 primary displays: the head-up display for optical projection of flight information to correlate with real-world cues, the electronic vertical display for multisensor display requirements, the engine management display to allow engine/fuel control through a management by exception routine, a horizontal moving map display for tactical/navigation requirements, and a warning panel display. The development of these displays will use laser holographic techniques, light emitting diode solid-state displays, wide-angle optics, digital information processing, and microelectronics.

The feasibility of using electronic speech synthesis for oral readout of digital discretized was investigated under a contract. Laboratory feasibility models were constructed to evaluate voice quality. A flight-test model was being built for installation in the F-4 aircraft for tests to be conducted at the Naval Air Test Center.

Efforts were being directed toward eventual introduction of standard-size modular containers (similar to those in regular commercial shipping service) aboard Navy attack carriers. The use of such containers on attack carriers would reduce chronic impediments of limited space, reduce facility access, reduce fire threat through encapsulation and isolation of the majority of aviation support facilities, and reduce proliferation of support equipment. The modular units would be positioned around hangar bay areas in spaces constructed for them. The units would be air-transportable by fixed- or rotary-wing aircraft and could be exchanged rapidly in response to operational need.

An automatic catapulting capability was also under development with the objective of reducing the catapult crew on the carrier by as much as 75 percent. Contributing to the projected capability was the ongoing development of an automatic aircraft weighing station and of an automatic aircraft positioner to direct the aircraft to the hookup position by means of guide tracks in the deck.

A "programmed drum" energy absorber, under development for carrier aircraft recovery systems, offers significant advantages over the present hydraulic arresting engines. The primary advantage is a reduction of almost 50 percent in weight (40,000 pounds as opposed to 78,000 pounds for the MK7 arresting engine). In addition, a 25 percent reduction in gallery deck space requirements appeared feasible.

The foregoing are only examples of the many research and technology efforts pursued in 1969. Other advanced, including radically new, concepts were under investigation or development in areas such as air-launched ordnance, missile propulsion, missile guidance and control, command and control, anti-submarine surveillance, and astronautics.

FEDERAL AVIATION ADMINISTRATION DEPARTMENT OF TRANSPORTATION

Automation of the air traffic control system received continued emphasis in research and development programs conducted by the Federal Aviation Administration of the Department of Transportation in 1969.

During the same time period, the agency also continued research and development efforts to bring about in-service improvements in the system, and long-range planning studies to develop the evolu-

tionary changes in the system needed to accommodate projected increases in air traffic. Estimates indicated that air traffic would double by 1980 and increase fivefold by 1995.

FAA research and development programs are managed by the agency's Systems Research and Development Service (SRDS), Aircraft Development Service, Office of Aviation Medicine, Office of Noise Abatement, and Office of Supersonic Transport Development. The agency's 2 principal research and development centers are the National Aviation Facilities and Experimental Center (NAFEC) near Atlantic City, New Jersey, and the Civil Aeromedical Institute in Oklahoma City. Since industry conducts a large part of the FAA-sponsored research and development on a contract basis, the agency holds annual "Report to Industry" meetings to inform the aviation community of the status of projects.

The Report to Industry meeting held in June 1969 included an evaluation of STOL aircraft, runway traction, propulsion, flight handling qualities of aircraft, VFR-IFR experimental training program, ice prevention and removal from light aircraft, en route and terminal automation, all-weather landing systems, aviation visibility measurements, application of time order technology to the future national airspace system, and noise and sonic boom research programs.

FAA's program for automating air traffic control in airport terminal areas progressed in 1969 with the award of a contract to Univac for the manufacture and installation of the Advanced Radar Terminal System (ARTS III) at 64 locations. One of the units was to be installed at the FAA Aeronautical Center in Oklahoma City for training purposes and another at NAFEC for future system development and test purposes. The remaining 62 units were to be installed at the nation's busiest airports.

The addition of the ARTS III components to existing airport surveillance radars and beacon interrogator equipment will permit the display of such vital flight information as aircraft identity and altitude directly on the face of the radar scopes used by air traffic controllers. This information will be presented in the form of an alphanumeric (letters-numbers) data tag which will be attached to and move with the appropriate aircraft target, or blip, on the radar scope.

The ARTS III system is a modular system and will permit the agency to add more sophisticated levels of data or activity as required at a specific terminal. FAA contracted for the development of expansion modules to increase radar tracking capability, and for data acquisition, processing, and display systems. Other add-ons planned for the ARTS III included processed weather outlines and metering, sequencing, and spacing to achieve maximum utility of available runway space and airspace.

To accommodate low-activity airports, the agency was evaluating a programmable ARTS II system

which uses some of the basic ARTS III components but does not supply the same level of automation.

Another terminal system, called Direct Altitude and Identity Readout (DAIR), designed for use at towers serving low-density terminals and at military radar approach control facilities (RAPCONs), also was evaluated by the agency. This system provides controllers with aircraft identity and altitude from compatible airborne equipment. DoD issued a request for proposals for the purchase of 300 such systems for use at military facilities.

Work continued toward the achievement of improved airport surveillance radar (ASR). A number of projects were under way to increase the efficiency of radar receiving equipment, including the development of an improved radar performance monitor. In addition, FAA completed initial evaluations of the log-FTC-antilog receiver device to improve ASR target reception in rain clutter.

A new airport surveillance radar, the ASR-7, was under contract. The FAA contracted with Texas Instruments for 13 advanced S-band solid-state terminal radars. The new equipment is designed to overcome the problems of instability, inflexibility, drift, and poor reliability associated with previous ASR models. The result is a system which should provide a high degree of performance with a high "on-the-air" time record. First delivery was scheduled for December 1969.

Another innovation was an improved radar presentation for air traffic controllers in the tower cab. Known as BRITE (Bright Radar Indicator-Tower Equipment), it consists of a small, high-resolution plan position indicator (PPI) viewed by a TV vidicon camera. The output of the camera is displayed on a high brightness TV display at the controller's position. Eighty-eight installations had equipment installed in the tower, and an additional 144 units will be placed in FAA and Department of Defense facilities in the future.

In the area of air-to-ground voice communication, the FAA was working on a backup system that would effectively prevent any catastrophic outages in the future. The system will use available audio channels over FAA's RML (radar microwave link) network to provide backup air-ground communications capability for the RCAG (remote control air-ground communications) frequencies serving each Air Route Traffic Control Center.

For long-range communications in remote areas or for oceanic air traffic control, the FAA was actively exploring the possibility of using geostationary satellites. The agency was working closely with NASA and other government agencies as well as with industry in this matter.

Extensive research and development work was conducted on navigation and landing aids. Areas of consideration included self-contained navigation units, precision VOR, instrument landing systems (ILSs) and automatic landing systems, ILS for STOL

**NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION**

aircraft, high-altitude navaid performance, and ILS localizer performance analysis and low-cost scanning beam system.

One of the most promising techniques under study for future air traffic control involved the application of time-ordered technology, or T/F as it is more commonly known. T/F is based on a method of establishing and maintaining precisely synchronized time and frequency references between aircraft and ground stations. This technique has definite promise for meeting the requirements for 1980 and beyond.

In the area of aircraft safety, the FAA continued its research and development programs in hazardous combustible characteristics of cabin interior materials, runway friction and grooving, natural lightning, aircraft fuels, jet aircraft air pollution, cargo fires, fire extinguishing methods, explosive detective devices, airline hijacking problems, ice prevention and removal for light aircraft, pilot training devices, wake turbulence, and flight characteristics for improved stability and control of modern high-performance light aircraft when operated under instrument conditions by an average pilot.

Research in the area of aviation medicine was related primarily to the human factor and its effect on safety both in air traffic control and in the operation of aircraft. The agency also announced a joint study with the Department of Health, Education, and Welfare to measure the amounts of tobacco smoke contaminants in air transport.

In noise research, the agency continued its studies of the sonic boom and aircraft noise. Granted authority by Congress to set aircraft and sonic boom certification standards, the agency also issued the first aircraft noise rule setting noise standards for aircraft type certification. In addition, a special agency/industry STOL task force was appointed to study standards for STOL transport noise certification. Other noise rules were to be forthcoming in 1970.

The FAA's supersonic transport development program was given the go-ahead by President Nixon on September 23, 1969. In making the announcement, President Nixon said, "And the decision is that now we go forward and the first prototype will be flown in 1972 and that the United States will continue to lead the world in air transport." The FAA supersonic transport program would permit the development of 2 prototypes and 100 hours of flight testing. The Boeing Company was to build the airframe; General Electric Company, the engines.

In addition to these major research and development programs, the FAA published 14 advisory memoranda and handbooks for the guidance of FAA and industry personnel. It also issued national aeronautical standards for STOLports, tall tower lights, air traffic control radar beacon system characteristics, and multitransmissometer requirements for Category II and Category III instrument runways, plus 4 notices of proposed rule making.

In 1969, with the Apollo 11 flight, NASA reached the goal set for the manned space flight program in 1961 by President Kennedy—landing men on the moon and returning them safely to earth. On July 20, Neil Armstrong stepped from the Lunar Module onto the surface of the moon, and 18 minutes later Edwin Aldrin followed him. On July 24, the Apollo 11 crew returned to earth, splashing down in the Pacific Ocean about 950 miles southwest of Honolulu. The second moon landing took place in the November flight of Apollo 12. Earlier manned missions in March and May, Apollos 9 and 10, provided essential operational experience and confidence.

Apollo 9, the second manned Apollo mission using the Saturn V vehicle, was launched on March 3, 1969, to evaluate performance of the complete Apollo system. The crew consisted of astronauts James A. McDivitt, commander, David R. Scott, Command Module pilot, and Russell L. Schweickart, Lunar Module pilot. The Lunar Module was flown manned for the first time, moved over 100 miles from the Command/Service Modules, maneuvered in space, and rejoined the Command/Service Modules after 6 hours of separation. All launch vehicle and spacecraft systems functioned satisfactorily through the mission which ended on March 13 with splashdown in the Atlantic.

Apollo 10 was launched May 18 on a lunar orbit mission. Thomas P. Stafford, commander, Eugene A. Cernan, Lunar Module pilot, and John W. Young, Command Module pilot, were the crew. Once in lunar orbit, the Lunar Module, with Stafford and Cernan aboard, separated from the Command and Service Modules; the 2 craft flew in formation and then the Lunar Module descended to within 50,000 feet of the lunar surface. After an independent flight of 8 hours, the Lunar Module rejoined the Command and Service Modules, the crew returned to the Command Module, and the Lunar Module was cast loose. The return to earth was precisely as programmed and splashdown took place in the mid-Pacific on May 26.

The historic Apollo 11 flight, with astronauts Neil A. Armstrong, commander, Edwin E. Aldrin, Jr., Lunar Module pilot, and Michael Collins, Command Module pilot, as crew, was launched from Cape Kennedy on July 16. An estimated 1,000,000 eyewitnesses and a worldwide television audience watched the spacecraft leave the earth. On July 20, the Lunar Module, with Armstrong and Aldrin aboard, separated from the Command Module and landed on the moon. Armstrong radioed mission control, "The *Eagle* has landed." The astronauts remained at Tranquillity Base for about 21 hours, carrying on extravehicular activities for some 90 minutes, then lifted off the lunar surface and re-

joined the Command Module. Splashdown was in the Pacific Ocean on July 24.

While on the moon, Armstrong and Aldrin unveiled the plaque on the Lunar Module. This plaque bore the inscription, "Here men from the planet earth first set foot upon the moon, July 1969, A.D. We came in peace for all mankind." Signatures of the astronauts and of President Nixon were on it. The astronauts also erected an American flag, collected core samples, and picked up 54 pounds of discretely selected rocks and soil. In addition, they placed a seismic detector, a laser ranging retro reflector, and a solar wind composition experiment to remain on the moon.

Apollo 12, the second lunar landing mission, was launched on November 14, and the Lunar Module landed on the moon about 600 feet from Surveyor 3, as planned, on the 19th. Surveyor 3 had landed on the moon in 1967, over 2 years before the Apollo 12 mission; the Lunar Module landed nearby so the astronauts could photograph and study the Surveyor and bring back components for analysis. Flight crew members were commander Charles Conrad, Jr., Command Module pilot Richard F. Gordon, Jr., and Lunar Module pilot Alan L. Bean.

After a 4½-hour period of rest and preparation, astronauts Conrad and Bean left the Lunar Module, took a contingency sample of lunar soil, and deployed the S-band antenna for voice communication during EVA, a solar wind experiment, and an American flag. The Apollo Lunar Surface Experiments Package (ALSEP) was set out about 600 feet from the Lunar Module. This first period of extravehicular activity lasted about 4 hours.

The second extravehicular activity also took place on November 19 and lasted for 3 hours 49 minutes. The astronauts went to the ALSEP deployment site, to several craters, and to the Surveyor 3; they took photographs, gathered a variety of samples, and retrieved parts from the Surveyor.

Lift-off from the moon and docking with the Command and Service Modules took place on November 20. The docking sequence was clearly seen by TV viewers on earth. Splashdown occurred on November 24 in the Pacific about 4 miles from the recovery ship.

The Apollo Applications Program concentrated on the Orbital Workshop—defining the configuration; mission planning; and design and development of the modified Command and Service Modules, the Airlock Module, the Multiple Docking Adapter, the Apollo Telescope Mount, and the flight experiments.

NASA's space station activities were focused on defining the uses and the intrinsic nature of a manned earth-orbital research facility and certain space station general characteristics. The concept to be studied for operation in the mid-70s is a 12-man station, capable of growth to accommodate about 50 men and of lasting for at least 10 years. It

would be an orbiting research and development facility and an operations and maintenance center for unmanned satellites.

NASA's Space Shuttle Task Group determined that an economical shuttle should have reusable elements and require minimum ground-support operations and minimum refurbishment between missions. It should also have airline-type operations with comparable passenger safety and shirt-sleeve environment, be able to operate with a 2-man flight crew (one in an emergency), and have the capability to be self-sustaining for about 7 days.

In the space sciences and applications area, NASA continued to use a number of unmanned spacecraft. For planetary exploration, Mariners 6 (February 24) and 7 (March 27) were launched on Mars flyby missions, encountering the planet on July 31 and August 5, respectively. The 2 spacecraft sent back a very large number of measurements of the chemical composition of the Martian atmosphere and surface, temperature data for the surface and atmosphere, and nearly 200 high-quality TV pictures of the surface.

Numerous craters up to 300 miles in diameter were observed, and 3 types of terrain—cratered, featureless, and chaotic—were seen.

Further investigation of Mars was planned for 1975, when 2 instrumented spacecraft in the Viking project will be launched. Each spacecraft will be made up of a soft-lander like Surveyor and of an orbiter. Before the landers are released, the orbiters will photograph the Martian surface and carry out other experiments to help select landing sites. Then the landers will set down on the surface to take closeup pictures and to search for organic compounds and living organisms.

To explore the region beyond Mars, NASA will fly the Pioneer F and G spacecraft. They will report on the interplanetary medium, the asteroid belt, and the environment and atmosphere of Jupiter. During 1969, NASA selected the spacecraft contractor and the experiments and planned the launches for 1972 and 1973.

Pioneers 6 through 9—launched into solar orbits between 1965 and 1968—were still transmitting data on the interplanetary medium and on solar activity, and their influence on the earth's environment.

Three orbiting observatory satellites were launched during 1969: OSO 5, January 22; OSO 6, August 9; and OGO 6, June 5. OSO 5, in a nearly circular orbit 350 miles high, carried experiments to monitor solar hydrogen, deuterium, gamma rays, X-rays, and ultraviolet radiations, and to observe the zodiacal light. OSO 6, resembling OSO 5, was designed to better scan the solar disk from a similar orbit. It can accurately aim at any of 16,384 points in a grid over the solar disk. Aboard OGO 6 (which was sent into low earth orbit, 250 to 675 miles) were 25 experiments to investigate geophysical and

solar-terrestrial phenomena; the data from these experiments will increase understanding of the earth-sun relationship.

On June 21, NASA launched another Interplanetary Monitoring Platform (IMP-G), Explorer 41, which carried 12 experiments to study particles and fields near the earth and out to 100,000 miles in space.

Launches for outside organizations included ISIS 1, a Canadian/American spacecraft carrying 10 experiments to study ionospheric physics, on January 30; ESRO 1B for the European Space Research Organization, on October 1; and the first cooperative satellite with West Germany, Azur, on November 7. A communications satellite, Skynet-A, was launched on November 21 for the British Ministry of Defense.

A primate was orbited for 8½ days aboard Biosatellite 3 (June 28–July 7) and recovered. The most important result of the flight (about 200 miles above the earth) was the direct measurement of an increase in venous blood pressure due to weightlessness, caused by blood pooling in the central part of the body. Preliminary findings attributed the physiological deterioration of the monkey, which died after landing, mainly to the effects of weightlessness.

Three Intelsat 3 commercial communications satellites were launched in 1969, 2 successfully. Each has 1,200 2-way voice channels and is capable of operating for 5 years.

In conjunction with its communications satellite activities, NASA was involved in 3 significant planned or proposed user experiments. First, the agency was cooperating with the governor of Alaska to work out a system, using Applications Technology Satellite 1, to transmit instructional and other public television programs from Fairbanks to 3 relatively heavily populated areas. Through this effort, educational radio programs will also be transmitted to many more remote areas. Second, through an agreement with India, NASA planned to participate in an experiment involving use of one of its satellites to broadcast instructional television programs throughout the country. Such broadcasts would be particularly useful in connection with India's agriculture and population control efforts. And third, under an agreement with the Corporation for Public Broadcasting, NASA began participating in an experiment involving noncommercial television programs. On a pilot basis, programs provided by the corporation at NASA's Rosman ground station will be relayed for 3 hours each evening from Sunday through Thursday to the Mojave, California, ground station via the ATS 1 or ATS 3 satellite. The pilot program was scheduled for early 1970.

Applications Technology Satellite 5, launched August 12, failed to stabilize properly, but a large number of its experiments returned useful data. Earlier launched ATS satellites (1 and 3) continued to provide experimental services. A meteorological satellite, Nimbus 3, was placed in a polar orbit on

MAJOR NASA LAUNCHES 1969

Date	Name	Launch Vehicle	Launch Site	Mission	Results	
					Vehicle	Mission
1/22	OSO 5	Delta	KSC	Solar observation	Success	Success
1/30	ISIS 1	Delta	WTR	Ionosphere sounding	Success	Success
*2/5	Intelsat 3 (F-3)	Delta	KSC	Communications	Success	Success
2/24	Mariner 6	Atlas/Centaur	KSC	Mars flyby	Success	Success
*2/26	ESSA 9	Delta	KSC	Weather	Success	Success
3/3	Apollo 9	Saturn V	KSC	LM check-out	Success	Success
3/27	Mariner 7	Atlas/Centaur	KSC	Mars flyby	Success	Success
4/14	Nimbus 3	Thor/Agena	WTR	Weather research and development	Success	Success
5/18	Apollo 10	Saturn V	KSC	LM lunar orbit	Success	Success
*5/21	Intelsat 3 (F-4)	Delta	KSC	Communications	Success	Success
6/5	OGO 6	Thor/Agena	WTR	Geophysical studies	Success	Success
6/21	Explorer 41	Delta	WTR	Interplanetary studies	Success	Success
6/28	Biosatellite 3	Delta	KSC	Biological studies	Success	Unrated
7/16	Apollo 11	Saturn V	KSC	First manned lunar landing	Success	Success
*7/25	Intelsat 3 (F-5)	Delta	KSC	Communications	Failure	Failure
8/9	OSO 6	Delta	KSC	Solar physics	Success	Success
8/12	ATS 5	Atlas/Centaur	KSC	Communications and technology	Success	Unrated
8/27	Pioneer 5	Delta	KSC	Solar studies	Failure	Failure
*10/1	ESRO 1-B	Scout	WTR	Polar ionosphere	Success	Success
*11/7	GRS 1	Scout	WTR	Energetic particles	Success	Success
11/14	Apollo 12	Saturn V	KSC	Manned lunar exploration	Success	Success
*11/21	Skynet	Delta	KSC	Communications	Success	Success

*Non-NASA Mission

April 14. It sent back excellent quality cloud cover photographs and the first quantitative measurements of vertical temperatures, atmospheric vapor content, and wind speeds.

NASA launched ESSA 9, a Tiros operational weather satellite, for the Environmental Science Services Administration (ESSA) on February 26. It replaced ESSA 8, which had experienced camera and recorder failures, in providing global cloud cover data.

NASA also continued to carry on a wide variety of research and development activities. Work ranged from laser research to studies of group dynamics and included investigations of sonic boom, aircraft operating problems, air safety, V/STOL aircraft, noise alleviation, bioinstrumentation, water reclamation, effects of noise on people, lifting bodies, space suits, solar cells, electric propulsion, and chemical propulsion.

In work on the laser, an all-chemical laser was developed in which continuous operation is achieved by mixing commercially available bottled gases. The device is compact and simple and requires no electrical power source. Sonic boom studies produced data indicating that substantial boom reductions are feasible; acoustical and sociometric surveys provided information on the psychological and physiological effects of noise on people. Engine noise reductions of 10 to 15 decibels were found to be feasible, and in the quiet engine program, a contractor was selected to develop technology for noise reduction by quieting the noise sources within an engine through basic changes in engine design.

In aeronautics, wind tunnel research on advanced aircraft configurations indicated that the supercritical airfoil could increase speed about 20 percent (to 660 miles per hour) without penalties in range or payload. The same technology may be applicable to supersonic aircraft. Preparations were being made for full-scale flight tests.

Work moved forward on NASA's V/STOL transition research tunnel at Langley Research Center, with operations scheduled to begin early in 1970. This is the first new wind tunnel constructed by NASA since the agency was established in 1958. Designed specifically to test V/STOL models, the tunnel has slotted removable walls which make it possible to obtain accurate data on high-lift models at very low speeds. Flight research on the operational problems of VTOL aircraft stressed the low-speed descent and landing phases under instrument flight conditions. The objective of this program is to assess the amount of control power and automatic stabilization needed to minimize time, fuel consumption, pilot work load, and airspace in instrument landings.

NASA investigators developed an electrooptical instrument to measure the oxygen in the blood and a spirometer which measures respiratory gas flow

in such a way that it can be automatically recorded and computer-analyzed. Both instruments are potentially useful in laboratories and hospitals. Another device with utility outside the space program is a reverse osmosis water reclamation unit. The unit uses glass membranes which do not clog or deteriorate, as do organic membranes; the glass is also chemically inert and resistant to corrosion, and it can be heat sterilized.

During the year, NASA made important progress in avionics-related aeronautical research and development. Programs relating directly to NASA's electronics research in air traffic control, collision avoidance, navigational and communications satellites for aviation, and support technologies were carried on chiefly at the Electronics Research Center, Cambridge, Massachusetts.

For air traffic control, NASA established programs to develop more precise and reliable on-board navigation systems. Those under development will serve the needs of conventional jet transports, V/STOL aircraft, and general aviation aircraft. Devices being researched included on-board digital computers to generate displays for the crew; a fully automatic guidance, navigation, and flight control system with manual override for V/STOL; and an airspeed sensor for VTOL applications that will be accurate at low speeds. A prototype sensor with no moving parts was tested in a low-speed airstream and a conventional wind tunnel with good results.

Collision avoidance effort included research on a pilot warning indicator device and on an electromechanical head-up attitude indicator. The former uses a high-intensity xenon light, whose flash the pilot can see, and a simultaneously emitted pulse of infrared radiation, which can be detected by a silicon detector mounted in the aircraft. Cost studies indicated that the unit would be reasonably priced for general aviation use.

The attitude indicator places a rod between the pilot and windshield. The rod maintains alignment with the horizon and, because of its location, moves the pilot's eyes to the outside so that the pilot can be more alert to collision hazards. Pilots have shown a preference for the indicator over the instrument panel artificial horizon when the natural horizon is obscured.

The work on satellites serving aviation reached the hardware stage with the testing of an L-band receiver. The tests sought data on background noise, multipath measurements, and ranging accuracy, and used a high-altitude aircraft to simulate a spacecraft. When ATS-F is launched in 1972, it will be used for these tests.

Supporting technologies related to aeronautical electronics included fly-by-wire systems, detection of clear air turbulence, and biotechnology.

The fly-by-wire systems replace mechanical control systems and have high potential for use in

large aircraft like the wide-bodied jetliners and the supersonic transport. The electrical, or fly-by-wire, systems eliminate the heaviness and high friction forces of the mechanical systems, but their reliability remains a matter of concern. NASA research was therefore concentrated on achieving high reliability and improved technology in fly-by-wire systems.

Two approaches were used in the work on clear air turbulence. Langley Research Center tested laser technology to detect turbulence, and the Electronics Research Center did complementary work on sensing atmospheric temperature fluctuations with a millimeter microwave radiometer.

Biotechnology activity focused on methods of monitoring pilot, crew, and ground controller performance and the man-machine interface during stress. Tests were conducted on a remote oculometer—an electrooptical instrument which measures eye-pointing direction, pupil position, pupil diameter, and blink occurrence—which was expected to contribute to several research areas, including flight safety.

Propulsion research efforts extended knowledge of chemical, electric, and nuclear sources. Space storable liquid propellant combinations were investigated, a tripropellant thrust chamber was test-fired, and a high-energy (solid) restartable motor weighing over 3,000 pounds was manufactured.

Electric systems powered by solar arrays completed the ground systems demonstration, and the SERT 2 (Space Electric Rocket Test) orbital flight was rescheduled to 1970. The NERVA (Nuclear Engine for Rocket Vehicle Application) program, a joint NASA/AEC effort, was concerned with systems analysis of flight engine design requirements and with planning the facilities for engine development tests. During 1969, the technology investigation phase of this program culminated in the completion of tests on a ground-experimental nuclear rocket engine in the desert at Jackass Flats, Nevada. Based on this technology, development of the NERVA engine began.

The 3 basic tracking and data networks—Manned Space Flight, Deep Space, and Satellite—handled a substantial work load during the year. The accurate communications support provided for the flights of Apollos 9 through 12 enabled millions of persons to follow these flights and to witness man's first step on the moon's surface during Apollo 11. The networks also supported the highly successful Mariner 6 and 7 missions to Mars, the 4 Pioneer missions, and the OSO, ATS, and Biosatellite flights.

In June, after the Biosatellite flight, the station at Lima, Peru, was deactivated, and following the launch of ATS 5, the transportable station at Toowoomba, Australia, was closed.



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Boeing 747 superjet, the world's largest commercial jetliner, is now in service, ushering in an entirely new era of spaciousness and comfort in air travel.

Twin turbine Boeing helicopters, built by Vertol Division, are deployed to Vietnam. They serve with U.S. Army, Navy, Marine Corps.

727-200, long-body version of standard 727, world's most popular jet, seats up to 189 for maximum profit on high-density commuter routes.

NASA's Boeing-built Lunar Orbiter was the first U.S. spacecraft to orbit the moon and photograph far side of moon. In five

flawless moon missions, Boeing Lunar Orbiter photographed all potential Apollo landing sites and 99% of the moon's surface.

NASA's Apollo/Saturn 5 moon rocket, largest, most powerful in world, launches Americans on spectacularly successful voyages to the moon. Boeing builds the first-stage booster, integrates Saturn 5 with Apollo command, service and lunar modules, and performs systems engineering, launch and integration support for NASA on entire Saturn 5 system.

Burner II, USAF's new Boeing-built upper stage vehicle, is smaller, less costly than

other upper stages. It's applicable to almost all USAF launch vehicles, also scientific experiments, weather, navigation or communications satellites.

Minuteman is U.S. Air Force's quick-firing, solid-fuel ICBM. Boeing is weapon system integrator, responsible for assembly, test, and launch control as well as ground support systems.

Advanced Boeing 737, available next year, will be even more versatile than the outstanding current models. Advanced 737s will fly farther, carry more payload and operate from airports now inaccessible to jet transports.



747, world's largest commercial jet



Boeing helicopter



727-200 trijet airliner



NASA's Boeing-built Lunar Orbiter



NASA's Apollo/Saturn 5 moon rocket



Burner II

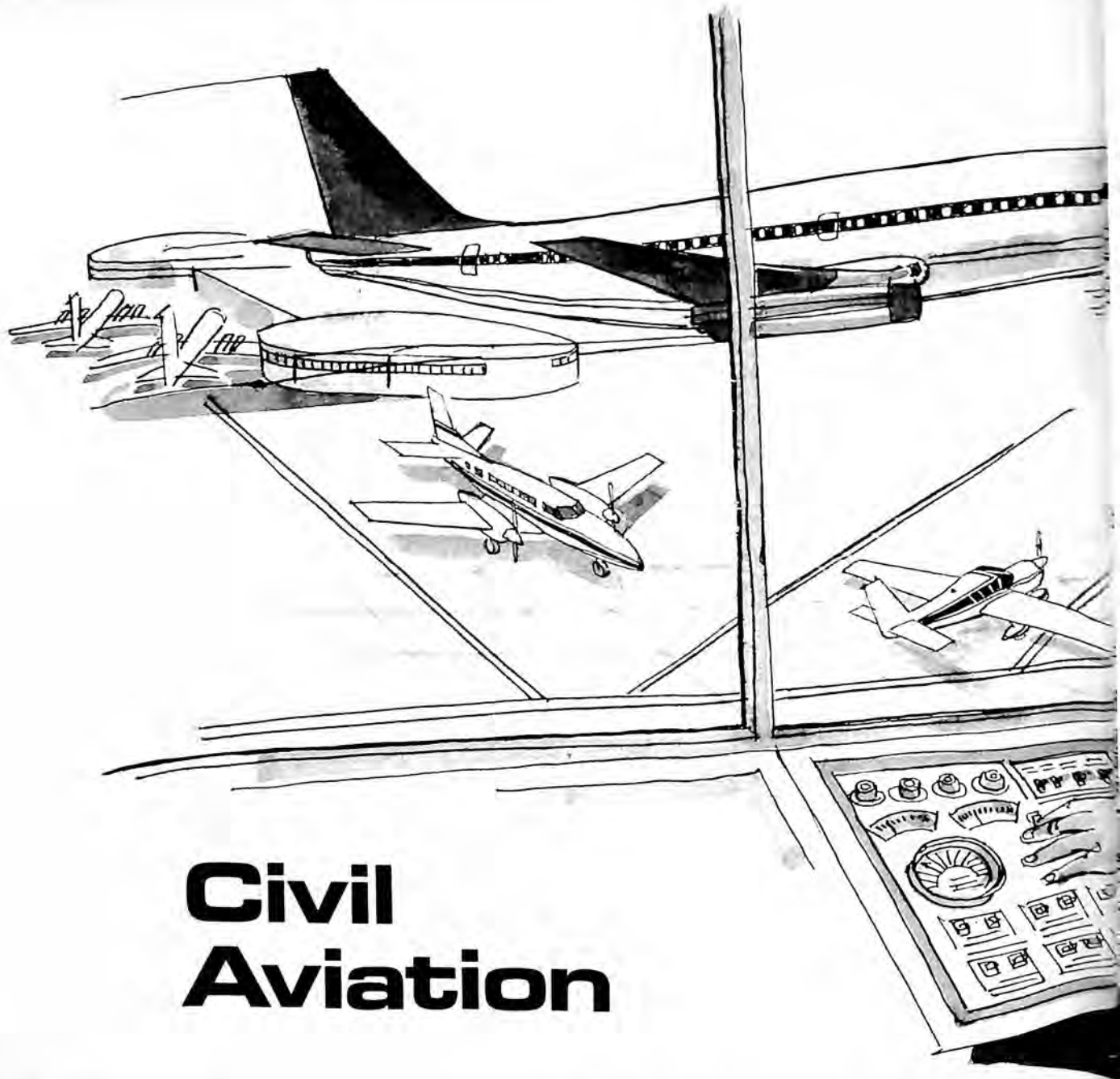


U.S. Air Force Minuteman ICBM



Advanced 737

BOEING



Civil Aviation

THE AIRLINES

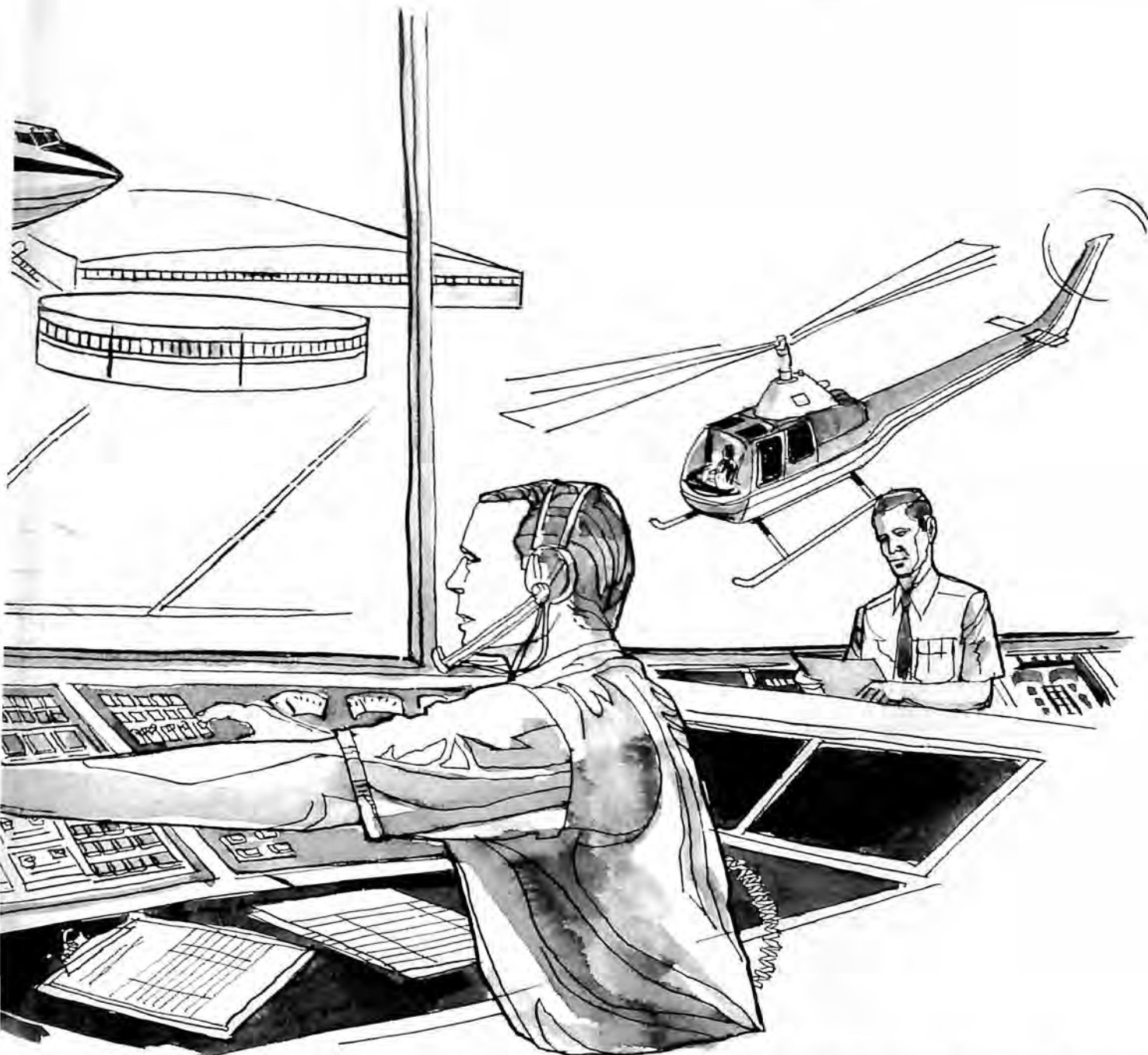
At the dawn of the civil jet age—little more than a decade ago—the scheduled airlines made a \$2.5 billion decision. That decision represented an investment of $2\frac{1}{2}$ times the industry's net worth. It also represented the public's response to a new kind of transport—transport by jet aircraft.

Since the advent of the jet, passenger traffic has increased by about 200 percent, from some 56,000,000 passengers in 1959 to approximately 162,000,000 at the end of 1969. The number of airline passengers was expected to double by 1975 and to triple by 1980. Cargo traffic (mail, express, and freight), which accounted for about 4.7 billion cargo ton-miles in 1969—up 545 percent over 1959—was expected to increase at a greater rate. To meet this demand, the airlines estimated that they would spend \$12.5 billion on new equipment during the 1970-74 period alone. About \$10.3 billion of this

sum would go for flight equipment and the rest for associated ground equipment.

The era of the introduction of the first-generation jets—the McDonnell Douglas DC-8 and the Boeing 707, for example—is past its peak. The airlines in 1969 were in a transitional period characterized by the addition to their fleets of “stretched” versions of first-generation jets and by the advent of medium- and short-haul equipment such as the Boeing 727 and 737 and the McDonnell Douglas DC-9.

In 1970, the airlines enter the era of the superjets, often referred to as “wide-bodied” jets. The first to enter service is the Boeing 747. It is approximately 230 feet long, about the length of a football field, and from the ground measures upward some 60 feet, about the height of a 6-story building. The 747 will fly around 625 miles per hour, somewhat faster than the 707 and the DC-8, and will have a nonstop range of over 4,000 miles, or the distance from Washington, D.C., to Moscow. Its 185- by 20-



foot cabin is capable of carrying as many as 490 passengers, although most airlines ordering the 747 are planning initially a seating configuration for about 360 passengers, with around 15 percent occupying the first-class section.

The 747 will be followed in 1971-72 by other wide-bodied jets—the Lockheed L-1011 and the McDonnell Douglas DC-10. These 3-engine aircraft, which will carry from 250 to 300 passengers, are designed to operate over short- and medium-range routes. More than 150 of these “airbuses” were on order as of June 1, 1969.

The early seventies will also see the first of the supersonic transports, the 1,400-mile-an-hour British/French Concorde, entering service. Then, in the late seventies, the U.S. SST, with a passenger capacity of some 300 and a speed of about 1,850 miles per hour, is expected to be operative.

The jet age revolution, still in progress, does not end with the aircraft. For airline operations and

maintenance people, the aircraft is just the beginning. Improvements are being made continuously in devices on the aircraft and in the aircraft’s operating environment to make air transportation safer, more dependable, and more efficient.

The most impressive airborne equipment changes have been made in the cockpit. Take navigation, for example. The earliest transatlantic jets had to rely on radio signals from shore-based transmitting stations, supplemented by occasional resort to the age-old seagoing practice of celestial navigation. Today’s overocean jets use self-contained Doppler navigation, a device that bounces electronic waves off the surface of the earth or ocean and measures speed by the frequency shift in the reflected signal.

Soon to be available is an even better device, the inertial navigator, which is in effect a very precise gyroscope. This device will free the pilot of dependence on the number, location, and communicability of ground stations.

When the early jets went into service, they were equipped with a device that could reply to interrogation by the Federal Aviation Administration's ground radar, thus reinforcing the identification of a given plane on the radar scope used by air traffic controllers. Although, through a system of codes, such functions as climbing or descending could be registered, the altitude at which a plane was flying could not.

On jets entering service, this radar beacon equipment has been further developed to permit a plane to report automatically its altitude as well as its identity. Together, altitude and identity are displayed in name-tag form beside the blip representing the aircraft on the controller's radar scope. The new jets come equipped with this capacity, and aircraft already in the fleet are being retrofitted with units to upgrade their beacon capabilities. It was expected that over 70 percent of the airline fleet would have both altitude- and identity-reporting capability by 1971 and that virtually the entire fleet would have identity-reporting capability by that time.

Initiative taken by the airlines to improve the safety and reliability of their operations is nowhere better illustrated than in their pilot training programs. At the heart of these programs is the flight simulator, which is becoming to an increasing degree a valuable tool in training pilots in the characteristics of new aircraft.

Flight simulators have the cockpit, the instruments, and the controls of a real airplane, with computers that simulate the operations, noises, and responses of a real airplane. Because simulators provide safer and more effective training, the airlines and the FAA are working to accomplish more pilot training in simulators, less in aircraft. This trend is being accelerated by the use of visual attachments that allow the pilot to see a dynamic display of the airport and the runway through the window of his simulator cockpit. Simulators with visual capacity can be used for training in takeoffs and landings, including normal, emergency, and low-visibility landings.

At mid-1969, 10 scheduled airlines had \$83,300,000 invested in 52 flight simulators for pilot training. They planned to acquire 20 more simulators by January 1972, representing an additional investment of \$53,900,000.

The growing public demand for air travel has had an effect not only on the kind of aircraft the airlines are buying but also on techniques for handling the increasing number of airline passengers. Reservations must be made, tickets must be issued, and baggage must be controlled in ever-growing numbers—with jet age speed and precision. For example, each Boeing 747 generates about 600 bags every time it pulls up to a gate. By way of attacking the baggage problem, the industry was working toward an automated baggage delivery system

which promises to deliver a passenger's bag to him anywhere in the terminal area in less than 3 minutes after the bag is removed from the aircraft.

The reservations problem was being confronted squarely by the airlines through the investment of hundreds of millions of dollars in new computerized reservations systems.

Another development which holds great promise is the automation of ticketing. Tomorrow's airline passenger will not have to stand in line at the airport waiting for his ticket. All he will have to do, once his reservation is made, is insert his Air Travel Card into an automatic ticketing machine and press a few buttons to indicate flight number and class of service; the ticket will then drop into his hands.

Prototype models of these machines were being developed in 1969 by several airlines and were to be in limited use in some major airport cities before the end of the year.

The new equipment the airlines are introducing into their fleets is a dynamic force in the creation of new jobs. For the past decade, airline "hires" have averaged about 25,000 a year. In 1969, employment in the industry came to about 325,000 men and women, representing a gain of nearly 10 percent over the previous year and an increase of over 100 percent in a decade.

Looking down the road to the SST, and depending upon the number of SSTs built, \$20 billion to \$50 billion of economic growth will result over the next 5 to 10 years. To build these new aircraft, 250,000 new jobs will be created. And one of the most important economic facts about the SST investment is that the new jobs will be created just as soon as the prototype development program begins.

Of the 250,000 new jobs, there will be 50,000 for prime contractors and 100,000 for subcontractors. These 150,000 jobs will create an additional 100,000 jobs in nonmanufacturing industries such as wholesale and retail trade; professional and business services; finance, insurance, and real estate; transportation; communication and other public utilities; and agriculture.

The 250,000 new jobs, with an estimated payroll of \$2.5 billion, were estimated to represent one of every 50 new civilian jobs created by 1975. Few programs can claim so great a contribution to employment.

Moreover, this employment will have a broad geographical spread. As in the case of other large technically intensive programs, e.g., Saturn/Apollo, Minuteman, and the Boeing 747, manpower will be drawn from almost every segment of industry in almost all of the 50 states. Thus the SST will be a truly national product.

As indicated, the airlines are making a tremendous investment in tomorrow's air transport system. Crucial to the success of this system in serving the public is recognition by the federal government of its responsibility to keep pace with the airlines'

multimillion-dollar investment by helping to provide the necessary airport and air traffic control facilities vital to the continued growth of air transportation. In this way, the remarkable progress made by the air transport industry during the first decade of the jet age will be continued into the second.

AIR CANADA

The year 1968 was the most successful in Air Canada's 31-year history. The company earned a record \$8,200,000 net income, up 131 percent over the \$3,500,000 earned in 1967. Return on investment for the year was 6.3 percent, as compared with 5.2 percent the year before.

However, the picture for 1969 was not as bright. Year-end figures were affected by a 28-day shutdown of operations in April and May, the result of strike action on the part of the International Association of Machinists and Aerospace Workers.

In addition to losing traffic and revenue during the shutdown period, the company was unable to regain the impressive growth rate recorded during the early months of the year. Because of the occurrence of the strike at a time when many Canadians were making plans for overseas vacation travel, and because of the impact of rapid growth in the non-scheduled charter market, Atlantic passenger traffic was particularly discouraging, and it appeared the 1968 level would not be reached.

During the first 9 months of 1969, the airline carried 4,820,057 passengers, slightly below the 4,862,878 flown during the same period the year before. Airfreight continued its impressive growth rate. Despite the strike, the airline carried 103,465,588 pounds of airfreight during the first 8 months of the year, as compared with 94,181,142 pounds during the first 8 months of 1968.

In 1969, Air Canada accepted delivery of 2 DC-9-32s and of 5 long-bodied DC-8-63s, and it expected to add 3 more DC-9s and 8 more DC-8-63s by May 1970. These deliveries will increase the Canadian carrier's total jet fleet to 76 aircraft: 36 DC-9-32s and 40 DC-8s including 20 of the long-bodied versions.

During the year, the airline continued to retire its Vickers Viscounts and Vikings. At year-end, 13 Vikings and 25 Viscounts remained in service, as compared with 18 Vikings and 33 Viscounts at the end of 1968.

Air Canada introduced service between Toronto-Montreal and Brussels, increased frequencies on transatlantic and Caribbean services, and added more nonstop services to its domestic schedule. Unduplicated route miles increased to over 90,000, from 79,000 a year earlier.

The airline also increased its charter business sub-

stantially. In 1969, for the first time, 2 DC-8s were used exclusively for charter operations and were kept in full-time operation. The airline planned to increase its charter fleet to 4 DC-8s for 1970 and reported that they were almost fully booked. One aircraft was to be kept busy flying charter operations to Japan for Expo '70.

Expansion of cargo-handling facilities continued with the opening of highly automated new facilities at Winnipeg and London. Meantime, the airline was continuing installation of its highly computerized new reservations system, the Reservec II.

The airline was making plans for the introduction of the Boeing 747 and the Lockheed L-1011 to its fleet. An expansion of maintenance facilities was under way at major cities across the system. Air Canada planned to add 3 747s to its fleet in early 1971 and the first 6 of 10 L-1011s in 1972. In addition, the airline held delivery positions for 4 Concorde and 6 Boeing supersonic transports.

Air Canada was looking for expansion of its international route structure. The first step was to be taken in May 1970 with the introduction of service to Prague. Meanwhile, the Canadian government was due to enter bilateral negotiations with a number of major countries, including the United States, and the airline was hopeful that these negotiations would result in a number of major new destinations.

AIR WEST

Air West was born out of 3 of the oldest regional carriers in the United States. In mid-1968, Air West became the product of the merger of Pacific, Bonanza, and West Coast airlines. The new airline was able to serve more cities in the West than all other airlines serving the area combined.

In 1969, Air West operated a fleet of 15 McDonnell Douglas DC-9-30s, 4 DC-9-10s, 32 Fairchild Hiller F-27 twin-engine turboprops, and 4 Piper Navajo MiniLiners. The airline's system at year-end totaled 10,800 unduplicated route miles in 8 western states, Canada, and Mexico. In all, 77 airports serving more than 150 cities were on the Air West system.

Air West boasted one of the best on-time performance records in the airline industry. Through the first 9 months of 1969, the line's system average for on-time departures was 77 percent. Six of the last 7 months averaged above 80 percent in on-time performance (the airline industry considers 70 percent on-time performance very good).

Headquarters for the nation's newest major airline was at San Francisco International Airport; maintenance and training facilities were at Phoenix, Arizona.

The Air West family at year-end numbered 3,800. During the year, Air West carried just over 3,000,-

000 passengers between points in the West and operated close to 600 flights daily.

In 1969, the Civil Aeronautics Board authorized Hughes Tool Company to acquire Air West. Consummation of the sale was expected in the first half of 1970.

ALASKA AIRLINES

For Alaska Airlines, which in 1969 shattered all previous records by carrying more than 420,000 passengers almost 300,000,000 revenue passenger-miles, earning the airline the No. 1 position in the Alaska travel market, the prospect for future years looked outstanding.

The record compiled in 1969 was the result not only of a larger portion of the Alaska travel market but also of an increase in the size of the market. Unprecedented numbers of people were taking advantage of the 30,000 miles of Alaska coast, the innumerable streams and rivers, the lush valley of southern Alaska, and the tundra of the Arctic. Also, Alaskans themselves were traveling more frequently. To accommodate the increased demand for air transportation, Alaska Airlines increased its aircraft fleet and its ground service facilities, inaugurated first-class service, augmented its tour program, revised its schedules, and added 3 new regional sales offices.



Alaska Airlines added another Boeing 727 to its fleet and increased Seattle-Alaska frequencies to 5 flights a day.

Alaska Airlines was providing direct jet service from Seattle to more Alaska cities than all other carriers combined. It added another Boeing 727 to its fleet in order to increase the number of flights between Seattle and the major cities of Alaska to 5 per day during the summer of 1969.

As southeast Alaska communities such as Petersburg and Wrangell added hard-surface runways in addition to water-landing facilities, Alaska Airlines

was replacing its amphibious aircraft with Convair 240s. During the year, 2 Twin Otter carriers were also added to the fleet serving southeast Alaska.

Alaska Airlines prides itself on offering not only the most modern fleet to Alaska but also the most unique service. Passengers are treated to a true Alaskan flavor from the time they check in for their flight to their arrival at their destination. In 1969, the airline introduced a new aspect to this inflight service—first class. Using elegant, full-size china, crystal, and silverware, the passengers enjoy dining with an international flair. More of the Alaskan flavor was added as a result of naming Alaska Airlines' first-class service "Golden Samovar" and mingling into the service the traditions of days when Alaska was possessed by Russia.

Continuing its offering to tourists of other services in support of its transportation functions, Alaska Airlines expanded its interest in resort and hotel facilities and its tour program. The biggest boost in hotel and resort facilities for both Alaska and Alaska Airlines was completion of the Alyeska Nugget Inn. The hotel changed the status of Alyeska, located 40 miles outside of Anchorage, from a ski area to Alaska's largest ski resort.

Alaska Airlines filed for a route from Nome to Irkutsk, on Lake Baikal in Siberia, and for a route between Nome and Providenia, located on Chukotka Peninsula in Siberia. Flights to Nome would originate in Seattle, and also operate via Anchorage.

Looking ahead to 1970, Alaska Airlines planned to continue using its ability to market and promote the areas it serves. The airline was also to seek other avenues of growth. The growth in the resort, hotel, and tour industry was indicative of this approach. Development of new routes is also a vitally important area. At year-end, Alaska Airlines had 3 petitions before the Civil Aeronautics Board, one asking for rights to fly Seattle-Twin Cities-Milwaukee routes, one seeking routes to California, and one requesting routes connecting Seattle and Portland with Phoenix.

ALLEGHENY AIRLINES

During the last half of 1968 and all of 1969, Allegheny Airlines was concerned primarily with consolidation and reorganization of the new air system created through its merger with the former Lake Central Airlines on July 1, 1968.

Priority was given to connecting the major points of both systems. Tossing off the image of a "feeder," or multistop, carrier, Allegheny pressed to improve local service and, at the same time, compete for longer routes. By the end of 1969, Allegheny was either the leading carrier or a very strong contender in many major markets formerly considered suitable for only a trunk carrier.

Allegheny continued its program of seeking expanded authority in 1969. Complementing new markets it entered in the latter half of 1968, Allegheny started Chicago-Pittsburgh service in 1969 with 7 nonstop, round-trip fanjet flights daily and nearly doubled the number of daily nonstops on its newly acquired Pittsburgh-New York route. In December, Allegheny began nonstop service between Indianapolis and New York.

Other Allegheny petitions for route development pending before the Civil Aeronautics Board included requests to serve Minneapolis/St. Paul-Baltimore, Philadelphia; Atlanta-Cincinnati, Detroit; Cleveland-Nashville, Toronto; Norfolk-Baltimore, New York; Washington-Buffalo, Albany; and Pittsburgh-Montreal.



Allegheny Airlines introduced new hostess fashions, such as these fall/winter ensembles.

Allegheny's program to modernize its fleet gained momentum during 1969. By November 1, the carrier had standardized its aircraft inventory on 2 types, the DC-9-31 fanjet (23 aircraft) and the Convair 580 turboprop (42 aircraft), as compared with 4 types operating in December 1968. The F-27Js were retired in June and the Nord IIs in September. Meanwhile, new DC-9s were being delivered at an average rate of one a month, providing a substantial net increase in capacity.

Another emphasized and highly successful program was the Allegheny Commuter, which was introduced in 1969 into 3 more cities: DuBois, Pennsylvania, Mansfield, Ohio, and Elkins, West Virginia. Allegheny Commuters, at year-end operating in 7 localities, are independently owned air transport operations that are tailored to the specific needs of intermediate-size cities and are closely affiliated with Allegheny Airlines. Utilizing 15-passenger Beechcraft 99 Airliners, they offer regular Allegheny services and operate without government subsidy.

In 1969, Allegheny launched a \$20,000,000 facili-

ties expansion program which was to continue over a 4-year period and eventually involve 23 of the 76 stations Allegheny serves. Two of the biggest projects were planned for Boston's Logan International Airport: a 10-gate extension of the new South Terminal building and a revolutionarily designed maintenance hangar. Major expansions were also planned for Philadelphia, Pittsburgh, Indianapolis, and Dayton.

Accompanying the fleet and facilities modernizations was a new look in inflight fashion. Spring/summer and fall/winter ensembles emphasizing style and practicality were introduced in 1969.

The consolidation phase of Allegheny's development was to continue past 1969. Leslie O. Barnes, president of Allegheny Airlines, believed it might take until 1973 to realize fully the benefits of the merger, but it appeared that 1969 would be looked upon as the critical year when Allegheny met the test.

AMERICAN AIRLINES

American Airlines became an intercontinental carrier in 1969 with the award of a route to Hawaii, American Samoa, Fiji, New Zealand, and Australia. American was authorized to serve these destinations from Boston, St. Louis, New York, Chicago, Washington, and Dallas. President Nixon made his decision in July in the Transpacific Case and service on the route was expected to begin early in 1970. Although confined until 1970 to the United States, Canada, and Mexico, American has been active in international markets for years. In 1969, the airline again sent marketing teams to major areas of the world, including Europe and the South Pacific.

American also won new rights in the Gulf States-Midwest Case that enabled it to begin nonstop service between such points as Detroit-San Antonio, Chicago-San Antonio, Dallas-Detroit, and Houston-St. Louis. A new Houston-San Francisco nonstop route was received in the Southern Tier Case.

President George A. Spater was elected to the additional responsibility of chairman of the board in 1969. Marion Sadler, who had served American as president until his retirement in 1968 for reasons of health, returned to full-time duty and was elected vice chairman.

American launched 1969 with a new concept in service for air travelers, one that it termed the industry's "finest transcontinental service package." Called "Americana," it drew its inspiration from the nation's rich history. "Americana" was introduced between New York and San Francisco and New York and Los Angeles routes and then quickly extended to other transcontinental routes. Late in the year, the service bowed on semitranscontinental flights.

American's stewardesses began wearing a new wardrobe with accents drawn from significant periods of American history, such as an innkeeper's weskit of Colonial days and buckled shoes from days of the Pilgrims.

The start of 1969 also marked an immensely important milestone—the 10th anniversary of American's introduction of the first jet service across the nation. The inaugural transcontinental flight took off from Los Angeles on January 25, 1959, racing to New York in 4 hours 3 minutes to slash 3 hours off the piston airplane record. The flight returned to Los Angeles that evening.

To point up again its role as an airline for sportsmen, American staged the third annual Astrojet Golf Classic at La Costa Country Club near San Diego. Professional baseball and football stars teamed in the \$30,000 best-ball test, with Los Angeles Dodgers outfielder Willie Davis and Green Bay Packers guard Jerry Kramer emerging as champions.

A strike by the Transport Workers Union halted American's operations for 3 weeks during the early part of the year. Throughout the strike, maintenance supervisors kept the fleet in top shape and the jets were ready to go when service resumed on March 20.

American was the first airline in the world to achieve operational approval for an automatic inertial navigation system. In 1969, AA asked the Federal Aviation Administration to designate a specific area navigation route from Chicago to New York. This would allow eastbound jets to fly away from the conventional airways. The system, proved out by American on more than 700 flights, allows a pilot to use an airborne computer to travel cross-country on any desired course instead of using the present airways made up of signals from ground radio stations.

As progress was being made in this field, American was speeding up work on the largest airline personnel training center in the world. Located on an 80-acre campus between Dallas and Fort Worth, Texas, the complex was to include American's expanded Stewardess College and a new Academy of Flight for pilots.

The Stewardess College, first of its kind, added 3 new buildings as part of a multimillion-dollar improvement program. The structures included a 3-story dormitory unit; a one-story building with large convertible classrooms complete with closed-circuit television, responder training units, and 5 aircraft cabin simulators; and a 2-story dining room, kitchen, and office building. Dedication of the enlarged college was scheduled for March 1970 in conjunction with that of the Flight Academy.

At midyear, American announced a \$40,000,000 expansion program for its maintenance and engineering center at Tulsa, Oklahoma. The additions will boost the value of the facility to over \$100,000,000. In addition to caring for American's Astro-

jets, the center maintains the airplanes of more than 10 international airlines. The Tulsa expansion was to provide capability for servicing larger jets arriving in the 1970s, the 747s and the DC-10s.

As it awaited these large jets, American disposed of the last of its Convair 990s and phased out its turboprop Electras, leaving the airline with a fleet of 247 jet airplanes late in the year.



American Airlines' fleet of the 1970s was to include the Boeing 707 (foreground), the McDonnell Douglas DC-10 (center), and the Boeing 747 (rear). At the end of 1969, American was operating 247 planes.

American continued to expand its hotel activities through its wholly owned subsidiaries Sky Chefs and Flagship Hotels. Flagship will supply technical and management assistance to a corporation that will operate the Fiesta Palace, a handsome 700-room addition to Mexico City's expanding list of luxury hotels. It was scheduled to open in the spring of 1970. Flagship Hotels and the same corporation will be associated in the operation of another facility, the Condesa Del Mar in Acapulco. It will open in the spring of 1971.

American and the Dillingham Corporation of Hawaii formed a partnership to manage and operate the Ala Moana Hotel in Honolulu. Flagship Hotels was to be operating manager of the 1,268-room unit which will open in the summer of 1970. The \$36,600,000 Ala Moana will be a major addition to tourist and convention facilities in Hawaii. It will be close to Ala Moana Park, to the beach, and to Ala Moana Center, the world's largest shopping complex.

Sky Chefs and Flagship Hotels will also operate the dining rooms, the hotel, and the convention facilities aboard the ocean liner *Queen Mary*, which was being refurbished before being anchored in the harbor of Long Beach, California. The *Queen Mary* was scheduled to open in 1970 as a major tourist and convention attraction in Long Beach.

American's Astrojets began appearing in broad red, white, and blue striping late in the year, with a distinctive new corporate symbol on the jet tails. The markings are part of a total new look for the 1970s that will extend to ticket offices and other facilities. The colorful new design was the first significant change in the thin red lightning stripe and the AA symbol that have been identified with the company's airplanes since American Airlines was incorporated 35 years ago. The final design was adopted only after a year-long marketing test sought reaction from the public, customers, and employees.

Another service innovation at American was "Picnic in the Sky," a unique snack service on some medium-haul segments. A cheese or meat sandwich, fresh fruit, and a bottle of wine, served in individual baskets, were the main ingredients.

In October, American observed the 25th anniversary of its introduction of the first scheduled domestic airfreight service. A twin-engine DC-3 made that first flight with a load of war supplies, clothing, shoes, cosmetics, and fresh flowers—6,000 pounds of freight, about all the airplane could lift. American's jet freighters of 1969, Boeing 707s, were carrying 90,000 pounds each and crossing the continent in less than 6 hours. In 1945, the first full year of scheduled cargo operations, American hauled 2,000,000 ton-miles of freight, as compared with a 1968 total of 527,000,000 ton-miles.

In 1968, American carried 19,136,000 passengers. Net earnings for the year were \$35,456,000. Revenues totaled \$957,198,000. For the first 9 months of 1969, American reported net earnings of \$25,479,000, or \$1.26 a share against \$1.78 a share during the same period of 1968. American's 21-day strike adversely affected earnings. Revenues for the first 9 months were \$748,947,000, as compared to \$719,666,000 for the comparable period of 1968. Revenue passenger-miles for the first 10 months of 1969 were 13,361,000,000, and commercial freight volume in the first 10 months was 425,926,000 ton-miles.

AMERICAN FLYERS AIRLINE

For American Flyers Airline, the sixties were a period of immense change and revitalization. In just a few short years, every aspect of the supplemental's operations—from equipment to staff, to maintenance, to ownership, to management—was reexamined and modernized. The result in 1969 was a leading professional carrier able to offer quality service

and performance unexcelled in the supplemental industry.

During the year, AFA's activities culminated in a well-defined program that insured continued growth and development for the future. In 1969, AFA greatly increased its fleet with the addition of 2 250-seat McDonnell Douglas DC-8-63 convertible aircraft. They joined aircraft including 2 Boeing 727-100C convertible fanjets which seat 125 and a fleet of 5 89-passenger Lockheed Electras.

The new aircraft raised the airline's charter capacity by 80 percent and permitted nonstop flight service on routes such as New York to Rome or Chicago to Hawaii. They also significantly expanded AFA's role in all 50 states, the Caribbean, Canada, Mexico, Europe, Africa, and Asia. Two new stretched DC-8s were scheduled for delivery to the AFA fleet in April and May 1970.

In 1969, AFA implemented a new marketing plan, which features 1,054 jet departures to Europe, the Caribbean, Mexico, and the United States. It was one of the most extensive and intricately planned programs ever designed over a year's period of time. The total program involved affinity charter operations combined with inclusive tour charter packages from eastern and midwestern cities to the destination points mentioned. On a destination basis, AFA was to operate 261 flights to Europe, 156 flights to Mexico, 309 to the Bahamas, 98 to the Caribbean, and 230 to Las Vegas. Weekly flight frequencies were to vary seasonally throughout the year, with the major concentration to Europe being in the summer months and the highest frequencies to the Caribbean and to Las Vegas in the winter months.

Unique in the airline's marketing plan were the programmed affinity charters which are available on over half of the flights. American Flyers Airline is the first, and only, supplemental carrier to provide this service, which operates from New York to Las Vegas, Puerto Rico, and the Bahamas and from Chicago and Detroit to Las Vegas and the Bahamas.

The Civil Aeronautics Board in January 1969 granted multiple-load charter authority to the supplementals. With the increased seating capacity of the DC-8s, AFA was able to take full advantage of this ruling by carrying the many charter-worthy groups and organizations that simply cannot fill 250 or even 150 seats. The supplemental took the leading steps in this vast market area and planned to continue to structure its merchandising programs along this line. An intensive advertising campaign was initiated to familiarize both the consumer and the trade press with the advantages of this unique program.

In 1969, AFA was most instrumental in developing the inclusive tour charter market to Mexico. Fifty-two flights, one per week, made round trips to Mexico. AFA was actively pursuing additional programs into other ITC areas such as southern Spain and Morocco.

In April 1969, the company moved its headquarters from Ardmore, Oklahoma, to the Olmsted State Airport near Harrisburg, Pennsylvania. Here the airline's executive offices, operating facilities, and maintenance crews are domiciled. The maintenance crew at year-end consisted of more than 110 experts. American Flyers took pride in being the first supplemental carrier to provide its own maintenance and in being granted a permanent Federal Aviation Administration Repair Station Certificate. The massive hangar at Olmsted permits 2 DC-8s to be serviced indoors, significantly improving maintenance downtime.

The year 1969 saw another "first" for American Flyers when the airline became the first, and only, supplemental to provide its own meals for flights. It was accomplished through Nairobi Air Service, which has catering facilities at Olmsted. Meals are transported in refrigerated trucks to a number of AFA departure points. AFA helped establish NAS in this country as a means of providing consistent quality of inflight meal service.

Under the direction of its parent company, Pittsburgh Coke and Chemical, and the leadership of President Lucian Hunt, AFA multiplied its executive and sales staff. Regional sales offices were increased to include new facilities in Amsterdam. In addition, the 1969 list of regional sales offices included New York, Detroit, Los Angeles, Chicago, London, and Frankfurt. To staff these offices, Hunt brought in a team of dynamic young professionals, all with several years of airline experience. In 1969, AFA increased the U.S. eastern regional sales staff sixfold.

The total number of passengers flown by the carrier to all 50 states and more than 30 foreign countries increased in 1969. In 1967, the figure was 215,483; in 1968, over 265,000. The final count for 1969 was expected to tally over 300,000.

A survey showed that the average age of AFA flight crews was 42 and that the pilots had an average of 22 years of flying experience, had flown over 2,000,000 miles, and had 12,800 hours of flying time. Stewardesses doubled in number, from 70 in 1968 to 142 in 1969.

BRANIFF INTERNATIONAL

The year 1969 was characterized by expansion at Braniff International, expansion that saw the airline's fleet increased to 75 jets with the complete phase-out of all propeller-driven aircraft.

The biggest news in 1969, however, was the extension of Braniff routes into 7 new U.S. cities: Atlanta, Detroit, Hilo, Honolulu, Los Angeles, San Francisco, and Tampa/St. Petersburg/Clearwater.

In February, Braniff began operating over new route authority from 7 U.S. gateway cities into South

America. New York, Washington, D.C., New Orleans, Los Angeles, and San Francisco were added to Miami and Houston as BI's gateway cities to Latin America; at year-end, the airline was offering 74 flights weekly between the United States and 9 countries in South America.

In June, Braniff began nonstop service between Houston and the Pacific Northwest and daily through-plane service from Portland and Seattle/Tacoma to South America, via Houston.

In July, Braniff inaugurated service into Detroit, with daily nonstops from both Dallas/Fort Worth and Kansas City, and one-stop service from Houston.

In August, service over a long-awaited route between the mainland and Hawaii was begun with daily service between Atlanta and Dallas/Fort Worth to Honolulu. In September, the frequency was increased between the mainland and Hawaii. In October, BI's service was increased again, and the airline was providing a total of 48 flights weekly between the islands and the mainland, including daily nonstop service from Atlanta, twice-daily nonstops from Dallas/Fort Worth, 3 nonstops weekly from Houston, 2 daily flights from Miami/Fort Lauderdale, and daily service from both New Orleans and Tampa/St. Petersburg/Clearwater.

Braniff's colorful jets began operating over new Southern Tier routes in October and were providing multiple daily flights between Dallas/Fort Worth and Miami/Fort Lauderdale, via New Orleans and Tampa, with nonstop service in all 4 markets daily.

Braniff, the U.S. airline on-time leader for 1968, continued to lead the industry in this important reliability yardstick during 1969 and retained its No. 1 position through the first 9 months of 1969.

At the same time, Braniff moved to make its services even more comfortable and attractive to the public by phasing out of service its last 8 propeller-driven aircraft, the turboprop Lockheed Electra IIs, and replacing them with pure-jet airliners on all routes.

Braniff took a giant step forward in passenger convenience during 1969 when the airline's new \$12,000,000 IBM computerized reservations system went on-stream. Called "The Cowboy," the system is the most modern and versatile in the airline industry and provides the fastest, most accurate system of passenger and cargo reservations possible.

As a result of the new services, new equipment, and continued operational reliability, Braniff's revenue passenger-miles flown rose by 9.5 percent in the first 3 quarters of 1969 as compared with the same period in 1968.

The airline took delivery of 10 Boeing 727 trijets and of 2 McDonnell Douglas ultralong-range DC-8 Super 62s during 1969. It had 3 stretched Boeing 727-200 jets on order for delivery in the second quarter of 1970. For the future, BI had on order 2 Boeing 747s for delivery in the first quarter of 1971.

and 3 Concorde and 2 Boeing supersonic transports ordered for delivery in the mid- and late 1970s.

Late in 1969, Braniff, with its South American partners, opened the Tambo de Oro restaurant and marketplace, called "the world's most beautiful restaurant," in Lima, Peru, and a spectacular country club, the Granja Azul Inn, just outside Lima, and at year-end was preparing for the opening in early 1970 of the luxurious Santa Maria Beach Club, also near Lima. Other South American projects were under construction for early opening to insure that South America will indeed be the next place to become a must for U.S. travelers.

Looking to the future, Braniff applied to the Civil Aeronautics Board for authority to extend its routes from the Southwest and the Rocky Mountains into Canada and Alaska and from Chicago to Alaska, via Canada.

CARIBAIR

For Caribair, 1969 was a year of route awards, equipment transition, and new route inaugural services combined with some developmental and growth difficulties not uncommon in the industry.

On April 1, Caribair inaugurated nonstop service from San Juan to Aruba and Curacao. On May 1, Caribair reached the U.S. mainland for the first time by inaugurating scheduled service into Miami from Haiti and San Juan.

In October, Caribair received final authority from the Jamaican government to serve Kingston and Montego Bay from Miami and San Juan.

Caribair filed a petition with the Civil Aeronautics Board in October to temporarily suspend service into destinations which could not accommodate jet aircraft. Upon approval by the board, the company standardized its operating fleet with 3 DC-9 Series 30 aircraft.

Caribair's management instituted as part of its fleet standardization program "Operation Bootstrap," the name chosen for the programmed revitalization and streamlining of the airline. The 1969-70 winter season found Caribair with a vast and new route network and a fully integrated jet fleet schedule.

CONTINENTAL AIRLINES

In 1969, Continental Airlines increased its unduplicated route mileage from 9,008 to 14,729 by winning routes between 7 mainland cities and Hawaii, between Los Angeles and Dallas, between Chicago and Albuquerque, and between Albuquerque and San Francisco.

The mainland-Hawaii award permitted Continental to link Honolulu and Hilo with Seattle/Tacoma,

Portland, Denver, Chicago, Kansas City, Phoenix, and Los Angeles/Ontario/Long Beach. With the receipt of the award, Continental announced that it would introduce an \$85 economy fare between the mainland and Hawaii, effective Monday through Thursday. Other carriers followed suit and the new low rate went into effect in early September.



Continental Airlines was allocating an average of 6 of its 13 Boeing 707-320Cs to Military Airlift Command contract flights.

Continental's all-fanjet fleet remained at 56 during 1969, but its 3 Boeing 747 superjets were to arrive in the spring of 1970 (with a fourth due in 1971), and its 3 Concorde supersonic transports were scheduled for delivery in 1972. The company also held delivery positions on 3 Boeing SSTs, with probable delivery in 1978.

Continental's short-range DC-9C passenger-cargo convertible fleet totaled 19; the medium- and long-range fleet stood at 36, with 13 Boeing intercontinental 320Cs, 14 727-200s, one 727-100, and 8 720Bs.

Continental was the first, and only, airline to offer 5-abreast seating on all of its aircraft, a unique passenger service feature. The 1969 passenger was being offered a choice of 3 classes of service (economy being about 15 percent less expensive than coach class). The spacious 5-abreast seating was being provided for both economy- and coach-class passengers in a single cabin, allowing the line a flexibility of seat allocation between coach and economy class on each flight segment.

Continental's SONIC 360, the world's first third-generation real-time passenger-name record reservations system, offered the finest and fastest reservations service available. Based on IBM's PARS system, the Continental complex includes a unique seat reservation capability that enables the agent to display the aircraft seating plan on SONIC's TV-like screens for seat selection. Reservations offices in Hawaii, Los Angeles, Denver, Houston, and Chicago have instant access to the vast storage of the 2 IBM

System 360 computers that are the heart of the SONIC complex, located in the line's general office building in Los Angeles. Immediate confirmation of reservations is possible because of the system's instantaneous reaction to all demands.

During 1969, Continental continued as a contractor with the government for Military Airlift Command flights. An average of 6 Boeing 320Cs were allocated to this service, mostly originating flights in California for destinations in Southeast Asia.

Continental's air service in the Trust Territory of the Pacific Islands continued to fly a route network of 6,377 miles to, from, and within Micronesia. The twice-weekly Micronesia service from Saipan through Guam, Truk, Ponape, Kwajalein, and Majuro to Honolulu and down to Palau forged a completely new link between the Trust Territory islands and the outside world.

During the first 9 months of 1969, net earnings after taxes were \$1,568,000, or 14 cents per share. For the same period of the previous year, earnings amounted to \$1,721,000, or 17 cents per share. Operating revenues were \$70,258,000, as compared with \$155,400,000 for the first 3 quarters of 1968.

CP AIR

Increased frequencies, rising revenues and traffic, new operations facilities, plans for fleet expansion, and a new department—all contributed toward making 1969 a year of change and expansion for CP Air.

One of the most significant changes in CP Air's 1969 operations occurred on its transcontinental service, which was expanded to 5 return flights a day, from 2, between Vancouver and Montreal. As a result of this improved situation, Ottawa was brought on-line for the first time, nonstop service was introduced between Vancouver and Toronto and between Calgary and Toronto, and both Edmonton and Calgary were provided with daily cross-Canada service.

CP Air's frequency between Vancouver and San Francisco was doubled to 2 daily return flights.

Charters reappeared on the CP Air scene in 1969, and a 240-seat DC-8-63 was devoted entirely to this program. It operated out of both eastern and western Canada.

Corresponding with this expansion, the airline's transportation revenue for the first half of the year increased 31 percent over the same period in 1968, to \$63,200,000. At the same time, operating expenses rose 22 percent. Passenger revenue, which accounted for about four-fifths of the total, moved ahead by 27 percent, to \$52,000,000.

John C. Gilmer, CP Air's president, said that, because of expanded passenger and charter operations, year-end results would probably be favorable.

Though CP Air was caught in a spiral of rapidly rising costs, along with all airlines, Gilmer felt the long-term outlook was reassuring.

Despite a low 1968 net income of \$2,300,000, operating revenue passed the \$100,000,000 mark (\$106,700,000) and the number of passengers totaled over 1,000,000 (1,036,000), both milestones for CP Air. In order to improve the profit picture, CP Air hoped to expand service on many of its more lucrative routes and to acquire certain new destinations.

Further improvements in transcontinental service were expected in the spring of 1970, when CP Air was to take possession of 2 Boeing 727 aircraft. With delivery of the 727s, the airline planned to add 2 more return flights each day.

CP Air's ambitions in the realm of international and overseas routes were formally outlined to the government during the year. As a result of air bilateral negotiations between Canada and the United States, CP Air hoped to be designated the Canadian carrier between Vancouver-San Francisco-Los Angeles, Vancouver-Chicago-New York, Toronto-San Francisco, and Toronto-Chicago.

Immediate worldwide route ambitions were centered on the Middle East, the People's Republic of China, and Yugoslavia. Extensions into these areas depended largely upon the results of diplomatic negotiations with the countries involved.

Playing a major role in the airline's plans for the future was the construction of a \$24,000,000 maintenance, overhaul, and training base at Vancouver Airport. This Operations Centre, largest of its kind in Canada, became functional at the end of the year; it is capable of servicing any aircraft flying or on the drawing boards. It was expected to meet CP Air's requirements for the next 20 years.

Both wide-bodied jets and SSTs fit easily into the hangar area of this new facility. CP Air held delivery positions on 3 Boeing supersonic transports, which are to enter commercial use in the late 1970s, but no decision was made regarding the selection of a wide-body. Information on the Boeing 747, the McDonnell Douglas DC-10, and the Lockheed L-1011 and the routes over which they would fly was fed into the company's computer to obtain a week-by-week summary of projected revenue. From these studies, CP Air was confident it would choose the aircraft most suitable for its particular requirements. It appeared that the 747 would be too large for the relatively low loads on CP Air's long runs, but no definite decision was to be made until all the facts and figures were compiled.

With the introduction of wide-bodies and SSTs in the seventies, the airline industry enters a period of even keener competition than that experienced during the sixties. Since all airlines will be flying relatively the same aircraft, the only area for effective competition is in customer service. With this in mind, CP Air set up a new customer service department directed by a vice president, G. E. Manning.



CP Air opened a new \$24,000,000 Operations Centre for maintenance, overhaul, and training at Vancouver Airport.

For the first time in the company's history, all areas of operations involving customer contact came within the bounds of a single department. Effects of this changeover will be felt gradually as the new division systematically develops improved standards and procedures for the various areas of customer service.

The year also provided CP Air with an opportunity to pause and reflect upon some of its past achievements. Both the South Pacific service to Sydney and the North Pacific route to Tokyo and Hong Kong celebrated 20th anniversaries.

By the end of 1969, CP Air had become Canada's first all-jet airline and was approaching the revolutionary seventies with both caution and ambitious plans for the future.

DELTA AIR LINES

Anniversaries, operating achievements, route expansion, and an accelerated building program marked 1969 as a significant and profitable year for Delta Air Lines.

The Atlanta-based carrier in June completed 40 years of scheduled passenger service, which began in 1929 with 3 single-engine Travelaires over 393 route miles and in 1969 extended over a 20,539-mile system serving the financial and industrial centers of the East and the Midwest, the major growth cities of the South and the Southwest, the dynamic West Coast, and the vacation areas of Florida and the Caribbean.

Delta pioneered jet service in September 1959 and was the only airline to introduce 3 jetliners to commercial aviation: the DC-8, the Convair 880, and the DC-9.

During 1969, Delta accepted deliveries of 6 Super DC-8s, 15 Super DC-9s, and 2 standard DC-8s, permitting an expansion of over 30 percent in jet capacity and the virtual elimination of piston services.

Two standard DC-8s, needed to cover requirements for new route awards, were purchased from Pan American World Airways. This was in addition to 5 purchased from Pan American in 1968 for the operation of interchange flights to Europe. The fifth anniversary of that service was observed in May.

At year-end, Delta operated a jet fleet of 16 Convair 880s, 28 standard DC-8s, 13 Super DC-8s, 15 DC-9s (including one which was purchased in July 1969 upon expiration of a short-term lease), and 53 Super DC-9s, plus 3 L-100-20 all-cargo turboprops. Three Convair 440s remained in service for those cities where expansion of airport facilities to accommodate DC-9 service had not been completed.

On order were 5 additional Super DC-9s, 5 747s, and 24 L-1011s, representing a capital outlay of \$475,000,000. Financing was to be provided from internally generated funds and proceeds from the company's 1967 bank credit agreement, which was amended in 1969 to increase the total amount available from \$175,000,000 to \$220,000,000.

Delta's fleet by the end of 1975 was to consist of 159 jets, representing a total cost of over \$1 billion.

Fiscal year-end, in June 1969, registered new highs of \$516,100,000 operating revenues, 8.25 billion revenue passenger-miles, and 178,600,000 cargo ton-miles. Net earnings of \$39,200,000, or \$2.05 per share, were 8 percent above fiscal 1968 despite the full impact of the 10 percent surtax and the accelerated inroads of inflation on operating expenses.

Delta carried 12,107,061 revenue passengers on its domestic and international routes during fiscal 1969. This total, too, was a record, and represented a gain of 17 percent over the 10,368,831 passengers carried during fiscal 1968.

An expansion of DC-9 schedules during the year brought the first jet service of any kind to Paducah, Kentucky, and Alexandria, Louisiana, and the first Delta jet service to Springfield, Missouri, and Hot Springs, Arkansas.

Two new cities were added to Delta's system in 1969 and received initial DC-9 service: Nashville, Tennessee, on August 1, and Phoenix, Arizona, on October 1. The Nashville award was the result of a Civil Aeronautics Board decision in the Gulf States-Midwest Service Case granting Delta an alternative Chicago-New Orleans route via Nashville or Birmingham and terminating the company's Hot Springs authority. Chicago-Nashville and Chicago-Birmingham services were inaugurated August 1; Nashville-New Orleans services were inaugurated September 8. Following a favorable decision in the Service to Phoenix Case, Delta inaugurated 4 daily jet flights to Phoenix from the South and Southeast.

In other route awards, Delta received new non-stop authority between San Francisco/Oakland and Miami/Fort Lauderdale and between Houston and Miami, and turnaround authority between Dallas/Fort Worth and Los Angeles and between Dallas/Fort Worth and San Francisco. Delta also started

operations into New York's LaGuardia Airport in 1969.

Other regulatory matters were pending at year-end. In the North Carolina Points Service Investigation, the CAB examiner recommended that Delta be awarded unrestricted authority between New York and Charlotte and a new segment on its route between Chicago and Miami/Fort Lauderdale via the intermediate points Raleigh/Durham, Greensboro/High Point/Winston-Salem, and Charlotte. In the Omaha/Des Moines Case, the examiner recommended grant to Delta of Omaha-Kansas City, Omaha-Twin Cities, and Omaha-St. Louis authority. In the Kansas City-Atlanta Nonstop Investigation, Delta was the first to utilize a new expedited CAB procedure, seeking authority to operate nonstop in the Kansas City-Atlanta market, where Delta carries the bulk of the traffic.

Delta was also seeking nonstop St. Louis-Minneapolis/St. Paul authority; a route between Minneapolis/St. Paul and Milwaukee in the North, and southeastern points; and nonstop authority between Augusta, Columbia, and the Northeast.



Delta Air Lines became the first airline to order and use the Link VAMP (Visual Anamorphic Motion Picture) system in its DC-9 simulator, here being flown by Captain Charles Green, system manager-flight training.

Keeping pace with the jet aircraft acquisition program and route expansion was Delta's continuing modernization program for ground facilities. Early in 1969, plans were announced for the construction of 4 new buildings adjacent to Delta's computer center at the Greenbriar complex. Incorporating a total of 112,538 square feet, the buildings will house Delta's new flight simulator operations, communications and flight control, simulator support and flight training, and the Atlanta Reservations Center.

Already in service in the new buildings was the first of 4 new Visual Anamorphic Motion Picture (VAMP) systems developed by the Link Division of The Singer Company. Delta was the first airline

to purchase VAMP, considered the world's most sophisticated audiovisual flight simulation system, and will operate one DC-8, one L-1011, and 2 DC-9 simulators. VAMP was designed to add a high-fidelity visual dimension to simulator training; it is the first visual system to optically alter motion picture film so that actual landing and takeoff scenes are realistically changed according to the pilot's manipulation of the controls.

Delta's new Ground Training Center was completed in 1969 at the Atlanta Airport and an average of 350 students daily was entering its doors to learn new technologies of the airline industry. The facility contains over 55,000 square feet of classrooms, faculty offices, and stewardess trainees' dormitory rooms.

In September, Delta announced that it would more than double its existing 752,000-square-foot main aircraft overhaul base located on the Atlanta Airport. The base will be increased by 780,000 square feet to include new hangars, engine test facilities, maintenance and service shops, offices, ramps, and parking areas. It will be the largest facility of its type in the South.

Other facilities, concluded or under way, included a new ticketing facility at Love Field in Dallas, a second-level concourse in Jackson, and new reservations offices in Jacksonville and Jackson, plus expanded airport projects at Atlanta, Chicago, Cincinnati, Detroit, Kansas City, Memphis, New Orleans, New York, Philadelphia, and Tampa.

In February, Delta introduced a new standard of excellence in meal service. On a wide range of jet flights, Royal Service meals are served at the passengers' seats from carts, on gleaming white china designed especially for Delta. The service features epicurean entrees preceded by cocktail service and hot hors d'oeuvres.

Delta stewardesses were given a new look with striking ensembles created exclusively for Delta by Harry Gilbert of Lady Simpson. The dress design, retained year-round, is a classic princess style with jeweled neckline and comes in a variety of colors: red or black for winter; blue, green, or yellow for summer. Airport ticket counters and downtown airline offices also claimed the fashion spotlight in late 1969 as the distaff side of Delta's ticket agent corps donned smart new uniforms in red or blue, also designed by Gilbert in the basic princess style.

Greater emphasis was placed on Delta's Women's Services activities during the year. The program, established in 1957 as a consulting service for women's clubs and organizations, makes its impact through fashion shows, packing demonstrations, and slide presentations.

A pioneer in the package vacation program, Delta continued to offer quality Dream Vacations and to publish comprehensive vacation guide booklets, as well as brochures listing specific fares and other package details.

In November 1969, Delta cosponsored the first annual Heritage Golf Classic at Sea Pines Plantation, Hilton Head Island, South Carolina. The Heritage, a 4-day, 72-hole tournament at stroke play for a \$100,000 purse, attracted top-ranking professional golfers from the United States and a number of professional golfers from foreign nations.

Delta employees at year-end numbered almost 20,000, with total salaries and related employee benefit costs totaling over \$200,000,000.

Consistent with Delta's commitment to development and promotion from within the company, 5 new officers were named in October. They were H. T. Fincher, vice president-technical operations; Hollis Harris, assistant vice president-facilities; George E. Shedd, assistant vice president-public relations; Sidney F. Davis, assistant secretary and assistant to general counsel; and Ike Lasseter, assistant secretary.

Seven assistant vice presidents were promoted to vice presidents: R. W. Allen, administration; W. A. Atchison, computer services; T. P. Ball, flight operations; S. D. Dement, marketing administration; M. O. Galloway, comptroller; E. L. Hammer, stations; and C. P. Knecht, sales. The action was taken to further broaden Delta's management base for the increased scope of company activities.

EASTERN AIRLINES

The year 1969 was the year in which Eastern Airlines reached California and reaffirmed its right to call itself a "transcontinental" carrier. But it was the year also in which its ambitions and hopes to serve Hawaii and the South Pacific were thwarted by the Civil Aeronautics Board and by the decisions of 2 Presidents of the United States.

Enabled on September 23 to increase its unduplicated route mileage by 10 percent with the award of Atlanta-Los Angeles and Atlanta-Dallas/Fort Worth routes in the Southern Tier Case, Eastern was also able during 1969 to expand in other directions. In the spring, it inaugurated new services between Miami and both St. Thomas and St. Croix in the Virgin Islands and started new nonstop flights between both Chicago and Detroit to Bermuda. In the fall, it added nonstop Chicago to New Orleans service to its domestic operations. And at year-end, it further expanded its growing list of Caribbean destinations to include Montego Bay and Kingston, Jamaica, via direct flights from Newark, Philadelphia, and Friendship Airport serving Washington/Baltimore.

As year-end approached, Eastern was in process of trimming its operations to meet an anticipated cautious atmosphere in the national economy and a resultant slackening in rate of growth in air travel. With the advent of larger aircraft of the 200-seat

DC-8-61, DC-8-63, and Boeing 727-200 series, and with better utilization of other types of jets acquired earlier, Eastern was providing revenue plane miles and available seat miles over 20 percent above the capacity flown the previous year. The number of individual passengers carried, however, was only about 4 percent above the 1968 level, while the revenue passenger-miles produced rose 10.5 percent, reflecting at least Eastern's success in stretching the average passenger haul to about 640 miles. Passenger load factors, on the other hand, dropped to a 51.5 percent average for the 12 months.

By the end of December, Eastern had flown over 13.3 billion revenue passenger-miles and had carried more than 21,390,000 passengers.

Showing surprising strength, in spite of intensive competition both in the air and on the ground, was Eastern's no-reservations Air-Shuttle, operating in the high-density Northeast Corridor between Boston-New York/Newark-Washington. This unique commuter service, faced for the first time with a new rival in the form of modern, high-speed trains offering airplane-type amenities, managed to continue its growth and by year-end had carried more than 3,183,000 passengers.

Air cargo, the fastest-growing segment of air transportation, showed appreciable gains on Eastern, with revenue ton-miles up some 26 percent as the year was ended. Airfreight, with gains of 30 percent, led air express and mail as Eastern's principal load producer in this field.

At the end of the fourth quarter, Eastern showed an earnings deficit of \$2,323,000, or 27 cents per share. Preliminary figures indicated that a net profit of \$3,800,000 had been made during the month of December. However, a general fare increase, benefiting all the scheduled airlines, took effect on October 1 and, as expected, brought in substantially increased revenues during the final quarter of the year. The Civil Aeronautics Board, in granting the increase, estimated that Eastern would realize a 5.49 percent increase in future passenger revenues.

Although there were significant gains in revenue passenger-miles, air cargo revenues, and overall operating revenues during July and August, the September results were disappointing. Both business and pleasure travel were affected by a general slowing down of passenger traffic activity during this historically weak month in the air transport industry.

In the process of modernizing its fleet during 1969, Eastern phased out its twin-engine propeller-driven Convair 440s and all of its turboprop Electras except those assigned specifically to the Air-Shuttle as backup to provide extra sections to the primary DC-9-30 jets. It also returned 6 of its original Boeing 720 4-engine jets to the manufacturer as part payment for an equal number of the more economical Boeing 727-200s.

During the year, Eastern acquired 11 Boeing 727-

200s, valued at \$66,000,000, under a 15-year lease with Armco/Boothe Corporation, a subsidiary of Armco Steel Corporation. Additionally, it acquired one leased DC-8-61, one leased and 5 purchased DC-8-63s, and 5 leased DC-9-31s. Allowing for aircraft retired or returned to the manufacturers, Eastern ended the year with a fleet of 221 jets.

These and other aircraft to be acquired in 1970 and through the early 1970s were being financed through a \$244,000,000 program negotiated during the year. In addition to the Armco/Boothe deal, it included a \$100,000,000 revolving credit with 38 banks headed by Chase Manhattan, and a 10-year financing with Rolls-Royce for 90 percent of the cost of the RB.211 turbofan engines for Eastern's first 25 Lockheed L-1011 TriStar aircraft.

In support of improvements to its air fleet, Eastern placed in service during the year a \$19,000,000 passenger facility at Boston's Logan International Airport. Designed in distinctive modern style by Minoru Yamasaki, of Troy, Michigan, in collaboration with the Boston architectural firm of Desmond & Lord, the terminal incorporates 3 levels of parking space to accommodate 1,000 automobiles, telescopic loading bridges, and systems of baggage conveyors to make travel easier than ever before.



In November, Eastern Airlines occupied its new, ultramodern \$19,000,000 passenger terminal at Boston's Logan International Airport.

Also placed in service during 1969 were Eastern's new regional reservations offices at Woodbridge, Chicago, Houston, Montreal, Seattle, and Tampa. These are tied in electronically with a battery of IBM 360 computers at Miami to provide fast and accurate reservations and flight information service.

In marketing its product during the year, Eastern used as its slogans "Smiling Faces Going Places—On Eastern" and, later, "Eastern—The Wings of Man." It introduced many service innovations. Among these were 42 "Eastern I" flights in exclusively first-class configuration between various city pairs in DC-9 aircraft specially fitted out to provide uncrowded comfort and amenities. Also introduced were early morning "Sunrise Express" flights between New York and Miami and late-evening

"Nightcap" flights for the benefit of theatergoers and others who wished to travel the Boston-New York-Washington routes after departure of the last Air-Shuttle.

The Eastern Travel Club (ETC) continued to be an active part of Eastern's marketing program throughout 1969, with new resort facilities added to a growing list in the Caribbean, Florida, Mexico, and even Europe. By December, the membership had grown to 100,000. Several foreign-flag airlines entered into agreements with Eastern during the year to utilize ETC facilities in conjunction with their "Visit U.S.A." programs.

A new look for various employees became evident throughout 1969 as, first, stewardesses, flight attendants, and ground hostesses, and later, ticket agents and ramp service personnel were outfitted with smart uniforms of varying hues.

In Eastern's top administrative ranks, a number of important changes took place during the year. Samuel L. Higginbottom was advanced to the new post of executive vice president and general manager, reporting directly to Eastern's president, Floyd D. Hall. Charles J. Simons became senior vice president, finance department; Thomas B. McFadden, senior vice president, marketing division; Dwight D. Taylor, senior vice president, planning and public affairs; W. Glen Harlan, senior vice president, legal affairs; and Ralph H. Skinner, senior vice president, industrial and personnel relations.

FLYING TIGER LINE

For the Flying Tiger Line, 1969 was a historic year. The transpacific route, finally approved by President Nixon early in May, was put into service on August 12. Initial scheduled service was a daily military mail and cargo flight to Okinawa and Saigon, followed by 6 flights daily to Tokyo, 3 a week to Hong Kong, 2 a week to Taipei, Taiwan, and one a week to Seoul, Korea. The number of flights to those points was to be increased as volume increased. Thailand and the Philippines were to be added in the near future.

Domestically, the airline's system was expanded to include Syracuse, joining upper-state New York with the domestic Tiger system, which includes Boston, Hartford/Springfield, New York, Newark, Buffalo, Philadelphia, Cleveland, Detroit, Milwaukee, Chicago, Los Angeles, San Francisco/Oakland, Portland, and Seattle/Tacoma.

Hand in hand with the expansion of the airline's wide-flung international route went the growth of its fleet of aircraft. Tigers at year-end operated 17 DC-8-63Fs, costing some \$12,000,000 each. Standardization of the fleet made for outstanding economy in maintenance and operation. The last CL-44 was retired from service in September.

A growing trend was making itself evident in the area of maintenance. Because of the outstandingly high qualifications of the Flying Tiger Line's maintenance facilities in Los Angeles, a number of other airlines flying DC-8s were using the Tigers' Los Angeles facilities and staff for routine maintenance.

With the tremendous loads made possible by the DC-8, the airline broke a number of weight records. In the early part of the year, Tigers flew 112,000 pounds on a flight from Los Angeles to Chicago.

Transpacific record loads presaged the exciting potential of that route. The airline flew a record military cargo load of some 99,124 pounds from San Francisco and Seattle to Okinawa and Saigon, breaking its own previous record of 98,300 pounds on an international flight.

Another historic milestone was reached in 1969. Formed in 1945 as the nation's first all-cargo airline, the company celebrated the 20th anniversary of its first certificated flight for Route 100 in 1949. Route 100 generated \$192,000 of revenue in its first month of operation. This same route in 1969, with a few variations, had monthly revenues exceeding \$1,800,000. The new transpacific service was expected to double that figure when in full operation.

The Flying Tiger Line, a \$200,000,000 company, was approaching the \$100,000,000 gross revenue mark as the year ended.

FRONTIER AIRLINES

Highlighting Frontier Airlines' 1969 activities were extensive route awards from the Civil Aeronautics Board which expanded the carrier's services between major hub markets in the Rocky Mountain West, the Midwest, and the Southwest.

The first of these new services was the inauguration in June of twice-daily nonstop round-trip service between Dallas/Fort Worth and Denver with continuing through jet service to and from Salt Lake City. This award was the result of the final CAB decision in the Reopened Pacific Northwest-Southwest Area Investigation.

In July, as a result of the CAB decision in the Route 81 Case, Frontier was able to inaugurate a new run with twin-engine Boeing 737 jets between Dallas/Fort Worth and Kansas City, operated nonstop with continuing jet service to Omaha and Lincoln, Nebraska. On August 1, Frontier was given a liberated operating authority between Denver and Casper, Wyoming, plus Billings and Great Falls, Montana. This was under a Subpart M proceeding, making it possible for Frontier to open up an entirely new service which the carrier gave the title of Petroleum Club. By a reworking of schedules, the Petroleum Club Service was able to provide the oil and natural gas producing areas of Montana and Wyoming with twice-daily round-trip service to the

oil headquarters and supply centers of Denver and Dallas/Fort Worth. Featured on the Petroleum Club Service were special meals and liquid refreshments aimed to appeal particularly to the representatives of the oil and natural gas industries.

Later in the fall of 1969, as a result of a favorable CAB decision in the Albuquerque Service Case, Frontier was able to inaugurate another jet route between Dallas/Fort Worth and Las Vegas via Albuquerque. This twice-daily jet service was being operated with 97-passenger Boeing 737 jets flying both morning and evening services in each direction.

In June, Frontier began the acquisition of a new fleet of twin-engine Boeing 737-200 jets. These aircraft provide both coach and deluxe coach accommodations with a seating capacity of 97 passengers. The first 2 were acquired in June and by the end of 1969 Frontier was flying 8. Two additional 737s were to be added in January 1970, giving the airline a total of 10 737s plus 3 Boeing 727-200 tri-engine aircraft which can accommodate up to 134 passengers. In addition, the carrier was operating a basic fleet of turboprop Convair 580 aircraft, each seating 53 passengers.

Frontier Airlines began 1969 with a new president, E. Paul Burke. Burke came to Frontier with a background of nearly 30 years in the airline industry, the bulk of which had been accumulated with Trans World Airlines. In the first quarter of the year, Burke, along with Frontier Airlines' board of directors, met with stockholders of the company to dedicate the carrier's new \$10,000,000 operations base at Stapleton International Airfield. This is Frontier's major overhaul base, the heart of its reservations system, and the facility which houses the carrier's IBM 360-65 computer.

In the summer of 1969, Frontier undertook an extensive tour promotion of the 10 national parks and major recreational areas located on the carrier's extensive 16-state system in the West. Frontier Airlines was the first carrier to introduce personally escorted tours; the escorts were from the carrier's sales and marketing department. These package tours were geared to a full vacation in the national parks of Yellowstone, Grand Teton, Glacier, and Waterton.

In the fall, the carrier came up with a new approach to the hot and cool winter attractions on its system. Package plans for winter vacationers desiring a wide assortment of skiing in the high country of Colorado, Utah, Wyoming, and New Mexico feature the best in nationally known ski areas such as Aspen, Vail, Jackson Hole, Brighton, Park City, and Taos. For vacationers more interested in a palm tree background, the carrier came up with a "hot spot" winter promotion geared to the attractions to be found in Phoenix, Tucson, Las Vegas, and south of the border into Mexico.

Toward the end of the year, a joint promotion

was undertaken between Frontier and Ralph Williams Rent-A-Car of southern California. Frontier Airlines' extensive reservations system was to be geared to handle a string of rent-a-car agencies to be opened by Ralph Williams throughout the West.

At the close of 1969, Frontier had been recommended by hearing examiners for new nonstop routes between Denver and Omaha, Omaha-St. Louis, and Omaha-Kansas City in the Omaha-Des Moines Service Investigation. The carrier also was an active participant in the Salt Lake City Service Case with jet route applications between the Utah capital and San Francisco.

Frontier closed the year 1969 with a 6.5 percent increase in revenue passenger-miles, having flown 924,000,000 revenue passenger-miles during the year. This increase was the result of an average longer haul per passenger which showed a 10 percent gain over 1968, with the average Frontier passenger flying 392 miles per flight. Passengers originated by the carrier totaled 2,355,000, approximately 3 percent under the 1968 showings. With the combination of a longer haul per passenger and only a 2 percent increase in available seat miles, the carrier came up with a load factor for the year of 45 percent. This was a 2 percent gain over the passenger load factor recorded in 1968.

HAWAIIAN AIRLINES

Hawaiian Airlines marked its 40th birthday on November 11, 1969. The airline started operations in 1929 with a brace of S-38 amphibians which plied the Hawaiian skies over warm tropical waters with almost yacht-like elegance. The pleasures of polished woods and of water landings have gone from aviation, but the ever-beautiful scenery of the islands remains unchanged—and is dramatically more accessible by Douglas DC-9s. The Hawaiian Airlines fanjets sweep in for landings over the same cane fields once rustled by the low passage of the boat-hulled Sikorskys.

During the year, Hawaiian Airlines experienced a growth pattern parallel to the striking expansion of the Hawaiian tourist industry. In the summer of 1969, the inter-island carrier operated twice the jet seat-miles as in the previous year, employing a DC-9 fleet increased from 4 to 8 aircraft.

Hawaiian was serving 9 communities on the 6 major islands of the Hawaiian group. Jet operations were inaugurated to Molokai in July 1969, bringing to 7 the number of stations receiving DC-9 service. Lanai and the tiny airport of Hana on Maui continued to be served by Hawaiian's fleet of Convair 640 turboprops. Hawaiian operated 5 of the versatile turboprop Convair Liners and one jet-powered all-cargo Convair. Hawaiian carried approximately 95 percent of the inter-island airfreight.

In introducing jets to the island of Molokai, Hawaiian continued its practice of pioneering every advance in aviation technology and passenger service in the Hawaiian Islands.

During 1969, the airline introduced cocktail service to the cabins of its DC-9s, an added touch of service even though the average flight segment was little over 20 minutes. On the ground, at Hawaiian Airlines' terminals, the line's Redcoats were providing friendly touches of additional service. The Redcoats rove the terminals to be of assistance wherever they are needed.



Hawaiian Airlines introduced cocktail service in 1969 although the average flight segment was little over 20 minutes.

The hub station of the Hawaiian system, Honolulu International's Inter-Island Terminal, was given a stem-to-stern rejuvenation that makes the super-bungalow-style terminal easy and pleasant to use. Twin air-conditioned holding lounges flank the central check-in facilities to minimize walking distance and baggage-handling time. Special group check-in facilities were incorporated into the new terminal, which has 10 aircraft positions.

In Waikiki, Hawaiian relocated one of the 2 ticket offices to the street level of the new Surfrider Hotel and added offices in the Reef and Hawaiian Village hotels.

In the summer of 1969, Hawaiian applied a new scheduling policy: 2 DC-9 fanjets were retained as reserve unscheduled aircraft to handle the additional sections which are a characteristic of Hawaiian's operations. The extra jet fleet proved a

successful way of serving the "peaky" traffic pattern and supported Hawaiian's fine reliability record.

Hawaiian's 1969 schedules included a wider selection of reduced-fare Earlybird morning flights and evening Starlighter flights. These services are money savers for visitors who are not able to use the common fare, the travel bargain for holders of round-trip tickets from the mainland.

The enormous investment of the Hawaiian hoteliers in a diverse array of attractive accommodations opened the islands to the traveler who wishes to move around at will or has the fine inspiration of a Hawaiian holiday just a few days before the time becomes available.

Hawaiian Airlines' mainland representation expanded to 13 cities, with district sales managers and their staffs located in Los Angeles, San Francisco, Chicago, and New York.

LOS ANGELES AIRWAYS, INC.

Beginning its 22nd year of scheduled operations in southern California, Los Angeles Airways continued its expansion program designed to extend service to numerous additional points in Los Angeles, Orange, Riverside, San Bernardino, and Ventura counties.

Early in the year, the Civil Aeronautics Board amended the company's certificate to permit it to conduct its scheduled operations utilizing either fixed-wing or rotary-wing aircraft. In October, the first 2 Series 300 Twin Otters, the latest version of the well-known de Havilland STOL aircraft, were added to Los Angeles Airways' fleet. Service to Riverside, San Bernardino, and Oxnard/Ventura with these aircraft was scheduled to begin before the end of the year. The company also acquired a new 28-passenger Sikorsky S-61L helicopter incorporating the manufacturer's latest design changes, and increased service to existing heliports was being planned.

Aside from its common carrier activities, Los Angeles Airways continued to work closely with airport, airline, and Federal Aviation Administration officials in the development of fog dispersal techniques utilizing large transport helicopters. A significant breakthrough in this project occurred during the early morning hours of August 8, 1969, at Los Angeles International Airport when Los Angeles Airways dispatched several of its multi-engine all-weather-equipped S-61L helicopters up through the fog and they cleared the runways sufficiently to permit normal airline takeoff operations to resume.

On August 19, 1969, the staff at Los Angeles Airways' Anaheim/Disneyland Heliport welcomed the 1,000,000th passenger to be carried on the Anaheim to Los Angeles segment of the system. In addition to passengers, millions of pounds of airmail and air

express have been accommodated through Anaheim Heliport, which ranks as the world's busiest heliport.

Los Angeles Airways' system-wide traffic totals at the end of its 22nd year of service stood at well over 2,000,000 passengers flown and 90,000,000 pounds of mail and 42,000,000 pounds of express carried.

MODERN AIR TRANSPORT, INC.

The year 1969 marked another period of progress for Modern Air Transport, Inc. The company's operations expanded more than 25 percent, totaling over 400,000,000 revenue passenger-miles and 340,000 passengers carried.

Operations in 1969 varied from the normal domestic charters for Gulf American Corporation, Modern's parent company, and military CAM flights throughout the United States to transatlantic and intra-European operations.

The year was another one of "firsts" for Modern's innovative marketing staff. Early in the year, Modern pioneered the first inclusive tour charters to Mexico. It was considered the top charter operator from the United States to Mexico for both ITC and affinity groups.

From its Berlin base, Modern carried more than 112,000 passengers to points in southern Europe and the Mediterranean area. It inaugurated the first winter inclusive tour program ever operated from Berlin, placing its operations there on a year-round basis. The company was also offering its own "Fly Now—Pay Later" program to the citizens of Berlin and expected a substantial increase in patronage from this source.

During the summer, Modern operated its own transatlantic program from Canada to various points in Europe and established a permanent sales office in Toronto.

Another of Modern's historic transpolar round-the-world flights was contracted with Hemphill Travel Agency, Los Angeles, for operation in 1970. Several similar flights were under negotiation.

During early 1969, Modern modified all of its Convair 990A aircraft from the existing 134 to 139 seating configuration to a standard 149 seats, providing a highly attractive, comfortable interior. The company also completed certification of its integral auxiliary power unit installation, making the Convair 990 the only self-sufficient 4-engine jet in operation.

The year was one of consolidation for the new management group organized in 1967 and 1968 by Morten S. Beyer, executive vice president. The sales department, under the direction of Ralph Sacks, consolidated its hold in the Mexico and West Coast charter market and contracted for a 1970 charter

program over 3 times greater than the 1969 program. Sacks was assisted in his sales program by 3 veteran executives: Al Forsyth, Al Teweles, and Ben Topfer. The Canadian sales program for 1970 was also expected to show a substantial increase over the \$1,000,000 volume recorded in 1969 under the direction of Ted Sawicz.

Modern's Berlin base at Tegel Airport continued to develop, and in 1969 the company was awarded a contract by the Berlin Airport Authority to provide ground services for all airlines using Tegel Airport. Modern was providing complete technical servicing, catering, and passenger handling not only for its own flights but also for other carriers operating into Tegel Airport.

In early 1969, Modern's parent company, Gulf American Corporation, was purchased by GAC Corporation of Allentown, Pennsylvania; Modern, therefore, became a subsidiary of GAC Corporation. The take-over of Gulf American by GAC Corporation resulted in a sharp increase in Modern's operations on behalf of Gulf American and during 1969 more than 150,000 passengers were carried to Gulf American land development projects in Florida and Arizona.

The company also continued to be the second largest carrier of CAM business on domestic military flights, grossing almost \$1,500,000 of revenue and carrying nearly 30,000 military passengers.

In late 1969, Modern added the sixth Convair 990A to its fleet under a lease purchase deal with Alaska Airlines. This aircraft was modified to the 149-passenger configuration at Modern's self-sufficient maintenance facility at Miami International Airport.

In addition to performing its own maintenance, Modern was handling the technical requirements of Varig at Miami as well as outside maintenance for other operators as required.

At the end of 1969, Modern employed 250 persons, of whom 40 were located at the Berlin base and the bulk of the remainder at Miami. The company employed 15 flight crews.

Modern was an applicant for transatlantic and Caribbean authority to supplement its domestic and Mexican routes. The Civil Aeronautics Board initiated a transatlantic charter route proceeding and was expected to deal with Modern's Caribbean application soon.

MOHAWK AIRLINES

Mohawk Airlines ended 1969 with a decade-long goal achieved: extension of its service beyond the carrier's historical confines of the Northeast and Canada. Starting in early 1970, Mohawk was to serve both Chicago and Minneapolis/St. Paul, 2 key Midwest areas.

The new Chicago and Twin Cities routings were to increase Mohawk's flight lines by a total of 25 percent, from 5,140 to 6,440 route miles. It was estimated that 200,000 passengers would use the new routes during the first year of service, contributing nearly \$9,000,000 in new revenue for the company.

Starting January 6, Mohawk planned to operate 3 round-trip jet flights daily to Minneapolis/St. Paul, 2 serving Hartford/Springfield-Rochester-Buffalo-Twin Cities and one serving Hartford/Springfield-Syracuse-Buffalo-Twin Cities.

Mohawk was to begin service to Chicago with 4 round-trip flights daily, 2 on each of these routings: Albany-Binghamton-Elmira-Chicago and Utica/Rome-Syracuse-Erie-Chicago.

While increasing its flight lines, Mohawk also spent a good deal of 1969 strengthening its regional operational base. The airline added nonstop service between Albany-Buffalo, Syracuse-Washington, Rochester-Washington, and Syracuse-Boston.

Mohawk was also a partner in a plan proposed to the Civil Aeronautics Board which would allow the first 3-way restructuring of regional air service in the United States. Seven petitions were filed with the CAB by Mohawk and Northeast Airlines which would allow the transfer of various New England routes to carriers more suitably equipped to serve them. Under the plan, Northeast would continue to serve key cities in the region with long-haul flights, Mohawk would gain authority for medium-haul service previously operated by Northeast in New England, and 3 commuter carriers would handle short hops formerly flown by Mohawk and Northeast in the area.

In July Mohawk began offering the only scheduled airline service into the new Sullivan County International Airport. With this service, Sullivan County, heart of the Catskill resort area, is within easy flying distance of nearly one-quarter of the people in the United States.

In off-line cases, Mohawk sought approval in 1969 for service to Miami, Tampa/St. Petersburg, Atlanta, Charlotte, Norfolk, Louisville, Nashville, St. Louis, Dallas, Birmingham, Cincinnati, and Indianapolis.

Early in 1969, Mohawk opened up its telephone lines with a \$4,000,000 reservation-computer system called DART (Direct Airline Reservations Ticketing). The system was attuned to accept data on 5,000,000 passengers a year. Late in 1969, DART was wed to Tele-Ticketing, a nationwide gadabout whose reputation is well known by traveling businessmen. The union of the 2 gave the airline the opportunity to render more service to its passengers by sending tickets nationwide via an electronic communications network of ticketing devices. A single call to Mohawk reservations can have a ticket the same day in the hands of a businessman located many miles from the nearest Mohawk facility.

In the realm of extra service to its passengers,

Mohawk inaugurated in 1969 a Fly-Drive & Save plan in conjunction with Budget Rent-A-Car. By calling Mohawk reservations, passengers are able to reserve cars at reduced rates with large savings possible.

Savings on Mohawk were still possible in the reduced-fare specials: Weekends Unlimited, Consecutive Executive, and Long Weekends Unlimited. In 1969, a fad developed among high school and college students utilizing these fares. The object was to see who could fly the farthest for the least money. The winner at year-end was a lad from Michigan who managed to fly over 20,000 miles for less than \$130.



Mohawk Airlines put into service a \$4,000,000 computerized reservations system called DART (Direct Airline Reservations Ticketing) and later in the year merged DART with the nationwide system Tele-Ticketing.

Mohawk's cargo figures continued to soar in 1969, sometimes with increases of more than 30 percent over cargo carried the previous year. "Hustlepak" customers also continued to increase, primarily because of the Mohawk guaranteed small package air service whereby for \$10 a shipper gets to pick his flight with the knowledge that his package will be at the Mohawk ticket counter one-half hour after the flight arrives at its destination.

Mohawk took a step into the recreation field with the start of construction of its new \$1,800,000 Horizon Hotel, unveiled in Utica, New York, by Governor Nelson A. Rockefeller. The 100-room luxury accommodation, which was to open May 1, 1970, will be the first in a chain of Horizon Hotels to be built by Mohawk and the Ramada Overseas Corporation, operating under their newly formed subsidiary, MOROC Oneida, Inc. Designed with an aviation-oriented motif, hotel features include a gourmet restaurant and cocktail lounge, banquet and meeting rooms, sauna baths, and a pool area shaped like a Mohawk jetliner, with "runway type" lighting on paths leading to the pool.

All of the piston aircraft were phased out of scheduled service early in 1969 and Mohawk added 5 on-line jets, bringing the airline's fleet to 20 Mo-

hawk One-Eleven fanjets and 17 FH-227 propjets. Mohawk planned to acquire 80- to 100-passenger jets in the early 1970s, 100- to 150-passenger aircraft by the mid-1970s, and possibly 200- to 250-passenger jets by the end of the decade.

Early in 1970, Mohawk, one of the world's largest regional carriers and an international airline, was serving 12 states, the District of Columbia, and 2 provinces in Canada, via 41 airports.

NATIONAL AIRLINES

Highlight of National Airlines' 1969 year was the carrier's emergence as the third U.S. transatlantic airline. During the year, the airline was awarded flying rights between Miami and London.

Under terms of the U.S./United Kingdom bilateral agreement, National was to inaugurate nonstop service over the international route on January 1, 1970. Its London route was to be served by intercontinental DC-8 jets configured to carry 129 passengers. The planes were to be equipped with in-flight movies and stereo entertainment.

The carrier also inaugurated service between San Francisco and Atlanta during the year. A result of final awards in the Southern Tier Competitive Non-stop Investigation, the authority gave National its first entry into the Georgia industrial hub.

In mid-October, National ordered 9 McDonnell Douglas wide-bodied DC-10s and optioned 8 more. The trijets, which will eventually replace the carrier's complement of 15 DC-8s on domestic operations, were to be placed in service in November 1971. Delivery was to continue through December 1973. The new jets will be financed through internally generated funds, plus additional debt, with no dilution of stockholders equity.

The DC-10s will be maintained at National's home base in Miami in a new \$17,000,000 hangar complex, which was under construction at year-end. The facility, part of a \$34,600,000 base expansion, was specially designed to accommodate the DC-10s and the Boeing 747s.

Late in the year, National opened a new \$40,000,000 terminal at John F. Kennedy International Airport in New York. The facility was designed for efficient passenger service. Departing and arriving passengers are completely separated, moving in and out of the ultramodern glass-and-concrete complex with unprecedented ease and minimum delay.

National ended its fiscal year July 31 by posting the third highest earnings record in its history. Earnings were \$18,900,000, or \$2.25 a share, on record operating revenues of \$260,000,000. Record operating revenues were recorded despite a temporary schedule reduction earlier in the year caused by an illegal walkout of the airline's maintenance employees. Traffic for the fiscal year was up also. Na-

tional boarded 5,300,000 passengers, an increase of 11 percent over the previous year. Revenue passenger-miles rose 12 percent, to 4.3 billion. Capacity increased 24 percent, to 9.4 billion seat miles. Air cargo for the year increased 27 percent.

For the first 4 months of the new fiscal year, National netted \$2,600,000 on operating revenues of \$87,500,000. Gains in traffic were also posted for the July-October period. The airline flew 1,800,000 passengers 1.4 billion revenue passenger-miles. Capacity increased to 3.4 billion available seat miles.

Financial results were encouraging enough for National's board of directors to increase the quarterly dividend on common stock by 33½ percent, from 7½ cents to 10 cents per share.



Late in the year, National Airlines opened its new \$40,000,000 passenger terminal at New York's Kennedy International Airport.

In mid-October, on the eve of the carrier's 35th anniversary, National launched the most ambitious advertising campaign in its history. Developed by F. William Free & Company, the \$10,500,000 campaign encompassed all major media, with the heaviest emphasis placed on 10-, 30-, and 60-second spot TV commercials. "You're Gonna Have a Great Flight!" was the theme of the campaign.

Earlier in the year, the airline inaugurated the \$200,000 National Airlines' Open, richest golf event in the South. It carried a top prize of \$40,000; because of its success, it will be an annual event. The 1970 golf classic was set for March 26-29 at the Country Club of Miami.

National at year-end was serving 43 cities in 15 states and the District of Columbia. Its route structure stretched from Miami up the East Coast through the major northeastern cities to Providence, and across the Gulf Coast through New Orleans, Houston, and Las Vegas to Los Angeles, San Francisco, and San Diego. The carrier was seeking authority to fly to 13 additional U.S. cities, 10 more states, and 12 European countries.

NEW YORK AIRWAYS

New York Airways completed its first year of scheduled STOL operation in the Metropolitan New York area in November 1969.

Two STOL aircraft—twin-engine de Havilland Otters—with their higher speeds and greater operating efficiency, enabled New York Airways to accommodate the increasing public demand for its connecting services. Plans called for the operation of 2 Twin Otter STOLs daily starting at 7:00 a.m. and continuing through 11:20 p.m. linking the 3 major airports on a high-frequency shuttle basis.

In 1969, New York Airways shifted its operations at LaGuardia and Kennedy airports to American Airlines passenger terminals under a 10-year agreement between the 2 carriers.

In November 1969, the Civil Aeronautics Board approved an agreement between New York Airways and Pan American World Airways whereby Pan American would purchase 45 percent of New York Airways' stock.

For the 12 months ended December 1, 1969, New York Airways carried 265,461 revenue passengers. Of these, 116,759 were carried by STOL aircraft. Revenues for the 12-month period ending October 31, 1969, were \$3,753,114.

NORTH CENTRAL AIRLINES

The conversion to a turbine-powered fleet, the inauguration of major route awards, and the opening of a new headquarters complex highlighted the activities of North Central Airlines during 1969, the company's 22nd year of scheduled operations.

The airline's equipment transition program, begun in April 1967, was completed early in the year. North Central at year-end operated an all turbine-powered fleet of 13 100-passenger DC-9 fanjets and 34 Convair 580 turboprops. Two additional DC-9s were available for use.

Every day, these aircraft served some 90 cities in 12 states and Canada over an 8,200-mile route system. For the first 10 months of 1969, "Northliners" flew over 500,000,000 passenger-miles, an increase of 19 percent as compared with the same period in 1968. More than 2,700,000 passengers were carried on the airline's system, a gain of 9 percent. Cargo, including airfreight, express, and mail, registered an 18 percent increase as almost 7,000,000 ton-miles were flown through October.

Recapping the company's rapid passenger growth, North Central carried 11,398 travelers in 1948, its first year of operation. On June 17, 1955, it became the first regional airline to have carried 1,000,000. Nine years later, in 1964, the company was recognized as the first regional to reach 10,000,000 passengers, and in July 1967, the 15,000,000 mark was

exceeded. In April 1969, just 21 months later, the airline carried its 20,000,000th passenger.

Several major route awards were granted to North Central in 1969 by the Civil Aeronautics Board, including nonstop service in the important markets of Minneapolis/St. Paul-Denver, Minneapolis/St. Paul-Chicago, and Milwaukee-Cincinnati, Dayton, and Columbus. The airline was also recommended for nonstop routes between Minneapolis/St. Paul, Milwaukee, and New York. If granted, the Twin Cities-New York segment would be the longest ever awarded to a regional airline.

North Central was continuing its aggressive route development program with applications filed for 20,000 additional route miles to serve 24 new cities in 9 states, the District of Columbia, and Manitoba, Canada. These routes would more than triple the system and extend the airline north to Winnipeg; south to Dallas/Fort Worth, Houston, San Antonio, Atlanta, and Miami; and east to Boston, New York/Newark, Philadelphia, Washington/Baltimore, and several North Carolina cities.

To keep pace with the continued expansion of the company, North Central moved into its new \$15,000,000 general office and main operations base at the Minneapolis-St. Paul International Airport. The headquarters combines all of the company's major corporate and operational functions into one massive complex located on a landscaped 100-acre site adjacent to the airport. More than 1,200 of the airline's 3,100 employees were based there.

The main operations base includes 3 huge hangar bays which together are 2½ times as long as a football field and are capable of servicing 9 DC-9 fanjets at one time or 15 Convair 580 turboprops. Related shop areas are located behind the hangar bays, with a separate building for testing jet and turbo-prop engines. An adjoining 2-story building houses the general office. In addition, North Central was operating an employee cafeteria and flight kitchen, becoming the first regional airline to cater its own aircraft.

Another highlight of the year was the announcement that the company planned to install an \$8,000,000 passenger reservations and communications system, known as ESCORT (Electronic System Combining Operations, Reservations, and Telecommunications). ESCORT was to be operational in March 1970 and was designed to expedite passenger reservations and flight information inquiries. The electronic equipment was located in the airline's new general office and was also to be used to produce financial, maintenance, and inventory control information.

Facility improvement programs were in progress at several major traffic points served by the airline. In Milwaukee, a \$2,500,000 boarding terminal, designed exclusively for North Central, was dedicated. Eight new passenger gates, located in a circular concourse, provide more efficient ticket and bag-

gage service in the loading areas. At Minneapolis/St. Paul, construction was completed on the company's second-level passenger gates. Green Bay also had new boarding "jetways."

North Central entered its 23rd year of operation with a turbine-powered fleet, increased service facilities, and the anticipation of new routes. The airline looked forward to realizing the rewards of its extensive expansion program and 1970 promised to be a year of further growth.

NORTHEAST AIRLINES

As 1969 ended, Northeast Airlines was seeking government approval for a merger with Northwest Orient Airlines.

The action came after a year during which Northeast began operating new routes to Bermuda; to Chicago, Cleveland, and Detroit; and to Los Angeles. Despite the new routes, Northeast's financial outlook remained bleak because of the continuing slow growth in air passenger totals and because of the nation's economic problems.

President James O. Leet said he hoped the Civil Aeronautics Board and other federal agencies would complete action on the merger plan within the first half of 1970. Meanwhile, he said, Northeast would continue operations.



Northeast Airlines introduced the seat-and-a-half concept, in which passengers on light-load flights may turn the middle seat into a combined table and armrest.

As evidence of its plans, the line in the fall of 1969 began extensive advertising of its new "seat-and-a-half" concept. Provided on a nonguaranteed basis on light-load flights, the new concept allows passengers to turn the middle seat into a combined table and armrest. The innovation forms the main theme for 1970 advertising.

For Northeast, 1969's first major event came in

mid-March when the line began service on its new Boston-Bermuda nonstop route. In late April, Yellowbird jets began flying a second new route, linking northern New England cities such as Bangor, Portland, and Manchester with Cleveland, Detroit, and Chicago. And on October 1, Northeast began flying jets between Los Angeles and Miami.

While new routes were being added, Northeast was also adding to its facilities. A new reservations center opened in the fall at Logan International Airport in Boston using the line's new IBM Minute-man reservations system. The airline's pilot training center was also moved into the same building.

New 727-200 jets were added and at year-end Northeast's fleet included 13 Boeing 727-200s, 8 Boeing 727-100s, 14 McDonnell Douglas DC-9s, and 6 Fairchild Hiller FH-227 turboprops.

The Fairchild Hiller planes were used largely within New England, where a preponderance of short routes added to Northeast's worsening financial problems. These short routes compounded problems caused by a declining national economy, increasing interest rates for purchase of new jets and other equipment, and a slow increase in fares as compared with a rapid increase in the cost of fuel, labor, and other expenses.

In an effort to meet the problem, Northeast took the lead in restructuring New England's internal air service. The airline asked the Civil Aeronautics Board for permission to turn over various routes to other carriers. The net effect was to seek approval of a plan under which Northeast would operate long-haul flights, Mohawk would operate medium-haul flights, and Executive Airlines and other commuter carriers would operate short-haul New England flights.

The extent of Northeast's problem was illustrated by the third-quarter financial report. Northeast reported that for the first 9 months of 1969 the company realized a net loss of \$8,700,000, as compared with net earnings of \$719,000 for the same period a year earlier. Total operating revenues for the 9 months were \$95,900,000, up 11.8 percent, but operating expenses were \$101,400,000, up 23.2 percent.

NORTHWEST ORIENT AIRLINES

During 1969, Northwest Orient Airlines continued to demonstrate the financial vitality which had seen it lead all air carriers in net earnings in 1968. For the first 9 months, through September, total operating revenues were \$347,740,548, as compared with 1968 revenues of \$313,762,793. Net income after taxes through September 1969 was \$40,080,694, off slightly from the \$40,237,567 for the same period in 1968.

Northwest Orient added 19 new Boeing 727-200 stretched trijets to its fleet in 1969, bringing the

total number of the company's fanjet aircraft to 108 at year-end. Fifteen Boeing 747s were on order; 10 of them were to be delivered in 1970 and the remaining 5 in 1971. Fourteen McDonnell Douglas DC-10-20 long-range trijet transports were on order for delivery in 1972-73. Northwest Orient had an option for an additional 14 DC-10-20s for delivery in 1973 and 1974. The airline had also reserved delivery positions for 6 Boeing supersonic transports.

Principal 1969 route case decisions affecting Northwest Orient were in the Transpacific Route Investigation and the Twin Cities-California Service Investigation. Northwest Orient's transpacific route was amended to authorize service over a new Central Pacific segment extending between the co-terminal points New York/Newark, Philadelphia, Washington, Cleveland, Detroit, Chicago, Minneapolis/St. Paul, Seattle/Tacoma, Portland, San Francisco/Oakland/San Jose, and Los Angeles/Ontario/Long Beach, the intermediate points Hilo and Honolulu, intermediate points in Okinawa, and beyond Okinawa, intermediate points and a terminal point in Japan; and by adding New York/Newark, Philadelphia, Washington, Cleveland, Detroit, Chicago, Minneapolis/St. Paul, San Francisco/Oakland/San Jose, and Los Angeles/Ontario/Long Beach as co-terminal points with Seattle/Tacoma and Portland on its Great Circle segment to the Orient via Anchorage, Alaska.

As a result of the Twin Cities-California Service Investigation, Northwest Orient's route was extended from the Twin Cities to Los Angeles and to San Francisco/Oakland. These 2 cases provided Northwest Orient with its first access to California.

Following the awards, new services were inaugurated. On August 1, 1969, the first scheduled Northwest Orient flight ever to serve California was operated over the San Francisco-Hawaii-Tokyo route. On September 1, a new service, operating from New York to Chicago and then nonstop to Hawaii, was inaugurated. On October 4, Northwest Orient began service over its Twin Cities-California routes with 4 round trips per day in the Los Angeles market and 3 in the San Francisco market. Service over the Los Angeles-Honolulu-Tokyo route was to begin in late 1969.

Numerous service improvements over existing routes were also provided. Three additional transpacific round trips per week were added in May 1969, bringing Northwest Orient's total transpacific services to 35 passenger and 11 cargo round-trip flights per week. Through-plane service between the Twin Cities and London via Detroit was inaugurated on June 1 upon receipt of CAB approval of the Northwest Orient-Pan American interchange agreement. First nonstop service between Seattle and Detroit was inaugurated on October 4 and service was inaugurated from Milwaukee to Miami on December 17.

Northwest Orient was participating in a number of other CAB proceedings:

- Service to Omaha and Des Moines Investigation. Northwest Orient was seeking new routes from Omaha and Des Moines to many of the principal terminals on the East and West coasts, to the Twin Cities, and to Kansas City.

- Service to Salt Lake City Investigation. The authority being sought in this proceeding was a route from Salt Lake City to San Francisco, to Washington/Baltimore, to New York, and to Chicago and beyond.

- Pacific Northwest-California Investigation. The company was seeking extension of its route from Seattle/Portland to San Francisco/Oakland, Los Angeles, and San Diego. An examiner of the Civil Aeronautics Board recommended that Northwest Orient's route be amended by adding a new segment between the terminal point Seattle/Tacoma, the intermediate points Portland and San Francisco/Oakland (to be served through San Francisco International Airport and Metropolitan Oakland International Airport), and the terminal point Los Angeles/Ontario (to be served through Los Angeles International Airport and Ontario International Airport). The route would be subject to a condition requiring that all Pacific Northwest service between the Pacific Northwest and the San Francisco and Los Angeles international airports be rendered on a nonstop basis.

- Twin Cities/Milwaukee Long-Haul Service Investigation. Among the issues was the possibility of a route extension from the Twin Cities and Milwaukee to Boston, an extension earlier recommended by a CAB examiner.

A major expansion of Northwest Orient's main base in the Twin Cities of Minneapolis/St. Paul was begun in 1969 with completion set for 1970. This was to include 2 hangars capable of housing the 747 aircraft, together with expansion of shop facilities. Cost estimate was \$16,000,000. Also to be constructed at the main base was a flight services facility and cargo services building at an estimated \$3,500,000.

In Seattle, a new 747 hangar was under construction, to be completed by April 1970. Cargo-handling facilities were also being enlarged. New flight kitchens were constructed and were in operation at Seattle International Airport and at Anchorage International Airport.

Other physical improvements included new reservations offices in Honolulu and Los Angeles; new ticket offices in Honolulu, Cleveland, St. Petersburg, Atlanta, and Rochester, Minnesota; a new VIP lounge at Cleveland Hopkins International Airport; and new 747 second-level loading bridges at Anchorage and Minneapolis/St. Paul international airports.

Two rate increases were granted by the Civil Aeronautics Board in 1969. The first, in February,

approximated a 3.5 percent increase for all carriers; the second, approved by the CAB in September, provided Northwest Orient with an increase of approximately 7.78 percent, which was above the industry average of 6.35 percent.

Northwest Orient filed new transpacific 14-21-day excursion fares and bulk fares which became effective October 1. These new promotional fares were expected to stimulate additional tourism to the Far East.

Bulk unitization rates were also introduced across the Pacific on October 1, providing substantial reductions to shippers who containerize their traffic. A number of transpacific general commodity rates were reduced. Some specific commodity rates were reduced and certain new specific commodity rates were added.

Early in 1969, Northwest Orient unveiled its new corporate identity. Its hallmark was a new symbol, a contemporary derivative of the well-established red tail. The new look was being applied to everything to which the public is exposed. New aircraft delivered were in the new paint design. City ticket offices, boarding passes, flight bags, and even silverware use the new identity. Reasons for the decision to embark on a corporate identity program were essentially to achieve a consistency in presentation to the public and to achieve a more contemporary look.



In 1969, Northwest Orient unveiled a new corporate symbol, shown here on a Boeing 747 model.

Announcement of agreement in principle to merge with Northeast Airlines was made in New York on November 11 by Northwest Orient President Donald W. Nyrop and Northeast Airlines Board Chairman George B. Storer, Sr. Under terms of the agreement, Northeast Airlines stockholders would receive one share of Northwest Orient stock for each 5 shares of Northeast held. The proposed merger was subject to approval by the boards of directors of Northeast Airlines and Northwest Orient, the stockholders of Northeast Airlines, and the Civil Aeronautics Board.

OVERSEAS NATIONAL AIRWAYS

A major increase in fleet and traffic, plus diversification into the cruise ship, riverboat, and hotel businesses, marked the year at Overseas National Airways.

ONA acquired 3 DC-9-33s and 3 DC-8-63s, to bring its all-turbine fleet to 20 aircraft after one DC-8-55 had been sold. The company's charter business grew correspondingly. During the first 10 months of 1969, ONA's blue-and-white jets flew 1,163 transatlantic crossings; 1,012 of these were commercial charters between the United States and Europe, 76 were commercial charters between Canada and Europe, and 75 were military charters between the United States and Europe.

Total revenues exceeded \$50,000,000, as compared with \$30,000,000 in 1968.



As part of its diversification program, Overseas National Airways acquired Greene Line Steamers of Cincinnati, Ohio, operator of the last overnight riverboat in the United States, the Delta Queen. ONA was building a successor riverboat and a 15,000-ton cruise ship, and was also moving into hotel operation.

ONA continued its international Military Airlift Command flights, its domestic Logair flights for the Air Force, and its ground handling of cargo for the Navy's Quicktrans program. In addition, ONA began in 1969 to fly Quicktrans cargo.

ONA broadened its charter activity by flying the first inclusive tour charters to the Soviet Union, from New York. The company also inaugurated a pattern of affinity charter flights to Mallorca from various points in the United States for a major tour operator, American International Travel Service.

Looking to growing charter activity in the future, ONA ordered from McDonnell Douglas Corporation 3 DC-10F aircraft for delivery in 1973 and 1974, with options on 3 more. ONA's order was the first for the convertible passenger-cargo version of the DC-10.

As its air operations grew, Overseas National laid

the keel at the Rotterdam Dockyard Company for its 15,000-ton cruise ship. The vessel, as yet unnamed, will be launched in January 1971 and will go into service in the Caribbean and the Mediterranean in April of that year. With a service speed of 25 knots, she will be the fastest ship of her class. Although ONA planned to operate the ship—and a second one, if an option to build is exercised—independently of its other activities, the company hoped to link up charter flights with ship cruises.

Thanks to a favorable ruling by the Civil Aeronautics Board, ONA acquired in 1969 Greene Line Steamers, Inc., of Cincinnati, owner of the last overnight riverboat in the United States, the *Delta Queen*. ONA and the Greene Line will continue to operate the stern-wheeler between Cincinnati and New Orleans while building a new boat to succeed her.

In a third area of diversification, ground was broken for the Sonesta Beach Hotel at Cable Beach, Nassau. ONA Hotel Corporation has a 25 percent interest in the 400-room luxury hotel, participating in cooperation with the Hotel Corporation of America and Butlers Bank, Ltd.

OZARK AIR LINES

For Ozark Air Lines, 1969 was a year of expansion. The company received the longest route award ever made to a local service carrier, and another of almost equal length. This made the system two-thirds transcontinental as it extended to the East Coast from the Rocky Mountains, and from border state to border state traveling north and south.

At the same time, Ozark continued to set new passenger records and improved its all-turbine fleet with the addition of more jet aircraft.

The Civil Aeronautics Board award authorized Ozark service to New York and Washington, D.C., direct from several midwestern cities. Flights were inaugurated to the East Coast in April with nonstop flights from Peoria and Champaign/Urbana and direct flights from Sioux Falls, Sioux City, Des Moines, Waterloo, Cedar Rapids, and the Quad Cities. Prior to this award, service from these cities to the East was possible only by making connections at busy terminal cities.

In August, Ozark added service on its second major new authority with nonstop flights to Dallas/Fort Worth from both St. Louis and Tulsa.

In addition, during 1969 the company received approval from the CAB for a route realignment, reducing its 18 segments to 3. This gave the company authority to fly nonstop between virtually every noncompetitive pair of points on the system and provided for one-stop authority between almost all other cities. The award also gave Ozark authority to add new nonstop service between Milwaukee

and Omaha, Des Moines, and Kansas City, and made permanent Ozark's take-over of Braniff service in Waterloo and Rochester.

Another route award in October added authority to fly nonstop from Milwaukee to both Indianapolis and Louisville.

During the year, Ozark applied for a number of new routes which could add new cities to the system. In several different cases, the company was seeking authority to serve such new cities as Baltimore, Philadelphia, Cleveland, Pittsburgh, and Lincoln, and to operate between several cities already on the system which did not have direct service.

From a traffic standpoint, the company was fast approaching its second 2,000,000-passenger year, with 1,942,911 travelers having used the carrier through October. In 1968, the first 2,000,000-passenger milestone was reached, only 3 years after the first 1,000,000-passenger year in 1965.

On the way to this total, Ozark set a 6-month record of 1,108,594 passengers through June. Helping to establish the record were the 211,939 passengers who flew with Ozark in June, more than in any other month in the airline's history. That monthly record was surpassed quickly, however, when 220,191 passengers flew with Ozark in August.

During the year, Ozark received 4 new DC-9 jets. This made a total of 14 DC-9s and 21 FH-227B turboprops in Ozark's fleet, which is the most modern in the industry. No plane was over 3½ years old and all but 3 were less than 3 years old.



Ozark Air Lines added 4 McDonnell Douglas DC-9s in 1969, bringing the fleet total to 14 DC-9s and 21 Fairchild Hiller FH-227Bs.

In August, a regional concept of customer services management responsibility for the company's ever-expanding system was put into operation. It divided the system into 3 regions, with a manager for each.

At about the same time, the company added a new communications system which allows direct

telephone contact from dispatch to any pilot in any aircraft anywhere on the system, on the ground or in the air. The system ties the telephone into the company's radio network for transfer of such information as the latest weather and flight advice.

In September, the company's well-known "Go-Getter" theme became something else again around Ozark Land as a new inflight magazine was put aboard all aircraft for the first time. The *Go-Getter* is published quarterly for seat-pocket distribution and is edited for the pleasure of Ozark Air Lines' passengers.

Looking toward the future, the company signed an agreement for an all-new reservations system. It provides for storage of complete passenger information and automatic ticketing and keeps an inventory of available seats and sold seats. Every city on Ozark's system was to have direct access to the new reservations computer when it went into operation in 1970.

PAN AMERICAN WORLD AIRWAYS

During 1969, its 42nd year, Pan Am received delivery of the first Boeing 747 delivered to an airline and prepared its personnel and facilities for the aircraft's first flight, scheduled for early 1970.

Traffic and revenues for Pan Am during 1969 remained constant, while the airline suffered a net loss for the first time since 1930.

In 1969, the company was burdened by labor difficulties, the most serious a 4-day strike by the International Brotherhood of Teamsters in August. It was estimated that this walkout would cost the company some \$13,000,000.

The losses incurred during the year prompted the board of directors to pass on the third- and fourth-quarter dividend. Chairman Harold E. Gray said the decision by the board was considered prudent in light of the reduced earnings.

Late in 1969, Najeeb E. Halaby, president, was named chief executive officer by the board of directors, succeeding Harold E. Gray, who remained as chairman of the board of directors. Gray indicated he would retire from Pan Am in 1970. The board also named Richard S. Mitchell senior vice president and general manager-transport services. Mitchell had been vice president, aerospace services division.

In an effort to improve profitability, the company announced in October a reduction in schedules between the West Coast and Hawaii. The cutback was necessitated by the increased number of carriers certified to operate these routes by the U.S. government. Similarly, the company announced schedule cutbacks between New York/Newark and San Juan.

The company also filed with the Civil Aeronau-

tics Board for fill-up rights between New York and California on its international flights.

Before year-end, Pan Am received the first Boeing 747 delivered to any airline. Pan Am was to have 747s in service by early 1970 and, barring further delays, expected to have a fleet of 25 operating during the 1970 peak summer season. The Boeing 747 was expected to have an immediate effect on the company's profit situation.

Chairman Gray also noted that "merger within the industry can and will do much to solve the airlines' problems." He said that "in addition to these benefits, domestic rights would strengthen Pan Am's position, and we are prepared to investigate opportunities that may arise for either acquisition or merger."

SATURN AIRWAYS

For Saturn Airways, 1969 was a period of growth and expansion in commercial charter operations.

Utilizing a fleet of DC-8 fanjets, the U.S. supplemental air carrier operated a record total of over 796,470,000 revenue passenger-miles during the first 9 months of 1969. Commercial revenues for the 9-month period reached 51 percent of total operating revenues, as compared with 30 percent in the same period in 1968.

In April 1969, Saturn added a fourth DC-8 jet to its expanding fleet of modern fanjet aircraft, which included 2 252-passenger DC-8-61F stretched jets and 2 180-passenger DC-8-50 series jets. In keeping with the company's fleet modernization program, Saturn removed its DC-6A aircraft from service and offered these piston-powered aircraft for lease or sale. Further expansion of the airline's fleet was planned and a number of aircraft purchase proposals were being evaluated.



Saturn Airways added a fourth McDonnell Douglas DC-8 and removed its DC-6A piston-powered aircraft from service.

On June 15, 1969, Saturn commenced operation of an extensive series of inclusive tour charter (ITC) flights for the Rogal-Colpitts Travel Corporation. Through mid-August, the airline operated twice-weekly round-trip flights from major East Coast cities to the Hawaiian Islands via Las Vegas and Oakland/San Francisco. The ITC program provided for weekly round-trip flights to these cities through May 1971.

Saturn anticipated further expansion into the ITC markets, both domestic and international. The international programs being developed included such exciting destinations as England, Spain, and Africa.

During the year, a number of key executive appointments and promotions were made, including the promotion of Howard K. Howard to the position of vice president-marketing and planning. John F. Riley, Jr., was appointed vice president, secretary, and general counsel; Mac E. Driggs was appointed vice president-sales; and F. Kelley Weiss joined Saturn as vice president-operations.

In early 1969, Saturn received the Silver Medal Award of the New York City United Services Organization for its outstanding performance in international airlift for the Military Airlift Command. The airline also received the National Safety Council's Award of Merit for its fine safety record.

On January 28, 1969, Saturn Airways' common stock and debentures were listed for the first time on the American Stock Exchange, and on November 17, 1969, Saturn began its 25th year of air charter operations, serving military and commercial markets throughout the world.

SFO HELICOPTER AIRLINES

A new direct sales program, new leadership, and the initiation of a streamlined schedule marked 1969 as a year of change and progress for SFO Helicopter Airlines.

While hit by a sharp decline in passenger traffic during the last quarter of 1969, reflecting a general decline in air travel throughout the nation, SFO Helicopter managed to establish an increase in total traffic over the previous year and to claim several new records.

In August, an all-time high of 33,220 revenue passengers was carried by the airline, breaking the previous record of 32,868 which had been set in June 1969. In addition, SFO Helicopter carried more passengers in July 1969 than in any other July in its 8-year history.

Much of 1969's success was attributable to a special direct sales and marketing program designed to increase communication between SFO Helicopter and airline reservations and sales personnel in metropolitan areas throughout the United States.

The purpose of the program was to acquaint the

airline sales personnel and travel agents with the complex ground travel situation in the San Francisco Bay Area. Starting in May 1969, SFO sales representatives traveled to all major domestic markets to explain how the airline, working in cooperation with the major domestic carriers, could help ease the ground travel problem and at the same time save money for the traveler.

In addition to the sales program, SFO Helicopter introduced a new schedule designed to improve service between the Bay Area's major airports and surrounding communities. One-gate service at TWA's San Francisco International Airport facilities was initiated to improve enplaning and deplaning at the airport and decrease time on the ground.

In September 1969, it was announced that Joseph A. Young would succeed M. F. Bagan as president of SFO Helicopter. Young, a veteran of some 35 years in the air transportation industry, including 14 years with Saturn Airways, said on taking office: "SFO's potential is limitless in its opportunities to serve the community. The immediate job will be to apply some new, sophisticated, and workable techniques to bring about a steady acceleration of the company's already strong position among the third-stage carriers in the nation."

During the year, SFO Helicopter assured full utilization of its fleet of Sikorsky S-61 and S-62 helicopters by completing leasing arrangements with 3 different firms which were to use the equipment for carrying men and supplies to offshore drilling operations off the coasts of Canada, Alaska, and Australia.

One of the highlights in 1969 for SFO Helicopter was the announcement by the National Safety Council that the airline had been awarded the council's Certificate of Commendation. The award, the third highest in the annual Aviation Safety Awards program, is granted only to carriers that operate during the calendar year without a fatal accident and with a rate for all accidents that is lower than the average in its airline category for the preceding 3 years.

SFO Helicopter at year-end was operating a fleet of 3 26-passenger Sikorsky S-61 helicopters over a 102-mile system within the San Francisco Bay Area. The carrier services Marin County, Berkeley, Contra Costa County, San Francisco and Oakland international airports, Palo Alto, and San Jose with more than 100 flights daily.

SOUTHERN AIR TRANSPORT, INC.

The 22nd year of Southern Air's operation saw the airline making progress by purchasing new Lockheed L-100-20 stretched Hercules airfreighters and by moving into new facilities at Miami International Airport, Miami, Florida.

Two Hercules were put into operation in early January, offering customers for the first time an aircraft capable of carrying outsize cargo with payloads up to 48,000 pounds. The Hercules features ease of ground handling, rear loading at ground level or at truck-bed height into an unobstructed cabin 46 feet long, and the capability of operating into airports that cannot accommodate most jet-powered equipment.



Southern Air Transport introduced into service the Lockheed-Georgia L-100-20 stretched Hercules transport, capable of carrying outsize cargo and payloads up to 48,000 pounds.

Training of flight crews and maintenance personnel was accomplished at Marietta, Georgia, by Lockheed-Georgia Company. Also providing training were Allison Division and Hamilton Standard. A number of cargo, operations, and sales personnel were trained in Miami with the assistance of Lockheed. Training consisted of techniques for loading the Hercules and for ground handling.

The requirement for the Hercules came from almost every continent in the world. Some of the cargo handled included oil rigs to Africa, aircraft parts to England, desalinization units to Antigua, and helicopters to Australia. Space satellites, tractors, and canning machinery were also transported. A good part of the domestic operation was the movement of JT9D aircraft engines.

With the acquisition of the Hercules, the DC-7s and C-46s were phased out of operation. Much of Southern Air's Bahamas traffic had utilized the C-46s. However, most customers were converted to the larger and better-suited DC-4s. The DC-4 lends itself to palletized cargo, and greater utilization of the aircraft was realized on the shorter Miami to Bahamas traffic. Hotel supplies, foodstuffs, and live pullets were the commodities most in demand for the Bahamas. Livestock, dynamite, building materials, and nursery stock were shipped in large quantities throughout the Caribbean area.

Also operating from the Atlantic Division was one DC-6 on military contract carrying military person-

nel and supplies from Patrick Air Force Base to bases in the Bahamas and the Caribbean.

Southern Air's new building, located on an 8-acre site, has 24,000 square feet on the first floor, which houses executive, scheduling, maintenance, and sales offices, and 3,600 square feet on the second floor, which houses the accounting department and the radio shop. Cargo warehouse space in the new facility was increased by 50 percent, allowing cargo to be accumulated in planeload lots in specified areas of the warehouse. This system enables faster and more efficient loading of the aircraft with less handling of freight. A new 45,000-pound outside scale was installed for convenience in weighing palletized, containerized, or outsize cargo before the cargo enters the warehouse. Larger and better-equipped shops were provided in the new building. Electric, hydraulic, radio, and sheet metal shops were handling all required maintenance. An expanded supply room was able to handle inventory more efficiently than before.

Earnings and revenue for 1969 showed an improvement over 1968 for the first 3 quarters. Cargo poundage for the same period increased more than 5 percent over 1968, and ton-miles increased 29 percent.

TEXAS INTERNATIONAL AIRLINES, INC.

At the stroke of midnight March 31, 1969, Trans-Texas Airways disappeared and Texas International Airlines, Inc., was born. The name change was felt to be more in keeping with the rapidly growing airline.

Texas International boarded 1,586,034 passengers through September 1969, showing a 10.6 percent increase over the same period in 1968. The airline's cargo ton-mileage increased 13.1 percent over the same period in 1968, to 3,598,938, and cargo pounds transported climbed to 32,486,223, reflecting a 10.8 percent gain in mail, freight, and express.

The company reported a \$439,000 operating loss through September 1969, as compared with an operating profit of \$999,000 in 1968. A net loss of \$2,734,000, as compared with \$569,000 for 1968, was reported.

The Houston-based regional service carrier at year-end had a fleet of 25 Convair 600s and 15 DC-9s; 4 of the DC-9s were the stretched 99-passenger Series 30 version.

Texas International added 3 new cities to its route map in 1969. On June 2, the airline began service to Denver, Colorado, from 7 cities in Texas and Louisiana pursuant to new authority granted the airline by the Civil Aeronautics Board in the Reopened Pacific Northwest-Southwest Case.

In July, the CAB issued a final decision in the Service to Albuquerque Case. The airline received

nonstop authority in the Dallas-Albuquerque market and a new nonstop segment between Albuquerque and Los Angeles.

On November 3, the CAB granted Texas International unrestricted authority between Salt Lake City, Houston, San Antonio, and New Orleans, thus adding the ninth state to Texas International's system. Salt Lake City and Denver were to be co-terminals. Service was to begin in the early part of 1970.

Texas International's 2 largest stations, Dallas and Houston, were relocated into new facilities in 1969. At Love Field in Dallas, the airline leased a large terminal segment with 6 gate lounges, 2 jetway boarding entrances, and expanded office space.



Texas International's new Houston terminal design won top recognition from an interior design trade magazine.

The Houston move occurred the first part of June with the opening of the city's new Intercontinental Airport. Texas International's colors—purple, gray, and white—already adopted for the fleet of planes, were used as a basis for the color schemes; and the soft, rounded lines of the aircraft exteriors were repeated in the interior terminal forms of ticket-lift desks, information pylons, the kiosk in the center of the flight station, and the low railing dividing the individual departure lounges. Installations in New Orleans and Dallas were similar.

Contract magazine, a national monthly publication in the interior design field, named Texas International and the airport architects, Golemon & Rolfe and G. Pierce, Goodwin & Flanagan, the winner of the Airports Design Category of the Contract 1969 Awards Program for the Houston installation.

Color was the word in fashions for the women of Texas International. In May, women ticket agents and passenger service agents donned attractive, soft, feminine jumpers with jackets in fuchsia and purple. Hostesses joined the well-dressed women's world in November with the introduction of their new uniform, a mix-and-match ensemble consisting of a dress, a skirt and overblouse, and wide-legged

pants plus a long pull jacket. Carrying out the Texas International color scheme, the hostesses were in gray, electric purple, and flaming pink.

Projected plans for 1970 included the leasing of 2 Beechcraft 99A 15-passenger aircraft to test the marketability of the aircraft on some of Texas International's shorter routes. The planes were to be delivered in January and in use by the first part of February.

TRANS CARIBBEAN AIRWAYS

By the spring of 1969, Trans Caribbean had implemented all of the new services authorized by the Civil Aeronautics Board's decision in the Caribbean Basin Investigation announced in November 1968. This decision had the effect of tripling the airline's certificated route system and established Trans Caribbean as the only carrier authorized to operate direct service to Haiti from the northeastern part of the United States, to serve Aruba and Curacao in the Netherlands Antilles from the northeastern part of the United States, and to serve the Virgin Islands of St. Thomas and St. Croix from mainland terminals New York/Newark and Washington, D.C. As a result of this expansion, new offices were opened in Port-au-Prince, Curacao, St. Thomas, and St. Croix and scheduled passenger service by mid-year was running well ahead of the previous year. The airline also opened new sales outlets in New York City.

In March, Trans Caribbean occupied over 120 feet of new counter space at the Isla Verde International Airport of San Juan, doubling the size of the previous facility. Shortly thereafter, as part of the same improvement, a new Flying Island Club Lounge was inaugurated.

In the continuing improvement and upgrading of its facilities, Trans Caribbean was gearing for occupation before year-end of the spacious new \$40,000,000 terminal complex which it will share with National Airlines at John F. Kennedy International Airport in New York.

On September 25, Trans Caribbean Airways announced the filing with the Civil Aeronautics Board of an agreement with American Airlines to provide through-service flights from a number of mainland cities to points served by Trans Caribbean Airways in the Caribbean. Under the agreement, through-service flights will operate from San Francisco, Los Angeles, Chicago, Cincinnati, and Boston.

In May and June 1969, the airline took delivery on 2 new Boeing 727-200 aircraft, replacing smaller-capacity aircraft which had been on lease. At year-end, in addition to the 727-200s, the airline's fleet consisted of one 727-100C, 3 McDonnell Douglas DC-8s, and 3 stretched DC-8s of the -61 series. One aircraft of the -55 series was on lease to another

carrier. In October, President O. Roy Chalk announced plans for a comprehensive time-sharing program for joint use of aircraft with other operators on a seasonal, monthly, weekly, or day or night basis.



Trans Caribbean Airways was preparing for the arrival of its Boeing 747s, which it planned to put into operation in 1970 on its New York-San Juan service.

During the first 10 months of 1969, Trans Caribbean carried over 1 billion revenue passenger-miles in both commercial and Military Airlift Command services, with the former registering a 16 percent increase over 1968; military passenger volume was only half as much as in the previous year. System cargo volume for the same period was up a hefty 86 percent, accounting for 67,000,000 ton-miles in the January-October period, as compared with 36,000,000 in 1968.

The airline expected to put Boeing 747 aircraft in operation in the New York-San Juan service before the end of 1970.

Revenues generated by the airline accounted for about 85 percent of gross income. Other income was received from activities conducted in the field of communications through component companies, which included *El Diario/La Prensa*, the largest Spanish language daily newspaper in the United States; in Puerto Rico, Station WRSJ Radio San Juan and WTSJ Channel 18, which offers English language programming; D.C. Transit, one of the largest and most modern rapid transit systems in the country; and the *Examiner*, a Washington, D.C., weekly newspaper.

TRANS INTERNATIONAL AIRLINES

Trans International Airlines, the first all-jet supplemental air carrier, enjoyed another successful year in 1969.

TIA, based in Oakland, California, took delivery of 2 McDonnell Douglas DC-8-63CF aircraft in April and August 1969 and expected to take deliv-

ery of 4 additional aircraft of the same type by April 1, 1970. At that time, TIA's all-fanjet fleet was to consist of 7 DC-8-63CF aircraft, 3 DC-8-61CF aircraft, and 2 Boeing 727-171C aircraft. This fleet will be larger than that of any other U.S. supplemental air carrier.

TIA also had on order 2 330-passenger McDonnell Douglas DC-10-30 wide-bodied trijet aircraft for delivery in April and May 1973 and had an option for 2 additional DC-10s for delivery in April and May 1974.

In September 1969, TIA began installing the Litton inertial navigation system in its aircraft and expected to be the first airline in the world to have its international fleet so equipped.

TRANS WORLD AIRLINES

Trans World Airlines in 1969 began flying around the world, with inauguration of daily service across the Pacific, and, in the same year, it became the No. 1 carrier over the Atlantic.

Since first filing for a round-the-world route in 1944, TWA has steadily expanded its routes. On April 11, 1969, the carrier was certificated to fly via the Pacific and on August 1 started daily transpacific and round-the-world flights each way.

In June, TWA became the No. 1 airline across the Atlantic in terms of revenue passenger-miles flown and in October it offered more cargo lift from more U.S. cities across the Atlantic than any other carrier.

The new transpacific route, via Hawaii, Guam, Okinawa, and Taiwan, closed the Pacific gap between California and Hong Kong on TWA's worldwide system. The 4 Pacific points boosted to 67 the number of major centers in the United States, Europe, the Middle East, Africa, and Asia served by TWA, including 40 U.S. cities. It raised TWA's unduplicated route miles by 17.5 percent, to 59,424 miles.

On the basis of figures for 10 months and estimates for November and December, the airline in 1969 offered the public 25.9 percent more available seat miles than in 1968 (up from 28.1 billion in 1968 to 35.4 billion in 1969) and flew 11.3 percent more passengers (from 13,600,000 in 1968 to 15,100,000 in 1969) and 14.8 percent more passenger-miles (from 15.2 billion in 1968 to 17.5 billion in 1969).

In the field of cargo service, TWA estimated it increased its capacity 12.5 percent over 1968 (5.9 billion available in 1969, as compared with 5.2 billion in 1968) and flew 17.6 percent more cargo ton-miles (606,500,000 in 1969, as compared with 515,800,000 in 1968).

Within the 3 categories of this cargo volume, freight ton-miles in 1969 rose an estimated 19.2 percent over 1968 (from 358,400,000 to 427,300,000),

mail ton-miles increased 15.3 percent (from 141,500,000 to 163,200,000), and express ton-miles increased 1 percent (from 15,800,000 to 16,000,000).

In addition to round-the-world and transpacific service, TWA during the year inaugurated nonstop flights between Washington, D.C., and Europe and direct flights between Hartford/Springfield and Europe. Additional service on TWA's international routes included a second weekly flight between the United States and East Africa.

On domestic routes, TWA in 1969 introduced nonstop service between New York and Tulsa, Chicago and Harrisburg, Chicago and Hartford/Springfield, Los Angeles and Wichita, and Los Angeles and Honolulu. TWA's increased service included a 26 percent jump in winter flights between 13 U.S. cities and Phoenix/Tucson, to 24 round trips each day.

The airline took delivery of 28 Boeing jets in 1969, increasing its all-jet fleet to 224. TWA had on order 47 subsonic jets through 1972, including 15 Boeing 747s, 22 Lockheed L-1011 TriStars, 2 Boeing 707s, and 8 Boeing 727s. The carrier also was holding positions for 6 Concorde supersonic transports and 12 Boeing SSTs. (TWA held the first delivery position on the U.S. supersonic transport.)

TWA in late 1969 was gearing up its worldwide operations for the introduction of the 747 on transcontinental and transatlantic routes in early 1970. A vast ground facility expansion program designed to facilitate the new 747s and supersonic jets included the completion early in the year of an addition to the airline's engine plant in Kansas City, Missouri, that more than doubled the building's capacity. Late in the year, the first class of TWA hostesses graduated from the carrier's new Breech Training Academy in Kansas City. Meanwhile, in New York, TWA's superjet-generation Flight Wing One addition to its terminal at Kennedy International Airport was nearing completion, with its opening set for the end of February 1970.

At year-end, TWA was in the final stages of setting up its multiprocessing computer system at Rockleigh, New Jersey, which will support the airline's new centralized, fully automated reservations service. The new system, which was to be operational in early 1970, will include such features as a systemwide flight information service and a tie-in with the Hilton Hotel reservations system.

On October 1, TWA announced the acceptance of the airline industry's first Boeing 747 simulator for pilot training. Earlier in the year, the carrier opened its Sales Training Center in midtown New York, which features many of the advanced training techniques used in pilot instruction.

Inflight innovations initiated by TWA during the year included the purchase of microwave ovens for preparing meals in seconds for individual tastes and the testing, on select routes, of a system which offers a choice between 2 movies, one for "general audi-

ences" and the other for "mature audiences." The airline's hostesses also donned their new summer wardrobe in 1969. The outfits featured blue, brown, and green jackets with matching plaid skirts. (The hostesses introduced their fall ensemble in 1968.)

TWA in 1969 was recommended by a Civil Aeronautics Board examiner to serve Des Moines and Omaha from New York, Washington, Baltimore, Los Angeles, San Francisco, and Chicago in the CAB's Service to Omaha and Des Moines Case.



TWA was gearing its worldwide operations and crews for the introduction of the Boeing 747 on transcontinental and transatlantic routes in 1970.

On April 24, Ernest R. Breech retired as chairman and was named honorary chairman of the board at the annual TWA shareholders meeting. He was succeeded by Charles C. Tillinghast, Jr., who had been president since 1961; Tillinghast was elected chairman and chief executive officer. F. C. Wiser, Jr., who had joined TWA in October 1968 as executive vice president, was elected president and chief operating officer.

Midway through the year, TWA expanded its diversification activities. The Special Services Department, which directed the airline's government contract projects, management of associated airlines, and business development that included acquisitions and mergers, was divided into 2 new departments. The newly created Corporate Development Department was made responsible for new acquisitions and mergers; Special Services continued to direct the operational activities.

Some 1,000,000 visitors were estimated to have

toured the Kennedy Space Center in 1969 under a National Aeronautics and Space Administration program operated by TWA. More than 2,000,000 persons have taken the tour since 1964, when the airline started performing the base-support operations at the space center.

The opening in 1969 of 5 new hotels—in Kuwait, Mainz, Marbella, Addis Ababa, and Caracas—brought to 46 the number of Hilton Hotels in 29 countries, Hawaii, Puerto Rico, and the Virgin Islands operated by Hilton International Company, a wholly owned subsidiary of TWA since 1967. In addition, the Nairobi Hilton started taking guests late in the year, although the formal opening was to be in early 1970. Eight more hotels were under construction and 16 were in development.

UNITED AIR LINES

The most significant event for United Air Lines in 1969 involved a reorganization under which United became a wholly owned subsidiary of UAL, Inc., a holding company.

The reorganization plan, first announced in December 1968 and approved by stockholders 4 months later, became effective August 1 when the tax-free exchange of United Air Lines stock for UAL, Inc., stock was affirmed by the Internal Revenue Service. The objective behind formation of the holding company was to develop a diversified enterprise that would both complement and be complemented by the air transport industry.

The airline operation continued under the subsidiary company, United Air Lines, Inc., with G. E. Keck as president of both the holding company and the subsidiary.

In September, in its first move, UAL, Inc., purchased a 39 percent interest in the planned \$13,000,000 Hotel Stanford Court in San Francisco. The 400-room hotel was to be rebuilt to provide luxurious accommodations, with occupancy scheduled by early 1971.

Two decisions in 1969 by the Civil Aeronautics Board enabled United to add to its existing route structure and to increase its service to the Hawaiian Islands. As a result of the authority granted in the domestic phase of the Transpacific Route Investigation, United was authorized to operate nonstop between Honolulu and 11 mainland cities. The company began daily nonstop service from Chicago on August 1, from San Diego on August 25, and from New York City on October 1. The last segment is the nation's longest domestic air route—4,979 miles. Nonstop service from other cities was to be activated in the near future. Previously, United's service between Hawaii and all mainland interior points required stops at Los Angeles or San Francisco.

The other major addition involved the granting of nonstop jet service to Los Angeles from Memphis, Birmingham, and Huntsville. This gave the Huntsville aerospace center its first direct service to the West Coast.

The authority also enabled the company to offer the first direct same-plane service between Greensboro and Raleigh/Durham, North Carolina, and the West Coast, and additional same-plane service between Norfolk and Newport News, Virginia, and California.

United took delivery of 10 long-range McDonnell Douglas DC-8-62s during 1969 and received the last of 75 short-range Boeing 737s on order. The twin-engine jet was introduced in 1968 and enabled the company to begin replacing all piston and turbo-prop aircraft.

Delivery of the 737s and of the DC-8-62s brought United's jet fleet up to full strength until arrival of the Boeing 747s beginning in mid-1970 and of the McDonnell Douglas DC-10s beginning in late 1971. United had on order 18 747s and 30 DC-10s.



United Air Lines took delivery of 10 long-range McDonnell Douglas DC-8-62s (shown) and received the last of 75 short-range Boeing 737s on order.

United received its first 2 Link VAMP flight training visual systems and began training Boeing 727 flight crews with them during the year. The VAMP (Variable Anamorphic Motion Picture) adds lifelike conditions to simulated flight and allows pilots to practice approaches, landings, and takeoffs in all types of weather conditions, including Category II and Category III. Two more systems, or units, were scheduled for delivery in 1970.

The company placed an \$11,300,000 order for more than 14,500 seats for the 747 and the DC-10, the largest order ever for aircraft seats. United also had an option to buy an additional \$7,800,000 in seats, which would bring the total value of the order to \$19,100,000.

In 1969, United organized the largest Hawaiian airlift ever operated for travel agents; 2,000 agents were flown to the islands between October and December. The 7-day tours, which provided travel

agents with firsthand knowledge about specific resorts and vacation areas, represented the most extensive familiarization program ever conducted by any carrier serving Hawaii.

The company had more than 20 major construction projects either planned or under way and most were to be completed by the end of 1970. The expansions resulted from forecasts of increased traffic and from new aircraft deliveries. For the most part, they involved new construction or improvements of hangars and terminals at airports across the country.

Included in projects at the company's engineering and maintenance base in San Francisco were a new \$2,000,000 test cell, for operational testing of DC-10 and 747 engines, scheduled for completion in early 1970, and expansion of an engine shop at a cost of about \$6,000,000. Also to be built at the San Francisco base in 1970 were a 2-story maintenance and office building at a cost of \$4,000,000 and a 4-story expansion of the shop and office building at a cost of \$9,000,000.

Estimates late in the year (including Military Airlift Command operations) indicated total revenue passengers for 1969 of about 30,171,512, an increase of 10.8 percent over 1968; 25,506,900,000 revenue passenger-miles, for a gain of 15 percent; and a total of 774,324,000 cargo ton-miles, for an increase of 15.7 percent.

By the end of the year, United's fleet included 59 standard DC-8s, 30 DC-8-61s, 10 DC-8-62s, 15 DC-8F jet freighters, 86 Boeing 727s, 28 Boeing 727-222s, 36 Boeing 727 QCs (quick change), 75 Boeing 737s, and 20 Caravelles.

UNIVERSAL AIRLINES

Four major developments occurred at Universal Airlines in 1969: placement of an order for Boeing 747s, creation of a new marketing department, inauguration of service to Mexico, and phasing into an all-turbine fleet.

Universal became the second airline in the world to order Boeing 747 convertible airplanes. These aircraft can be converted from passenger to freight configuration in 10 hours. In passenger arrangement, the 747 can accommodate 490 passengers at a speed of 625 miles an hour. The extra-wide cabin and double aisles afford a level of comfort and spaciousness unmatched in previous interior accommodations. Passengers can board through 10 double-width doors, 5 on each side.

In freight configuration, the 747 is the first airplane capable of handling containers 8 feet high and 8 feet wide, the dimensions of a standard truck body. Fourteen such units, each 20 feet long, and 2 units, each 10 feet long, can be carried on the main deck. Also, the lower compartments can carry 9 pallets 88 inches by 125 inches in size, standard on

707 jet freighters. The Universal 747 convertibles will go in service in May and June 1971.

At mid-1969, Universal created an entirely new marketing department headed up by David A. Highman, an experienced senior executive. Sales offices and management were added in Mexico City and Los Angeles; others were already functioning in New York, Chicago, and Detroit. An extensive advertising campaign was developed involving national media such as *Business Week* and the *Wall Street Journal* as well as travel and freight trade publications. In the fall of 1969, Universal began a long series of network TV coverage, the first supplemental airline to do so. New promotional booklets and folders were also produced to round out the marketing effort.



Universal Airlines, the largest supplemental freight carrier, phased into an all-turbine fleet in 1969 and arranged to lease 2 Boeing 747C passenger/freighter convertibles starting in 1971.

Universal began service to both Mexico City and Acapulco in the fall of 1969. These flights carried inclusive tour charters on long-range series, as well as affinity groups. Universal hoped to expand and develop the Mexican travel market.

In 1969, the company commenced the full phase-out of remaining piston aircraft, leaving it with an all-turbine fleet: turboprop Electra and Argosy freighters and pure-jet DC-8s in both passenger and freight configurations.

Universal's passenger revenues increased dramatically in 1969 and the company continued to be the largest hauler of airfreight for the automotive industry.

WESTERN AIR LINES

For Western Air Lines, 1969 was a year of expansion and transition. The addition of a fleet of 30 Boeing 737 twin-jet aircraft and of 5 Boeing 707-347C intercontinental jets vastly increased Western's seat capacity. The 707s were ordered for the anticipated new Hawaii route awards; the twin-jets

were to replace the Lockheed Electras on mainland routes.

While awaiting the final decision in the Transpacific Case, which was delayed from January to July through a series of postponements, Western operated 707s on its California-Twin Cities and California-Mexico routes. The opening of new facilities in Honolulu and the training of personnel for Hawaii service also were stretched by the postponements.

The final decision in the Transpacific Case gave Western new routes from Hawaii to Anchorage, San Diego, Los Angeles/Long Beach/Ontario, San Francisco/Oakland/San Jose, Phoenix, Denver, and Minneapolis/St. Paul. The decision was released on July 22; only 69½ hours later, on July 25, Western inaugurated an initial service pattern that was to provide 34 round trips a week and provide new Hawaii service for every major airport to which the airline had been certificated in the case.

After the introduction of 737s, Western converted 3 of its Electras for all-cargo service, which began on April 3 on 3 routes: Anchorage-San Francisco-Los Angeles, Los Angeles-Minneapolis, and San Francisco-Denver-Twin Cities. Five other Electras were converted to passenger-cargo dual configuration for use on the company's intra-Alaska routes. The transfer of the turboprop Electras to Alaska left Western with all jet aircraft on routes south of Seattle/Tacoma. The company continued to use 4-engine jets on Seattle-Anchorage and other major Alaska routes.

Western participated in several major route cases, 3 involving transcontinental routes. The Northern Tier Case concerned routes from the Pacific Northwest through the Twin Cities and Milwaukee to points on the East Coast including New York and Washington, D.C.

Western was also seeking East Coast routes in the Service to Salt Lake City Case and in the Additional Service to San Diego Case. In the latter, Western was recommended by the CAB examiner for nonstop routes linking San Diego with New York and Washington. The company also sought a San Diego-Chicago route in the case.

In the Omaha-Des Moines Case, Western was recommended by the examiner for routes linking Omaha with Seattle-Portland, Denver, and Chicago. All of the cases were awaiting further action by the CAB at year's end.

On October 22, Terrell C. Drinkwater, president of Western since 1947, became chairman of the board. He was succeeded as president and chief executive officer by J. Judson Taylor, formerly senior vice president and treasurer and board member. Taylor is a veteran of 27 years with Western.

During November, Western inaugurated service to Hilo, Hawaii, and announced several innovations on its Hawaii service aimed at attracting a greater share of the market in 1970. They included inflight

movies; stereo with special headsets, the newest and best in the industry; 2-plus-2 seating for coach passengers; and increased seat pitch in coach and economy class for all Hawaii flights. The 2-plus-2 seating means that whenever the middle seat in the coach section is unoccupied, the center armrests may be replaced with a portable "Aloha Table" with armrests. This adds up to 3 inches of seat width. Seat pitch increase is to 38 inches (the same as for first class) from the previous 34 or, in some cases, 36 inches.

Eleven of the company's 707 and 720B jets, used in Hawaii service, were to have these features installed. Modification began at the end of the year, with introduction of the new features beginning on January 15. Replacing some of these aircraft on domestic routes were 6 newly acquired Boeing 727-200 trijets.

In addition to the service innovations, the year ended for Western with a thorough examination of its entire operation, procedures, and organization, to insure the best possible service to the public and to meet the challenges of the seventies.

WORLD AIRWAYS, INC.

World Airways made significant progress in 1969 and stepped up planning for the 3 Boeing 747Cs that were to be delivered to the company early in 1971. The addition of the 3 747Cs will almost double the company's fleet capacity. At year-end, World owned 9 707-320Cs and 6 727-173Cs.

The flexibility of the 747C to accommodate a full planeload of passengers or of cargo, or a combination of both passengers and cargo, will permit the company to avail itself of many revenue possibilities denied to single-purpose aircraft.

In the United States, World opened new offices in Detroit, Boston, and Philadelphia; overseas, new offices were opened in Copenhagen, The Hague, and Rome. These sales offices provided the company with important new bases in strategic areas for more intensive development of commercial traffic.

The excellent progress made by First Western Bank, acquired by World in mid-1968, continued during 1969. An 11 percent increase was reported by the bank. Total resources as of September 30 were \$931,826,000, an increase of over \$38,000,000 from 1968. Six new branches were opened to bring the statewide total of First Western Banks to 93.

World was named recipient of the National Safety Council's Award of Merit for 1968, marking the ninth year that the airline had won National Safety Council recognition for outstanding flight safety.

A record number of commercial charter flights were carried by World to holiday destinations in Europe, Hawaii, the Caribbean, the Orient, and Latin America. Those who had planned to travel

abroad in 1968 but decided to wait a year, and those who had originally planned to go in 1969, combined to make 1969 a banner year for overseas charter travel. In addition, charter travel from Europe to the United States continued to expand by virtue of World's efforts and of the vigorous promotional campaign by the U.S. Travel Service.

World was one of 6 airlines—and the only supplemental airline—to receive the USO Gold Medal Award, highest honor bestowed by the United Services Organization of New York City. World was cited for having safely transported more than 500,000 armed forces personnel since 1966. Approximately 200 members of World's crews received special awards of recognition and appreciation bestowed by the Military Airlift Command (MAC). These certificates were awarded for the participation of the individuals in the support missions conducted for MAC.

General Howell M. Estes, Jr., who retired from the Air Force in August after a distinguished career spanning 33 years, was named senior vice president-planning and development. He was also elected a director of World Airways and of Worldamerica Investors Corporation. During his career, General Estes served in a wide variety of duties, including major assignments in research, planning, and development. He became commander of the Military Airlift Command in 1964 and was promoted to 4-star rank. Among his honors was the General H. H. Arnold Trophy, highest military honor of the Arnold Air Society, for his contributions to military aviation and aerospace programs.

George Killion, a director of World Airways, was elected to the board of directors of First Western Bank. Killion was also serving as chairman of the board of Metro-Goldwyn-Mayer and as a director of American President Lines and of the Communications Satellite Corporation.

In another executive appointment, Brian A. Cooke, a director of World, was named a senior vice president.

The progress of the company in 1969 provided a starting point for further developments in the seventies. With the advent of the 747, the company expected to continue its leadership with a balanced fleet of convertible aircraft and unusually strong capital resources.

VERTICAL LIFT AIRCRAFT

Rotary-wing aircraft continued to prove their versatile capabilities on the battlefield and in civil assignments.

In Vietnam, "Dust-Off" was the call signal for the air ambulance helicopter. These lifesaving vehicles of the Army Medical Department averaged 17,000 evacuations per month in 1968 and 1969. For the first time in history, no casualty was more than 20

to 25 minutes away from sophisticated modern hospital facilities. The Army considered evacuation a vital link in its health care system.

Statistics based on 766,000 Vietnam combat missions showed that a helicopter was hit by ground fire once in 325 combat sorties, downed only once in 6,400 sorties, and lost to ground fire beyond repair only once in about 13,000 sorties.

The Army's Flying Crane and Chinook helicopters added still another capability to the rescue roles. These heavy-lift helicopters were picking up downed aircraft and airlifting them back to maintenance bases, thereby saving millions of dollars and helping to keep the inventory of combat aircraft up to strength.

The helicopter has changed the military concept of the horizontal approach to "vertical envelopment" tactics. To put men, equipment, supplies, and artillery wherever needed, helicopters are an important command tool.

In 1969, the Army was flying the light observation OH-6 helicopter, which was operating near the nap of the earth and finding the enemy. The Huey-Cobra (gunship) was providing cover. The armed Huey was serving as troop carrier, ambulance, reconnaissance aircraft, resupply aircraft, and personnel transport, and in psychological warfare operations.

The Navy and the Marine Corps were using the 27-place turbine-powered Sea Knight transport and the 12-place twin-turbine Seasprite utility aircraft. The Air Force had the 28-passenger turbines, the Jolly Green Giants, and the 12-place Huskies.

In response to continuing requests, the Vertical Lift Aircraft Council published a 1969 *Directory of Foreign Helicopter Operators—Military—Civil Government—Commercial*. Based on available information, the directory listed 884 operators of 6,754 helicopters in 104 countries. This was a marked increase over the 1965 directory which listed 544 operators of 4,116 helicopters in 81 countries.

Of the 6,754 helicopters listed in the new foreign directory, 3,628 were U.S.-built. Of the foreign-built, 1,076 were of U.S. design but built by foreign licensees and 2,050 were of foreign design.

France, with 1,199, led in the number of helicopters. West Germany was second with 917, followed by Japan with 327.

Through September 1969, exports of U.S. helicopters were holding at the 1968 levels. For example, by September, 167 units with a value of nearly \$19,500,000 had been shipped. This was a slight unit increase over the same period in 1968.

The 1969 *Directory of Helicopter Operators in the United States and Canada—Commercial—Executive—Civil Government and Helicopter Flight Schools* showed an increase of 35 percent in the number of operators and 41 percent in the number of helicopters, as compared with the 1967 totals.

The directory listed a total of 1,379 operators and 3,433 helicopters. The largest increase in operators

—40 percent—was in the number of companies and executives owning and operating helicopters. The 596 corporate users also showed the largest increase in the number of helicopters operated—770 as compared with 487 operated in 1967, an increase of 58 percent. The 27 percent increase in the number of civil government agencies using helicopters reflected the effective role of helicopters as the air arm for law enforcement.

This continuing growth in the civil use of rotary-wing aircraft emphasizes the need for the establishment of public-use city-center and hospital heliports. To assist in the establishment of these needed helicopter landing facilities, the Federal Aviation Administration, in cooperation with government, civil, military, and industry groups, recommended criteria for heliport design on a national basis, issued as the 1969 revised edition of the FAA Advisory Circular *Heliport Design Guide*.

The VLAC's *ad hoc* committee, together with representatives of the Air Transport Association and the Helicopter Association of America, after reviewing the several FAA draft revisions, submitted for the 3 associations coordinated and official recommendations on the proposed revised guide. The 1969 FAA *Heliport Design Guide* was scheduled for publication early in 1970.

To further implement a needed nationwide heliport program, the VLAC voted in 1969 to join with the American Helicopter Society and the Helicopter Association of America to form a National Heliports Standards Council. The purpose of this joint effort is to assist city, county, state, and federal government agencies in the design of ground-level and elevated heliports and in the standardization of heliport regulations and requirements.

The number of deaths on U.S. highways continued to increase. In order to reduce the injuries and the loss of life and property occurring daily on the nation's highways, the Highway Safety Act and the Motor Vehicles Safety Standards Act were passed in 1966. The Department of Transportation was charged with implementing the acts and the National Highway Safety Bureau was created to administer the 2 laws. Matching funds were authorized for the states for improvement of emergency highway medical services, including hospital heliports and highway helicopter patrols.

Upon completion of the first funded helicopter highway patrol test demonstration in Philadelphia, the Pennsylvania State Police in 1969 had daily helicopter patrol of the state's highway system. This brought a new dimension of patrol and emergency service to highway motorists. Funded by the Commonwealth of Pennsylvania with matching federal funds, 2 helicopters were put into service initially. With this "eye in the sky," the police can cover large areas in a short time. Lives have been saved with this fast response to an emergency call, and escaped criminals have been tracked down and captured.

In Mississippi, state and federal funds were being used to develop an emergency medical service plan that can be expanded throughout the state. In Arizona, the state university and the highway patrol were conducting a one-year evacuation system to serve remote areas. Other states operating helicopter highway patrols included California, Illinois, Louisiana, Maryland, Massachusetts, New Jersey, New York, and Texas.

Crime does not pay anymore in Lakewood, California—or in more than 30 other cities around the country. Lakewood pioneered the concept of an around-the-clock police patrol by helicopter. The concept has been proved effective in reducing robberies and burglaries. Even the high-speed getaway car cannot escape from the overhead crime copter.

With the Omnibus Crime Bill, Congress authorized funds for crime control. They are administered by the Department of Justice's Law Enforcement Assistance Administration. Lakewood's Sky Knight project was the first crime prevention program using helicopters that was funded under this act.

In Indianapolis, Indiana, a unique combination of city, county, and metropolitan government agencies was providing what may be the first multi-office public service helicopter operation. Six agencies crossed city and county lines, and budgets, to provide an ambulance helicopter, operated under contract with the Indiana Helicopter Corporation. The helicopter patrols in the morning and in the evening, 7 days a week. Ambulance missions have top priority. The helicopter has proved itself an effective adjunct to the land ambulance service.

In 1969, 12 of the 14 member companies of the Vertical Lift Aircraft Council had 86 models in operation or production, ranging in size from one to 50 places. In addition, there were 20 flight-test, research, and development models.

Gates Learjet Corporation of Wichita, Kansas, and the R. J. Enstrom Corporation of Menominee, Michigan, a subsidiary of Purex Corporation, Ltd., were admitted to membership in the Council in 1969. In addition, LTV Aerospace Corporation formed a subsidiary, Vought Helicopter Incorporated, which initially was to market the Sud-Aviation of France Alouette II and III turbine helicopters and provide service for the helicopters sold in the United States.

During 1969, with the world watching, helicopters again picked up the Apollo astronauts after splashdown. Recovery of the Apollo 12 crew brought to 36 the total number of U.S. astronauts picked up by helicopter since the manned space flights began in 1961.

With the opening of the new North Slope oil fields in Alaska, the helicopter was again proving its unique ability to overcome terrain barriers. There helicopters were opening up an almost inaccessible area, bringing in a new industry and creating new jobs.

GENERAL AVIATION

The year 1969 marked the end of a decade of solid growth in general aviation and industry leaders were in full agreement that the short- and long-range future of general aviation held the brightest promise for commercial growth ever experienced in the industry.

As a new decade begins, a review of general aviation history is in order. In a statement released in December 1960, Joseph T. Geuting, Jr., manager of the Utility Airplane Council of the Aerospace Industries Association of America, said: "The past decade [the fifties], during which unit sales and their dollar value more than doubled, has laid a solid foundation for future growth. Industry leaders predict the next decade will mark the greatest acceptance of business and private plane use."

In 1959—the last year of the fifties—7,689 general-type aircraft with a retail value of about \$170,000,000 were delivered. By contrast, the average number of aircraft delivered in each of the past 10 years (1960 through 1969) was 10,600 units with a retail value of \$360,000,000. During this 10-year period, according to statistics compiled annually by the Utility Airplane Council, more than 106,000 general aircraft with a retail value of over \$3.6 billion were delivered.

Export sales of general aircraft during this same 10-year period approximated 20 percent of total annual deliveries and resulted in approximately three-fourths of a billion dollars being brought to bear in a positive manner on the nation's balance of payments problem. Aircraft in varying numbers were shipped to almost every country of the free world and, at year-end 1969, aircraft of American manufacture composed three-quarters or more of the total general aviation fleet operating in areas other than the United States.

The year 1969 saw the general aircraft industry deliver more than 13,000 units with a retail value of about \$650,000,000, as compared with 7,588 units with a retail value of about \$200,000,000 in the year 1960.

There were many other measures of the growth which occurred during the decade. The fleet of active general aircraft grew from about 70,000 in 1960 to more than 125,000 at year-end 1969. Annual hours flown increased from 13,100,000 to over 25,000,000. Active airmen, pilots with valid certificates, increased from 348,000 to almost 700,000. Some qualification is required in accounting the pilot statistics since intermixed with them were approximately 30,000 pilots with airline transport ratings. But it must also be stated that with few exceptions the pilots who fly the several thousand high-performance turboprop and jet aircraft in the general aviation fleet and the additional thousands of single- and twin-engine aircraft in use for business and executive travel also have ratings identical to

those of the pilots who fly the nation's fleet of airliners.

Perhaps one of the most startling statistics to be uncovered in the past several years is that just the companies which belong to the National Business Aircraft Association, together flying only about 2,500 of the more than 30,000 aircraft used almost exclusively for business purposes, account for over one-third of the nation's total Gross National Product. This serves to place into sharp focus the vital nature of air transportation in private aircraft to the nation's business economy.

In April 1969, the Utility Airplane Council publicly released the initial findings of a research activity which it had conducted during the latter part of 1968, and which was being continued. Despite the existence of such readily available information as numbers of aircraft, hours flown, airmen, and production, there has been a dearth of adequate data concerning the size and potential growth of general aviation and the manner in which general aviation serves the nation's air transportation economy. In contrast, there has been a great variety of information concerning the nation's airline industry because of the homogeneous nature of that industry and because the Civil Aeronautics Board has required large volumes of statistical data in connection with its economic regulatory function. The explosive growth of air travel in the past decade, the acceptance of the general aviation aircraft for extensive business use at and away from hub airports, and the availability of an increasing variety of highly useful aircraft, created the need for more complete data to be used in planning the airport/airways system—the most pressing and immediate need being to measure activity and future growth trends more definitively.

In order to define the information required for proper planning, the Utility Airplane Council undertook plans to commission a basic and objective independent study by a non-industry group utilizing different methods of data collection and forecasting. After the work program had been determined, several research organizations of known competence were invited to submit proposals, and the firm of R. Dixon Speas Associates was selected and commissioned to carry out the first step of the research. A basic element of the research was an assumption that no unusual constraints would be imposed on civil aviation, or any segment thereof, including general aviation, in the belief that the airport/airways system must at all times be adequate to insure that the continuing growth of all forms of air transportation will be encouraged.

This research effort was entitled "The Magnitude and Economic Impact of General Aviation." The first step in the analysis established a new data base concerned with the size and parameter of general aviation activity upon which forecasts have been made, projected to 1980 as to its size in terms of

quantity of aircraft, flying hours, aircraft movements, and other identifying parameters. Along with this, a study of the impact of general aviation on the nation's economy was conducted.

In 1967, the base year of the study, general aviation carried 100,000,000 passengers in "itinerant" movement. During the same year, the nation's scheduled airlines carried 119,000,000 passengers over domestic routes. An itinerant aircraft movement is from one airport to another, as distinguished from a local movement which would be about a single airport; in short, it is the air transportation of people and things from place to place all over the nation. This number of passengers carried by general aviation was projected to increase from 100,000,000 during the year 1967 to 317,000,000 by 1980.

The massive movement of passengers by general aviation is not as publicly visible as airline passenger movements. The nation's airlines serve about 600 places in the nation; fewer than 100 of these places receive what could be called real frequency of service. Concentrations of airliners and their passengers at busy hub airports are, therefore, quite visible. General aviation, on the other hand, carries passengers to and from not only all these places but also 9,500 other airports all over the nation not served by the airlines.

The year 1969 saw the imposition of constraints on the movement of aircraft about the nation. The inadequacies of the existing airport system and the related airways brought about a "rationing" system imposed at 5 of the nation's major airports, affecting both airline and general aviation access to those airports. Unless steps are taken to increase the capacity of the national aviation system, such constraints will inevitably spread to additional cities where there are concentrations of air traffic of all kinds, both airline and general. General aviation needs access to these busy hub areas for exactly the same reason as do the nation's airlines, and that simply is the transportation of businessmen and private citizens to and from the centers of commerce of the nation so that they can conduct their business.

The nation's air transportation system is composed of the scheduled airlines and general aviation. Though they are separate elements of the nation's total air transportation system, they are identical in one very fundamental respect. Their objective is satisfying the total requirements of the air traveler, and their combined strength is the sum of their different functions. While the airlines operate over specified routes at specific times, general aircraft move when and where they must in order to conform to times set by the air traveler. Thus, the needs of the public are served through 2 separate systems, each dependent upon the other and together forming one complete system.

The year saw evidence of real concern on the part of the Congress. Legislation which would cause

a massive influx of new funds, some to be derived from user charges on both airline and general aviation and some from appropriated public funds in recognition of the fact that the public benefits from an adequate national aviation system, was introduced in the Congress. Late in 1969, it had passed the House and was close to passage in the Senate. It appeared most likely that the decade of the seventies would see the national system of airports and airways vastly improved, with adequate capacity to permit and encourage unconstrained growth of all forms of air transportation.

The general aviation manufacturing industry vigorously supported the legislation. Apart from providing expert testimony to the concerned Congressional committees, it also carried on a campaign of public information.

One program of national significance conducted in 1969 to bring the importance of general aviation to the attention of the public was a unified effort by the many different elements of the general aviation industry which called on the public to "Discover Flying." In a special message as a part of the Discover Flying campaign, Federal Aviation Administrator John H. Shaffer said:

"For every aircraft operated by the airlines in the United States, there are 50 in the general aviation fleet. And yet general aviation continues to be the least understood and most underrated segment of our transportation system. Perhaps the most striking aspect of general aviation is its great diversity. It includes those people who fly for business purposes, and those engaged in a wide variety of commercial enterprises such as agricultural operations, aerial surveys, and pipeline patrols. Even air taxi operators fall within this category. . . .

"And we can reasonably expect that general aviation will continue to grow not only in size but also in importance. And the effects of this growth will be reflected in increased aircraft sales and related services, establishment of new airport facilities, and improved communications in many other areas beneficial to the American public."

Looking to the future, the Utility Airplane Council offered these predictions based upon the findings of its research study:

- General aviation would grow from 122,000 units in 1967, base year of the research study, to 260,000

by 1980, an increase of 113 percent. (The fleet size in 1969 was on the order of 130,000 units.)

- Flying hours would grow at an annual compound rate of 7½ percent, going from 24,000,000 in 1967 to 63,000,000 in 1980.

- Aircraft movements, 98,000,000 in 1967, would climb to 242,000,000 by 1980.

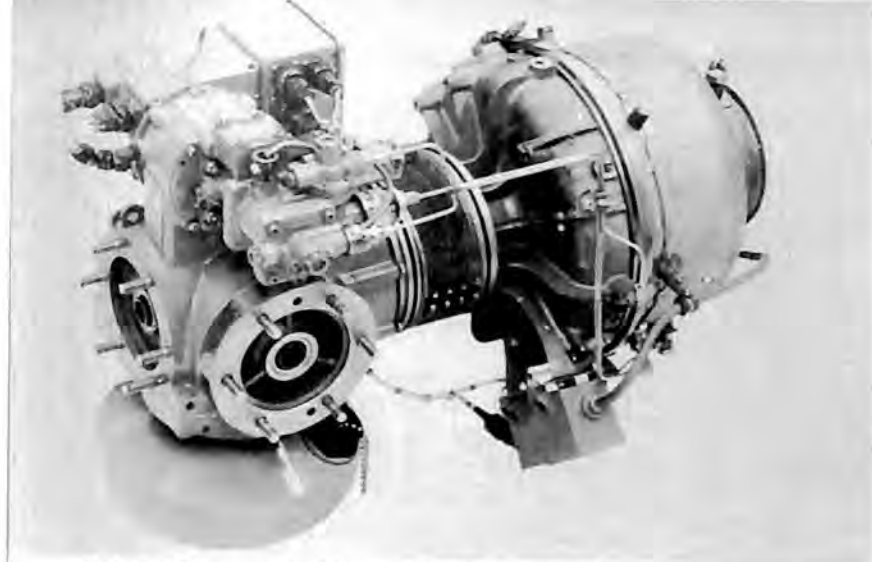
- The pilot population, numbering about 647,000 in 1967, would more than double by 1980, reaching 1,400,000.

Domestic sales alone for 1980 were projected to have a value of \$1.6 billion. In view of the fact that over 20 percent of 1969 production was exported, and that export sales have also shown a strong and continuing growth trend, the 1980 sales outlook becomes even more significant.

The significance of general aviation's contribution to the development of an integrated national transportation system can also be expressed in terms of the magnitude of its impact upon the economy resulting from direct dollar expenditures generated by general aviation. These direct dollar expenditures were determined to be at a 1969 level of approximately \$3 billion and were estimated to increase by 1980 to over \$7 billion. Economists note that, as every direct dollar expenditure flows into the economy, a multiplier factor takes over which increases the impact 2 to 3 times as it triggers additional expenditures.

Applying a standard matrix type input-output analysis, readily available to economists, which brings into play the added impact of indirect expenditures generated by these direct dollars as they flow into the economy, raises the 1969 general aviation contribution to the Gross National Product to between \$6 billion and \$9 billion, which will grow to as much as \$20 billion by 1980.

This contribution will also be growing at a more rapid rate than total GNP, which was expected to increase by 143 percent, whereas the general aviation increase will be on the order of 220 percent. Of course, GNP is made up of untold numbers of individual increments drawn from the nation's highly diverse economy. But even here the measure of general aviation's contribution becomes significant, considering that its proportion of total GNP in 1969 was estimated to be .62 percent, with a growth expectancy to .82 percent by 1980.



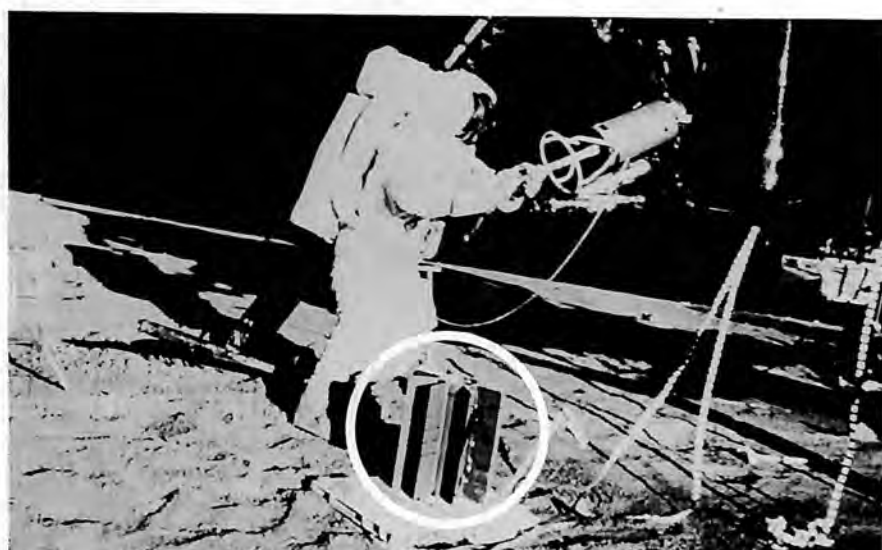
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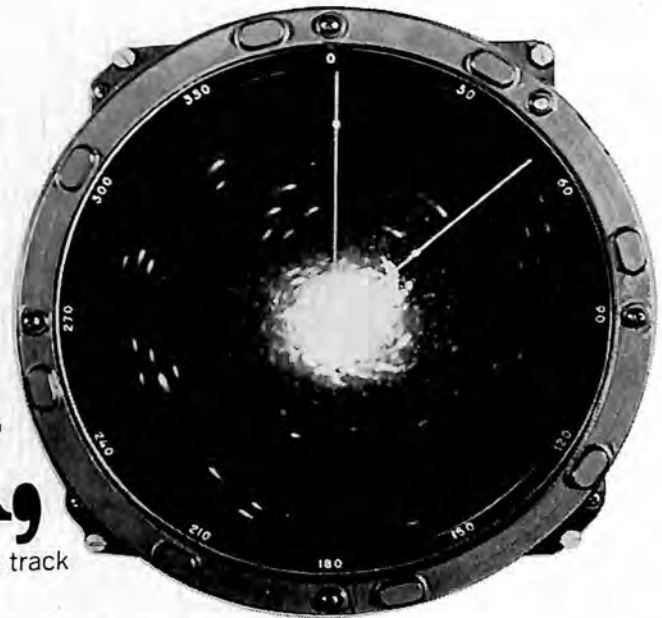
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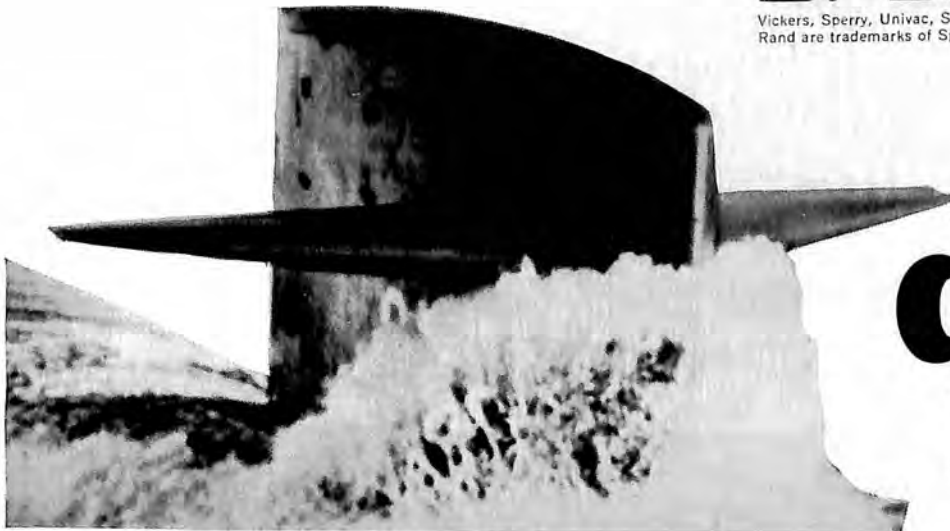
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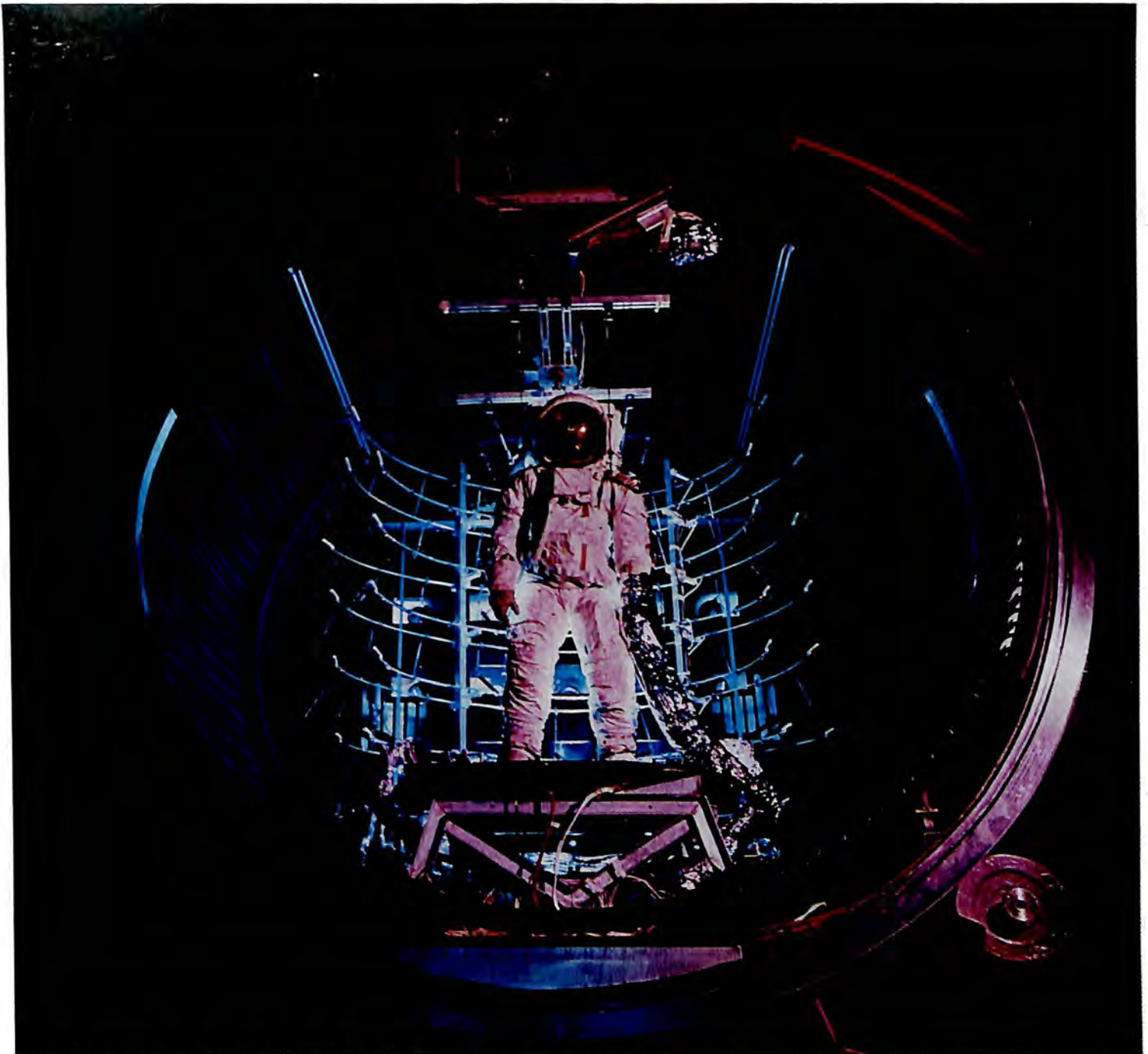


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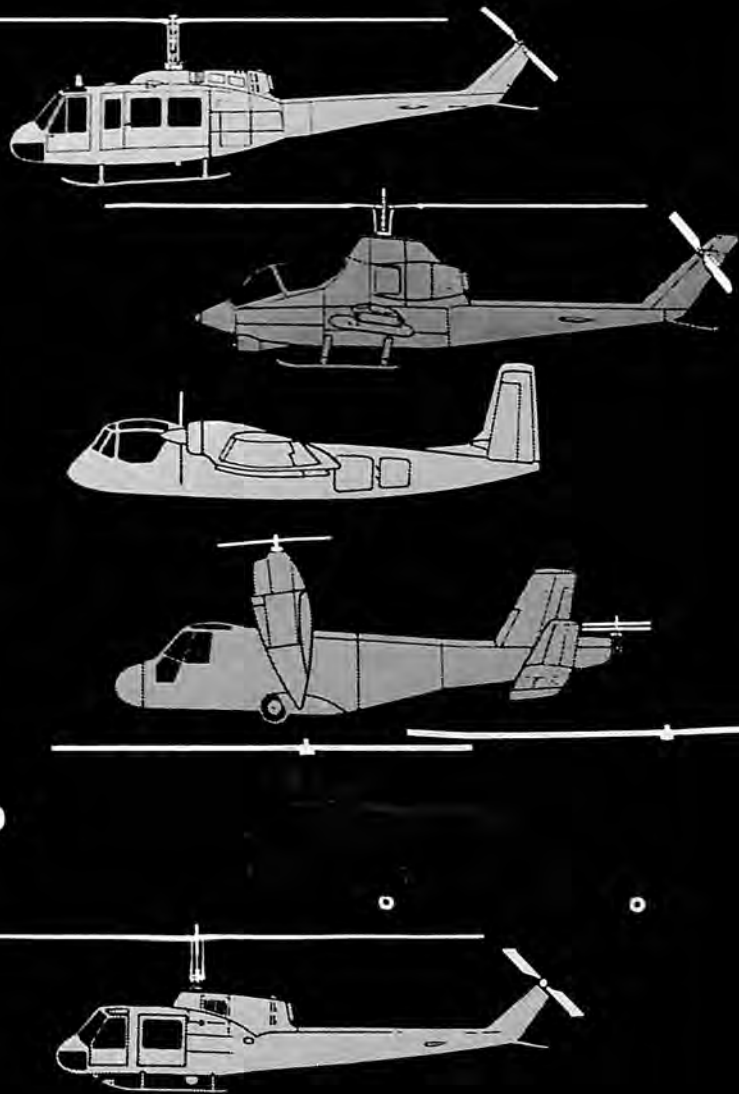
**If
it
flies,
floats,
beeps,
hovers,
orbits,
soars,
tracks
or
attacks...**

**its progress is
our most important product**

GENERAL  ELECTRIC

996-34

WHAT
DO
ALL
THESE
AIRCRAFT
HAVE
IN
COMMON?



Simple... their GUTS!

Avco Lycoming Gas Turbine engine type guts.

When these manufacturers wanted to build a rugged aircraft — particularly a helicopter — where did they turn first?

To Avco Lycoming, naturally where gas turbine power is synonymous with guts — with ruggedness — with reliability — with experience — where turbines are designed and manufactured to live in flight, not in a laboratory.

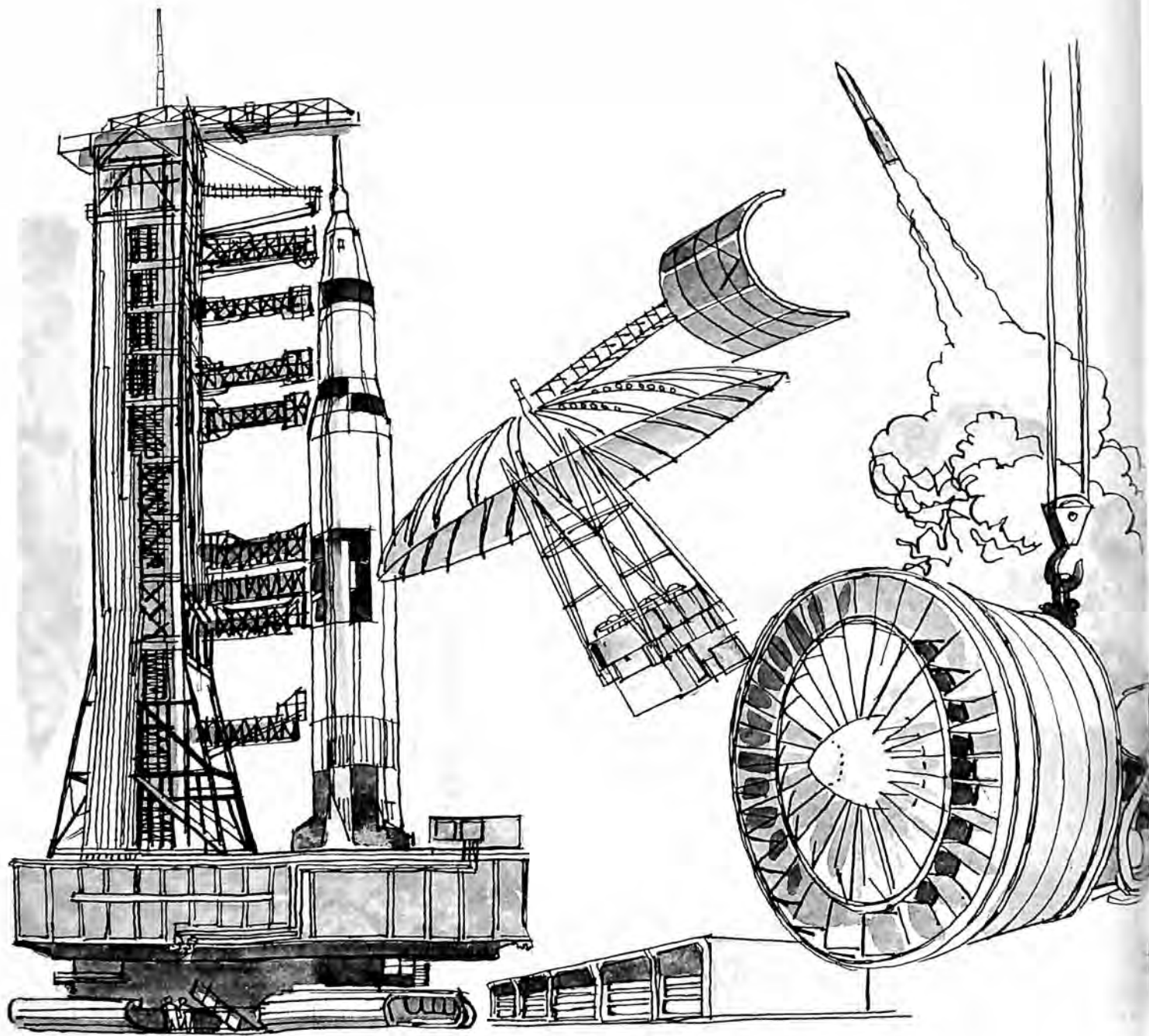
Where more than 10 million flight hours have proven their dependability under every conceivable condition.

Where design and development is always one step ahead of the requirement.

Where people like Bell, with its UH-1H Huey and AH-1G HueyCobra; where people like Grumman, with its OV-1 Mohawk; where people like Canadair, with the new tilt-wing CL-84; where people like Boeing, with its CH-47 Chinook family; and many others, turn when they need gas turbine power.

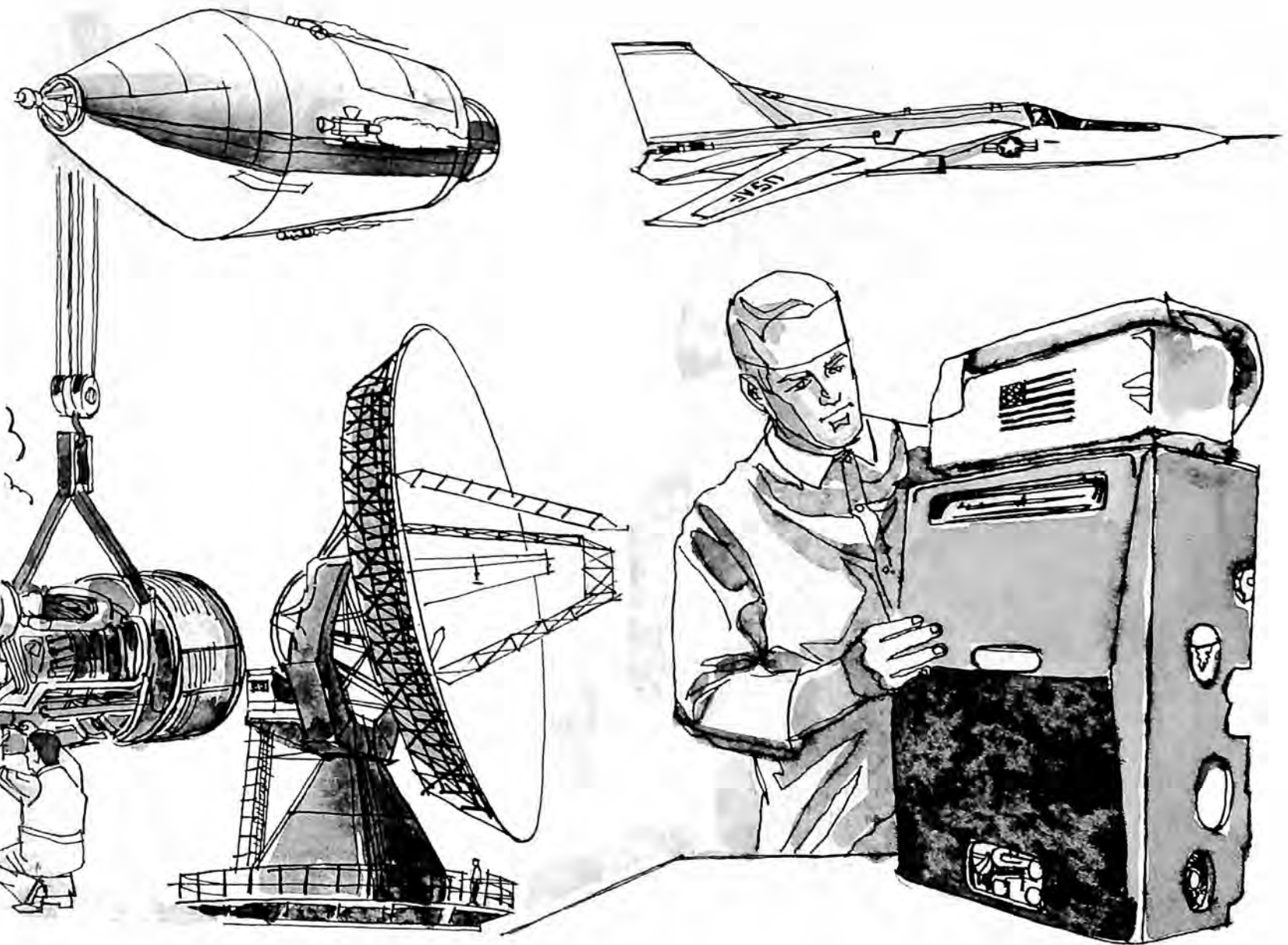
It's no wonder — we've got the guts to do the job.





Reference Section

The following pages, designed for reference use, contain specifications, performance, and other data on some 700 products of the aerospace industry. In addition to the primary products—aircraft, missiles, spacecraft, launch vehicles, engines, targets, drones, and sounding rockets—the AEROSPACE YEAR BOOK includes a section devoted to systems. The term *system* here denotes ground-based and airborne



aerospace equipment other than primary products, together with certain non-aerospace items produced by aerospace manufacturers. The systems section is intended to be representative rather than all-inclusive; although more than 150 systems are listed, they constitute only a fraction of the industry's extremely broad product line. For easier reference, missiles and spacecraft are organized by functional

groups, such as surface-to-surface missiles and meteorological spacecraft. All other products are arranged in alphabetical order by name of the prime contractor. The term *prime contractor*, as used throughout the reference section, refers to the builder of the product listed, regardless of whether it is a primary product or a subsystem, military or commercial.

AIRCRAFT



PREGNANT GUPPY (B-377PG)

Prime Contractor: Aero Spacelines, Inc.

Remarks

Following its formation in 1961, Aero Spacelines converted a Boeing 377 Stratocruiser into a transport for large booster rockets. The modification involved lengthening the aircraft by 16 feet 8 inches and enlarging the fuselage to accept cargo up to 19 feet 7 inches in diameter. The craft was successfully flight tested on September 19, 1962.

Specifications

Span 141 feet 3 inches; length 127 feet; height to top of fuselage 31 feet 3 inches; height to top of tail 38 feet 3 inches; cargo compartment: 19 feet 7 inches wide by 19 feet 7 inches high, constant section length 30 feet, overall length 80 feet; engines 4 Pratt & Whitney Aircraft R4360 piston-type; maximum gross weight 133,000 pounds (145,000 pounds after programmed modification).

Performance

Cruise speed 250 miles per hour; payload 33,000 pounds.



SUPER GUPPY (B-377SG)

Prime Contractor: Aero Spacelines, Inc.

Remarks

The Super Guppy, a modification of the Boeing Stratocruiser family, was designed to permit air movement of the S-IVB stage and the Lunar Module adapter, components of the Saturn V launch vehicle which could not be carried in any other airplane. It incorporates the wing, flight deck, and forward fuselage of the turboprop-powered C-97J and has a hinged nose section for straight-in loading of bulky cargo. Sections of 4 Stratocruisers plus modifications make up the Super Guppy. Like the Pregnant Guppy, it is operated under contract with NASA.

Specifications

Span 156 feet 3 inches; length 141 feet 2 inches; height to top of fuselage 36 feet 6 inches; height to top of tail 46 feet 5 inches; cargo compartment: 25 feet wide by 25 feet 6 inches high, total length 94 feet 6 inches; engines 4 Pratt & Whitney Aircraft T34-P-7 WA turboprops; maximum gross weight 175,000 pounds.

Performance

Cruise speed 285 miles per hour; payload 45,000 pounds.



MINI GUPPY (B-377MG)

Prime Contractor: Aero Spacelines, Inc.

Remarks

Designed for commercial airlift of large aircraft sections, helicopters, power packages, oil drilling equipment, and related cargoes, the Mini Guppy is another modification of the Boeing 377 Stratocruiser. The aircraft made its initial flight on May 24, 1967.

Specifications

Span 156 feet 3 inches; length 132 feet 10 inches; height to top of fuselage 27 feet 6 inches; height to top of tail 38 feet 3 inches; cargo compartment: 18 feet 2 inches wide by 15 feet 5 inches high, total length 99 feet, constant section length 75 feet 10 inches; maximum gross weight 142,800 pounds; engines 4 Pratt & Whitney Aircraft R4360 piston-type.

Performance

Cruise speed 250 miles per hour; payload 32,000 pounds.



GUPPY-101

Prime Contractor: Aero Spacelines, Inc.

Remarks

To meet known and anticipated commercial market demand, Aero Spacelines has scheduled construction of a fleet of outsize cargo aircraft in 2 standardized configurations, one being the Guppy-101. Essentially, Guppies are lengthened and modified versions of the B-377/C-97 airframes. Unlike the prototype piston-powered Mini with a swing-tail loading assembly, the Guppy-101 has a swing-nose loading system, hinged on the left side to allow a 110-degree swing; it also has a larger cargo compartment. Among other new features are increased horsepower, which adds significantly to range and payload; water-injection systems; and pressurized cockpits and anti-icing equipment, permitting operation at higher, more efficient altitudes. Closed-circuit television cameras in the cargo compartment provide constant surveillance and cargo inspection from the cockpit area. The first Guppy-101 was scheduled for roll-out late in 1969.

Specifications

Span 156 feet 8 inches; height to top of fuselage 26 feet 8 inches; height to top of tail 40 feet 9 inches; cargo compartment: maximum width 18 feet 4 inches, maximum height 15 feet 6 inches, constant section length 73 feet 2 inches, overall length 103 feet 2 inches, maximum width at floor level 13 feet 4 inches; plane length 135 feet 6 inches; maximum gross takeoff weight 180,000 pounds; engines 4 Allison 501-D22C turboprops.

Performance

Cruise speed 325 miles per hour; payload 64,000 pounds.



GUPPY-201

Prime Contractor: Aero Spacelines, Inc.

Remarks

The Guppy-201 is the first of a fleet of Guppy aircraft in standardized configuration. In manufacturing the Guppy-201 aircraft, the lower fuselage, wings, empennage, and cockpit of B-377/C-97 airframes are utilized. Portions of the lower fuselage sections of Stratocruisers are joined to increase the plane length to 144 feet. Like its prototype sister ship, the Super Guppy, the Guppy-201 has a swing-nose loading system, hinged on the left side to allow a 110-degree swing. Guppy-201 standardized features include increased horsepower, pressurized cockpits, water-injection systems, anti-icing equipment, and a cargo compartment equipped with closed-circuit television cameras to provide constant surveillance and cargo inspection from the cockpit area.

Specifications

Span 156 feet 8 inches; height to top of fuselage 37 feet; height to top of tail 48 feet; cargo compartment: maximum height 25 feet 6 inches, maximum width 25 feet 1 inch, constant section length 32 feet, overall length 111 feet 6 inches, maximum width at floor level 13 feet; plane length 144 feet; engines 4 Allison 501-D22C turboprops; maximum gross take-off weight 170,000 pounds.

Performance

Cruise speed 300 miles per hour; payload 50,000 pounds.



BEECHCRAFT KING AIR B90

Prime Contractor: Beech Aircraft Corporation

Remarks

A third-generation, pressurized, turboprop corporate transport, the Beechcraft King Air B90 reflects a solid leadership among all turbine-powered airplanes, pure jet or turboprop. The King Air series, introduced in late 1964, has captured 45 percent of the turboprop market. Approximately 500 have been produced.

Specifications

Span 50 feet 3 inches; length 36 feet 6 inches; height 14 feet 8 inches; gross weight 9,650 pounds; engines 2 550-shaft-horsepower Pratt & Whitney Aircraft PT6A-20 free turbines with reverse-pitch propellers optional.

Performance

Cruise speed, maximum cruise power, 256 miles per hour; cruise range, including 45-minute reserve, at 21,000 feet, 1,466 statute miles; rate of climb, 2 engines gross weight, 2,000 feet per minute; service ceiling, 2 engines gross weight, 27,200 feet.



BEECHCRAFT KING AIR 100

Prime Contractor: Beech Aircraft Corporation

Remarks

New flagship of the Beechcraft corporate aircraft fleet is the pressurized, turbine-powered Beechcraft King Air 100, introduced in May 1969. A companion to the Beechcraft King Air 90 series, the King Air 100 is available in a variety of interior configurations including a 15-place commuter version. Fifty inches longer than the King Air 90 series, the Beechcraft King Air 100 features dual-wheel main landing gear, new empennage, new pressurization and fuel systems, and more powerful turbine engines.

Specifications

Span 45 feet 10.5 inches; length 39 feet 8.5 inches; height 15 feet 4.3 inches; gross weight 10,600 pounds; engines 2 Pratt & Whitney Aircraft PT6A-28 free turbines with full-feathering, reversible propellers standard.

Performance

Cruise speed, maximum cruise power, 285 miles per hour; cruise range, including 45-minute reserve at 21,000 feet, 1,252 statute miles; rate of climb, 2 engines gross weight, 2,200 feet per minute; service ceiling, 2 engines gross weight, 25,900 feet.



BEECHCRAFT QUEEN AIR A65

Prime Contractor: Beech Aircraft Corporation

Remarks

The Queen Air A65 is the economy leader of Beechcraft's Queen Air series. An optional fuel supply provides the 7- to 11-place A65 with increased range, and de-icing and advanced avionic equipment permit all-weather flight. An air-stair door allows easy access to the 3-compartment interior designed for optimum crew and passenger privacy and comfort. Center-aisle cabin design permits freedom of movement about the cabin in flight.

Specifications

Span 45 feet 10.5 inches; length 35 feet 6 inches; height 14 feet 2.5 inches; gross weight 7,700 pounds; useful load 2,740 pounds; engines 2 Lycoming IGSO-480-A1E6 rated at 320 horsepower.

Performance

Cruise speed 214 miles per hour; cruise range 1,300 miles with standard fuel, 1,655 miles with optional fuel; rate of climb at gross weight 1,300 feet per minute; service ceiling 31,300 feet.



BEEHCRAFT QUEEN AIR 70

Prime Contractor: Beech Aircraft Corporation

Remarks

Adding even greater versatility to the Beechcraft Queen Air line of piston-powered corporate aircraft is the Beechcraft Queen Air 70. It offers passenger seating configurations to 11-place, 50 separate cabinetry and avionics choices, cargo door and cargo pod options, and convertibility of cabin arrangements from corporate to utility use.

Specifications

Span 50 feet 4 inches; length 35 feet 6 inches; height 14 feet 2.56 inches; gross weight 8,200 pounds; useful load 3,205 pounds; engines 2 Lycoming ICSO-480-A1E6 rated at 320 horsepower.

Performance

Cruise speed 214 miles per hour; cruise range 1,655 miles with optional 264-gallon fuel tanks; rate of climb at gross weight 1,375 feet per minute; service ceiling 30,000 feet.



BEEHCRAFT QUEEN AIR B80

Prime Contractor: Beech Aircraft Corporation

Remarks

An established high-performance, 7- to 11-place twin-engine business and utility aircraft, the Queen Air B80 offers such comfort options as 3 individual compartments for the privacy of crew and passengers, restroom facilities, a center aisle and writing tables allowing passengers to move about and work in flight, a 4-place couch interior, and an 11-place configuration with airline-style seating for commuter airline operation or high-density corporate use. Queen Air B80 also has air ambulance and scientific research applications. An optional cargo door is available.

Specifications

Span 50 feet 3 inches; length 35 feet 6 inches; height 14 feet 2 $\frac{5}{16}$ inches; gross weight 8,800 pounds; useful load 3,760 pounds; engines 2 380-horsepower Lycoming ICSO-540-A1D.

Performance

Cruise speed 224 miles per hour; cruise range 1,200 miles standard, 1,560 with optional 264-gallon fuel tanks; rate of climb at gross weight 1,275 feet per minute; service ceiling 28,900 feet.



BEECHCRAFT 99 AIRLINER

Prime Contractor: Beech Aircraft Corporation

Remarks

The Beechcraft 99 Airliner is a 17-place turbine-powered aircraft introduced in 1967 to complement the 11-place Beechcraft Queen Airliner in the airline and scheduled air taxi markets. More than 100 are in scheduled airline service. Versatility of loading can be achieved by means of an optional cargo door adjacent to the regular passenger air-stair door and of a movable bulkhead to provide a cargo compartment separated from the passenger cabin. Dual-wheel main landing gear, reverse-thrust propellers, and automatic propeller feathering are other features. A more powerful Beechcraft 99A Airliner is offered for use in areas at high altitudes and with extreme temperatures.

Specifications

Span 45 feet 10.5 inches; length 44 feet 6.81 inches; height 14 feet 4.25 inches; gross weight at takeoff 10,200 pounds; engines 2 Pratt & Whitney Aircraft PT6A-20 of 550 shaft horsepower (99), 2 Pratt & Whitney PT6A-27 of 625 shaft horsepower (99A).

Performance

Cruise speed at 8,000 feet and maximum cruise power, 254 miles per hour; cruise range in airline use 375 miles; rate of climb, 2 engines 10,400 pounds, 1,700 feet per minute; service ceiling 2 engines 26,160 feet.



BEECHCRAFT SUPER H18

Prime Contractor: Beech Aircraft Corporation

Remarks

Since its introduction in 1937, the Beechcraft Model 18 has had an outstanding record as an executive, military, and utility twin-engine airplane. Powered by reliable Pratt & Whitney Aircraft Wasp Jr. engines, the Super H18 is in service throughout the world. More than 7,000 have been produced.

Specifications

Span 49 feet 8 inches; length 35 feet 2.5 inches; height 9 feet 4 inches; gross weight 9,900 pounds; useful weight 4,055 pounds; engines 2 450-horsepower Pratt & Whitney Wasp Jr.

Performance

Cruise speed at 300 horsepower per engine 220 miles per hour; cruise range 1,530 miles; rate of climb, 2 engines 9,900 pounds, 1,400 feet per minute; service ceiling, 2 engines 9,400 pounds, 21,400 feet.



BEECHCRAFT BARON B55

Prime Contractor: Beech Aircraft Corporation

Remarks

Lowest priced of the Beechcraft Baron line, the B55 offers 225-mile-an-hour cruise, range in excess of 1,220 miles, including reserves, and remarkable economy. More than 2,100 Barons have been produced by Beech Aircraft since the introduction of the plane in 1961. Barons are in private, government, and training use throughout the free world.

Specifications

Span 37 feet 10 inches; length 27 feet 3 inches; height 9 feet 7 inches; gross weight 5,100 pounds; useful load 2,025 pounds; engines 2 Continental IO-470-L rated at 260 horsepower.

Performance

Cruise speed 225 miles per hour; cruise range, 45 percent power on 142 gallons, 1,225 miles; rate of climb 2 engines 1,670 feet per minute; service ceiling 19,700 feet.



BEECHCRAFT DUKE, MODEL 60

Prime Contractor: Beech Aircraft Corporation

Remarks

The Beechcraft Duke is a 6-place addition to the company's fleet of pleasure, business, corporate, and airline aircraft. It ranks in size between the light-twin Beechcraft Baron and the heavy-twin Beechcraft Queen Air. Cabin pressurization allows sea-level atmosphere conditions to a flight level of 10,100 feet and a cabin altitude of only 8,000 feet at 21,600 feet. A highly efficient environmental system includes optional air conditioning. Turbocharged engines and all-weather avionics as standard equipment afford fast, reliable, over-the-weather flight.

Specifications

Span 39 feet 3 inches; length 33 feet 10 inches; height 12 feet 4 inches; gross weight 6,725 pounds; engines 2 Lycoming TIO-541-E1A4 rated at 380 horsepower each.

Performance

Cruise speed 278 miles per hour; cruise range at 45 percent power, 204 gallons, 1,175 miles; rate of climb, 2 engines 5,200 pounds, 2,373 feet per minute; service ceiling, 2 engines 5,200 pounds, 35,800 feet.



BEECHCRAFT TURBO BARON

Prime Contractor: Beech Aircraft Corporation

Remarks

A combination of high speed and spectacular single-engine performance provided by twin 380-horsepower turbocharged Lycoming engines makes the Beechcraft Turbo Baron the fastest light twin in its class. The Turbo Baron was designed expressly for high-altitude instrument flight, yet it retains the ability of the Beechcraft Baron family to carry big loads long distances with outstanding flight characteristics under all conditions. The Beechcraft Turbo Baron also pioneered the introduction of refrigeration-type air conditioning in the light-twin field.

Specifications

Span 37 feet 10 inches; length 28 feet 3 inches; height 9 feet 7 inches; gross weight 5,990 pounds; useful load 2,340 pounds; engines 2 Lycoming TIO-541-E1B4.

Performance

Cruise speed 290 miles per hour; range 1,299 miles on 204 gallons at 45 percent power; rate of climb at gross weight 2,020 feet per minute; service ceiling 32,200 feet at gross weight.



BEECHCRAFT BARON D55

Prime Contractor: Beech Aircraft Corporation

Remarks

Twin 285-horsepower fuel-injection engines make possible safe, reliable operation from improved or unimproved landing areas as short as 968 feet. Actual takeoff ground run needed for the fully loaded Baron D55 is only 596 feet. Useful load of 2,225 pounds can include up to 6 people as well as 820 pounds of cargo.

Specifications

Span 37 feet 10 inches; length 28 feet 3 inches; height 9 feet 7 inches; gross weight 5,300 pounds; useful load 2,225 pounds; engines 2 Continental IO-520-C rated at 285 horsepower each.

Performance

Cruise speed 230 miles per hour; cruise range at 45 percent power, 142 gallons, 1,143 miles; rate of climb 2 engines 1,670 feet per minute; service ceiling 20,900 feet.



BEECHCRAFT TURBO BONANZA

Prime Contractor: Beech Aircraft Corporation

Remarks

Pacing the Bonanza line of single-engine, retractable-gear Beechcrafts is the Turbo Bonanza with a 285-horsepower turbocharged engine for high-altitude and high-speed performance. A maximum speed of 250 miles an hour at 19,000 feet and an absolute ceiling of over 30,000 feet are possible. The 4- to 6-place Turbo Bonanza features a speed-sweep one-piece windshield and stylish interior selections of leathers, vinyls, and fabrics.

Specifications

Span 33 feet 5.5 inches; length 26 feet 4.5 inches; height 6 feet 6.5 inches; gross weight 3,400 pounds; useful load 1,379 pounds; engine Continental 285-horsepower TSIO-520-D.

Performance

Cruise speed 230 miles per hour; cruise range 574 miles standard, 1,082 with optional 80-gallon tanks; rate of climb 1,225 feet per minute; service ceiling 29,500 feet.



BEECHCRAFT BONANZA V35A

Prime Contractor: Beech Aircraft Corporation

Remarks

The Beechcraft Bonanza has earned its place as a classic among single-engine aircraft, with more than 9,000 units produced. Refinements include a speed-sweep windshield, a wide range of exterior paints, and options in quality custom interior appointments and communication and navigation systems. The Bonanza V35A seats 4 to 6.

Specifications

Span 33 feet 5.5 inches; length 26 feet 4.5 inches; height 6 feet 6.5 inches; gross weight 3,400 pounds; useful load 1,442 pounds; engine Continental IO-520-B rated at 285 horsepower.

Performance

Cruise speed 203 miles per hour; cruise range 599 miles standard, 1,111 miles with optional 80-gallon tanks; rate of climb 1,136 feet per minute; service ceiling 17,500 feet.



BEECHCRAFT BONANZA E33A

Prime Contractor: Beech Aircraft Corporation

Remarks

One of 7 models in the Beechcraft Bonanza line, the E33A brings a choice of swept vertical fin and horizontal stabilizer to the line. The Bonanza E33A offers roomy comfort for 4 or 5 passengers, a 285-horsepower fuel-injection engine for speeds to 208 miles per hour, and traditional Bonanza quality and structural integrity.

Specifications

Span 32 feet 10 inches; length 25 feet 10 inches; height 8 feet 3 inches; gross weight 3,300 pounds; useful load 1,385 pounds; engine Continental IO-520-B rated at 285 horsepower.

Performance

Cruise speed 200 miles per hour; cruise range 595 miles standard, 1,080 with optional 80-gallon tanks; rate of climb 1,200 feet per minute; service ceiling 18,300 feet.



BEECHCRAFT BONANZA E33

Prime Contractor: Beech Aircraft Corporation

Remarks

Economical entry in the Beechcraft Bonanza family, the Bonanza E33 is capable of routine operation on 80-octane fuel. Its fuel-injection engine provides 185-mile-an-hour cruise, range in excess of 1,100 miles, useful load of over 1,100 pounds, and seating for 4 or 5 passengers.

Specifications

Span 32 feet 10 inches; length 25 feet 6 inches; height 8 feet 3 inches; gross weight 3,050 pounds; useful load 1,188 pounds; engine Continental IO-470-K rated at 225 horsepower.

Performance

Cruise speed 185 miles per hour; cruise range 650 miles standard, 1,170 with optional 80-gallon fuel tanks, plus 45-minute reserve; rate of climb 930 feet per minute; service ceiling 17,800 feet.



BEECHCRAFT BONANZA 36

Prime Contractor: Beech Aircraft Corporation

Remarks

Aimed at the utility aircraft market, the Beechcraft Bonanza 36 accommodates 6 passengers or a useful load of 1,620 pounds. Ten inches longer than others of the retractable-gear, single-engine Beechcraft line, the Bonanza 36 has double doors to provide a 12-square-foot opening on the right rear side of the cabin. Folding fifth and sixth seats and removable third and fourth seats quickly convert the new Beechcraft to cargo configurations.

Specifications

Span 32 feet 10 inches; length 26 feet 8 inches; height 8 feet 5 inches; gross weight 3,600 pounds; useful load 1,620 pounds; engine Continental IO-520-B rated at 285 horsepower.

Performance

Cruise speed 195 miles per hour; cruise range 980 miles, plus reserves; rate of climb 1,015 feet per minute at gross weight; service ceiling 16,000 feet.



BEECHCRAFT AEROBATIC BONANZA

Prime Contractor: Beech Aircraft Corporation

Remarks

An aerobatic model of the Beechcraft Bonanza line, designated the Aerobatic Beechcraft Bonanza E33C, was introduced in 1968. When operated in the acrobatic category of FAA regulations, the Aerobatic Beechcraft Bonanza is licensed for such flight maneuvers as rolls, inside loops, Immelman turns, Cuban Eights, split "S" turns, snap rolls, spins, and limited inverted flight. Four- or 5-place in utility and business use, the aircraft is limited to pilot and one passenger during aerobatic maneuvers. Standard equipment includes shoulder harnesses for both front-seat passengers, quick-release cabin door, and g meter.

Specifications

Span 32 feet 10 inches; length 25 feet 6 inches; height 8 feet 3 inches; gross weight 3,300 pounds; useful load 1,382 pounds; engine Continental IO-520-B rated at 285 horsepower.

Performance

Cruise speed 200 miles per hour; cruise range, optional fuel, 1,080 miles, plus reserves; rate of climb 1,200 feet per minute; service ceiling 18,300 feet.



BEECHCRAFT MUSKETEER SUPER

Prime Contractor: Beech Aircraft Corporation

Remarks

Performance leader of the Musketeer line of sport, training, business, and pleasure aircraft, the Musketeer Super has a 200-horsepower fuel-injection engine and standard 4-place interior. Options include seating for 6, constant-speed propeller, and left-side entry door.

Specifications

Span 32 feet 9 inches; length 25 feet 1 inch; height 8 feet 3 inches; gross weight 2,200 pounds utility category, 2,550 pounds normal category; useful load normal category 1,140 pounds; engine 200-horsepower Lycoming IO-360-A2B.

Performance

Cruise speed 150 miles per hour; cruise range 823 miles; rate of climb 880 feet per minute; service ceiling 14,850 feet.



BEECHCRAFT MUSKETEER CUSTOM

Prime Contractor: Beech Aircraft Corporation

Remarks

A wide selection of exterior colors and of interior colors, fabrics, and vinyl combinations is offered in the versatile Beechcraft Musketeer Custom. Economical in operation from paved or unpaved airports, it also offers optional aerobatic capabilities. Its 180-horsepower fuel-injection engine gives a top speed of 151 miles an hour and a range up to 860 miles, with a useful load of 1,085 pounds.

Specifications

Span 32 feet 9 inches; length 25 feet 1.25 inches; height 8 feet 3 inches; gross weight utility category 2,030 pounds, normal category 2,450 pounds; useful load normal category 1,085 pounds; engine 180-horsepower Lycoming O-360-A2G.

Performance

Cruise speed 143 miles per hour; cruise range 860 miles; rate of climb 820 feet per minute; service ceiling 13,650 feet.



BEECHCRAFT MUSKETEER SPORT

Prime Contractor: Beech Aircraft Corporation

Remarks

Sport flying for 2, pilot training, and optional aerobatic capabilities set apart the Beechcraft Musketeer Sport. Top speed is 140 miles an hour; range is about 900 miles. As in the entire Musketeer line, latest technology, including metal bonding, is employed for weight reduction, strength, and optimum performance. More than 2,000 Musketeers have been produced.

Specifications

Span 32 feet 9 inches; length 25 feet; height 8 feet 3 inches; gross weight utility category 2,030 pounds, normal category 2,250 pounds; useful load normal category 900 pounds; engine 150-horsepower Lycoming O-320-E2C.

Performance

Cruise speed 131 miles per hour; cruise range 883 miles; rate of climb 900 feet per minute; service ceiling 14,900 feet.



BEECHCRAFT MODEL 45 MENTOR

Prime Contractor: Beech Aircraft Corporation

Remarks

The Beechcraft Model 45 Mentor, a single-engine, 2-place airplane, has been in service as a primary and basic-advanced trainer since 1948. Designated T-34A (photo) by the Air Force and T-34B by the Navy, it gained universal acceptance as a highly successful postwar trainer. Eleven nations—including Chile, Venezuela, Argentina, Colombia, El Salvador, Japan, Mexico, the Philippines, Spain, and Turkey—operated or still operate the versatile aircraft for pilot training and special missions. The Mentor has been manufactured in Japan and Argentina under license from Beechcraft.

Specifications

Span 32 feet 10 inches; length 25 feet 11 inches; height 9 feet 7 inches; empty weight 2,174 pounds (T-34A), 2,228 pounds (T-34B); engine 1 225-horsepower Continental O-470-13; landing gear tricycle, retractable (same as for Bonanza); tandem cockpits under continuous canopy.

Performance (T-34A)

Maximum speed 189 miles per hour; maximum cruise speed 173 miles per hour; service ceiling 20,000 feet; maximum cruise range 737 miles.



T-42A INSTRUMENT TRAINER

Prime Contractor: Beech Aircraft Corporation

Remarks

The T-42A, military counterpart of the Beechcraft Baron B55, is used as a fixed-wing, twin-engine instrument trainer by the Army Aviation School Instrument Training Division at Fort Rucker, Alabama. Secondary mission of the aircraft is twin-engine transition of single-engine-rated aviators and service as a light personnel transport.

Specifications

Span 37.9 feet; length 27.3 feet; height 9.6 feet; gross weight 5,100 pounds; empty weight 3,423 pounds; engines 2 Continental 6-cylinder IO-470-L fuel-injection engines rated at 260 horsepower; constant-speed, full-feathering propellers; dual instrumented for student training and equipped for all-weather flying; cabin arranged for 3 students and an instructor.

Performance

High speed at sea level 205 knots; cruise speed at 65 percent 191 knots; rate of climb 1,670 feet per minute; service ceiling 19,700 feet; absolute ceiling 21,000 feet; range, 45 percent power 10,000 feet, 1,065 nautical miles plus 45-minute reserve.



L-23D, U-8D SEMINOLE

Prime Contractor: Beech Aircraft Corporation

Remarks

The U-8D is the military version of the Beechcraft Model E50 Twin Bonanza. Under contract in 1960, a number of U-8Ds were modified to the RL-23D (RU-8D) configuration incorporating the APQ-86 SLAR radar installation. The U-8D is a high-performance, all-weather personnel transport for 6 persons, including one or 2 pilots. The all-metal, low-wing monoplane is readily adaptable for carrying litter patients as an air evacuation ambulance, or it can be used as a cargo transport or twin-engine trainer. A total of 206 U-8Ds were purchased from 1952 through the 1965 fiscal year.

Specifications

Span 45 feet 3 $\frac{3}{8}$ inches; length 31 feet 6 $\frac{15}{16}$ inches; height 11 feet 6.5 inches; empty weight 5,036 pounds; gross weight 7,000 pounds; engines 2 340 Lycoming O-480-1, 6-cylinder, horizontally opposed, supercharged; retractable tricycle landing gear with single wheels; controls single column throw-over; bench seats front and back.

Performance

Maximum diving speed 261 knots/300 miles per hour; maximum cruise speed at 6,500 feet 202 knots/232 miles per hour; cruise speed at 65 percent power at 10,000 feet 176 knots/202 miles per hour; service ceiling 2 engines 26,300 feet; service ceiling single engine 10,000 feet; maximum range 1,298 nautical miles/1,493 statute miles.



L-23F, U-8F SEMINOLE

Prime Contractor: Beech Aircraft Corporation

Remarks

The U-8F (L-23F) is the military version of the Beechcraft Queen Air Model 65. The 7-place command liaison transport is quickly adaptable to cargo transporting or air ambulance applications. It is also adaptable as an instrument or twin-engine trainer. Oxygen supply outlets are located at each station. Engine fuel injection eliminates icing from fuel vaporization. Propeller blade anti-icing alcohol, de-icing boots on outboard wing and stabilizer leading edges, and windshield defrost, alcohol spray, and wipers permit all-weather operation. Seventy-one of the aircraft were delivered to the Army between 1959 and 1964.

Specifications

Span 45 feet 10.5 inches; length 33 feet 4 inches; height 14 feet 2 inches; empty weight 5,112 pounds; gross weight 7,700 pounds; engines 2 340 Lycoming O-480-3, supercharged, fuel-injected, 6-cylinder, horizontally opposed; retractable tricycle landing gear with single wheels; dual controls side by side; 2 seats in pilot compartment, 5 in cabin.

Performance

Maximum diving speed 261 knots/301 miles per hour; maximum cruise speed at 12,000 feet 208 knots/240 miles per hour; cruise speed at 65 percent power at 10,000 feet 165 knots/190 miles per hour; service ceiling 2 engines 27,000 feet; service ceiling single engine 7,650 feet; maximum range 1,189 nautical miles/1,367 statute miles.



U-21A

Prime Contractor: Beech Aircraft Corporation

Remarks

The U-21A is a military combination of the corporate turbine-powered Beechcraft King Air 90 and the Beechcraft Queen Air. The unpressurized, high-performance, all-weather utility transport features a spacious, comfortable cabin with a large cargo door that accommodates articles up to 53.5 inches by 51.5 inches. It is designed to carry 10 combat-ready troops and 2 pilots, but it can be quickly adapted to carry 3 litter and 3 ambulatory patients as an air evacuation ambulance. Beech Aircraft Corporation received a contract to produce 129 of the aircraft.

Specifications

Span 45 feet 10.5 inches; length 35 feet 6 inches; height 14 feet 2 $\frac{1}{16}$ inches; empty weight 5,235 pounds; gross weight 9,650 pounds; engines 2 550-shaft-horsepower Pratt & Whitney Aircraft PT6A-20 free shaft turbines with full feathering and reversing propellers; retractable tricycle landing gear with single wheels.

Performance

Maximum cruise speed at 10,000 feet 248 miles per hour; service ceiling 2 engines 26,100 feet; service ceiling single engine 12,200 feet; maximum cruise range 960 miles.



SURFACE EFFECT SHIP

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

A 100-ton Surface Effect Ship (SES) is being designed for the Navy and the Maritime Administration of the Department of Commerce by Textron's Bell Aerospace Company, U.S. pioneer in air-cushion vehicle design, production, and operation since 1958. A radical departure from standard ship-building design, materials, and techniques could make the proposed craft capable of speeds of 80 knots or more. The test craft would ride on a drag-reducing cushion of air contained by catamaran-style side hulls and flexible bow and stern seals. When cruising, the center portion of the hull would be clear of the water and entirely supported by the air cushion. The air cushion would be generated and maintained by a system of multiple lift-fans. High-powered marine gas turbine engines would provide propulsion by driving supercavitating propellers located astern of each of the 2 side hulls. The cabin design is for maximum comfort and safety for observers and a crew of 4. In addition to living quarters, it would also house navigation, communication, and test monitoring equipment.

Specifications

Length 72 feet; width 33 feet; height 25 feet; normal gross weight 100 tons; normal payload 10 tons.

Performance

Speed 80-plus knots.



SK-10

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

A new concept for military air-cushion vehicles has been designed by Textron's Bell Aerospace Company. The SK-10 can quickly and efficiently transport personnel, supplies, and equipment from a ship through the surf inland to an appropriate debarkation zone. With a 75-ton payload from stage lengths up to 240 nautical miles, the SK-10 can carry cargoes at 55 knots in sea state 3 or 65 knots in sea state 1 without regard to water depth or submerged hazards. The craft utilizes an open well deck with bow and stern ramps which expedite the loading and unloading of cargo. With its flexible air-actuated trunks extending 4 feet below the hard structure, the SK-10 will operate into and out of a landing ships dock (LSD) and an amphibious transport dock (LPD), and consideration has been given to the planned FDL and LHA ships. Four 3,610-shaft-horsepower gas turbine engines provide power for the SK-10.

Specifications

Length 80 feet; width 48 feet; height (on cushion) 23 feet; cargo area 1,800 square feet; normal gross weight 308,000 pounds; normal payload 150,000 pounds.

Performance

Maximum speed 71 knots.



SK-5 (U.S. ARMY)

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

Three Bell-built SK-5 air-cushion vehicles (ACV), delivered to the U.S. Army in the spring of 1968, served as a unit in Vietnam during 1969. They were based in the Mekong River Delta region. The high-speed amphibious craft can be used for river patrol, reconnaissance, troop insertion, rescue, search and destroy, and logistic support missions over water, land, mud, marsh, ice, or snow. The 3 craft were the first to roll off Bell's new quantity production line and represented the Army's first ACV production buy. The armed and armored craft also are the first combat ACVs built exclusively in the United States to military specifications. They feature an improved control system, an expanded cabin door which will accommodate a jeep-size vehicle, a self-contained auxiliary power unit and split hydraulic system, and high-strength flat sidedecks in place of the curved sidedecks of previous models.

Specifications

Length 38 feet 10 inches; width 23 feet 9 inches; height (skirt inflated) 15 feet 11 inches; cabin floor area 12 feet by 8 feet; gross weight 17,000 pounds; power plant 1 General Electric LM100 1,150-shaft-horsepower marine gas turbine.

Performance

Maximum speed 60 knots; range 175 nautical miles at 50 knots; wave clearance at 40 knots 4.5 feet; obstacle clearance 3.5-foot solid wall, 5-foot earth mound, 5- to 6-foot vegetation, ditches up to 12 feet wide and 8 feet deep.



SK-5 (U.S. NAVY)

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

Three Model 7232 SK-5 air-cushion vehicles (ACV), delivered to the U.S. Navy in 1966, were deployed to Vietnam in May of that year. The high-speed amphibious craft, designated PACVs for Patrol Air-Cushion Vehicles, have been utilized for river patrol, troop insertion, reconnaissance, rescue, search and destroy, and logistic support missions. They have been instrumental in a number of Allied victories in the Mekong River Delta region and farther north in the area of Hue. The craft are modified SR. N5 Hovercraft produced in England by British Hovercraft Corporation Ltd.

Specifications

Length 39 feet; width 22.9 feet; gross weight 18,350 pounds; power plant 1 General Electric 1,000-shaft-horsepower marine gas turbine.

Performance

Maximum speed 55 knots; obstacle clearance 3.5-foot solid wall, 5-foot earth mound, 5- to 6-foot vegetation, ditches up to 12 feet wide and 8 feet deep.



X-14B VTOL RESEARCH AIRCRAFT

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

The X-14, designed and built by Bell under an Air Force contract awarded in 1955, was the first VTOL airplane to employ the jet vectored thrust principle. The airplane was delivered to NASA's Ames Research Center, Moffett Field, California, in October 1959. NASA replaced the original Armstrong-Siddeley Viper engines with General Electric J85 turbojets for increased thrust. The X-14B has improved thrust diverters and hover controls and a new digital computer Variable Stability System (VSS). Primary purpose of NASA's X-14B program is to research and define the stability and control system requirements for V/STOL aircraft. In addition, it has been used for test pilot familiarization and for investigation and simulation of the approach phase of lunar landings for Project Apollo.

Specifications

Span 34 feet; length 25 feet; tail height 8 feet; gross weight 4,000 pounds.

Performance

Operational speed 160 knots; maximum speed 180 knots.



AIRCRAFT

X-22A V/STOL RESEARCH AIRCRAFT

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

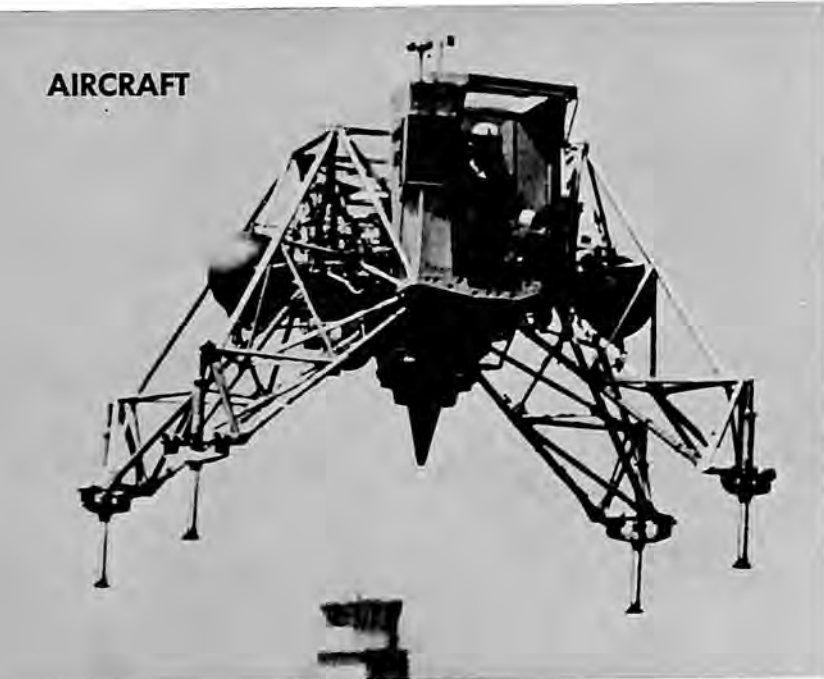
The X-22A research aircraft was developed by Bell Aerospace as part of a triservice V/STOL program to explore the mechanical and aerodynamic characteristics of this revolutionary concept of flight and to evaluate the military potential of the concept. Under a Navy-administered contract, Bell built 2 of these dual-tandem, ducted-propeller aircraft. A unique variable stability and control system is combined with high control power levels and a 3-engine hovering capability to provide an extremely versatile V/STOL research aircraft. The X-22A was rolled out on May 25, 1965; it made its first flight on March 17, 1966. It made its first vertical takeoff and transition to conventional flight on March 1, 1967. The aircraft has completed the aerodynamics and structural demonstration program flights of the Variable Stability System. The X-22A was scheduled for delivery to the Navy for additional research.

Specifications

Span 39.2 feet; length 39.6 feet; height 20.69 feet; VTOL gross weight 15,980 pounds (standard day, 1 engine out); engines 4 General Electric YT58-8D turboshaft 1,250 horsepower each.

Performance

Speed 325 miles per hour; endurance 3 hours; range 480 nautical miles.



LUNAR LANDING TRAINING VEHICLE

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

The Lunar Landing Training Vehicle (LLTV), designed and built by Bell Aerospace for NASA, is an earth-based, nonaerodynamic craft used to train astronauts in lunar landing techniques for the Apollo program. It employs a gimbaled General Electric CF700-2V turbofan engine mounted vertically in the center of the vehicle. The engine is constantly throttled to provide support for only five-sixths of the total weight of the vehicle. Thus, the engine counteracts five-sixths of the earth's gravity. The remaining one-sixth earth gravity is comparable to the gravity of the moon. Lift for the remaining one-sixth of the LLTV's weight is provided by 2 Bell lift rockets. Controlled by the pilot, these rockets simulate the engine used for the lunar landing. A closed-loop acceleration sensing system automatically controls the jet engine attitude and jet throttle to cancel aerodynamic drag forces. There are 16 attitude control rockets coupled with a variable stability autopilot system. Together, they provide a simulation of the actual Lunar Module reaction control system. Settings of the attitude control rockets can be ground adjusted between 18 and 90 pounds thrust, permitting exact duplication of Lunar Module control characteristics.

Specifications

Height 11 feet 4 inches; 4 truss legs spread 13 feet 4 inches; power plant single gimbaled, vertically mounted GE CF700-2V, axial flow aft fan, 4,200 pounds thrust; takeoff weight 4,051 pounds.

Performance

Speed 30 feet per second (vertical), 60 feet per second (horizontal); maximum altitude 1,000 feet.



47G-3B-1, 47G-3B-2 HELICOPTERS

Prime Contractor: Bell Helicopter Company

Remarks

The 47G-3B-1 3-place utility helicopter was first delivered in January 1963. Its successor, the 47G-3B-2, joined the Bell commercial line in 1968. The 47G-3B-2 is a balanced, all-purpose utility and passenger vehicle with a supercharged engine to provide maximum gross weight capability at high altitudes and elevated ambient temperature conditions. Its 24-volt electrical system, with a 50-ampere generator, provides ample electrical power for operation of utility equipment and accessories. The hydraulic pump is located on the transmission to assure operation of hydraulic boost controls during power-off autorotation.

Specifications

Fuselage length 32.6 feet; overall length 43.2 feet; main rotor diameter 37.12 feet; normal gross weight 2,950 pounds; basic configuration weight 1,892 pounds; useful load 1,058 pounds; engine Lycoming TVO-435 turbosupercharged, 270 takeoff horsepower (47G-3B-1), 280 shaft horsepower at 3,200 revolutions per minute (47G-3B-2).

Performance

Maximum speed, sea level, 105 miles per hour; cruise speed 81 to 83 miles per hour; maximum range at 10,000 feet 296 miles; rate of climb 880 feet per minute (47G-3B-1), 1,420 feet per minute (47G-3B-2); hover ceiling IGE 20,000 feet; service ceiling 20,000 feet.



47G-4A HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The 47G-4A is a balanced, all-purpose utility and passenger vehicle capable of a wide range of operations at medium altitudes and elevated temperatures. Its 24-volt electrical system, with 50-ampere generator, provides ample electrical power for operation of utility equipment and accessories.

Specifications

Fuselage length 32.6 feet; overall length 43.2 feet; main rotor diameter 37.1 feet; normal gross weight 2,950 pounds; basic configuration weight 1,777 pounds; useful load 1,117 pounds; engine Lycoming VO-540, 305 takeoff horsepower.

Performance (at normal gross)

Maximum speed, sea level, 105 miles per hour; cruise speed 85 miles per hour; maximum range at 5,000 feet 259 miles; rate of climb 800 feet per minute; hover ceiling OGE 3,900 feet, IGE 7,700 feet; service ceiling 11,200 feet; certificated altitude 20,000 feet.



47G-5 HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The 47G-5, Bell's economy model, is well suited to utility and government work. It is FAA certificated in the basic configuration described below and in a stripped configuration for greater useful loads. Its 12-volt electrical system accommodates many farm, automotive, and police accessories.

Specifications

Fuselage length 32.6 feet; overall length 43.2 feet; main rotor diameter 37.12 feet; normal gross weight 2,850 pounds; useful load 1,191 pounds; engine Lycoming VO-435, 265 takeoff horsepower.

Performance

Maximum speed, sea level, 105 miles per hour; maximum rate of climb, normal gross weight, 860 feet per minute; OGE hover ceiling, normal gross, 1,350 feet; IGE hover ceiling 5,900 feet; service ceiling 10,500 feet; certificated altitude 20,000 feet.



TWIN TWO-TWELVE HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

Scheduled for delivery in 1970, the Twin Two-Twelve provides new safety and performance for medium-size transport helicopters. The new twin-jet is powered by 2 PT6T free-turbine engines manufactured by United Aircraft of Canada. These are coupled to a combining gearbox with a single output shaft. Bell's new, 2-bladed, thin-tip main rotor, called "whisper blades" because of the low sound level, combines with the powerful engines. A variety of seating arrangements is available, from air taxi seating of 14 passengers plus pilot to seating of 6, 8, or 10 passengers in customized corporate versions. A separate 28-cubic-foot luggage compartment is provided in the tail boom. Quick, easy removal of passenger seats turns the Twin Two-Twelve into an airfreighter, aerial crane, aerial ambulance, or air rescue vehicle.

Specifications

Fuselage length 41.5 feet; overall length 57.1 feet; fuselage width 9 feet; main rotor diameter 48 feet; tail rotor diameter 8.5 feet; normal gross weight 10,000 pounds; external load gross weight 10,500 pounds; maximum useful load 4,415 pounds (external 4,875); engine United Aircraft of Canada PT6T Turbo Twin-Pac, 1,800 shaft horsepower derated to 1,250 for takeoff and 1,100 for continuous use up to maximum gross.

Performance (preliminary data)

Takeoff gross weight 10,000 pounds, sea level, standard day; range 280 miles; cruise speed 126 miles per hour; maximum rate of climb 1,850 feet per minute; hover ceiling OGE 10,000 feet, IGE 17,100 feet.



205A-1 HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The 205A-1 is designed to provide multiple capability as a 15-passenger transport, cargo transport, aerial crane, 6-litter ambulance, rescue vehicle, and general utility helicopter. All configurations are designed as kits for providing quick conversion from one configuration to another. The 205A-1 evolved from the 204B commercial and UH-1 military helicopters. It is a reliable, versatile vehicle large enough to perform heavy-duty operations yet small enough for operation by a crew of one.

Specifications

Fuselage length 41.5 feet; overall length 57.1 feet; overall width 9 feet; overall height 14.4 feet; main rotor diameter 48 feet; tail rotor diameter 8.5 feet; normal gross weight 9,500 pounds; external load gross weight 10,500 pounds; maximum useful load 4,418 pounds; engine Lycoming T53-13A, 1,400 shaft horsepower.

Performance

Maximum speed, sea level, 138 miles per hour; maximum continuous cruise speed at 8,000 feet 124 miles per hour; maximum rate of climb, sea level, 2,770 feet per minute; hover ceiling OGE 16,200 feet, IGE 20,000 feet; service ceiling 20,000 feet; range at sea-level cruise 334 miles, at 8,000-foot cruise 404 miles.



206A JETRANGER

Prime Contractor: Bell Helicopter Company

Remarks

The Model 206A JetRanger is a 5-place, turbine-powered, light business and utility helicopter. Introduced to commercial service in January 1967, the 206A has found exceptional acceptance. It is in production by Bell and licensees. More than 700 have been built; they are being used in 35 countries.

Specifications

Overall length 39.1 feet; overall width 6 feet 4 inches; overall height 9 feet 5 inches; normal gross weight 3,000 pounds; useful load 1,925 pounds; engine Allison Model 250-C18, 317 horsepower.

Performance (at normal gross)

Maximum speed, sea level, 150 miles per hour; cruise speed 131 miles per hour; range 392 miles at 8,000 feet; service ceiling 17,700 feet; hover ceiling OGE 3,350 feet, IGE 7,900 feet; rate of climb 1,450 feet per minute.



UH-1C, UH-1E IROQUOIS HELICOPTERS

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1C and the UH-1E are 8- to 10-place military utility and armed helicopters, in service since June 1965. UH-1C is the Army version; UH-1E, the Marine Corps configuration. Both are derived from the Army UH-1B, in service since 1961. A new version of the C is the HueyTug (photo). Introduced in 1968, the HueyTug is a retrofitted version of the UH-1C capable of lifting a 3-ton external payload. HueyTug uses a Lycoming T55 engine and has a 50-foot-diameter rotor and a maximum gross weight, with external load, of 14,000 pounds. Specifications listed are for the basic UH-1C. The Navy also employs TH-1L (training) and UH-1L (utility) versions of the UH-1E configuration with an upgraded T53-L-13 engine and has ordered a similar HH-1K helicopter for delivery in 1970.

Specifications

Overall length 53 feet; fuselage length 42.6 feet; height 12.6 feet; empty weight 4,842 pounds (C), 5,055 pounds (E); gross weight 9,500 pounds; engine Lycoming T53-L-11 turbine, 1,100 shaft horsepower.

Performance

Maximum speed 161 miles per hour; cruise speed 138 miles per hour; normal range 286 miles; rate of climb 1,849 feet per minute; service ceiling 21,000 feet; hover ceiling OGE 11,800 feet, IGE 15,800 feet.

AIRCRAFT



UH-1F IROQUOIS HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1F is the Air Force version of the Model 204 series. In service since March 1964, it seats 11 and is used as a missile site support vehicle.

Specifications

Fuselage length 41.1 feet; overall length 57.1 feet; main rotor diameter 48 feet; maximum gross weight 9,000 pounds; maximum payload plus fuel 4,098 pounds; engine General Electric T58-3, 1,272 shaft horsepower military rating, sea level.

Performance

Maximum speed at full gross weight 115 miles per hour; maximum still-air range 352 miles; maximum sea-level rate of climb, full gross, 1,360 feet per minute; hover ceiling OGE 5,800 feet, IGE 9,600 feet; service ceiling 12,400 feet.



UH-1H IROQUOIS HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1H, an Army tactical transport with a standard payload of 11 troops, became operational in 1967.

Specifications

Fuselage length 41.9 feet; overall length 57.1 feet; fuselage width 8.6 feet; main rotor diameter 48 feet; maximum gross weight 9,500 pounds; maximum payload plus fuel 4,181 pounds; engine Lycoming T53-13 of 1,400 shaft horsepower (sea-level takeoff).

Performance

Maximum speed at 9,500 pounds gross 127 miles per hour; maximum still-air range 318 miles; OGE hover ceiling at full gross 1,100 feet; IGE hover ceiling 13,600 feet; service ceiling 12,600 feet; maximum rate of climb, sea level, 1,600 feet per minute.

UH-1N IROQUOIS HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1N is a twin-engine version of the single-engine UH-1H. The Air Force has ordered 79 of the twinned N versions, deliveries starting in 1969. The Navy has ordered 62, of which 22 are earmarked for the Marines. Deliveries will start in January 1971. The UH-1N is powered by United Aircraft of Canada PT6 Twin-Pac, 1,800 shaft horsepower.



AH-1G HUEYCOBRA

Prime Contractor: Bell Helicopter Company

Remarks

The AH-1G HueyCobra is a 2-place, high-speed fire support helicopter in Army and Marine service; it incorporates stub wings for ordnance stores and a nose-mounted turret. The AH-1G has a 2-bladed, "door-hinge," 44-foot-diameter main rotor and a 2-bladed tail rotor. HueyCobra went into operational service in 1967.

Specifications

Fuselage length 44.4 feet; overall length 52.97 feet; fuselage width 3.5 feet; overall height 13.5 feet; maximum gross weight 9,500 pounds; maximum payload plus fuel 3,404 pounds; engine Lycoming T53-13, sea-level military rating of 1,400 shaft horsepower.

Performance

Maximum speed 219 miles per hour; maximum sea-level rate of climb, full gross, 1,580 feet per minute; IGE hover ceiling 9,900 feet; service ceiling 12,700 feet; maximum still-air range 387 miles.

AH-1J HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The AH-1J is a twin-engine version of the single-engine AH-1G. In 1968 the Marine Corps placed an order for 49 of the twinned high-speed weapons platforms, powered by UAC PT6 Twin-Pac, 1,800 shaft horsepower (military designation of PT6 Twin-Pac is T400).



OH-13S SIOUX HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

In service since September 1963 and still in production, the OH-13S is a 3-place Army observation helicopter.

Specifications

Fuselage length 32.3 feet; overall length 43.2 feet; main rotor diameter 37.1 feet; normal gross weight 2,850 pounds; empty weight 1,936 pounds; engine Lycoming TVO-435-25 supercharged, 260 horsepower.

Performance

Maximum speed 105 miles per hour; cruise speed 83 to 93 miles per hour; maximum still-air range 255 miles; maximum sea-level rate of climb 550 feet per minute; hover ceiling OGE 14,800 feet, IGE 18,000 feet; service ceiling 18,500 feet.



OH-58A OBSERVATION HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The OH-58A was named winner of the Army's re-opened light observation helicopter competition; Bell received an order for 2,200 of the 5-place, turbine-powered aircraft, with deliveries beginning in 1969 and continuing through mid-1972. The OH-58A is a variant of the commercial JetRanger.

Specifications

Fuselage length 32.3 feet; overall length 41 feet; fuselage width 6.4 feet; overall height 9.5 feet; maximum gross weight 3,000 pounds; maximum payload plus fuel 695 pounds; engine Allison T63-A-700, 317 shaft horsepower sea-level military rating.

Performance (at maximum gross)

Maximum speed 150 miles per hour; maximum sea-level rate of climb 1,560 feet per minute; hover ceiling OGE 6,000 feet, IGE 10,900 feet; service ceiling 16,200 feet; maximum still-air range 356 miles.



TH-13T TRAINING HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The TH-13T is a basic instrument trainer first delivered to the Army in December 1964. Still in production, it is a 2-place derivative of the Model 47.

Specifications

Fuselage length 32.3 feet; overall length 43.2 feet; main rotor diameter 37.1 feet; maximum gross weight 2,950 pounds; empty weight 2,057 pounds; engine Lycoming TVO-435-D1B supercharged, 270 horsepower.

Performance

Maximum speed 105 miles per hour; cruise speed 83 to 93 miles per hour; maximum still-air range 235 miles; maximum sea-level rate of climb 900 feet per minute; OGE hover ceiling at maximum gross weight 10,500 feet; IGE hover ceiling 16,000 feet; service ceiling 16,800 feet.



TH-57 TRAINING HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

In 1968 the Navy selected the TH-57A, a variant of the commercial Model 206A JetRanger, as its light turbine training helicopter. The Navy ordered 40 of the craft; all are in service at Naval Air Basic Training Headquarters, Pensacola, Florida.

Specifications

Fuselage length 31.2 feet; overall length 39.1 feet; fuselage width 6.4 feet; overall height 9.6 feet; maximum gross weight 2,900 pounds; maximum payload plus fuel 776 pounds; engine Allison 250-C18, 317 shaft horsepower military rating at sea level.

Performance (at maximum gross)

Maximum speed 150 miles per hour; maximum sea-level rate of climb 1,470 feet per minute; hover ceiling OGE 4,800 feet, IGE 8,700 feet; service ceiling 16,000 feet; maximum still-air range 380 miles.



MODEL 533 COMPOUND HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The Model 533 high-performance compound helicopter is a thrice-modified YH-40, the fourth aircraft of the UH-1 series, built in 1956. It has been involved in Army and company-sponsored flight testing since 1959. In April 1969 the Model 533 recorded 316 miles per hour in level flight—a rotorcraft record—during a program conducted for the Army Aviation Materiel Laboratories.

Specifications

Standard production UH-1H 2-bladed, semirigid rotor hub with low-twist, thin-tipped blades; modified UH-1 airframe powered by a Lycoming T53-L-13 1,400-shaft-horsepower engine and 2 Pratt & Whitney Aircraft JT12A-3 3,300-pound-static-thrust engines mounted on stub wings for high-speed flight.

Performance

Maximum speed 316 miles per hour.



B-47E MEDIUM BOMBER

Prime Contractor: The Boeing Company

Remarks

The B-47 Stratojet, first sweptwing, multijet airplane produced after World War II, was designed as a strategic weapon system capable, with aerial refueling, of operating over extended ranges. The first B-47 was delivered to the Strategic Air Command in October 1951; the last, in February 1957. During the production period, 2,041 B-47s were produced, 1,390 of them at Boeing-Wichita and the remainder under license agreements with 2 other aircraft firms. The bulk of the B-47s produced were bomber versions, of which the B-47E was the last. Other configurations of the Stratojet included a variety of reconnaissance versions designated RB-47E, RB-47H, and RB-47K.

Specifications

Span 116 feet; wing sweepback 35 degrees; length 107 feet; height 28 feet; weight 230,000 pounds; engines 6 General Electric J47, 6,000 pounds thrust each plus provisions for water injection and for 33 ATO rocket units of 1,000 pounds thrust each; gear dual main wheel in tandem with single outrigger attached to inboard engine pods.

Performance

Speed 600 miles per hour; range 3,000 miles; service ceiling over 40,000 feet.



B-52H MISSILE PLATFORM BOMBER

Prime Contractor: The Boeing Company

Remarks

The B-52H, capable of intercontinental flight and return to bases in the United States, is in service with the USAF's Strategic Air Command. In addition to its primary bomb load, the H carries 2 AGM-28 Hound Dog missiles in underwing installations; the air-to-surface weapons can be released hundreds of miles from their targets. Principal feature of the B-52H fuel system is the wing, in which integral construction forms virtually one huge fuel tank. The H was the final model of the B-52 Strato-fortress series, 744 of which were delivered to the Air Force. The last H was delivered October 26, 1962.

Specifications

Span 185 feet; length 157 feet 6.9 inches; height 40 feet 8 inches; wing sweepback 35 degrees; weight 488,000 pounds; engines 8 Pratt & Whitney Aircraft TF33 turbofans, 17,000 pounds thrust each; gear 8 main wheels in tandem, single outrigger near wing tip.

Performance

Speed 650-plus miles per hour; unrefueled range 12,500-plus miles; service ceiling over 60,000 feet.



707-120 SERIES JETLINERS

Prime Contractor: The Boeing Company

Remarks

The Boeing 707-120 (maiden flight December 20, 1957) was America's first jet airliner to go into service. First commercial flight of this 4-engine jetliner was made by Pan American World Airways October 26, 1958, from New York to Paris with 111 passengers. The turbojet airplane was developed from the Boeing 707 sweptwing jet prototype, as was the KC-135 tanker series for the USAF. The 707-120 gave way later to the advanced 707-120B (first flight June 22, 1960; in service March 12, 1961), which incorporated turbofan engines of greater power, a redesigned wing, and new control surfaces. The 707-120 was designed for transcontinental use but was capable of over-ocean ranges from the beginning. Sales of this veteran have been eclipsed by later-generation jetliners, but 143 were sold to 6 airlines and 3 (VC-137B) were sold to the Air Force.

Specifications

Span 130 feet 10 inches; length 144 feet 6 inches; height 42 feet; wing sweepback 35 degrees; weight 258,000 pounds; engines 4 Pratt & Whitney Aircraft JT3C-6 turbojets of 13,000 pounds thrust (707-120), 4 Pratt & Whitney JT3D-3 turbofans of 18,000 pounds thrust (707-120B); gear tricycle with 4-wheel bogie-type truck main units and dual nose wheels; payload up to 181 passengers.

Performance

Speed up to 600 miles per hour; range over 3,000 miles; ceiling over 40,000 feet.

707-320 SERIES JETLINERS

Prime Contractor: The Boeing Company

Remarks

Designed to serve long-range routes of over 4,000 miles, the 707-320 intercontinental jetliner went into service October 26, 1959. First flight was January 11, 1959. It was supplanted later by the 707-320B with a range of over 6,000 miles nonstop with normal passenger load. The 707-320B (first flight January 31, 1962; in service June 1, 1963) incorporated turbofan engines, new leading and trailing edge wing flaps, and other aerodynamic improvements. In 1962 a 7- by 11-foot forward cargo door and some structural strengthening, plus use of integral floor tracks and a cargo-handling system, developed the 707-320B into a multipurpose jet, the 707-320C (in service June 3, 1963). This airplane can carry all cargo on pallets, or it can be converted to carry all passengers or a combination of passengers and cargo.

Specifications

Span 145 feet 9 inches; length 152 feet 11 inches; height 42 feet 5 inches; wing sweepback 35 degrees; weight 328,000 pounds (707-320B), 332,000 pounds (cargo version of 707-320C), 336,000 pounds (passenger version of 707-320C); engines 4 Pratt & Whitney Aircraft JT3D-3 turbofans of 18,000 pounds thrust; gear tricycle, main undercarriage units 4-wheel bogie-type trucks, dual nose wheels; payload 189 passengers (707-320B), 202 passengers economy class or 96,800 pounds of cargo (707-320C).

Performance

Speed over 600 miles per hour; range over 6,000 miles; ceiling 42,000 feet.



720, 720B JETLINER

Prime Contractor: The Boeing Company

Remarks

A lighter, faster, and slightly smaller version of the original Boeing 707 jetliner, the medium-range 720 first flew November 23, 1959, and went into service in July 1960. The 720B, a version with more powerful, turbofan engines, was introduced on October 6, 1960. The 720 differs from the 707-120 in that it has a shorter body, lighter structure, less fuel capacity, a redesigned inboard wing, and new, full-span leading edge flaps. It has greater maximum speed and requires shorter field lengths. Turbofan engines give the 720B greater range and allow it to operate from still shorter runways. The B model went into service March 12, 1961. Altogether, 154 of the series were built for 16 airlines.

Specifications

Span 130 feet 10 inches; length 136 feet 2 inches; height 41 feet 6 inches; wing sweepback 35 degrees; weight 230,000 pounds (720), 235,000 pounds (720B); engines 4 Pratt & Whitney Aircraft JT3C-7 turbojets of 12,000 pounds thrust (720), 4 Pratt & Whitney JT3D-1 turbofans of 17,000 pounds thrust or JT3D-3 turbofans of 18,000 pounds thrust (720B); gear tricycle with 4-wheel bogie-type truck main units, dual nose wheels; payload up to 165 passengers.

Performance

Speed up to 615 miles per hour; range 3,300 miles; ceiling over 40,000 feet.



727 MEDIUM-RANGE JETLINER

Prime Contractor: The Boeing Company

Remarks

The 727, first American jet transport to depart from wing-mounted engine installation, has 3 engines grouped at the tail. Its 3-engine configuration was designed to give the best compromise between 4-engine power and reliability and twin-engine economy. In service since early 1964, it is designed specifically for medium-range routes, and it has a takeoff performance superior to all other jets in its class. Boeing offers 4 versions of this highly successful, widely sold airliner: the standard 727-100, the 20-foot-longer 727-200, the 727C (cargo/convertible), and the 727QC (quick-change cargo/convertible).

Specifications

Span 108 feet; length 133 feet 2 inches (727-200 is 153 feet 2 inches); height 34 feet; wing sweepback 32 degrees; weight 161,000 pounds (727-100), 170,000 pounds (other versions); engines 3 Pratt & Whitney Aircraft JT8D-1 or JT8D-7 turbofans, 14,000 or 14,500 pounds thrust each; gear tricycle, dual-wheel units; payload up to 131 passengers economy class (727-100), up to 179 passengers economy class (727-200), up to 46,600 pounds (727QC).

Performance

Speed 600 miles per hour; normal operating range 1,700 miles (727-200, 1,400 miles); operational ceiling 42,000 feet.



737 SHORT-RANGE JETLINER

Prime Contractor: The Boeing Company

Remarks

The 737 twin-jet is the smallest member of the Boeing jetliner family, with maximum gross taxi weight of 111,000 pounds, as compared with 161,000 pounds for the 3-engine 727. Contrary to the trend in twin-jet airliners toward aft-mounted engines, Boeing placed the engines under the wings on the 737 for the advantages of easier maintainability, reduction in structure weight, additional passenger space in the cabin, better balance characteristics, simplified systems, more loading flexibility, and better aerodynamic efficiency. Two versions of the 737 went into production in 1965, the 737-100 and the 6-foot-longer 737-200.

Specifications

Span 93 feet; length 94 feet (737-100), 100 feet (737-200); height 37 feet; wing sweepback 25 degrees; weight 111,000 pounds; engines 2 Pratt & Whitney Aircraft JT8D-7 turbofans, 14,000 pounds thrust each (JT8D-9 of 14,500 pounds thrust optional); gear tricycle, dual-wheel units; payload 31,000 pounds (structural limit) or up to 107 passengers (737-100), 32,500 pounds or up to 124 passengers (737-200).

Performance

Speed 575 miles per hour; normal operating range up to 1,500 miles; ceiling 35,000 feet.



747 JETLINER

Prime Contractor: The Boeing Company

Remarks

When the first 747 rolled from the factory on September 30, 1968, it became the largest commercial jetliner in history. It was to enter commercial service in late 1969 following extensive flight testing. Designed to carry up to 490 passengers in all-economy seating or 365 in mixed-class configuration over long ranges, this 625-mile-per-hour aircraft offers the opportunity for new standards in air travel. Its 185-foot-long, 20-foot-wide cabin permits spacious seating as well as such innovations as nurseries and lounges. In addition, a stateroom area is available on an upper level behind the crew. Its size may lead to new concepts in ticketing, baggage checking, and terminal arrangements. As a cargo carrier, it has straight-in nose loading and powered loading devices in the floor. Convertible and all-freighter versions are offered.

Specifications

Span 195 feet 8 inches; length 231 feet 10 inches; height 63 feet 5 inches; wing sweepback 37.5 degrees; maximum ramp weight 710,000 to 733,000 pounds; engines 4 Pratt & Whitney Aircraft JT9D turbofans of 43,500 pounds thrust each; dual nose wheels, 4 4-wheel bogie-type main trucks; payload up to 490 passengers in all-economy or 220,000 pounds in all-cargo version.

Performance

Speed up to 640 miles per hour; range over 4,000 miles; ceiling 45,000 feet.



KC/C-135 TANKER/TRANSPORT SERIES

Prime Contractor: The Boeing Company

Remarks

Shortly after Boeing's privately financed 707 prototype flew in July 1954, the Air Force ordered into limited production a derivative, the KC-135A jet tanker. The tanker, incorporating a highly streamlined flying boom developed by Boeing, for the first time allowed refueling of USAF jet bombers and fighters at jet speeds and altitudes. By the time the military production line phased out at Boeing at the beginning of 1965, the company had delivered 732 tankers plus 88 transports, flying command posts, and reconnaissance aircraft. A total of 820 KC/C-135s were built. The tankers and some transports used water-injection turbojet engines; a B model using turbofans was developed and put into transport service by the Air Force in 1961.

Specifications

Span 130 feet 10 inches; length 136 feet 6 inches; height 38 feet 5 inches (KC-135), 41 feet 8 inches (C-135B); wing sweepback 35 degrees; weight 297,000 pounds (KC-135), 275,000 pounds (C-135B); engines 4 Pratt & Whitney Aircraft J57 turbojets of 13,750 pounds thrust (KC-135), 4 Pratt & Whitney TF33-P-5 turbofans of 18,000 pounds thrust (C-135B); gear tricycle, 4-wheel bogie-type trucks, dual nose wheels; payload 87,100 pounds (C-135B).

Performance

Speed 600 miles per hour; range over 3,000 miles (tanker), 7,000 miles (transport); ceiling 41,000 feet.



SUPERSONIC TRANSPORT

Prime Contractor: The Boeing Company

Remarks

In May 1967 the Federal Aviation Administration signed a contract with Boeing for design of a prototype of an 1,800-mile-per-hour passenger jetliner. Late in 1969, President Nixon approved construction of 2 prototypes. Boeing originally planned a variable-sweep-wing configuration but announced late in 1968 that it favored switching to a fixed-wing design (photo) and that it would recommend the new program to the FAA and the airlines. Most of the SST will be built of an alloy of 90 percent titanium, 6 percent aluminum, and 4 percent vanadium.

Specifications

Length 280 feet; span 142 feet; height at tail 50 feet; leading edge sweep 50 degrees; prototype weight 635,000 pounds; passenger capacity, production version, estimated 280 passengers; wing area approximately 7,000 square feet; engines 4 General Electric GE4, 60,000 pounds thrust each.

Performance

Cruise speed Mach 2.7, or 1,800 miles per hour, at 60,000-plus feet.



CH-46D SEA KNIGHT ASSAULT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The CH-46D is a medium assault transport helicopter in production for the Marine Corps. The tandem-rotor helicopter, with all-weather and ship-board capabilities, features a power blade folding system which enables the blades to be folded automatically in less than one minute in winds up to 45 knots.

Specifications

Fuselage length 44 feet 10 inches; rotor diameter 51 feet; takeoff design gross weight 20,800 pounds; takeoff maximum gross weight 23,000 pounds; empty weight 13,276 pounds; engines 2 General Electric T58-10, each with 1,450 shaft horsepower.

Performance

Cruise speed at sea level 140 knots; mission radius 100 nautical miles; service ceiling 14,000 feet; payload at design gross weight 4,823 pounds, at maximum gross weight 6,998 pounds.



107 TWIN-TURBINE TRANSPORT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The Boeing-Vertol 107 is a multipurpose transport helicopter designed for commercial users requiring high performance, high load capacity, and operational economy.

Specifications

Fuselage length 44 feet 7 inches; rotor diameter 50 feet; takeoff gross weight 19,000 pounds; engines 2 General Electric T58 turbines.

Performance

Maximum speed 144 knots; best cruise speed 135 knots; range over 200 miles with reserve; payload 25 passengers plus baggage.



**CH-47C CHINOOK
TRANSPORT HELICOPTER**

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The CH-47C Chinook is the Army's standard medium transport helicopter. The Chinook can transport several types of missile systems complete with launch crews; tube-type artillery weapons with crew and ammunition; fuel; ground vehicles; high-density cargo; and command and control centers. It is used also to recover downed aircraft and to evacuate refugees. An important mission is air movement of combat elements. The Chinook can carry 44 fully equipped troops.

Specifications

Fuselage length 51 feet; rotor diameter 60 feet; takeoff design gross weight 33,000 pounds; takeoff maximum gross weight 45,700 pounds; empty weight 20,213 pounds; engines 2 Lycoming T55-L-11, each with 3,750 shaft horsepower.

Performance

Cruise speed at sea level 162 knots; mission radius 100 nautical miles; service ceiling 15,000 feet; payload at maximum gross weight, 10-nautical-mile mission, 24,000 pounds, 100-nautical-mile mission, 19,900 pounds.



107 MILITARY TRANSPORT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The 107 military transport helicopter is in service with the Canadian Defence Force Air Rescue Service and Mobile Command, the Swedish Navy, and the Royal Swedish Air Force. It has a crew of 3, plus space for as many as 25 troops. It can be used for search and rescue and for a variety of other missions, including transport of cargo, fuel, and passengers.

Specifications*

Fuselage length 44 feet 10 inches; rotor diameter 50 feet; takeoff design gross weight 18,700 pounds; takeoff maximum gross weight 21,400 pounds; empty weight 11,281 pounds; engines 2 General Electric T58-8, each with 1,050 shaft horsepower.

Performance*

Cruise speed 130 knots; service ceiling 15,600 feet; mission radius 100 nautical miles.

*Specifications and performance listed are for the CH-113A Mobile Command helicopter. There are slight variations in the specifications and performance of the 107 helicopters used by other military customers.



UH-46D MEDIUM TRANSPORT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The UH-46D, a twin-turbine, tandem-rotor helicopter, is the key to the Navy's vertical replenishment program. Although its primary mission calls for external loads, it can accomplish many missions involving internal loads. The UH-46D has a 24-foot 2-inch cabin which features straight-in loading through a rear ramp.

Specifications

Fuselage length 44 feet 10 inches; rotor diameter 51 feet; takeoff design gross weight 20,800 pounds; takeoff maximum gross weight 23,000 pounds; empty weight 12,929 pounds; engines 2 General Electric T58-10, each with 1,400 shaft horsepower.

Performance

Cruise speed at sea level 140 knots; mission radius 100 nautical miles; service ceiling 14,000 feet; payload at design gross weight 4,916 pounds, at maximum gross weight 7,136 pounds.



MODEL 150

Prime Contractor: Cessna Aircraft Company

Remarks

In addition to the earlier standard, trainer, and commuter versions, Cessna added to its 1970 Model 150 line an aerobatic version, the Aerobat.

Specifications (standard, trainer, commuter versions)

Gross weight 1,600 pounds; empty weight 975 to 1,060 pounds; baggage 120 pounds; wing loading 10.2 pounds per square foot; power loading 16 pounds per horsepower; fuel capacity 26 gallons, with long-range tanks 38 gallons; wingspan 33 feet 2 inches; length 23 feet 9 inches; height 8 feet 7.5 inches; engine 4-cylinder, 100 horsepower.

Performance

Maximum speed 122 miles per hour; cruise speed, 75 percent power at 7,000 feet, 117 miles per hour; range at cruise speed 475 miles, with long-range tanks 725 miles; rate of climb at sea level 670 feet per minute; service ceiling 12,650 feet.



MODEL 172, SKYHAWK

Prime Contractor: Cessna Aircraft Company

Specifications (172)

Wingspan 35 feet 9.5 inches; wing area 174 square feet; length 26 feet 11 inches; height (with depressed nose strut) 8 feet 9.5 inches; gross weight 2,300 pounds; empty weight (approximate) 1,245 pounds; baggage 120 pounds; wing loading 13.2 pounds per square foot; power loading 15.3 pounds per horsepower; fuel capacity 42 gallons; engine Lycoming O-320-E2D; propeller all metal, fixed pitch, 76-inch diameter. Skyhawk (photo) has same specifications with this exception: empty weight 1,315 pounds.

Performance (172)

Top speed at sea level 139 miles per hour; cruise speed, 75 percent power at 9,000 feet, 131 miles per hour; cruise range, 75 percent power at 9,000 feet, 615 miles; optimum range at 10,000 feet 640 miles; rate of climb at sea level 645 feet per minute; service ceiling 13,100 feet; takeoff distance over 50-foot obstacle 1,525 feet; landing distance over 50-foot obstacle 1,250 feet.

Performance (Skyhawk)

Top speed at sea level 140 miles per hour; cruise speed, 75 percent power at 9,000 feet, 132 miles per hour; cruise range 620 miles; optimum range at 10,000 feet 655 miles; rate of climb 645 feet per minute; service ceiling 13,100 feet; takeoff distance over 50-foot obstacle 1,525 feet; landing distance over 50-foot obstacle 1,250 feet.



CARDINAL, MODEL 177

Prime Contractor: Cessna Aircraft Company

Remarks

Cardinal and Model 177 are externally identical except for color styling; Cardinal (photo) is the deluxe version of the 177.

Specifications (Model 177)

Wingspan 35 feet 6 inches; wing area 174 square feet; length 26 feet 11.5 inches; height (with depressed nose strut) 9 feet 1 inch; gross weight 2,500 pounds; empty weight (approximate) 1,415 pounds; baggage 120 pounds; wing loading 14.4 pounds per square foot; power loading 13.9 pounds per horsepower; fuel capacity 50 gallons; engine Lycoming O-360-A2F; propeller all metal, fixed pitch, 76-inch diameter.

Specifications (Cardinal)

Same as Model 177 except for approximate empty weight of 1,475 pounds.

Performance (Model 177)

Maximum speed, sea level, 150 miles per hour; cruise speed, 75 percent power at 8,000 feet, 139 miles per hour; cruise range, 75 percent power at 8,000 feet, 675 miles; optimum range at 10,000 feet 775 miles; rate of climb, sea level, 840 feet per minute; service ceiling 14,600 feet; takeoff distance over 50-foot obstacle 1,400 feet; landing distance over 50-foot obstacle 1,220 feet.

Performance (Cardinal)

Same as Model 177 except for following: maximum speed, sea level, 153 miles per hour; cruise speed 142 miles per hour; cruise range 690 miles; optimum range 790 miles.



SKYWAGON 180

Prime Contractor: Cessna Aircraft Company

Specifications

Wingspan 36 feet 2 inches; wing area 174 square feet; length 25 feet 6 inches; height 7 feet 9 inches; gross weight 2,800 pounds; empty weight (approximate) 1,545 pounds; baggage capacity 400 pounds; wing loading 16.1 pounds per square foot; power loading 12.2 pounds per horsepower; fuel capacity 65 gallons; engine Continental, 230 rated horsepower; propeller constant speed, 82-inch diameter.

Performance

Maximum speed at sea level 170 miles per hour; cruise speed, 75 percent power at 6,500 feet, 162 miles per hour; cruise range, 75 percent power at 6,500 feet, 695 miles; optimum range at 10,000 feet 925 miles; rate of climb at sea level 1,090 feet per minute; service ceiling 19,600 feet; takeoff distance over 50-foot obstacle 1,205 feet; landing distance over 50-foot obstacle 1,365 feet.

Note: Model 180 also available as float plane and skiplane.



SKYWAGON 185

Prime Contractor: Cessna Aircraft Company

Specifications

Wingspan 36 feet 2 inches; wing area 174 square feet; length 25 feet 9 inches; height 7 feet 9 inches; gross weight 3,350 pounds; empty weight (approximate) 1,575 pounds; baggage capacity 400 pounds; wing loading 19.3 pounds per square foot; power loading 11.2 pounds per horsepower; fuel capacity 65 gallons; engine 6-cylinder, fuel-injection Continental, maximum rating 300 horsepower; propeller constant speed, 82-inch diameter.

Performance

Maximum speed at sea level 178 miles per hour; cruise speed, 75 percent power at 7,500 feet, 169 miles per hour; cruise range, 75 percent power at 7,500 feet, 660 miles; optimum range at 10,000 feet 825 miles; rate of climb at sea level 1,010 feet per minute; service ceiling 17,150 feet; takeoff distance over 50-foot obstacle 1,365 feet; landing distance over 50-foot obstacle 1,400 feet.

Note: Model 185 also available as float plane and amphibian.



SKYWAGON 206, TURBO-SKYWAGON 206

Prime Contractor: Cessna Aircraft Company

Specifications

Wingspan 36 feet 7 inches; length 28 feet; height (with depressed nose strut) 9 feet 6.75 inches; wing area 175.5 square feet; gross weight 3,600 pounds; empty weight 1,710 pounds (206), 1,795 pounds (Turbo); wing loading 20.5 pounds per square foot; power loading 12 pounds per horsepower (206), 12.6 pounds (Turbo); fuel capacity 65 gallons; engine 6-cylinder fuel-injection, 285 maximum continuous horsepower at 2,700 revolutions per minute (206), 6-cylinder turbosupercharged fuel-injection, 285 rated horsepower at 2,700 revolutions per minute (Turbo).

Performance (206)

Top speed at sea level 174 miles per hour; cruise speed, 75 percent power at 6,500 feet, 164 miles per hour; cruise range 650 miles; optimum range at 10,000 feet 800 miles; rate of climb at sea level 920 feet per minute; service ceiling 14,800 feet; takeoff distance over 50-foot obstacle 1,780 feet; landing distance over 50-foot obstacle 1,395 feet.

Performance (Turbo)

Top speed at 19,000 feet 200 miles per hour; cruise speed, 75 percent power at 24,000 feet, 184 miles per hour, at 10,000 feet, 170 miles per hour; cruise range 700 miles; optimum range at 15,000 feet 825 miles; rate of climb, sea level, 1,030 feet per minute; service ceiling 26,300 feet.



SKYWAGON 207, TURBO-SKYWAGON 207

Prime Contractor: Cessna Aircraft Company

Specifications

Wingspan 36 feet 7 inches; length 31 feet 9 inches; height (with depressed nose strut) 9 feet 6.5 inches; wing area 175.5 square feet; gross weight 3,800 pounds; empty weight 1,860 pounds (207), 1,960 pounds (Turbo); wing loading 21.7 pounds per square foot; power loading 12.7 pounds per horsepower; fuel capacity 65 gallons; engine 6-cylinder fuel-injection, 300 takeoff horsepower at 2,850 revolutions per minute (207), 6-cylinder turbocharged, 300 takeoff horsepower at 2,700 revolutions per minute (Turbo).

Performance (207)

Top speed at sea level 168 miles per hour; cruise speed, 75 percent power at 6,500 feet, 159 miles per hour; cruise range 585 miles; optimum range at 10,000 feet 695 miles; rate of climb at sea level 810 feet per minute; service ceiling 13,300 feet; takeoff distance over 50-foot obstacle 1,970 feet; landing distance over 50-foot obstacle 1,500 feet.

Performance (Turbo)

Top speed at 17,000 feet 189 miles per hour; cruise speed, 75 percent power at 20,000 feet, 176 miles per hour, at 10,000 feet, 163 miles per hour; cruise range 610 miles; optimum range at 20,000 feet 685 miles; rate of climb at sea level 885 feet per minute; service ceiling 24,200 feet.



MODEL 210 CENTURION, TURBO-SYSTEM CENTURION

Prime Contractor: Cessna Aircraft Company

Remarks

The deluxe Model 210 Centurion and the new Turbo-System Centurion bring many luxury and comfort features to the single-engine class of aircraft. These include specially trimmed and sculptured interior appointments, optional leather seats, heavy foam-padded carpeting, and optional center-aisle consoles for storage.

Specifications

Span 36 feet 9 inches; length 28 feet 3 inches; height 9 feet 7.5 inches; gross weight 3,400 pounds; empty weight 1,960 pounds (210), 2,060 pounds (Turbo); wing loading 19.3 pounds per square foot; power loading 11.9 pounds per horsepower; fuel capacity 90 gallons maximum; engine 6-cylinder fuel-injection, 285 horsepower (210), 6-cylinder turbosupercharged fuel-injection, 285 horsepower (Turbo); propeller constant speed, 82-inch diameter.

Performance (210)

Top speed 200 miles per hour; cruise speed, 75 percent power at 6,500 feet, 192 miles per hour; range at cruise speed 785 miles; maximum range with maximum fuel 1,360 miles; rate of climb at sea level 1,000 feet per minute; service ceiling 18,300 feet.

Performance (Turbo)

Top speed at 19,000 feet 234 miles per hour; cruise speed, 75 percent power at 24,000 feet, 223 miles per hour, at 10,000 feet, 197 miles per hour; cruise range, 75 percent power at 24,000 feet, 64 gallons, 860 miles; rate of climb at sea level 1,115 feet per minute; service ceiling 30,200 feet.



MODEL 310P, TURBO-SYSTEM 310P

Prime Contractor: Cessna Aircraft Company

Specifications

Span 36 feet 11 inches; length 29.5 feet (310P), 29.25 feet (Turbo); height 9 feet 11 inches (310P), 10.43 feet (Turbo); wing area 179 square feet; gross weight 5,200 pounds (310P), 5,400 pounds (Turbo); empty weight 3,170 pounds (310P), 3,292 pounds (Turbo); baggage capacity 600 pounds; wing loading 29 pounds per square foot (310P), 30.17 pounds (Turbo); power loading 10 pounds per horsepower (310P), 9.47 pounds (Turbo); fuel capacity 102 gallons standard; engines 2 6-cylinder fuel-injection Continental IO-470-V-0 (310P), 2 Continental TSIO-520-B, 285 horsepower at 2,700 revolutions per minute (Turbo); propeller constant speed, full feathering, 81-inch diameter.

Performance (310P)

Maximum speed at sea level 237 miles per hour; maximum recommended cruise speed, 75 percent power at 6,500 feet, 222 miles per hour; cruise range 777 miles; maximum range at 10,000 feet 966 miles; rate of climb at sea level 1,540 feet per minute (twin engine), 330 feet per minute (single engine); service ceiling 19,900 feet (twin), 6,850 feet (single); takeoff distance at sea level over 50-foot obstacle 1,716 feet; landing distance at sea level over 50-foot obstacle 1,673 feet.

Performance (Turbo)

Top speed at 16,000 feet 275 miles per hour; recommended cruise speed, 75 percent power at 10,000 feet, 234 miles per hour; cruise range 763 miles; rate of climb at sea level, 2 engines, 1,862 feet per minute; service ceiling 28,600 feet, one engine 18,100 feet.

AIRCRAFT



MODEL 182, SKYLANE

Prime Contractor: Cessna Aircraft Company

Specifications

Wingspan 36 feet 2 inches; wing area 174 square feet; length 28 feet .5 inch; height 8 feet 10.5 inches; gross weight 2,800 pounds; empty weight (approximate) 1,580 pounds (182), 1,635 pounds (Skylane); baggage capacity 120 pounds; wing loading 16.1 pounds per square foot; power loading 12.2 pounds per horsepower; fuel capacity 65 gallons, 84 gallons optional; engine 6-cylinder, 230 rated horsepower; propeller constant speed, 82-inch diameter.

Performance (182)

Top speed at sea level 167 miles per hour; cruise speed, 75 percent power at 6,500 feet, 159 miles per hour; cruise range, 75 percent power at 6,500 feet, 685 miles; optimum cruise range at 10,000 feet 905 miles; rate of climb at sea level 980 feet per minute; service ceiling 18,900 feet; takeoff distance over 50-foot obstacle 1,205 feet; landing distance over 50-foot obstacle 1,350 feet.

Performance (Skylane)

Top speed at sea level 170 miles per hour; cruise speed, 75 percent power at 6,500 feet, 162 miles per hour; cruise range 695 miles; rate of climb at sea level 980 feet per minute; service ceiling 18,900 feet.



SUPER SKYLANE, TURBO-SYSTEM SUPER SKYLANE

Prime Contractor: Cessna Aircraft Company

Specifications

Wingspan 36 feet 7 inches; wing area 175.5 square feet; length 28 feet 3 inches; height (nose strut depressed) 9 feet 7.5 inches; gross weight 3,600 pounds; empty weight (approximate) 1,835 pounds (Super), 1,935 pounds (Turbo); fuel capacity standard 65 gallons, optional 84 gallons; oil capacity 12 quarts; wing loading 20.5 pounds per square foot; power loading 12.6 pounds per horsepower; engine 6-cylinder fuel-injection, 285 horsepower (Super), same with turbosupercharging (Turbo); propeller constant speed, 82-inch diameter.

Performance (Super)

Top speed at sea level 174 miles per hour; cruise speed, 75 percent power at 6,000 feet, 163 miles per hour; cruise range, 63 gallons no reserve, 4 hours at 162 miles per hour; optimum range at 10,000 feet, 63 gallons, 810 miles; rate of climb at sea level 920 feet per minute; takeoff run over 50-foot obstacle 910 feet, total distance 1,810 feet; landing roll over 50-foot obstacle 735 feet, total distance 1,395 feet.

Performance (Turbo)

Top speed at 19,000 feet 200 miles per hour; cruise speed, 75 percent power at 24,000 feet, 184 miles per hour; cruise range, 63 gallons no reserve, 700 miles; rate of climb at sea level 1,030 feet per minute; service ceiling 26,300 feet.



**SUPER SKYMASTER,
TURBO-SYSTEM SUPER SKYMASTER**

Prime Contractor: Cessna Aircraft Company

Specifications

Wingspan 38 feet (Super), 39 feet (Turbo); wing area 201 square feet; length 29 feet 9 inches (Super), 29 feet 10 inches (Turbo); height 9 feet 4 inches; gross weight 4,400 pounds (Super), 4,500 pounds (Turbo); empty weight (approximate) 2,655 pounds (Super), 2,815 pounds (Turbo); baggage 365 pounds; wing loading 21.9 pounds per square foot (Super), 22.4 pounds (Turbo); power loading 10.5 pounds per horsepower (Super), 10.7 pounds (Turbo); fuel capacity 93 gallons; engines 2 6-cylinder fuel-injection IO-360, 210 horsepower (Super), 2 6-cylinder turbocharged 210 horsepower (Turbo); propellers constant speed, full feathering, 76-inch diameter.

Performance (Super)

Top speed at sea level 199 miles per hour; cruise speed, 75 percent power at 5,500 feet, 191 miles per hour; normal range, 75 percent power at 5,500 feet, 760 miles; optimum range at 10,000 feet 965 miles; rate of climb at sea level 1,200 feet per minute (twin engine); service ceiling 19,500 feet (twin); takeoff distance over 50-foot obstacle 1,545 feet; landing distance over 50-foot obstacle 1,650 feet.

Performance (Turbo)

Top speed at 20,000 feet 231 miles per hour; cruise speed, 75 percent power at 24,000 feet, 224 miles per hour, at 10,000 feet, 195 miles per hour; cruise range, 75 percent power at 24,000 feet, 860 miles; rate of climb at sea level 1,155 feet per minute (twin); service ceiling 30,100 feet (twin).



T-37B MILITARY TRAINER

Prime Contractor: Cessna Aircraft Company

Remarks

The Cessna T-37B twin-jet intermediate trainer is in use at Air Force training schools throughout the United States. The aircraft features side-by-side seating of student and instructor. More than 900 were built for the USAF and for air forces of other nations. The T-37C, with tip tanks and armament provisions, is being delivered to foreign countries under the Military Assistance Program.

Specifications

Span 33 feet 8 inches; length 29 feet 2 inches; height 9 feet 1 inch; empty weight 4,076 pounds; wing loading 35.7 pounds per square foot; power loading 3.2 pounds per pound thrust; engines 2 Continental J69-T-25.

Performance

Maximum speed 408 miles per hour; cruise speed at normal rated power 368 miles per hour; gross weight landing speed 85 miles per hour; rate of climb at sea level 3,200 feet per minute; service ceiling 35,000 feet; range with maximum fuel 796 miles.



A-37 STRIKE AIRCRAFT

Prime Contractor: Cessna Aircraft Company

Remarks

The A-37 is being delivered to the Air Force for close air support work. Evolving from the T-37B jet trainer, the A-37 is equipped with armor plating, partial self-sealing fuel tanks, and armament provisions, including a 7.62 minigun. The aircraft also has provisions for an access door under the fuselage for aerial cameras, a fire-control and electrical system to accommodate all weapons for close-support missions, and long-range fuel drop tanks. Two versions are in use by the USAF: the A-37A, which was formerly known as the AT-37D, and the A-37B (photo), which has the same performance as the A-37A but differs in several areas such as inflight refueling capabilities, higher engine thrust, and increased structural capabilities.

Specifications

Gross weight 14,000 pounds; length 29 feet 4 inches; wingspan 35 feet 9 inches; engines General Electric J85-GE-17A, total thrust 5,400 pounds; maximum external ordnance load 5,680 pounds.

Performance

Maximum speed 415 knots; gross weight takeoff distance over 50-foot obstacle 2,650 feet; landing distance over 50-foot obstacle 2,350 feet; rate of climb 6,800 feet per minute; single-engine performance after lift-off at gross weights up to 11,700 pounds.



T-41 MILITARY TRAINER

Prime Contractor: Cessna Aircraft Company

Remarks

Cessna has produced T-41A trainers in which Air Force student pilots are receiving first flight instruction. The T-41A is a version of the Cessna commercial Model 172, which holds the world's flight endurance record by remaining in flight continuously for 64 days and 22 hours. The company has supplied the Army with a similar version of this aircraft for use in training student aviators and for installation support roles. The Army version is known as the T-41B. A third version, the T-41C (photo), is in use with the USAF Academy flight training program.

Specifications

Wingspan 36 feet 2 inches; wing area 174 square feet; length 26 feet 6 inches; height (with depressed nose strut) 8 feet 11 inches; gross weight 2,300 pounds; empty weight (approximate) 1,260 pounds; wing loading 13.2 pounds per square foot; power loading 15.9 pounds per horsepower; fuel capacity 42 gallons; engine Continental O-300-C; propeller all metal, fixed pitch, 76-inch diameter. T-41B is equipped with a 210-horsepower engine and a constant-speed propeller to supply higher performance. T-41C is essentially the same aircraft.

Performance

Top speed at sea level 138 miles per hour; cruise speed, 75 percent power at 7,000 feet, 130 miles per hour; cruise range, 75 percent power at 7,000 feet, 595 miles; optimum range at 10,000 feet 720 miles; rate of climb at sea level 645 feet per minute; service ceiling 13,100 feet; takeoff distance over 50-foot obstacle 1,525 feet; landing distance over 50-foot obstacle 1,250 feet.



MODELS 401A, 402A

Prime Contractor: Cessna Aircraft Company

Remarks

Cessna's Model 401A is a turbocharged executive twin seating 6 to 8. The companion 402A Utilitwin (photo) is a utility version that can seat 10 or carry 2,000 pounds of cargo.

Specifications

Wingspan 39.86 feet; length 33.75 feet (401A), 35.83 feet (402A); height 11.68 feet; gross weight 6,300 pounds; 2 6-cylinder fuel-injection engines, 300 rated horsepower at 2,700 revolutions per minute; propellers 3-bladed, constant speed, full feathering; 76.5 inches diameter; empty weight (approximate) 3,674 pounds (401A), 3,719 pounds (402A); standard fuel capacity 102 gallons, 143 optional; baggage 930 pounds (401A), 590 pounds (402A); wing loading 32.2 pounds per square foot; power loading 10.5 pounds per horsepower.

Performance

Maximum speed at 6,300 pounds gross weight at 16,000 feet 261 miles per hour; cruise speed, 75 percent power at 20,000 feet, 240 miles per hour, at 10,000 feet, 218 miles per hour; cruise range, 75 percent at 10,000 feet, 100 gallons, 660 miles; maximum range at 25,000 feet, 140 gallons, 1,131 miles; rate of climb at sea level (twin engine) 1,610 feet per minute, (single engine) 255 feet per minute (401A), 225 feet per minute (402A); service ceiling (twin) 26,180 feet, (single) 11,700 feet (401A), 11,320 feet (402A); takeoff distance over 50-foot obstacle 2,220 feet; landing distance over 50-foot obstacle 1,765 feet.



MODEL 421A

Prime Contractor: Cessna Aircraft Company

Specifications

Wingspan 39.86 feet; length 33.75 feet; height 11.38 feet; gross weight 6,840 pounds; engines 2 6-cylinder fuel-injection GTSIO-520-D, 375 horsepower each; propellers 3-bladed, constant speed, full feathering, 90-inch diameter; empty weight (approximate) 4,252 pounds; standard fuel 175 gallons, optional 202 gallons; seating 6; baggage allowable 930 pounds; wing loading 34 pounds per square foot; power loading 9.06 pounds per horsepower; pressurized cabin.

Performance

Maximum speed, 6,840 pounds gross weight at 16,000 feet, 276 miles per hour; cruise speed, 75 percent power at 22,500 feet, 261 miles per hour, at 10,000 feet 233 miles per hour; normal cruise range 922 miles (standard fuel); maximum cruise range at 25,000 feet 1,174 miles (standard fuel); rate of climb at sea level (twin) 1,700 feet per minute, (single) 300 feet per minute; service ceiling (twin) 26,000 feet, (single) 13,340 feet; takeoff distance over 50-foot obstacle 2,516 feet; landing distance over 50-foot obstacle (6,500 pounds gross) 2,110 feet.



MODEL O-1E BIRD DOG

Prime Contractor: Cessna Aircraft Company

Remarks

Although currently not in production, the O-1 is still widely used by the Army and the Air Force for liaison and observation duties. Formerly known as the L-19, the aircraft can operate from rough, small fields.

Specifications

Wingspan 36 feet; length 25 feet 10 inches; height 7 feet 4 inches; wing area 174 square feet; gross weight 2,400 pounds; empty weight 1,614 pounds; wing loading 13.8 pounds per square foot; power loading 11.2 pounds per horsepower; fuel capacity 40 gallons; engine 213 horsepower; propeller 90-inch, fixed pitch.

Performance

Top speed at sea level 116 miles per hour; cruise speed 104 miles per hour at 70 percent power at 5,000 feet; maximum range 530 miles at 5,000 feet at 98 miles per hour; rate of climb at sea level 1,150 feet per minute; service ceiling 18,500 feet; stall speed 54 miles per hour.



MODEL O-2

Prime Contractor: Cessna Aircraft Company

Remarks

Military version of Cessna's Super Skymaster, the O-2 is produced in 2 versions. The O-2A is used primarily for forward air control, liaison, and observation functions. The O-2B (photo) is modified for psychological warfare roles. Two-engine reliability and ease of handling under varied power conditions are gained through its unique, centerline-mounted, opposed twin engines, one forward and one aft of the cabin between the twin tail booms.

Specifications

Wingspan 38 feet; length 29 feet 9 inches; height 9 feet 4 inches; wing area 201 square feet; engines 2 6-cylinder fuel-injected, 210 horsepower each.

Performance

Similar to commercial Super Skymaster version.



AGWAGON-A

Prime Contractor: Cessna Aircraft Company

Remarks

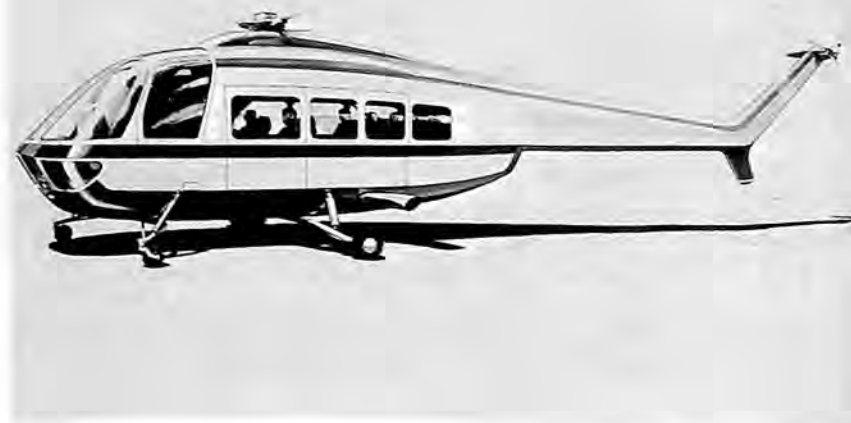
Latest of Cessna's Agwagon series is Agwagon-A, which incorporates some 50 design changes since the agricultural aircraft was introduced in 1966. The Agwagon-A comes in 3 models: 230 horsepower fixed pitch, 230 horsepower constant speed, and 300 horsepower constant speed.

Specifications

Gross weight 3,300 pounds (without dispersal equipment); length 25 feet 3 inches; height 7 feet 4.5 inches; wingspan 40 feet 4.5 inches; hopper capacity 200 gallons, 757 liters; wing loading 16.3 pounds per square foot; power loading 14.3 pounds per horsepower (230-horsepower engine), 11 pounds per horsepower (300-horsepower engine); engine Continental O-470-R or Continental IO-520-D.

Performance

Top speed at sea level (230 horsepower fixed pitch) 119 miles per hour, (230 horsepower constant speed) 138 miles per hour, (300 horsepower constant speed) 151 miles per hour; normal range (230 fixed pitch, 70 percent power at 5,000 feet) 325 miles, (230 constant speed, 75 percent power at 6,500 feet) 335 miles, (300 constant speed, 75 percent power at 6,500 feet) 320 miles; rate of climb at sea level for the 3 versions 710, 755, and 940 feet per minute; service ceiling 13,000 feet, 13,700 feet, and 15,700 feet.



MODEL D-10C COMMERCIAL UTILITY HELICOPTER

Prime Contractor: Doman Helicopters, Inc.

Remarks

The Doman D-10C, a 400-horsepower, 10-place helicopter, emphasizes high lift capacity and high-altitude performance. Commercial appeal is enhanced by the simplified hingeless lightweight rotor systems which are sealed and self-lubricated. Quiet operation is derived from the faired tips of the tapered rotor blades and from the inherent quietness of the United Aircraft of Canada PT6B shaft turbine engine. Versatility and convertibility of fuselage design permit quick change from deluxe passenger version to cargo, or stripping to an open structure for spraying, dusting, and sling load operations. Dynamic components and primary structure are taken from a previously certificated model of the same power rating, with changes for styling, drag reduction, and incorporation of the PT6B.

Specifications

Fuselage length 40 feet; width 5 feet; cargo doors 4 feet by 8 feet on each side; rotor diameter 48 feet; gross weight 5,500 pounds; maximum payload 2,570 pounds; normal range 300 miles; normal seating pilot and 9 passengers; engine flat rated at 400 horsepower to 16,000 feet.

Performance

Speed for best range 105 miles per hour at full gross; climb to 12,000 feet, 1,100 feet per minute.



F-27M PROPJET TRANSPORT

Prime Contractor: Fairchild Hiller Corporation, Aircraft Division

Remarks

Fairchild Hiller has built 197 F-27 airplanes that are flown by 15 airlines and many corporations. This aircraft, one of the most efficient and economical twin-turboprops in service, is now available in its latest certified version, the F-27M. Modified specifically for unimproved and high-elevation airfields, found frequently in South America, it is pressurized and completely air conditioned on the ground as well as in flight. Important features of the F-27 are a highly reliable, completely pneumatic, retractable landing gear and braking system and fuel-carrying wings that have never experienced algae corrosion. The F-27 meets medium- and short-range requirements of regional airlines, offers 36-, 40-, or 44-passenger seating, and operates from short runways and unimproved fields.

Specifications

Wingspan 95 feet 2 inches; length 77 feet 6 inches; empty weight 21,961 pounds; operational weights 42,000 pounds takeoff, 40,000 pounds landing; engine Rolls-Royce RDa 7/Mark 532-7N, 2,050 maximum horsepower; fuel capacity 1,364 or 2,063 gallons; propeller Rotol 4-bladed, constant speed; wing area 754 square feet.

Performance (at 34,000 pounds)

Cruise speed 300 miles per hour at 20,000 feet; rate of climb 2,200 feet per minute at sea level; maximum certified operating altitude 25,000 feet.



FH-227D PROPJET TRANSPORT

Prime Contractor: Fairchild Hiller Corporation, Aircraft Division

Remarks

The FH-227D is an enlarged and improved version of the F-27. With a 6-foot-longer fuselage, the FH-227D was designed to meet the requirements of short-haul airlines for additional capacity for both passengers and cargo. A second new freight area is offered in the aft section.

Specifications

Wingspan 95 feet 2 inches; length 83 feet; operational weights 45,500 pounds takeoff, 45,000 pounds landing; engine Rolls-Royce Dart RDa 7/Mark 532-7L, 2,100 maximum horsepower; fuel capacity 1,364 or 2,063 gallons; propeller Rotol 4-bladed, constant speed; wing area 754 square feet; aileron area 37.6 square feet; total flap area 136.9 square feet; vertical tail including dorsal 190 square feet; rudder area (aft of hinge line) 33 square feet; horizontal tail surfaces 172 square feet; elevator area (aft of hinge line) 34 square feet.

Performance (at 34,000 pounds)

Cruise speed 300 miles per hour at 20,000 feet; rate of climb 2,200 feet per minute at sea level; maximum certified operating altitude 25,000 feet.



PORTER

Prime Contractor: Fairchild Hiller Corporation, Aircraft Division

Remarks

Fairchild Hiller is producing 100 units of the Porter high-performance, single-engine, turbine-powered STOL aircraft for commercial markets. A spectacular performer, the Porter is the first single-engine propjet airplane to be certified in the United States. It is an all-purpose aircraft capable of operating from extremely small, unprepared fields. It features large double doors installed on one side or both sides, depending on customer requirements. Interior configuration can be changed in a matter of seconds by one man without tools because of 4 T-rails built into the floor to receive passenger seats, cargo tie-down rings, or stretchers. Arranged as a passenger aircraft, it can transport 11 people including the pilot.

Specifications

Wingspan 50 feet; length 36 feet; empty weight 2,270 pounds; gross weight 4,850 pounds; useful load 2,500 pounds; wing area 310 square feet; 2 integral wing tanks have total capacity of 130 gallons.

Performance

Cruise speed 130 knots; range 475 nautical miles plus 10 percent fuel reserve, 800 nautical miles with external fuel; takeoff run 305 feet at maximum gross weight on standard day with no wind; landing roll 210 feet (under same conditions); service ceiling at maximum load 30,000 feet.



AIRCRAFT

ARMED PORTER

Prime Contractor: Fairchild Hiller Corporation, Aircraft Division

Remarks

Fairchild Hiller has developed an armed version of its Porter for use in limited warfare and on other occasions calling for aerial patrols. The aircraft's STOL characteristics allow it to operate from extremely small, unprepared fields and to fly at very slow speeds. Large double doors, which can be installed on one side or both sides, make it unsurpassed for paradrop purposes. Its interior can be changed in seconds by one man without tools because of 4 T-rails built into the floor to receive passenger seats, cargo tie-down rings, or stretchers. As a passenger aircraft, it can carry 11 persons including the pilot. In its armed configuration, it can be fitted with guns, canisters, rockets, camera pods, or target launchers under each wing and below the fuselage.

Specifications

Wingspan 50 feet; length 36 feet; empty weight 3,300 pounds; gross weight (CAR Part 3) 4,850 pounds, (CAR Part 8) 6,100 pounds; useful load 3,385 pounds; wing area 310 square feet; 2 integral wing tanks have total capacity of 128 gallons.

Performance

Cruise speed 130 knots; range 475 nautical miles plus 10 percent fuel reserve, 800 nautical miles with external fuel; takeoff run 305 feet at maximum gross weight on a standard day with no wind; landing roll 210 feet (under same conditions); service ceiling at maximum load 30,000 feet.



FH-1100 HELICOPTER

Prime Contractor: Fairchild Hiller Corporation, Aircraft Division

Remarks

The FH-1100 5-place helicopter is designed for both executive transport and rugged field operation. Turbine powered, it is in production and flying throughout the world.

Specifications

Main rotor diameter 35.4 feet; tail rotor diameter 6 feet; length 28.3 feet; height 9.1 feet; empty weight 1,395 pounds; engine Allison 250-C18.

Performance

Cruise speed 128 miles per hour at sea level; maximum rate of climb 1,600 feet per minute; service ceiling 14,100 feet; range with maximum load 400 miles.



FH-1100 AIR AMBULANCE

Prime Contractor: Fairchild Hiller Corporation, Aircraft Division

Remarks

Proved by the Korean and the Vietnam wars, the air ambulance is gaining widespread use in the United States. Fairchild Hiller's FH-1100 air ambulance provides low-cost service with high-quality performance. This turbine helicopter, designed for a 2-plus-2 configuration (2 crewmen—pilot and medical attendant—and 2 patients), provides all the basic features required of an ambulance helicopter: twin internal litter capability, ease of entry for litters, room for an attendant, initial and operational costs within agencies' budgets, and high speed. The double-decked twin litter, positioned behind the pilot, is easily removed through large double doors.

Specifications

Main rotor diameter 35.4 feet; tail rotor diameter 6 feet; length 28.3 feet; height 9.1 feet; empty weight 1,395 pounds; engine Allison 250-C18 gas turbine.

Performance

Cruise speed 128 miles per hour at sea level; maximum rate of climb 1,600 feet per minute; service ceiling 14,100 feet; range with maximum load 400 miles; useful load 1,355 pounds.



SL-4 HELICOPTER

Prime Contractor: Fairchild Hiller Corporation, Aircraft Division

Remarks

Powered by a supercharged engine that automatically maintains full power through 13,000 feet, the SL-4 has a service ceiling of almost 19,000 feet at full gross weight. It is a 4-place craft, sister ship to the nonsupercharged L-4.

Specifications

Main rotor diameter 35 feet; tail rotor diameter 5.5 feet; length 29.1 feet; height 9.5 feet; empty weight 1,960 pounds; engine 1 Lycoming TIVO-540-A2A, 315 horsepower.



E-4 HELICOPTER (OH-23F)

Prime Contractor: Fairchild Hiller Corporation, Aircraft Division

Remarks

Built to meet the Army's high-altitude, rugged terrain requirements, the OH-23F is a 4-place utility helicopter. As a civilian craft, the E-4, it is in wide service in forestry work, missile site construction support, executive transportation, and offshore oil rig supply.

Specifications

Main rotor diameter 35.4 feet; tail rotor diameter 5.5 feet; length 29.8 feet; height 9.8 feet; empty weight 1,813 pounds; engine 1 Lycoming VO-540, 305 horsepower.

Performance

Maximum speed 96 miles per hour at sea level; cruise speed 92 miles per hour; maximum rate of climb 1,920 feet per minute; service ceiling 19,300 feet; range with maximum load 225 miles.



F-105 THUNDERCHIEF FIGHTER-BOMBER

Prime Contractor: Fairchild Hiller Corporation, Republic Aviation Division

Remarks

The F-105 Thunderchief is a Mach 2, multipurpose, all-weather fighter-bomber capable of delivering conventional as well as nuclear and thermonuclear weapons. There are 2 models: the single-seat F-105D and the 2-place F-105F. The F-105 is in service with the Tactical Air Force in the United States, Europe, and the Far East. Its speed, maneuverability, and aerial firepower qualify it for use in counterair, close-support, and interdiction roles in either limited or general war situations. The F-105 enables its pilot to perform a round-trip, low- or high-level bombing mission in any weather, day or night, over any terrain, without ever seeing the ground. The F-105 has been the workhorse in North Vietnam for strikes on heavily defended ground targets and has demonstrated a ruggedness equal to the Republic P-47 "Jug" of World War II. Its Vulcan 20-millimeter cannon has been particularly effective on all targets.

Specifications

Span 34 feet 11 inches; length 64 feet 3 inches (F-105D), 69 feet 7 inches (F-105F); height 19 feet 8 inches (F-105D), 20 feet 2 inches (F-105F); engine Pratt & Whitney Aircraft J75, 26,500 pounds thrust with water injection and afterburner; conventional ordnance load over 12,000 pounds.

Performance

Speed Mach 2; altitude ceiling 50,000-plus feet.



LEARJET 24B

Prime Contractor: Gates Learjet Corporation

Remarks

Certified in December 1968 as an improved version of the Learjet 24, the 24B also meets Air Transport Category requirements under Part 25 of Federal Air Regulations. Nearly 300 Learjets in corporate service in early 1970 had accumulated some 350,000 hours of flight, equivalent to 175,000,000 miles of travel. Learjets, which hold 22 internationally recognized performance records, have led the business jet industry in civil deliveries since 1965.

Specifications

Span 35 feet 7 inches; length 43 feet 3 inches; height 12 feet 7 inches; wing sweepback 13 degrees; takeoff gross weight 13,500 pounds; pressure differential 8.77 pounds per square inch; engines 2 General Electric CJ610-6.

Performance

Maximum speed 548 miles per hour; stall speed, normal landing weight, 104 miles per hour; maximum range with 45-minute reserve 1,895 miles; maximum operational altitude 45,000 feet; single-engine service ceiling 26,000 feet; rate of climb at sea level 6,300 feet per minute; 2-engine takeoff over 35-foot obstacle 2,607 feet; 2-engine landing over 50-foot obstacle 2,850 feet.



LEARJET 25

Prime Contractor: Gates Learjet Corporation

Remarks

Certificated in October 1967, the Learjet 25 measures 4½ feet longer than the Learjet 24. It carries 8 passengers plus a crew of 2. Offering essentially the same high-performance statistics as the Learjet 24, the larger Learjet 25 provides certain advantages in load-carrying ability, range, and other criteria. In February 1967 a standard production Learjet 25 was flown to 40,000 feet in 6 minutes 19 seconds, breaking the time-to-climb business jet record set previously by a Learjet 23.

Specifications

Span 35 feet 7 inches; length 47 feet 7 inches; height 12 feet 7 inches; wing sweepback 13 degrees; takeoff gross weight 15,000 pounds; pressure differential 8.77 pounds per square inch; engines 2 General Electric CJ610-6.

Performance

Maximum speed 543 miles per hour; stall speed, normal landing weight, 110 miles per hour; maximum range with 45-minute reserve 1,920 miles; maximum operational altitude 45,000 feet; single-engine service ceiling 27,500 feet; rate of climb at sea level 5,600 feet per minute; 2-engine takeoff over 35-foot obstacle 3,535 feet; 2-engine landing over 50-foot obstacle 3,303 feet.



F-102A ALL-WEATHER INTERCEPTOR

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

The single-seat F-102A, the world's first supersonic all-weather interceptor, is a prime air defense weapon of the Air Force in America, Europe, and the Far East. The F-102A carries Hughes Falcon missiles and 2.75-inch folding-fin rockets. The TF-102A combat proficiency trainer is similar to the F-102A except for a wider nose section to accommodate pilot and student in side-by-side seating. First flight of the YF-102 prototype was October 23, 1953, at Edwards Air Force Base, California. First flight of the YF-102A was December 20, 1954. First deliveries to the Air Force were in June 1955.

Specifications

Span 38 feet 1.6 inches; length 68 feet 5 inches; height 21 feet 2.5 inches; engine 1 Pratt & Whitney Aircraft J57-P-23 turbojet with afterburner, 10,000-pound-thrust class.

Performance

Speed supersonic; ceiling above 50,000 feet.



F-106A ADVANCED ALL-WEATHER INTERCEPTOR

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

The single-seat F-106A carries Hughes AIM-4F and AIM-4G missiles and the McDonnell Douglas AIR-2A special weapon equipped with a nuclear warhead. The F-106B is the 2-seat version of the F-106A, with all-weather capabilities and the same armament. First flight of the F-106A was December 26, 1956, at Edwards Air Force Base, California. First flight of the F-106B was April 9, 1958, at the same base. First deliveries of the F-106A to operational Air Force North American Air Defense Command squadrons were made in 1959.

Specifications

Span 38 feet 1.6 inches; length 70 feet 9 inches; height 20 feet 3.33 inches; engine 1 Pratt & Whitney Aircraft J75-17 with afterburner, 15,000-pound-thrust class; wing area 631.23 square feet.

Performance

Maximum speed 1,525 miles per hour; landing speed 167 miles per hour; other details classified.



CONVAIR 600, 640

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

Convair 600 is the general designation for a Convair Liner 240 airframe modernized with Rolls-Royce Dart turboprop engines. The Convair Liner 340 or 440 airframe with Dart engines is designated Convair 640. Among improved performance features of the 600s are a payload increase of up to 2,850 pounds and a cruising speed increase of 50 miles an hour.

Specifications

Wingspan 91 feet 9 inches (600), 105 feet 4 inches (640); length 76 feet 11 inches (600), 81 feet 5 inches (640); height 26 feet 11 inches (600), 18 feet 2 inches (640); passengers 40 (600), 44 (640); 2 Rolls-Royce MK 542-4 turboprops with 3,025 shaft horsepower each; 2 Dowty Rotol 4-bladed, 156-inch propellers; empty weight 28,250 pounds (600), 30,540 pounds (640); gross weight 46,200 pounds (600), 55,000 pounds (640).

Performance

Cruise speed at 10,000 feet at maximum cruise power 312 miles per hour (600), 300 miles per hour (640); rate of climb 1,600 feet per minute (600), 1,400 feet per minute (640); service ceiling 24,000 feet (600), 22,500 feet (640); maximum range 2,280 miles (600), 3,225 miles (640).



CONVAIR 880, 880-M

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

The basic Convair 880 was designed for operation from runways of 5,000 to 8,000 feet and for favorable operating costs on medium-range to transcontinental flights. Its sister airliner, the Convair 880-M, offers increased range, fuel capacity, and operating weights and shorter runway requirements. It has wing leading edge slats, power boost rudder, and engines with increased thrust. Both Convair 880s can cruise at 615 miles an hour. In a first-class, 4-abreast seating arrangement as used by initial operators, the 880 carries 84 passengers. In a 5-across coach configuration, it carries 110 persons.

Specifications

Wingspan 120 feet; length 129 feet 4 inches; height 36 feet 4 inches; empty weight 84,300 pounds; wing loading 92.95 pounds per square foot at maximum 880 takeoff weight of 184,500 pounds; engines 4 General Electric CJ805-3 turbojets with 11,200 pounds thrust each (880), 4 General Electric CJ805-3B turbojets with 11,650 pounds static thrust each (880-M).

Performance

Maximum speed 615 miles per hour at maximum cruise thrust at 22,500 feet; cruise speed 556 miles per hour at Mach .84 at 35,000 feet; landing speed 145 miles per hour, 1.3 stall speed; landing weight 121,000 pounds; rate of climb 3,565 feet per minute at sea level; service ceiling 41,000 feet; cabin altitude 8,000 feet at airplane altitude of 41,000 feet; range with maximum payload 3,200 statute miles.



CONVAIR 990A

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

The Convair 990A is a medium-range jet airliner with cruising speed and fuel capacity to fly nonstop transcontinental routes at near sonic speeds. The speed of the Convair 990A is boosted by 4 speed capsules, which resemble inverted canoes, extending beyond the trailing edge of the swept wing. They increase the airliner's speed by delaying formation of shock waves of air which otherwise would tend to cling to the trailing edge of the wing and create drag. The speed capsules serve also as fuel tanks.

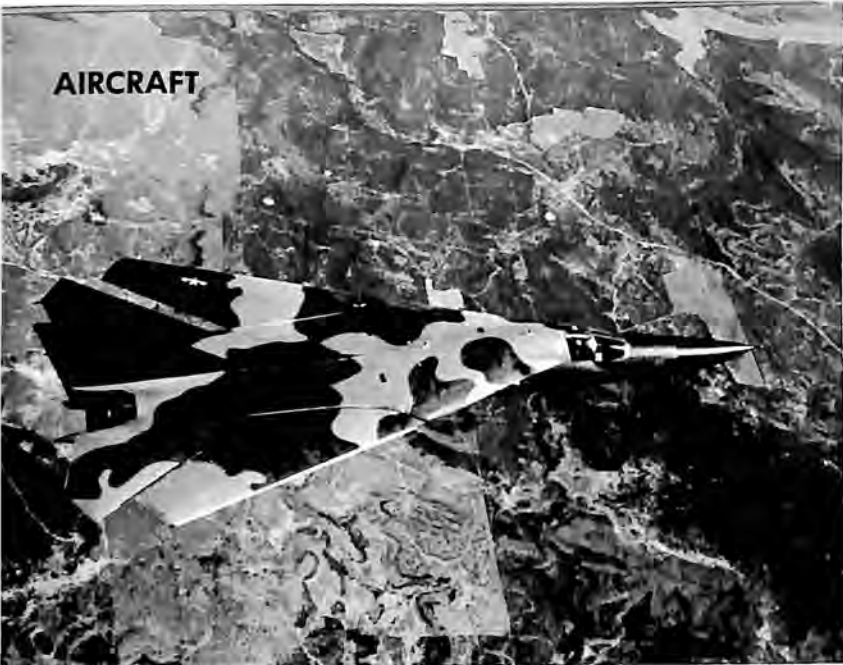
Specifications

Wingspan 120 feet; length 139 feet 5 inches; height 39 feet 6 inches; empty weight 110,750 pounds; wing loading 106 pounds per square foot at takeoff weight of 239,200 pounds; engines 4 CJ805-23B aft-fan turbojets with 16,050 pounds static thrust each; fuel capacity 15,188 gallons; wing area 2,250 square feet.

Performance

Cruise speed 621 miles per hour; landing speed 145 miles per hour, 1.3 stall speed; landing weight 151,000 pounds; rate of climb 3,250 feet per minute at sea level; service ceiling 41,000 feet; cabin altitude 8,000 feet at airplane altitude of 41,000 feet; range with maximum payload 4,050 miles.

AIRCRAFT



F-111A, F-111E TACTICAL FIGHTER-BOMBERS

Prime Contractor: Fort Worth Division of General Dynamics Corporation

Remarks

The F-111A, the Air Force's newest, fastest, most versatile fighter-bomber, is the basic aircraft of the variable-wing F-111 series. The wings of all versions can be moved in flight through sweep angles from 16 to 72.5 degrees, enabling the aircraft commander to perform any specified mission with peak aerodynamic efficiency. With wings extended, the F-111A can take off and land with less than 3,000 feet of ground roll. With wings swept into a high-speed delta design, the F-111A can fly at Mach 2.5 at altitude, and supersonically at sea level while guided by its terrain-following radar. First production aircraft were delivered to the Tactical Air Command in October 1967. The last F-111A (production sequence No. 159) was delivered to the Tactical Air Command in 1969. Aircraft in the production block beginning with No. 160 bear the designation F-111E. Major differences in this version are refined air inlets that improve engine operation at high speed and high altitude, and additional equipment to increase survivability.

Specifications

Span, wings extended, 63 feet, wings fully swept, 32 feet; height 17 feet; length 73 feet 6 inches; engines 2 Pratt & Whitney Aircraft TF30-P-3 afterburning turbofans, each in 20,000-pound-thrust class.

Performance

Speed at altitude Mach 2-plus; speed at sea level Mach 1-plus; ceiling 60,000 feet; range transoceanic without refueling; inflight refueling capability.

RF-111A RECONNAISSANCE AIRCRAFT

Prime Contractor: Fort Worth Division of General Dynamics Corporation

Remarks

The Air Force RF-111A is equipped with cameras, radar, and infrared sensors to record information about the area below and adjacent to the aircraft. Basic appearance of the F-111A tactical fighter-bomber and the RF-111A is the same. The only external differences are added radomes, and optical windows under the weapons-bay area, in the reconnaissance version. The main modifications required to produce the RF-111A are removal of weapons-bay doors and installation of a pallet in the bay to house the various reconnaissance sensors and related reconnaissance equipment. The RF-111A has virtually all the capabilities of other modern reconnaissance aircraft plus all the additional features and capabilities of the F-111A, such as added range and endurance. The RF-111A's long ferry range, coupled with short takeoff and landing capability, permits flexibility of deployment and utilization of many more bases. The RF-111A development program was announced by the Department of Defense in December 1965. First flight of the developmental aircraft was in December 1967.

Specifications and Performance

The RF-111A has essentially the same specifications and performance features as the F-111A, but its internal bay is used for special sensing and photographic equipment instead of weapons.



FB-111A STRATEGIC BOMBER

Prime Contractor: Fort Worth Division of General Dynamics Corporation

Remarks

The variable-wing FB-111A strategic bomber will replace the Strategic Air Command's C through F models of the B-52. It capitalizes on essentially the same performance capabilities as those demonstrated by the F-111A. The FB-111A enhances strategic air effectiveness by combining high subsonic penetration speed on the deck and supersonic speed at altitude with advanced penetration aids and other SAC avionics. The strategic bomber has the F-111A fuselage but a 7-foot-longer wingspan to provide greater range. The FB-111A's landing gear is strengthened to support heavier gross weights. It can carry conventional or nuclear weapons, including the new Short-Range Attack Missile (SRAM) which delivers a nuclear warhead at supersonic speeds. First flight of a production FB-111A was in July 1968. First deliveries to the Strategic Air Command were made in the last quarter of 1969.

Specifications

Span, wings extended, 70 feet, wings fully swept, 34 feet; height 17 feet; length 73 feet 6 inches; engines 2 Pratt & Whitney TF30-P-5 afterburning turbofans; armament, conventional and nuclear, including SRAM.

Performance

Speed Mach 1-plus at sea level, Mach 2-plus at altitude; ceiling 60,000 feet; range transoceanic without refueling; inflight refueling capability.

F-111C STRIKE AIRCRAFT

Prime Contractor: Fort Worth Division of General Dynamics Corporation

Remarks

The F-111C will be used by the Royal Australian Air Force for strike missions. The RAAF F-111C is outwardly identical to the U.S. Air Force FB-111A strategic bomber, but it is equipped with the U.S. Air Force F-111A avionic system. Australia has ordered 24 F-111Cs. First flight of an F-111C was in July 1968. Deliveries to Australia were to be completed in 1969. The F-111C is outwardly identical to the FB-111A, but it has essentially the same performance features as the F-111A.

F-111D TACTICAL FIGHTER-BOMBER

Prime Contractor: Fort Worth Division of General Dynamics Corporation

Remarks

In development flight testing during 1969, the F-111D uses a new generation of advanced avionic equipment to achieve pinpoint navigation and improved weapons delivery accuracy. The advanced avionics include attack radar, inertial navigation system, central digital computer complex, integrated display set, Doppler radar, and stores management set. They enable the F-111D to perform penetration missions with greater safety and to find and destroy targets more easily. Other F-111D avionics are basically the same as those in the F-111E. The F-111D is outwardly identical to the F-111E, but it is powered by 2 TF30-P-9 engines which provide increased thrust in military power and afterburner. Other performance features are essentially the same as those of the F-111E. First flight of a production F-111D was scheduled for late 1969.



B-58 HUSTLER BOMBER

Prime Contractor: Fort Worth Division of General Dynamics Corporation

Remarks

The B-58 Hustler is a supersonic Mach 2 strategic bomber in service with the Air Force's Strategic Air Command. It is this nation's first and only bomber to operate at over twice the speed of sound. B-58s have been operational since 1960 and are now used by the 43rd Bomb Wing at Little Rock Air Force Base, Arkansas, and by the 305th Bomb Wing, Grissom Air Force Base, Indiana. They were designed and produced at the Fort Worth Division of General Dynamics. First flight was November 11, 1956. One hundred sixteen were produced. Air Force crews flying B-58s set 19 world speed and altitude records and won the Thompson Trophy, the Mackay Trophy (twice), the Bleriot Trophy, and the Harmon Trophy (twice). The design uses the delta wing pioneered by the Convair Division of General Dynamics.

Specifications

Span 56 feet 10 inches; length 96 feet 9 inches; height 29 feet 11 inches; gross weight 160,000 pounds; engines 4 General Electric J79 turbojets mounted in pods; engine thrust 15,600 pounds each at takeoff with afterburners; landing gear tricycle, dual-wheel nose gear, 8-wheel truck main gear; wing area 1,542 square feet.

Performance

Maximum speed over 1,300 miles per hour (Mach 2); service ceiling above 60,000 feet; range intercontinental with refueling.



E-2 HAWKEYE

Prime Contractor: Grumman Aerospace Corporation

Remarks

Hawkeye's improved radar, computers, and high-speed data relay system provide the Navy with an excellent early-warning and intercept-control capability. The coordinated effort of the Hawkeye's crew of 5 and this speedy information collection, evaluation, and relaying equipment is called ATDS (Airborne Tactical Data System). The system provides fleet headquarters with the lead time necessary for action in nullifying high-Mach-number attacking aircraft. Hawkeye is able to remain airborne for prolonged periods. The aircraft is seeing extensive use in Vietnam as a flying command post. First flight was October 21, 1960. Grumman is retrofitting E-2As to include the Litton Industries L-304 microelectronic computer; the new version is known as E-2B. The prototype E-2B (photo) made its first flight on February 20, 1969. A third version, the E-2C, is under development and will feature the Grumman/General Electric-developed AN/APS-111 radar.

Specifications

Span 80 feet 7 inches; length 56 feet 4 inches; height 16 feet; engines 2 Allison T56-A-8 rated at 4,050 equivalent shaft horsepower.

Performance

Speed 274 knots true (average cruise speed); fuel 12,133 pounds.



S-2E TRACKER

Prime Contractor: Grumman Aerospace Corporation

Remarks

Grumman's S-2E Tracker, built for the Navy, was designed to perform the complete antisubmarine warfare mission: detection, localization, classification, and destruction of hostile submarines. The plane is equipped with a variety of electronic sensory and search devices coordinated with a tactical navigation system that features memory, display, and automatic computation for solving tactical and navigational problems. Armament includes nuclear depth charges, depth bombs, rockets, and homing torpedoes.

Specifications

Span 72 feet 7 inches; length 43 feet 6 inches; height 16 feet 7 inches; engines 2 Wright R1820, 1,525 horsepower.



A-6A INTRUDER

Prime Contractor: Grumman Aerospace Corporation

Remarks

The A-6A Intruder is a low-altitude, long-range, twin-engine attack aircraft with all-weather and night attack capability. It can deliver either nuclear or conventional stores and can fly in close support of ground troops on an around-the-clock basis. The integrated display system enables the crew to "see" targets or the environment around the aircraft, under zero-visibility conditions, by means of visual displays presented on viewing screens. The A-6A employs the Digital Integrated Attack Navigation (DIANE) system, which frees the pilot from details that can be performed automatically, thereby enabling him to focus his attention on the immediate tactical situation. The Intruder was the first aircraft in Navy inventory and on active flight status to employ the nose-to-tail catapult system. The A-6A is deployed with the Navy and the Marine Corps in Vietnam, where it has established an excellent record. Developmental versions of the A-6A include the A-6C, which features advanced infrared sensors and low-light television to enhance the aircraft's all-weather capability, the KA-6D tanker, and the A-6E. Grumman has a contract to convert 4 A-6As to tanker configuration and to initiate production of 20 additional KA-6Ds. The A-6E will have advanced radars built by Norden Division of United Aircraft Corporation.

Specifications

Span 53 feet; length 53 feet 3 inches; height 12 feet 1 inch; engines 2 Pratt & Whitney Aircraft J52-P-8A, 9,300 pounds thrust each.

Performance

Subsonic.



EA-6A INTRUDER

Prime Contractor: Grumman Aerospace Corporation

Remarks

The EA-6A is the progenitor of a line of aircraft created specifically to monitor electronic emissions and to interfere with automatically controlled weaponry. It is in service with the Marine Corps, first service to fly this type of weapon system. The 2-place EA-6A can detect, locate, classify, record, and jam radiations from enemy weaponry. Its main mission is to support strike aircraft and ground troops by suppressing air-to-air, air-to-ground, and ground-to-air electronically controlled weapons. The EA-6A, which has the same airframe as the A-6A Intruder, can function in all weather conditions.

Specifications

Span 53 feet; length 55 feet; engines 2 Pratt & Whitney Aircraft J52-P-8A turbojets, 9,300 pounds thrust each.

Performance

Subsonic.

EA-6B INTRUDER

Prime Contractor: Grumman Aerospace Corporation

Remarks

The EA-6B is a derivative of the already proven EA-6A aircraft now on active duty with the Marine Corps. Its most outstanding feature is the lengthened fuselage for accommodating 2 additional crew members. Sustained low-altitude flight capability, spacious crew stations, and armor plate protection are other features of this newest addition to the Intruder family. The prototype EA-6B made its first flight May 25, 1968, with Grumman test pilot Don King at the controls.

Specifications

Span 53 feet; length 59 feet 5 inches; height 16 feet 3 inches; engines 2 Pratt & Whitney Aircraft J52-P-8A rated at 9,300 pounds thrust each.

Performance

Subsonic.



OV-1 MOHAWK

Prime Contractor: Grumman Aerospace Corporation

Remarks

Designed to operate from small, unimproved fields, the Mohawk is used by the Army for observation work. Its bug-eye canopy offers exceptional visibility to its 2-man crew. A 55-knot stall speed and short takeoff and landing capabilities like those of the Army's light single-engine aircraft enable the Mohawk to "live" with the field army. The OV-1D (photo) is the latest version of the Mohawk. It provides for flight-line interchangeability of infrared and side-looking airborne radar surveillance equipment.

Specifications

Span 42 feet; length 41 feet; height 12 feet 8 inches; engines 2 Lycoming T53-L-15, 1,100 equivalent shaft horsepower each.

Performance

Maximum speed 325 miles per hour; normal cruise speed 207 miles per hour; landing speed 75 miles per hour; service ceiling 33,000 feet; range with maximum payload 774 miles.



HU-16B ALBATROSS

Prime Contractor: Grumman Aerospace Corporation

Remarks

Grumman's largest amphibian, the Albatross, is used by the Air Force, the Navy, and the Coast Guard as a general utility aircraft capable of performing as a sea-air rescue, cargo, transport, hospital, or photographic airplane. Most recent version is the HU-16B, which has greater wingspan, larger vertical and horizontal tail surfaces, and greater range than its predecessor, the HU-16A. Another version of the Albatross was built for antisubmarine warfare. Both types continue in active service, but the aircraft is no longer in production. Twelve foreign nations have purchased Albatross aircraft.

Specifications

Span 96 feet 8 inches; length 61 feet 4 inches; height 25 feet 10 inches; engines 2 Wright R1820-76 rated at 1,425 horsepower each.

Performance

Maximum speed 205 knots; best cruise 130 knots; maximum endurance speed 108 knots; range 2,850 nautical miles.



GULFSTREAM I

Prime Contractor: Grumman Aerospace Corporation

Remarks

The Grumman Gulfstream I is a twin-engine corporate transport with transcontinental range. The plane carries a 2-man crew; it is designed for 10 to 14 passengers in the executive version and up to 24 passengers in a high-density configuration. The plane has short-field flexibility. After sale of the 200th Gulfstream I in the spring of 1969, the assembly line was closed down.

Specifications

Span 78 feet 4 inches; length 64 feet; height 22 feet 9 inches; engines 2 Rolls-Royce Dart Mark 529-8X turboprops rated at 2,190 equivalent shaft horsepower.

Performance

Cruise speed 357 miles per hour; range over 2,500 miles; service ceiling 39,000 feet.



GULFSTREAM II

Prime Contractor: Grumman Aerospace Corporation

Remarks

A fast, long-range, corporate jet transport, Gulfstream II is a twin-turbofan, T-tail aircraft which can fly from New York to Los Angeles against a continuous 90-knot headwind. Powered by 2 aft-mounted Rolls-Royce Spey fanjets, the 10- to 19-passenger aircraft grosses 56,000 pounds. Gulfstream II retains the short-field flexibility of its predecessor, the turboprop Gulfstream I. First flight was in October 1966. In May 1968 the Gulfstream II became the first corporate jet to fly nonstop from New York to London. The east-to-west return trip was also nonstop. Grumman has more than 90 orders for the Gulfstream II. The aircraft is being produced at the rate of 3 per month at the company's Savannah, Georgia, factory.

Specifications

Span 68 feet 10 inches; length 79 feet 11 inches; cabin interior: length 34 feet, headroom 6 feet 1 inch; seating 10 to 19 normal, up to 30 in high-density version; engines 2 Rolls-Royce Spey RB163-25 turbofans rated at 11,400 pounds thrust each.

Performance

Speed up to 585 miles per hour; range 3,010 nautical miles; rate of climb 4,000 feet per minute; cruise altitude 40,000 feet.



C-2A GREYHOUND

Prime Contractor: Grumman Aerospace Corporation

Remarks

A new carrier on-board delivery system for the Navy, the C-2A Greyhound is designed to keep fleet units supplied with high-priority items like jet engines and to serve as a personnel transport for carrier groups. The C-2A permits the Navy to fly directly from land bases to operating forces at sea without disruption of battle efficiency. The aircraft has a fully pressurized fuselage and a tail-ramp loading device to facilitate loading operations. It is readily convertible into a personnel carrier.

Specifications

Span 80 feet 7 inches; length 56 feet 6 inches; engines 2 Allison T56-A-8 rated at 4,050 equivalent shaft horsepower each.

Performance

Range 1,300 nautical miles with 10,000-pound payload.



C-1A TRADER

Prime Contractor: Grumman Aerospace Corporation

Remarks

The C-1A Trader, cargo version of the S-2D/E Tracker, is used extensively as a carrier on-board delivery aircraft. It has a larger fuselage, with 9 rear-facing seats or cargo fittings. The C-1A is designed for use also as an instrument trainer, light cargo aircraft, utility or administrative aircraft, and carrier qualification trainer. It is no longer in production, but it continues to serve alongside the newer C-2A Greyhound as an important link between the fleet and fleet support bases on land.

Specifications

Span 69 feet 8 inches; length 42 feet; height 16 feet 3.5 inches; engines 2 Wright R1820-82 rated at 1,525 horsepower.

Performance

Cruise 150 knots; service ceiling 24,800 feet; range 964 miles.



TC-4C

Prime Contractor: Grumman Aerospace Corporation

Remarks

The TC-4C, as yet unnamed, is the result of mating A-6A radome and avionics to a conventional Grumman Gulfstream I. The aircraft retains the basic fail-safe airframe and engine of the Gulfstream I, but it has a higher-capacity electrical generating system to satisfy the demands of the additional A-6A avionics gear. The TC-4C was conceived in order to release more A-6As from training squadrons and to train a greater number of bombardier/navigators. In the TC-4C, Intruder training missions can be flown by a pilot and bombardier/navigator team seated in a full-scale A-6A cockpit. In addition, 4 bombardier/navigator trainees, seated at individual consoles forward of the simulated A-6A cockpit, can observe the same displays as those seen by the bombardier/navigator in the simulated cockpit. Students can follow development of the A-6A navigation-attack problem on their own scopes, observing target identification, radar picture size, terrain features, atmospheric and interference limitations, and optimum display selection. Capabilities of navigation and track radar can also be observed. Each console is also outfitted with navigational readouts.

Specifications

Span 78 feet 4 inches; length 67 feet 10.75 inches; height 23 feet 4 inches; engines 2 Rolls-Royce Dart MK 529-8X turboprops rated at 2,210 equivalent shaft horsepower.

Performance

Cruise speed 290 knots; ferry range 1,950 nautical miles; service ceiling 30,400 feet.



TF-9J COUGAR

Prime Contractor: Grumman Aerospace Corporation

Remarks

The TF-9J is a 2-seat version of the F-9F-8 Cougar outfitted for training purposes. The second seat is forward of the first, and the aircraft is outfitted with 2 guns only. The TF-9J was the first jet trainer in the Navy Advanced Jet Training Command capable of transonic speed. Performance, range, and combat capability very closely duplicate those of the F-9J. The TF-9J is well suited to intermediate and operational jet training, transonic flight indoctrination, carrier operations, instrument and navigation training, and gunnery and external store delivery training. Although the Cougar trainer is no longer in production, it is still in active service with the Navy and the Marine Corps.

Specifications

Span 34 feet 6 inches; length 44 feet 4.25 inches (with refueling boom add 4 feet 4.5 inches); height 12 feet 4 inches; engine 1 Pratt & Whitney Aircraft J48 rated at 6,250 pounds thrust.

Performance

Mach .87 at 35,000 feet; service ceiling 43,000 feet.



F-14

Prime Contractor: Grumman Aerospace Corporation

Remarks

Grumman was awarded the development contract for the Navy's new F-14 air superiority fighter in January 1969. The F-14 is a tandem-seat, variable-geometry, high-wing aircraft with 2 engines in podded nacelles. The F-14 is a 3-phased series development program: the F-14A will carry the Phoenix air-to-air missile and will use the Pratt & Whitney Aircraft TF30 afterburning turbofan engine; the F-14B will feature a lighter, higher-thrust engine; the F-14C will use the engines of the F-14B and more advanced avionic systems.

Specifications

Dimensions classified; engines 2 Pratt & Whitney Aircraft TF30-P-401 turbofans.

Performance

Subsonic to Mach 2-plus.



E-1B TRACER

Prime Contractor: Grumman Aerospace Corporation

Remarks

The E-1B Tracer, a development of the S-2/C-1 series aircraft, is distinguished by the large radome mounted on top of the fuselage. Airframe construction parallels the S-2/C-1 series. The aircraft has all-weather capability, and its long-range detection equipment serves the fleet with early-warning information regarding impending enemy attack. Equipment for vectoring friendly interceptors against specific targets is also on board. This aircraft is no longer in production, but it continues in active service on both ASW and attack carriers.

Specifications

Span 72 feet 4 inches; length 72 feet 4 inches; height 16 feet; engines 2 Wright R1820-82 rated at 1,525 horsepower.

Performance

Range 875 miles; service ceiling 15,800 feet.

AIRCRAFT



AG-CAT, SUPER AG-CAT

Prime Contractor: Grumman Aerospace Corporation

Remarks

The Grumman Ag-Cat is a biplane built specifically for crop dusting and spraying operations. It features high performance, safety characteristics, and easy maintenance. Extremely safe, the Ag-Cat has gentle stall characteristics, excellent handling and control qualities, and low maintenance costs. The plane is powered by a variety of engines; a new Super model (photo) uses a Pratt & Whitney Aircraft 450-horsepower engine. The Super Ag-Cat has stronger construction, increased fuel capacity, and higher gross weight. More than 600 Ag-Cats have been delivered.

Specifications

Span 35 feet 11 inches; length 24 feet 4 inches; height 11 feet; certified gross weight 4,500 pounds; hopper load 40 cubic feet; engines 220-horsepower Continental, 240-horsepower Gulf Coast, 245-horsepower Jacobs, 275-horsepower Jacobs, 300-horsepower Jacobs, or 450-horsepower Pratt & Whitney. Permissible operating gross weight limit may be as high as 6,075 pounds.

Performance

Working speed range 80 to 100 miles per hour; never-exceed speed 147 miles per hour; rate of climb 1,080 feet per minute.



MODEL 300

Prime Contractor: Hughes Tool Company, Aircraft Division

Remarks

The Model 300 is a 3-place aircraft designed for a wide variety of personal transportation and general utility assignments. Exceptionally smooth flight characteristics of the 3-bladed rotor have made this helicopter especially useful for aerial photography in addition to the traditional traffic and power-line patrol and construction site operations. Equipment includes litters, cargo racks, floats, and external load sling. The Model 300 has a top speed of 87 miles per hour. A version especially equipped for law enforcement has successfully demonstrated its crime-suppression capabilities in Project Sky Knight, a federally sponsored experiment utilizing helicopters as round-the-clock aerial patrol cars. It is being used by nearly a score of law enforcement agencies for patrol work. Equipment includes 3-way police radio, siren, high-power public address system, litters, and an internally controlled floodlight system which illuminates the average residential lot to daylight brilliance from 500-foot patrol altitude. Engineering refinements include quiet tail rotor and exhaust muffler which make all-night patrolling possible without disturbing sleeping citizens.



TH-55A HELICOPTER TRAINER

Prime Contractor: Hughes Tool Company, Aircraft Division

Remarks

The TH-55A is a 2-place primary trainer helicopter in use by the Army to train Army aviators. Hughes has delivered a total of 793 TH-55A helicopters to the Army since 1964. The TH-55A is a military version of the Hughes Model 269A commercial helicopter which entered production in 1961.

Specifications

Crew 2; main rotor diameter 25 feet 3.5 inches; length 28 feet 5 inches; height 8 feet 3 inches; design gross weight 1,670 pounds; useful load 662 pounds; engine Lycoming HIO-360-B1A, 180 horsepower.

Performance

Maximum speed 75 knots; endurance 2.5 hours at 65 knots; hover ceiling OGE 3,750 feet, IGE 5,500 feet.



OH-6A LIGHT OBSERVATION HELICOPTER

Prime Contractor: Hughes Tool Company, Aircraft Division

Remarks

Hughes Tool Company is delivering 1,435 OH-6A light observation helicopters to the Army. The helicopter holds 23 world records in speed, sustained altitude, time to climb to altitude, and distance. One distance record was achieved on a nonstop, nonrefueled cross-country flight of 2,215 miles from California to Florida. In addition to the low-level scout and observation roles assigned by the Army, a primary function in Southeast Asia is armed reconnaissance. The fast, highly maneuverable OH-6A mounts outboard of the left side of the cargo compartment an XM-27E-1 machine gun, a multibarrel 7.62-millimeter gun capable of firing 4,000 rounds per minute. Interchangeable with the XM-27E-1 gun installation is the XM-8 40-millimeter antipersonnel grenade launcher.

Specifications

Length 30.3 feet, rotors turning; height 8.2 feet; main rotor 4-bladed, 26.33 feet in diameter; empty weight 1,212 pounds including all GFE avionics and partial armor; gross weight 2,400 pounds; overload gross weight 2,700 pounds; useful load 1,488 pounds including 400 pounds full fuel; engine Allison T63-A-5A, 317 shaft horsepower derated to 252.5 takeoff horsepower.

Performance

Maximum speed 130 knots; cruise speed 118 knots; range 330 nautical miles; rate of climb 1,830 feet per minute; hover OGE 7,300 feet, IGE 11,800 feet; service ceiling 15,700 feet.



MODELS 500S, 500E, 500M

Prime Contractor: Hughes Tool Company, Aircraft Division

Remarks

The Hughes 500 series light turbine helicopters offer complete versatility in commercial and international applications. Although the 500 resembles the OH-6A in profile and retains the OH-6A basic structural features, it provides numerous advantages: greater speed, increased interior volume and spaciousness, higher gross weight, external cargo hook, very low maintenance requirements and costs. The 500S allows maximum utility by rapid conversion among such configurations as 5- to 7-place personnel transport, litter-evacuation ship, and internal or external cargo carrier. The 500E executive 5-place version features luxurious appointments, including rear compartment writing desks. The 500M is the international military version normally seating a crew of 2 and 2 troops, although a pilot and 5 armed troops can be accommodated easily. Fitted with hardpoints, the 500M can carry a rescue hoist, litter kit, machine gun, grenade and rocket launchers, cargo hook, and antisubmarine warfare equipment.

Specifications

Length 30.3 feet, rotors turning; height 8.2 feet; main rotor 4-bladed, 26.33 feet in diameter; normal gross weight 2,550 pounds; engine Allison 250-C18A gas turbine, 317 shaft horsepower derated to 278 takeoff horsepower; empty weight 1,085 pounds (500S), 1,186 pounds (500E), 1,124 pounds (500M).

Performance

Maximum speed 130 knots; cruise speed 126 knots; hover OGE 5,300 feet, IGE 8,200 feet; rate of climb 1,700 feet per minute; service ceiling 14,400 feet; range 358 miles with 416 pounds fuel (500S, 500E), 344 miles with 400 pounds fuel (500M).



HH-43B/F RESCUE-UTILITY HELICOPTER

Prime Contractor: Kaman Aerospace Corporation

Remarks

The Kaman Huskie has a unique intermeshing rotor system and servo-flap control system. In service with the Air Rescue Service of the Air Force and with foreign governments around the world, the Huskie has demonstrated an ability to perform in jungles, mountains, and remote corners of the world previously inaccessible to aircraft. The Huskie has established a record of safety and reliability far exceeding that of any other military aircraft ever in service.

Specifications

Height 12.6 feet; rotors 2 2-bladed, intermeshing, counterrotating, 47 feet in diameter; empty weight 4,585 pounds (HH-43B), 4,620 pounds (HH-43F); gross weight 6,100 pounds; maximum gross weight 9,150 pounds; engine Lycoming T53-L-11B (HH-43B), T53-L-11A (HH-43F).

Performance

Maximum speed 120 miles per hour; cruise speed 110 miles per hour; range 277 statute miles (HH-43B), 303 statute miles (HH-43F); rate of climb 2,000 feet per minute (HH-43B), 1,800 feet per minute (HH-43F); hover OGE 15,000 feet (HH-43B), 18,000 feet (HH-43F); service ceiling 23,000 feet (HH-43B), 25,000 feet (HH-43F).



UH-2A/B RESCUE-UTILITY HELICOPTER

Prime Contractor: Kaman Aerospace Corporation

Remarks

This compact, high-speed, turbine-powered helicopter is used by the Navy and the Marine Corps. The Seasprite carries a complete complement of the latest navigational and electronic flight aids including APN-130 Doppler, ASA-13A air mass computer, and a Kaman-developed autostabilization system. With all-weather instrumentation, retractable landing gear, and water-alighting capabilities, the Seasprite operates on a 24-hour-day basis and at long ranges compatible with today's around-the-clock, dispersed-fleet operations. The UH-2 is used for search, rescue, gunfire observation, reconnaissance, plane guard, courier, personnel transfer, ship-to-ship resupply, and tactical air controller operations. The UH-2 was first flown in June 1959. More than 150 are in service with the fleet and at shore stations around the world.

Specifications

Length 52.5 feet; height 13.6 feet; empty weight 6,100 pounds; gross weight 8,637 pounds; overload gross weight 10,000 pounds; engine General Electric T58-8, 1,250 shaft horsepower; main rotor single 4-bladed, 44 feet in diameter; tail rotor 3-bladed, 8 feet in diameter.

Performance

Maximum speed 162 miles per hour; cruise speed 152 miles per hour; normal range 671 miles; ferry range 950 miles; rate of climb at sea level 1,740 feet per minute; hover OGE 5,100 feet; service ceiling 17,400 feet.

UH-2C RESCUE-UTILITY HELICOPTER

Prime Contractor: Kaman Aerospace Corporation

Remarks

The UH-2C is a conversion to twin-turbine configuration of a number of UH-2A/Bs under a Navy contract awarded Kaman. Retrofitting the craft with 2 General Electric T58-8 engines provides the Seasprite with twin-engine reliability for nighttime overwater rescue missions. Compact and able to operate from fleet vessels as small as destroyers, the UH-2C has completely self-contained navigation capability.

Specifications

Length 52.5 feet; height 13.6 feet; empty weight 7,390 pounds; gross weight 9,951 pounds; overload gross weight 11,614 pounds; main rotor single 4-bladed, 44 feet in diameter; tail rotor 3-bladed, 8 feet in diameter; engines 2 General Electric T58-8, 1,250 shaft horsepower each.

Performance

Maximum speed 157 miles per hour; cruise speed 152 miles per hour; normal range 425 miles; ferry range 570 miles; rate of climb, sea level, 2,275 feet per minute; hover ceiling OGE 16,800 feet; service ceiling 18,400 feet.



HH-2C ARMED RESCUE HELICOPTER

Prime Contractor: Kaman Aerospace Corporation

Remarks

The HH-2C is an updated UH-2C outfitted with chin-mounted minigun turret and waist-mounted machine guns and protected with armor plate. The compact HH-2C, operating from the decks of destroyers, will be used by the Navy for search and rescue missions. The armament provides the rescue crew with a capability of delivering suppressive fire against enemy forces during rescue operations.

Specifications

Length 52.5 feet; height 13.6 feet; empty weight 8,165 pounds; gross weight 12,585 pounds; overload gross weight 12,840 pounds; main rotor single 4-bladed, 44 feet in diameter; tail rotor 4-bladed, 8 feet in diameter; engines 2 General Electric T58-8, 1,250 shaft horsepower each.

Performance

Maximum speed 156 miles per hour; normal range 340 statute miles; hover ceiling ICE 12,600 feet.



LA-4 AMPHIBIAN

Prime Contractor: Lake Aircraft Corporation

Remarks

The Lake LA-4 is an all-metal, midwing, 4-passenger amphibian aircraft. It has retractable tri-cycle gear and large flaps, both actuated by an engine-driven hydraulic system which is backed up for emergency use by a manually operated hand pump. The aircraft is powered by the Lycoming 180-horsepower O-360-A1A used in pusher configuration; it utilizes a Hartzell forged dural, controllable, constant-speed metal propeller. The aircraft is unusually rugged and is capable of operating from short fields and in extremely rough water conditions. In 1969 Lake initiated production of 2 new models based on the LA-4. The Lake Seaplane, a flying boat configuration similar to the LA-4, is equipped with removable wheels for beaching operations. It has a 1,050-pound useful load and a 140-mile-per-hour cruise speed. The Buccaneer, a larger and faster (150 miles per hour) version of the LA-4, is powered by a 200-horsepower Lycoming engine.

Specifications (LA-4)

Wingspan 38 feet; wing area 170 square feet; wing load 14.1 pounds per square foot; length 24 feet 11 inches; height 9 feet 4 inches; gross weight 2,400 pounds; empty weight 1,555 pounds; useful load 845 pounds.

Performance (LA-4)

Speed 132 miles per hour; stall speed 50 miles per hour; takeoff run 650 feet (land), 1,125 feet (water); landing roll 475 feet (land), 600 feet (water); rate of climb 800 feet per minute.



F-104S SUPER STARFIGHTER

Prime Contractor: Lockheed-California Company

Remarks

Lockheed-California Company's F-104 prototype made its initial flight in February 1954. The multi-mission fighter-interceptor became operational with USAF in January 1958 and remains in service today with USAF's Air Defense Command. An advanced Starfighter version, the F-104G, was manufactured in the aviation industry's largest international production program for the air arms of 14 free world nations—Germany, Canada, the Netherlands, Belgium, Norway, Denmark, Italy, Spain, Greece, Turkey, Pakistan, the Republic of China, Japan, and the United States. Nearly 2,500 Starfighters have been built, worldwide. Lockheed's newest Starfighter, the F-104S, is being manufactured in Italy. The Italian Air Force purchased 165 of the new Sparrow-missile-armed Starfighters for delivery beginning in 1969.

Specifications

F-104G: span 21 feet 11 inches; length 54 feet 9 inches; height 13 feet 6 inches; gross weight 28,800 pounds; engine General Electric J79-11A, 15,800 pounds thrust with afterburner. F-104S: same span, length, height; gross weight 31,500 pounds; engine General Electric J79-19, 17,900 pounds thrust with afterburner.

Performance

Speed Mach 2-plus; altitude above 100,000 feet.



P-2 NEPTUNE

Prime Contractor: Lockheed-California Company

Remarks

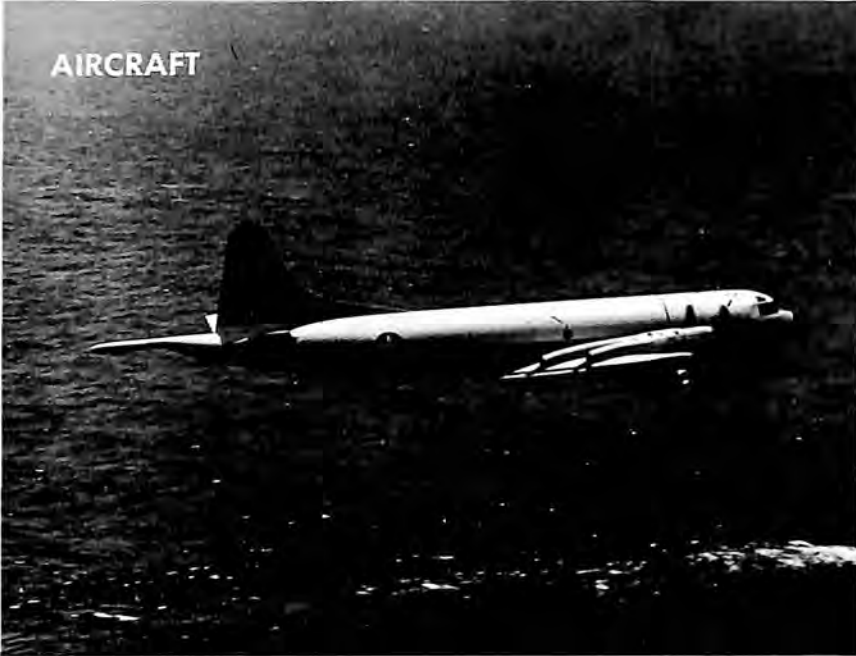
The P-2 Neptune made its first flight in May 1945, and today—more than 20 years later—it is ably performing its antisubmarine patrol mission for the U.S. Navy and for a number of free world nations. Steady refinements and new additions kept the P-2 modern and up to date through 7 models. Although the P-2 is gradually being replaced in the Navy by Lockheed's P-3A Orion, it still bears the insignia of 7 other nations: the Netherlands, France, Canada, Australia, Brazil, Japan, and Argentina.

Specifications

Span 103 feet; length 91 feet 5 inches; height 29 feet 4 inches; gross weight 72,000 pounds; engines 2 Wright R3350-32 turbocompounds.

Performance

Speed 300 miles per hour; altitude 22,000 feet.



P-3 ORION

Prime Contractor: Lockheed-California Company

Remarks

The P-3 Orion is an advanced long-range antisubmarine patrol aircraft which has been in service with the Navy since August 1962. The Orion carries the latest, most efficient ASW equipment and has sufficient space, weight, and power reserve to incorporate future ASW systems. Orions have been purchased by New Zealand, Australia, and Norway. The new P-3C Orion with the A-NEW avionics system was to be delivered to the Navy in 1969.

Specifications

Span 99 feet 8 inches; length 116 feet 10 inches; height 33 feet 9 inches; gross weight 135,000 pounds; engines 4 Allison T56-14, 4,591 shaft horsepower each.

Performance

Speed 413 knots; altitude above 30,000 feet.



S-3A

Prime Contractor: Lockheed-California Company

Remarks

The S-3A is Lockheed's newest venture into anti-submarine warfare aircraft, following its continuing success with the P-3 Orion. S-3A is a carrier-based twin-engine jet aircraft that will replace Grumman's S-2 Tracker. S-3A will be powered by General Electric TF34 high bypass turbofan engines. Its speed will be in excess of 400 knots with a range of over 2,000 nautical miles. The aircraft will have an all-weather capability of searching for, localizing, and destroying enemy submarines. It is configured to carry a variety of ordnance, including homing torpedoes, mines, depth charges, rockets, and missiles. First flight of the aircraft is earmarked for early 1972 with introduction to the fleet in the fall of 1973. Other details are classified.



SR-71 LONG-RANGE STRATEGIC RECONNAISSANCE AIRCRAFT

Prime Contractor: Lockheed-California Company

Remarks

The SR-71 is an Air Force long-range advanced strategic reconnaissance aircraft capable of flying above 80,000 feet at 3 times the speed of sound—over 2,000 miles an hour. The SR-71 made its first flight December 22, 1964. Operational with the Strategic Air Command at Beale Air Force Base, California, since January 1966, the SR-71 carries a wide variety of advanced observation equipment and is capable of both pre-attack and post-attack strategic reconnaissance. It can survey a strip of the earth's surface 30 miles wide and 2,000 miles long (60,000 square miles) in just over one hour. The twin-engine SR-71 is powered by the Pratt & Whitney Aircraft J58 turbojet, first engine to be flight qualified at Mach 3 for the Air Force.

Specifications

Span 55 feet; length 107 feet; height 18 feet 6 inches from ground to top of vertical stabilizers.

Performance

Classified.



YF-12A ADVANCED INTERCEPTOR

Prime Contractor: Lockheed-California Company

Remarks

The YF-12A, formerly designated A-11, is an advanced interceptor for use by the Air Force. It is a companion plane to the SR-71. An all-weather fighter, the YF-12A is equipped with an automatic navigation system. It is powered by 2 Pratt & Whitney Aircraft J58 engines and has a speed capability of over 2,000 miles per hour and a ceiling in excess of 80,000 feet. It has an ASG-18 fire-control system developed by Hughes Aircraft Company, and it is equipped with the Hughes AIM-47A air-to-air guided missile. Other details are classified.



T-33A JET TRAINER

Prime Contractor: Lockheed-California Company

Specifications

Span 38 feet 10.5 inches; length 37 feet 8.5 inches; height 11 feet 8½ inches; empty weight 8,084 pounds; gross weight 14,442 pounds; useful load 6,358 pounds; wing loading 60.8 pounds per square foot; power loading 3.3 pounds per pound thrust; fuel capacity 683 gallons; gear tricycle, fully retractable; engine Allison J33-23-400C5 turbojet, 4,600 pounds thrust.

Performance

Maximum speed 580 miles per hour; stall speed 117 miles per hour; rate of climb 5,525 feet per minute; service ceiling 40,000 feet; range 1,345 miles.



WV-2, RC-121 EARLY-WARNING AIRCRAFT

Prime Contractor: Lockheed-California Company

Remarks

Derivatives of the Lockheed Constellation series, the WV-2 (Navy) and the RC-121 (Air Force) are radar-equipped flying sentinels for long-distance early-warning missions. The planes carry 6 tons of electronic equipment to high altitudes. They were designed as aerial sentries, to locate sneak raiders at interception points far from the nation's borders. High fuel capacity and operational economy of the Wright turbocompound engines give the airplanes an extremely long on-station time. Wing-tip fuel tanks extend distance of scouting missions. The WV-2 is an enlarged version of the WV-1, which was the initial picket plane in Navy service.

Specifications

Span 123 feet; length 116 feet; height 24 feet 10 inches. WV-1: span 123 feet; length 94 feet 4 inches; height 23 feet 9 inches.

Performance

Endurance approximately 18 hours.



XH-51A HELICOPTER

Prime Contractor: Lockheed-California Company

Remarks

The XH-51A is a 2-place helicopter developed by Lockheed-California in Burbank under a joint Army/Navy contract as a research vehicle for high-performance rotary-wing aircraft. First flight was announced in November 1962. The 4-bladed XH-51A has the Lockheed-developed rigid-rotor system that gives the vehicle hands-off stability. It has retractable landing gear.

Specifications

Fuselage length 32 feet; height 8 feet 2 inches; main rotor blade diameter 35 feet; normal gross weight 4,000 pounds; engine 1 Pratt & Whitney Aircraft PT6B-6 turboshaft produced by United Aircraft of Canada.

Performance

Speed 175-plus miles per hour; cruise speed at sea level 160 miles per hour; still-air range 240 miles.



XH-51A COMPOUND ROTORCRAFT

Prime Contractor: Lockheed-California Company

Remarks

The XH-51A compound is a 4-bladed aircraft converted in 1964 under an Army-sponsored program from a "pure" XH-51A helicopter by the addition of stub wings and an auxiliary jet engine (mounted on left wing). In June 1967 the XH-51A compound achieved a speed of 302 miles per hour during a Lockheed flight program conducted for the Army Aviation Materiel Laboratories. Incorporated in the vehicle is the Lockheed-developed rigid-rotor system and retractable landing gear.

Specifications

Fuselage length 32 feet; maximum height 8 feet 2 inches; main rotor blade diameter 35 feet; normal gross weight 4,500 pounds; engines 1 Pratt & Whitney Aircraft PT6B-6 turboshaft and 1 Pratt & Whitney Aircraft J60-P-2; wingspan 17 feet.

Performance

Maximum speed 302 miles per hour; maximum rate of climb 3,500 feet per minute.



XH-51N RESEARCH HELICOPTER

Prime Contractor: Lockheed-California Company

Remarks

The XH-51N helicopter was built for NASA and was delivered in December 1964 to NASA's Langley Research Center, Hampton, Virginia, where it is being used for advanced flight research in the rotary-wing aircraft field. It can carry 5 persons. The 3-bladed XH-51N has the Lockheed-developed rigid-rotor system and retractable landing gear.

Specifications

Fuselage length 33 feet; rotor blade diameter 35 feet; weight 4,000 pounds; engine 1 Pratt & Whitney Aircraft PT6B-9 turboshaft produced by United Aircraft of Canada.

Performance

Speed 174 miles per hour; range 225 miles.



MODEL 286 UTILITY HELICOPTER

Prime Contractor: Lockheed-California Company

Remarks

The 5-place Model 286 helicopter made its first flight June 30, 1965, at the Lockheed plant in Burbank, California. Exactly a year later the Model 286 received its Federal Aviation Administration type certificate. It was the first rigid-rotor helicopter to be certificated by the FAA. This type of rigid-rotor helicopter has a wide potential for transport, rescue, and various military missions. As a light antisubmarine helicopter, it would be capable of rapid-action response from various Navy attack vessels. The similar Lockheed-built Army/Navy XH-51A has made landings on and takeoffs from the deck of a moving destroyer at sea. The 4-bladed Model 286 has the Lockheed-developed rigid-rotor system and is equipped with retractable landing gear. It has performed aerobatic-type maneuvers—barrel rolls and loops—to demonstrate stability and control made possible by the rigid-rotor system. Model 286 helicopters are being used extensively as rigid-rotor demonstrators. They have toured the continental United States and Hawaii and they participated in the 1967 Paris Air Show.

Specifications

Length 32 feet; rotor blade diameter 35 feet; weight 4,700 pounds; engine 1 Pratt & Whitney Aircraft PT6B-9 turboshaft produced by United Aircraft of Canada.

Performance

Design speed 176 miles per hour; estimated range 225-plus miles. It has reached 206 miles per hour in a slight descent.



U-2

Prime Contractor: Lockheed-California Company

Remarks

The U-2, originally proposed as an independent Lockheed project in 1954, has been in service with the Air Force and other government agencies since then. The planes furnish weather, fallout, radiation, and photographic data from lengthy flights at sustained high altitudes. A recent assignment has been investigation of HI-CAT (high-altitude clear-air turbulence) above 55,000 feet. Specifications and performance data are classified.



AH-56A CHEYENNE COMPOUND HELICOPTER

Prime Contractor: Lockheed-California Company

Remarks

The AH-56A Cheyenne, advanced aerial fire support system under development for the Army Aviation Materiel Command, will fly far faster than current combat helicopters. The winged and rotor-bladed AH-56A was rolled out at Lockheed's Van Nuys, California, plant in the spring of 1967, and first flight took place there in September of that year. An extensive flight test program is under way. Mission of this rigid-rotor compound aircraft is to escort troop-carrying helicopters in air mobile operations and to provide direct fire support in combat landing zones. The heavily armed AH-56A can carry wire-guided antitank missiles, rockets, a grenade launcher, and a belly machine gun that affords the gunner a complete circle field of fire. The aircraft has a 2-man crew.

Specifications

Fuselage length 55 feet; main rotor diameter 50 feet; tail rotor diameter 10 feet; pusher propeller diameter 10 feet; wingspan 27 feet; empty weight 11,700 pounds; mission design gross weight 16,995 pounds; engine T64-GE-16, 3,435 shaft horsepower.

Performance

Maximum speed 253 miles per hour; cruise speed 242 miles per hour; service ceiling 26,000 feet; maximum rate of climb 3,420 feet per minute; maximum range, design gross weight, 875 miles; maximum range ferry mission, without payload, short takeoff and landing, 2,900 miles; hover ceiling OGE 11,800 feet.



C-140 JETSTAR EXECUTIVE AND MILITARY JET TRANSPORT

Prime Contractor: Lockheed-Georgia Company

Remarks

The new version of the JetStar—the Dash 8—is a 570-mile-per-hour, 4-engine, multimission transport which stresses reliability and safety with double and triple backup systems; it is the only 4-engine executive jet. JetStars are in use around the world, flying 5 chiefs of state and other high government officials as well as executives of more than 60 of the world's top corporations. Because of this proven experience and reliability, it has been selected for use in the Presidential jet fleet. Air Force Communications Service and Military Airlift Command operate C-140A and VC-140B JetStars. In addition, 2 Dash 8 JetStars are being employed by a major airline for airborne pilot flight training. The compact jetliner seats 10 passengers and a crew of 2. It is also available in a 19-place military version which can be quickly transformed into a cargo-personnel transport with a 3,500-pound combined payload or into a hospital plane.

Specifications (Dash 8)

Span 54 feet 5 inches; length 60 feet 5 inches; height 20 feet 5 inches; wing sweepback 30 degrees at 25 percent chord; maximum takeoff weight 42,000 pounds; engines 4 Pratt & Whitney Aircraft JT12A-8, 3,300 pounds thrust each.

Performance

Maximum speed 570 miles per hour; unrefueled range 2,342 statute miles with 8 passengers; certificated altitude 43,000 feet.



C-130E HERCULES TRANSPORT

Prime Contractor: Lockheed-Georgia Company

Remarks

The C-130E, an advanced version of the C-130A and C-130B, embodies various structural and system modifications. Maximum payload has been increased to 45,000 pounds; this weight can be carried over 2,100 nautical miles. Using an overload takeoff weight, the payload can be carried over 3,100 nautical miles. The C-130E is designed for optional use of externally mounted wing fuel tanks. Use of external tanks gives this model Hercules true transoceanic capability. More than 435 C-130E models are being produced for the Air Force, the Navy, and foreign countries.

Specifications

Wingspan 132.6 feet; overall length 97.7 feet; height 38 feet; cargo floor height above ground 41 inches; maximum payload 45,000 pounds; maximum overload takeoff weight 175,000 pounds; maximum takeoff weight 155,000 pounds; fuel capacity 9,680 gallons; engines 4 Allison T56-A-7 propjets, 4,050 equivalent shaft horsepower each.

Performance

Range with maximum payload approximately 2,100 nautical miles; high-speed cruise 315 knots; takeoff run at 155,000-pound gross weight 3,800 feet; landing ground run at design weight 2,120 feet; propellers Hamilton Standard 4-bladed, 13.5 feet in diameter, full reversing capability.



HC-130H/P HERCULES

Prime Contractor: Lockheed-Georgia Company

Remarks

HC-130H and HC-130P Hercules are in worldwide service with the Aerospace Rescue and Recovery Service (ARRS) of the Air Force's Military Airlift Command. The HC-130H Hercules, equipped with a Fulton recovery system, can pick up as many as 5 humans in multiple pickups from land or sea and return home. Designed for all-weather search and rescue operations, the airplane can fly missions over 2,000 miles from its base. The helicopter aerial refueling version, HC-130P, enabled 2 Sikorsky/Air Force HH-3E "Jolly Green Giant" helicopters to make aviation history on May 31-June 1, 1967, when they flew nonstop from New York to the Paris Air Show. The Air Force and Lockheed-Georgia pioneered the helicopter inflight refueling techniques that made the flight possible and gave the HH-3E rescue helicopters worldwide deployment and rescue capabilities. HC-130P has beefed-up outer wing tank areas, additional backup pumps, and wing pods for refueling drogues. The 48-inch high-drag drogue is designed to accommodate the helicopters' lower speeds. Besides the unique Fulton system for surface-to-air retrieval of personnel, HC-130H/Ps are equipped for ARRS missions with a number of other subsystems, including spacecraft reentry tracker equipment and highly specialized electronics and communications gear. Two removable internal fuselage tanks give the HC-130H/P an additional fuel capacity of 3,600 gallons, bringing total fuel capacity to 13,280 gallons. Power plants are 4 Allison T56-A-15 propjets. Propellers are Hamilton Standard 54H60-91, 4-bladed, 13.5 feet in diameter.



EC-130E HERCULES

Prime Contractor: Lockheed-Georgia Company

Remarks

This new version of the military C-130E Hercules provides the Coast Guard with a multiple-duty, long-range aircraft. It is an electronics mission aircraft designed specifically for use in calibrating Loran-A and -C chains around the world. It will also test new airborne electronic equipment. Other missions include air search and rescue and logistics cargo-personnel transport. The EC-130E contains a specially designed Staff-Pak to provide a relatively noise-free environment for electronic evaluation/calibration missions. The Staff-Pak consists of 4 7.5-foot-cube compartments, or modules, which interlock into a single unit to provide work space, lavatory, and galley facilities for 12 persons.

Specifications

Wingspan 132.6 feet; overall length 97.7 feet; height 38 feet; maximum payload with maximum fuel 35,926 pounds; maximum gross takeoff weight 151,522 pounds; fuel capacity 6,960 gallons; engines 4 Allison T56-A-7 propjets.

Performance

Cruise speed 300 knots true airspeed with normal power at 148,000 pounds gross takeoff weight and 20,000-foot altitude; maximum range 2,800 nautical miles at long-range cruise with maximum fuel, 35,926 pounds payload, and 4,260 pounds reserve fuel.



LOCKHEED 100 HERCULES COMMERCIAL AIRFREIGHTER

Prime Contractor: Lockheed-Georgia Company

Remarks

Lockheed 100s are in service with air carriers. The Hercules, a turboprop commercial airfreighter, is capable of revenue payloads up to 45,409 pounds. The airplane carries, as a standard, 5 pallets plus a ramp container. The pallets are made of phenolic-surfaced plywood and have a capacity of 10,000 pounds each. They measure 88 inches by 118 inches and can be stacked with cargo to a height of 102 inches. The cargo compartment features straight-in-and-out loading at the rear of the fuselage; the ramp is adjustable from ground to truck-bed level. The compartment measures 38 feet from the forward barrier net to the ramp hinge, plus 10.3 feet on the ramp. It is 10 feet wide and 9 feet high. Lockheed 382B is version without built-in loading system.

Specifications

Length 97.7 feet; height 38 feet; wingspan 132.6 feet; maximum takeoff weight 155,000 pounds; maximum net payload 45,409 pounds; crew 3; engines 4 Allison 501-D22 turboprops, driving 4-bladed Hamilton Standard hydromatic propellers; fuel 52,492 pounds.

Performance

Maximum cruise speed 300 knots; range with maximum payload 2,050 nautical miles; takeoff distance at 155,000 pounds gross weight 6,910 feet; landing at 130,000 pounds gross weight 4,760 feet; actual landing roll 2,120 feet.



LOCKHEED 100-20 HERCULES COMMERCIAL AIRFREIGHTER

Prime Contractor: Lockheed-Georgia Company

Remarks

The Lockheed 100-20 Hercules is a stretched commercial version of the Hercules. It is in operation with airlines and carriers, including scheduled contract freight service with a carrier in USAF Logair operations and regular scheduled airline freight service. The Lockheed 100-20 and the Lockheed 100 constitute most of the airfreighters transporting supplies and equipment to Alaska's North Slope for oil explorations. The L-100-20 is 100 inches longer than the L-100. A new engine, the Allison 501-D22A, provides increased performance and reduced operating costs. Cruise speed at 25,000 feet is 31 miles an hour faster than the Lockheed 100. The L-100-20 provides a 14.8 percent reduction in cube ton-mile operating costs.

Specifications

Length 106 feet; height 38 feet; wingspan 132.6 feet; maximum takeoff weight 155,000 pounds; maximum net payload 49,036 pounds; crew 3; engines 4 Allison 501-D22A turboprops, driving 4-bladed Hamilton Standard hydromatic propellers; fuel 52,492 pounds.

Performance

Maximum cruise speed 327 knots; range with maximum payload 1,900 nautical miles; takeoff distance at 155,000 pounds gross weight 5,950 feet; landing distance at 130,000 pounds gross weight 4,760 feet.



C-141 STARLIFTER CARGO-TROOP CARRIER

Prime Contractor: Lockheed-Georgia Company

Remarks

The C-141 StarLifter, fanjet cargo-troop carrier which can cross any ocean nonstop, is in service with the Air Force's Military Airlift Command. It can airlift a 70,847-pound payload 3,975 miles nonstop, or 31,000 pounds 6,040 miles nonstop. Ferry range is 6,840 miles. The C-141 can transport the Minuteman missile, 154 troops, 123 paratroopers, or 80 litters with 16 ambulatory patients and/or attendants. It began squadron duty in 1965 and is setting records airlifting supplies to Vietnam and speeding the wounded to U.S. East Coast hospitals in less than a day's time. The C-141 is the first jet from which troops have jumped and the first jet to land in the Antarctic.

Specifications

Wingspan 159.9 feet; length 145 feet; height 39.3 feet; wing sweepback 25 degrees; takeoff weight 316,100 pounds; engines 4 Pratt & Whitney Aircraft TF33-P-7 fanjets, 21,000 pounds thrust each; dual-wheel nose landing gear, 4-wheel bogie main landing gear; cargo compartment 81 feet long including ramp, 9.1 feet high, 10.25 feet wide.

Performance

Speed 550 miles per hour; ferry range 6,840 miles; maximum payload range 3,975 miles; cargo compartment and flight station pressurized for 8,000-foot cabin altitude at 40,000 feet and sea-level cabin up to 21,000 feet.



C-5 GALAXY CARGO CARRIER

Prime Contractor: Lockheed-Georgia Company

Remarks

Primary mission of Lockheed's C-5 Galaxy, the world's largest aircraft, is to provide a significant increase in the Military Airlift Command's ability to airlift all types of combat and support equipment. Basic requirements are for very high payload and cargo volume, intercontinental range, support-area airfield operations, and air dropping of supplies. Double-deck design provides a cargo compartment 19 feet wide, 13.5 feet high, and 121 feet long between ramps. Flight or relief crews, and support personnel for vehicles carried below, ride on upper deck. First C-5 roll-out was in February 1968; first flight was in June 1968. Operational deliveries began in 1969.

Specifications

Wingspan 222.8 feet; length 247.8 feet; height 65.1 feet; wing sweep 25 degrees; gross takeoff weight, 2.5 g, 728,000 pounds; engines 4 General Electric TF39 turbofans of 41,100 pounds thrust each; 4-wheel nose landing gear, 4 6-wheel bogie main landing gears.

Performance

Maximum cruise speed 470 knots; long-range cruise speed 440 knots; range with 220,000 pounds design payload 3,050 nautical miles; range with 112,600 pounds payload 5,500 nautical miles.



L-500 GALAXY

Prime Contractor: Lockheed-Georgia Company

Remarks

A civil derivation of the USAF C-5 Galaxy, the Lockheed 500 has a main cargo compartment 13.5 feet high, 19 feet wide, and 143 feet long; and 2 upper deck compartments 7.8 feet high, totaling 126 feet in length. The main compartment takes 2 rows of containers or pallets on the floor plus an optional row of containers suspended from ceiling-mounted rails. Alternatively, the 500 can carry outsize cargo too large for any other airplane in production. The upper deck accepts palletized loads interchangeable with those carried in 707 or DC-8 all-cargo planes. Stackable suspended containers can be mounted together to form 8 by 8 by 10 standard, intermodal units. Maximum gross payload is 320,000 pounds. Visor nose permits all 3 rows of main deck pallets and containers to be transferred simultaneously. Design eliminates military transport's aft cargo doors. In 1969 the Galaxy 500 was in design status. In photo, a mock-up simulates the mammoth cargo hold of the 500 in an auto-carrier configuration.

Specifications

Wingspan 222.7 feet; length 247.9 feet; height 67 feet; gross takeoff weight 861,500 pounds; wing sweep at $\frac{1}{4}$ chord 25 degrees; engines 4 turbofans, 50,550 pounds thrust; 4-wheel nose landing gear, 4 independent 4-wheel bogie main landing gears.

Performance

Maximum cruise speed 480 knots; long-range cruise speed 444 knots; range with 320,000 pounds of cargo 2,571 nautical miles.



L-1011 TRISTAR

Prime Contractor: Lockheed-California Company

Remarks

The L-1011 TriStar is an advanced-technology, wide-bodied, multipurpose commercial trijet transport which will accommodate 250 to 345 passengers in a cabin nearly 20 feet wide. It has twin aisles, 2-abreast seat pairs, increased storage space, and 6 double-width doors. Below deck are 2 cargo compartments for standard preloaded containers and a compartment for bulk cargo; their total capacity is 3,228 cubic feet. The basic intermediate-range L-1011 will operate economically on short, medium, and transcontinental ranges up to 3,260 statute miles. The intercontinental L-1011 incorporates a larger wing and more powerful Rolls-Royce turbofan engines. Roll-out of the first production L-1011 was set for fall of 1970, followed by commercial operation one year later.

Specifications

Length 177 feet 8 inches, 182 feet 8 inches (intermediate and intercontinental range, respectively); height 55 feet 4 inches, 59 feet 4 inches; wingspan 155 feet 4 inches, 170 feet; wing sweepback 35 degrees; cargo volume 3,228 cubic feet, 3,309 cubic feet; maximum payload 87,000 pounds, 105,764 pounds; maximum gross takeoff weight 409,000 pounds, 575,000 pounds; engines 3 Rolls-Royce RB.211 high bypass ratio turbofans, 40,600 pounds thrust, 52,500 pounds thrust.

Performance

Maximum cruise speed over 600 miles per hour; range with 56,200-pound payload at Mach .85 3,260 statute miles (intermediate), with full passenger payload 6,000 statute miles (intercontinental); take-off distance 8,750 feet (intermediate), 10,000 feet (intercontinental).



NAVY A-7 CORSAIR II

Prime Contractor: LTV Aerospace Corporation, a subsidiary of Ling-Temco-Vought, Inc.

Remarks

Newest attack plane in the Navy's arsenal is the A-7 Corsair II, which first deployed aboard the *Ranger* to the Pacific Fleet in late 1967. Designed in response to the Navy's request for a light attack aircraft with greater capability and versatility, the A-7's overall design characteristics were derived from the F-8 Crusader series, but optimized for the attack role. The Corsair II can carry over twice the load of bombs, or the same bomb load over twice as far, as current light attack bombers. Its fuel capacity gives a choice of extended range or valuable loiter time over the target. Factory completed 3 weeks ahead of schedule, the A-7A made its first flight in October 1965; 199 production aircraft were delivered by early 1968. The A model is equipped with the Pratt & Whitney Aircraft TF30-P-6 engine. The Navy contracted for 196 B models with the more powerful TF30-P-8 engine. They were delivered in 1968-69. An Air Force version, the D model, and the Navy's updated E are equipped with an avionics suit combining a weapon delivery/navigation computer with Doppler radar, inertial platform, air data computer, forward-looking radar, and head-up display.

Specifications

Wingspan 38.7 feet; length 45.4 feet; height 16.2 feet; engine Pratt & Whitney Aircraft TF30-P-6 (A-7A), TF30-P-8 (A-7B, A-7E), Allison/Rolls-Royce TF41-A-2 Spey (A-7E).

Performance

Subsonic.



AIRCRAFT

AIR FORCE A-7D

Prime Contractor: LTV Aerospace Corporation, a subsidiary of Ling-Temco-Vought, Inc.

Remarks

The Air Force began procuring the A-7D for tactical use in 1968. Capable of carrying and effectively delivering all types of non-nuclear munitions, the A-7D will be used in tactical multipurpose attack missions. It is designed to achieve a high level of operational reliability with minimum maintenance support. The A-7D is equipped with an avionics suit which provides great improvement over other aircraft in day and night visual and all-weather weapon delivery and precise navigation for the attack mission. A digital-computer-equipped avionics package improves weapon delivery by a ratio of 3 to 1 over most other aircraft in the inventory. The first Air Force A-7 was test flown in Dallas in April 1968. Tactical Air Command received its first aircraft in August 1969. The Air Force airplane includes an arresting hook for emergency landings or aborted takeoffs, inflight refueling capability, folding wing sections, gas turbine self-starter, M-61 Vulcan 20-millimeter cannon capable of firing 6,000 rounds a minute, and 8 store stations on the fuselage and wings.

Specifications

Wingspan 39.73 feet; length 46.13 feet; height 16.7 feet; engine Allison/Rolls-Royce TF41-A-1 Spey.

Performance

Speed subsonic, over 650 miles per hour; ferry range over 2,780 miles; inflight refueling capability.



F-8 CRUSADER

Prime Contractor: LTV Aerospace Corporation, a subsidiary of Ling-Temco-Vought, Inc.

Remarks

Fifteen versions of the famed F-8 Crusader fighter are in active service with the U.S. Navy. Another, the F-8E (FN), is operational with 2 French Navy squadrons aboard the carriers *Clemenceau* and *Foch*. Ten basic Crusader versions were built originally: the F-8A/B/C/D/E fighters, the RF-8A photoreconnaissance aircraft, the F-8E (FN), the DF-8A/F target drone control versions, and the NTF-8A 2-seat trainer. An extensive modernization program at the company's Vought Aeronautics Division in Dallas has extended the service life of the Crusaders through 1975. Crusaders, after remanufacture, are redesignated F-8H/J/K/L and RF-8G. Modernization included improvements in wings, landing gear, electrical wiring, and radar. Armament of this fighter varies with the model and ranges from the basic 4 20-millimeter cannon and Sidewinder, Bullpup, and Zuni rockets to 2,000-pound bombs. An outstanding feature of the F-8 is its 2-position variable-incidence wing which provides a high angle of attack for takeoff and landing while the fuselage remains almost parallel to the deck for good pilot visibility.

Specifications (all models)

Span 35 feet 8 inches (22 feet 6 inches folded); length 54 feet 2 inches; height 15 feet 9 inches; engine Pratt & Whitney Aircraft J57-P-4 through J57-P-20A.

Performance

Near Mach 2.



XC-142A V/STOL

Prime Contractor: LTV Aerospace Corporation, a subsidiary of Ling-Temco-Vought, Inc.
Associate Contractors: Fairchild Hiller Corporation and Teledyne Ryan Aeronautical

Remarks

The XC-142A, the world's largest flying V/STOL aircraft, is undergoing testing at NASA's Langley Research Center. Two of the tilt-wing assault transports were delivered in July and August 1965 to Edwards Air Force Base, California, where a 12-man pilot team from the Air Force, the Navy, and the Army began tests which included high-altitude, rough-terrain, and aircraft carrier operations. Three other aircraft were built: 2 were delivered to the armed services in December 1965 and one was delivered in August 1966. Designed to operate from landing areas as small as 350 feet square, the XC-142A can carry 32 fully equipped combat troops or 8,000 pounds of cargo. Its 4 T64 turboprop engines permit it to take off vertically with the wing tilted straight up, make the transition to level flight, and fly up to 430 miles an hour. The XC-142A made its first flight September 29, 1964, its first hover flight December 29, 1964, and its first full transition flight January 11, 1965.

Specifications

Wingspan 67 feet 7 inches; length 58 feet; height 26 feet; engines 4 General Electric T64-1; propellers 15.5-foot Hamilton Standard fiber glass.

Performance

Speed zero to 430 miles per hour.



4-0-4 AIRLINER

Prime Contractor: Martin Marietta Corporation, Baltimore Division

Remarks

The 4-0-4 is an improved version of the earlier Martin 2-0-2. It has a crew of 3 and carries 40 passengers. Tricycle landing gear and retractable passenger steps facilitate ground operations. One hundred three 4-0-4s were built in 1951 and 1952.

Specifications

Length 74 feet 7 inches; height 28 feet 5 $\frac{3}{8}$ inches; span 93 feet 3 $\frac{3}{8}$ inches; fuel capacity 1,350 gallons; weight at takeoff 44,900 pounds (maximum), landing 43,000 pounds, operating empty 30,701 pounds; design useful load 15,774 pounds; engines 2 Pratt & Whitney Aircraft R2800-CB16.

Performance

Range 925 miles with 40 passengers and baggage plus 1,000 pounds cargo (total of 8,800 pounds); maximum engineering range at 10,000 feet with full fuel and 5,694-pound payload 2,525 miles; level flight high speed, 14,500 feet, 312 miles per hour; cruise speed, 18,000 feet, 280 miles per hour; maximum rate of climb at sea level, maximum gross takeoff weight, 1,250 feet per minute; service ceiling with engines at normal rated power and 40,000 pounds gross weight 29,000 feet.



B-57 BOMBER

Prime Contractor: Martin Marietta Corporation, Baltimore Division

Remarks

The B-57A, B, and C are designed to destroy surface military targets during tactical operations. Speed brakes on either side of the fuselage permit steep dives and additional control during low-altitude operations and landing approaches. Tactical versions carry a pilot and a radar operator/navigator/bombardier and can operate from most fighter strips, including sod fields. Turns can be made within the boundaries of average airports, and starting cartridges eliminate the need for ground equipment or outside power. The RB-57 and RB-57D are reconnaissance versions; the E model is a tow-target version. Martin built 403 planes between 1953 and 1959 and modified a number of aircraft in 1966, 1967, and 1968 for service in Vietnam.

Specifications

Span 64 feet (82 feet for RB-57D); length 65.5 feet; height 15 feet; gross takeoff weight 50,000 pounds; gear tricycle; engines 2 Curtiss-Wright J65 jets, 7,200 pounds thrust each; tactical versions have rotary bomb doors, pylon weapons mounts under the wings, and 4 20-millimeter cannons or 8 .50-caliber machine guns which fire from the leading edges of the wings.

Performance

Speed over 600 miles per hour; range over 2,000 miles; service ceiling over 45,000 feet.



F-4C PHANTOM FIGHTER-BOMBER

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The F-4C Phantom is an Air Force fighter-bomber aircraft, a 2-engine, 2-man, all-weather weapon system employed for the close-support and attack mission of Tactical Air Command, PACAF, and USAFE. Basic armament of the F-4C is 4 radar-guided Sparrow III air-to-air missiles carried semisubmerged under the fuselage; 2 additional Sparrow IIIs or 4 infrared-guided Sidewinders can be carried on wing stations. Over 8 tons of miscellaneous external payload (bombs, fuel tanks, rockets, mines, etc.) can be carried on 5 stations beneath the wings and fuselage. First flight of the F-4C was May 27, 1963, less than 14 months after McDonnell received contractual go-ahead from the USAF. The first 2 aircraft were delivered November 20, 1963, and the last of 583 F-4Cs was delivered May 4, 1966. The F-4D Phantom has augmented the F-4C in the USAF inventory.

Specifications

Length 58 feet; span 38.5 feet; wing sweepback 45 degrees; engines 2 General Electric J79-15, 17,000 pounds thrust each.

Performance

Speed 1,600-plus miles per hour; ferry range 2,300 miles; airborne in less than 3,000 feet, lands in even less distance.



F-4B PHANTOM AIR SUPERIORITY FIGHTER

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The F-4B Phantom is a 2-place, twin-jet, all-weather fighter built for the Navy and the Marine Corps. The Phantom has the greatest firepower of all Navy fighters. The crew consists of a pilot and a radar intercept officer. The plane is equipped with detection and tracking systems which enable it to destroy supersonic as well as subsonic enemy aircraft by day or night in any weather. The F-4B Phantom holds 8 time-to-climb world records including climbing to 12,000 meters (39,370 feet) in 1 minute 17 seconds. The F-4B is being augmented in Navy and Marine service by the F-4J.

Specifications

Length 58 feet; span 38.5 feet; wing sweepback 45 degrees; horizontal stabilizer slopes downward at 23 degrees; boundary layer control; engines 2 General Electric J79-8, 17,000 pounds thrust each.

Performance

Speed 1,600-plus miles per hour; service ceiling over 60,000 feet; has been flown to altitudes over 100,000 feet.



RF-4B PHANTOM RECONNAISSANCE AIRCRAFT

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The RF-4B is a tactical, all-weather, multisensor reconnaissance aircraft that utilizes the same basic configuration and engines as the fighter and attack versions of the Phantom. McDonnell has designed and is building the RF-4B to increase the reconnaissance capability of the Marine Corps. Basically, the RF-4B differs from the RF-4C reconnaissance version in that (1) the RF-4B has smaller wheels and is carrier-suitable and (2) the RF-4B has flight controls in the cockpit only, unlike the RF-4C which has dual controls. The RF-4B has inflight rotatable camera mounts in 2 camera stations. Cameras in the Air Force version can be repositioned on the ground only. The RF-4B has no armament capability.

Specifications

Length 63 feet; span 38.5 feet; wing sweepback 45 degrees; engines 2 General Electric J79-8, 17,000 pounds thrust each.

Performance

Speed 1,600-plus miles per hour; ferry range 2,000 miles; forward-looking radar, utilizing its terrain-following or terrain-avoidance mode, permits operation at very low altitude over varying terrains.



RF-4C PHANTOM RECONNAISSANCE AIRCRAFT

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The RF-4C Phantom is a high-performance fighter-type aircraft with an effective tactical, all-weather, multisensor reconnaissance capability. The Air Force RF-4C incorporates optical, infrared, and electronic sensors, necessary for performing reconnaissance missions day or night in any kind of weather. Its optical system includes cameras of various focal lengths and operational modes, an integrated sensor control system, automatic inflight film processing, and film ejection from the low-altitude panoramic camera station. By adding an HF communications transceiver to the electronic system, voice communication is possible between the aircraft and its home base anywhere within the performance envelope of the Phantom. In addition, the RF-4C has forward-looking radar for ground mapping and low-level penetration, side-looking radar, an infrared reconnaissance system, and an inerted navigation set.

Specifications

Length 63 feet; span 38.5 feet; retains air-to-ground nuclear attack capability of other Phantom versions; no conventional weapons; engines 2 General Electric J79-15; basically same aircraft as the Air Force F-4C, main difference being the nose section which contains cameras and other detection equipment.

Performance

Speed 1,600-plus miles per hour; ferry range 2,000 miles; service ceiling above 60,000 feet.



F-4D PHANTOM

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The F-4D, the Air Force's newest, fastest, and highest-flying fighter-bomber, is the second version of the Phantom to enter USAF service. The plane has essentially the same airframe and engines as its predecessor, the F-4C, but it carries major systems improvements which increase its capability of delivering accurate air-to-ground weapons. The F-4D is equipped with a new APQ-109 fire-control radar system. First flight of the F-4D was at Lambert-St. Louis Municipal Airport on December 8, 1965. On March 10, 1966, the first F-4D was delivered to the USAF at Warner-Robins Air Force Base, Georgia; it was flown later to Bitburg, Germany, as the forerunner of several squadrons of F-4Ds that replaced F-105 aircraft stationed in Germany. Two squadrons of F-4Ds were delivered to the Royal Iranian Air Force late in 1968.



F-4E PHANTOM AIR SUPERIORITY FIGHTER

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The F-4E is a tactical strike fighter version of the F-4 Phantom. Like the preceding F-4C and F-4D series, it is a twin-engine, 2-place fighter capable of performing air superiority, close-support, and interdiction missions of the tactical forces, using conventional or nuclear munitions. The F-4E has an internally mounted M-61A1 20-millimeter Gatling gun housed in the nose of the aircraft, an improved fire-control system, and engines with increased thrust. A Westinghouse-developed miniaturized radar installed in the nose enables retention of the radar-guided Sparrow III missile armament in addition to the gun. The multibarrel cannon, based on the Gatling-gun concept, is capable of firing shells at a rate of 100 rounds a minute. First flight of the production model of the F-4E was at St. Louis on June 30, 1967. On October 3, 1967, the first F-4E was delivered to the Tactical Air Command at Nellis Air Force Base, Nevada.



F-4J PHANTOM

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

An advanced version of the Phantom II series, the F-4J was the sixth model to reach production status. It made its first public flight on May 27, 1966, eighth anniversary of the initial flight of the first airplane of the Phantom II series. The F-4J is being delivered to the Navy and the Marine Corps. It has higher maximum speed, greater range, higher combat ceiling, shorter takeoff distance, lower approach speeds, and better air-to-air and air-to-ground combat capabilities than any previous Phantom model. Major improvements include a new radar system, a new bombing system, new electronic systems, improved control surfaces, and new engines. The 2 General Electric J79-10 engines produce 17,900 pounds thrust each at takeoff, provide additional acceleration at supersonic speeds, and operate with reduced fuel consumption at cruise speeds. Above Mach 2 each engine produces 2,000 pounds more thrust than the J79-8/15 engines that power the F-4B and F-4C models.



F-4K PHANTOM

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The F-4K, which made its initial flight on June 28, 1966, is the eighth production model of the Phantom II series and the first to be purchased outside the United States; it is a specially designed version for use by the United Kingdom's Royal Navy. In many respects the plane is similar to the U.S. Navy F-4J. Among the major differences are an extendible nose landing gear and provisions for folding the radome and radar antenna to permit use of the 54-foot elevators on the British carriers (folding reduces the overall length to just under 52 feet). Prime difference is the substitution of Rolls-Royce Spey engines for the J79 engines in the American versions; the larger Speys give the F-4K an increase in performance capability over U.S. versions in virtually every area of flight. The first F-4Ks were delivered to the Royal Navy at the RN station in Yeovilton, England, after a 4,700-mile transatlantic flight from St. Louis, on April 29, 1968.



F-4M PHANTOM AIR SUPERIORITY FIGHTER

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The McDonnell Douglas F-4M Phantom for the United Kingdom's Royal Air Force made its first flight on February 17, 1967, at Lambert-St. Louis Municipal Airport. The F-4M is similar to the latest U.S. Navy model, the F-4J. The F-4M, however, uses Rolls-Royce Spey engines and has an improved navigation/attack system, a strike camera, and an advanced AWG-12 missile control system. Unlike the U.S. Phantom models, the F-4M has either reconnaissance controls or dual controls in the rear seat. The dual controls permit the F-4M to be used for pilot training while retaining full mission capability. The reconnaissance controls, with a United Kingdom-supplied pod for sensors, provide a reconnaissance capability while keeping an air superiority and attack capability. The Spey engine is the MK-201 equipped with reheat and Plessey gas turbine starter. Design of the F-4M Phantom has been tailored for easy engine maintenance. In tests at McDonnell Douglas in St. Louis, the Spey has been installed in the Phantom from dolly roll in to dolly roll out in 12 minutes. The Spey engine is larger than the J79 and provides additional static thrust (20,100 pounds each engine) for short takeoffs and rapid climb. A major item of electronic equipment in the F-4M is the high-powered, forward-looking AWG-12 radar and missile computer system which prepares and launches the radar-guided Sparrow III or infrared heat-seeking Sidewinder missiles for air-to-air attack. The first F-4Ms were delivered to the Royal Air Force at Aldegrave, Northern Ireland, on July 20, 1968.



F-101B VOODOO INTERCEPTOR

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The F-101B has a combination of speed and long range exceeding that of any other operational interceptor in the Air Defense Command. It is equipped with Genie rockets possessing a nuclear capability. In addition, it carries conventional rockets and Falcon missiles. The F-101B is a 2-place interceptor; the second crewman is a radar operator. It operates under all weather conditions to execute 2 primary missions: identification of unknown aircraft and destruction of the aircraft if they are hostile. Fifteen squadrons of the F-101B Voodoo are in service with the Air Defense Command and 3 squadrons are in the inventory of the Royal Canadian Air Force.

Specifications

Length 67.5 feet; span 40 feet; height 18 feet; wing and stabilizer swept back at angle of 35 degrees; engines 2 Pratt & Whitney Aircraft J57.

Performance

Speed 1,200-plus miles per hour; range 2,000-plus miles; service ceiling 55,000-plus feet.



188E STOL TRANSPORT

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The 188E is designed to carry an 8-ton payload 575 miles, land safely with less than 500-foot ground roll on a 1,000-foot unprepared surface, and return to its base with payload, without refueling. Flight safety for short-field operations and maneuverability at low speed are provided through cross-shaft interconnection of the 4 engines. The 188E can make steep turns and gear-down landing approaches at airspeeds as low as 50 knots. A fully developed transport designed to meet short-haul transportation needs in the early 1970s, the 188 STOL has an extensive development, ground-test, and flight-test background. A production model has been used in demonstration programs with airline/industry/government agency participation to prove the practicality of the STOL concept and to establish operating criteria for STOL transport aircraft. The Breguet-designed aircraft will be built to U.S. military standards by McDonnell with U.S. tooling, material, and equipment and with the technical assistance of Breguet.

Specifications

Length 80 feet; span 77 feet; height 31 feet; gross weight 58,400 pounds; payload for 575-mile-radius mission 8 tons; troop capacity 55.

Performance

Cruise speed 250 knots; ferry range 3,500-plus miles.



A-3 SKYWARRIOR

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

The A-3 Skywarrior is a long-range bomber designed to perform various missions at high or low levels. Versions of the basic A-3 include the RA-3B photoreconnaissance aircraft, the TA-3B bomber-trainer, and the EA-3B reconnaissance model. An inflight refueling system converts it to a high-speed jet tanker. First A-3 flight was October 28, 1952. It is the largest of the Navy's carrier-based aircraft. Wings and vertical tail surface fold for convenience in carrier handling. The A-3 was phased out of production in 1961.

Specifications

Wingspan 72 feet 6 inches; length 74 feet 8 inches; height 22 feet 9 inches; normal gross weight 70,000 pounds; engines 2 Pratt & Whitney Aircraft J57; basic crew of 3.

Performance

Range over 2,500 nautical miles; other data classified.



**A-4F, TA-4F SKYHAWK
TRAINER-ATTACK BOMBER**

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

The A-4F and the TA-4F, the latter a jet trainer, are new versions of the versatile A-4 Skyhawk series of Navy attack bombers. The TA-4F modification includes the addition of a 28-inch section for a second seat and dual controls. New safety features include the Navy/Douglas ESCAPAC zero-level, zero-speed ejection seat system for both instructor and student. The A-4F, an improved attack bomber, incorporates the advanced avionics and the Pratt & Whitney Aircraft J52-P-8A engine of the trainer. Nose-wheel steering and landing spoilers have also been added to the original Skyhawk. The latest version is the TA-4J trainer (photo). It has eliminated certain weapon launch equipment, resulting in a lighter aircraft. All are produced at Long Beach with final assembly at Palmdale, California.

Specifications (TA-4F)

Wingspan 27 feet 6 inches; length 42 feet 10 inches; height 15 feet; empty weight 9,300 pounds; loaded weight 24,500 pounds; weapons weight 8,200 pounds; engine Pratt & Whitney Aircraft J52-P-8A.

Performance

Range transcontinental; speed 600 to 700 miles per hour.



B-66 DESTROYER BOMBER

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

Several versions of the B-66 tactical bomber are in service with the Air Force. Produced in bomber and reconnaissance versions, the Destroyer performs at stratospheric or minimum altitudes. The B-66 and the RB-66 were built at the Douglas Long Beach plant; the RB-66C and the WB-66D were produced at the Tulsa facility. The RB-66B is designed to be used with a wide selection of bomb combinations including the H-bomb. The RB-66C is a special-purpose reconnaissance plane. The WB-66D, last in the series, is a weather reconnaissance aircraft. Special features include a pressurized, air-conditioned compartment, inflight refueling system, and thermal cyclic de-icing system.

Specifications

Wingspan 72 feet 6 inches; length 75 feet 2 inches; height 23 feet 7 inches; gross weight 70,000 to 78,000 pounds; engines 2 Allison J71 jets; crew of 3 (RB-66C, 4); armament 2 20-millimeter tail turret guns electronically operated.

Performance

Speed 600 to 700 miles per hour; other data classified.



C-124 GLOBEMASTER

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

The C-124 Globemaster, first flown in November 1949, has been flying supply lines reaching almost around the world daily since May 1950, when it was first delivered to the Air Force. The C-124 can transport general cargo, 200 fully equipped troops, or many categories of military vehicles fully assembled. Special features include a clamshell nose door, a self-contained ramp, and an elevator located amidship, permitting loading and unloading at both points. The last C-124 was delivered in May 1955.

Specifications

Wingspan 174 feet 2 inches; length 130 feet; height 48 feet 3 inches; empty weight 101,052 pounds; gross weight 185,000 pounds; alternate gross weight 194,500 pounds; wing loading 74 pounds per square foot; power loading 12.2 pounds per brake horsepower; engines 4 Pratt & Whitney Aircraft R4360-63A; fuel capacity 11,000 gallons; wing area 2,506 square feet.

Performance

Maximum payload 70,000 pounds; capability of delivering a 50,000-pound payload 1,000 miles and returning to base without refueling.

AIRCRAFT



C-133 HEAVY CARGO TRANSPORT

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

The C-133A and the C-133B are capable of transporting any missile in the U.S. arsenal including intercontinental ballistic missiles. They also can carry virtually any Army field force equipment. Costly disassembly of large vehicles and equipment is unnecessary and vehicles are ready for use upon arrival. Simultaneous front and rear loading is afforded by 2 cargo entrances to the 13,000-cubic-foot-capacity cabin. Pressurization maintains a sea-level cabin altitude up to 16,000 feet; at 35,000 feet, cabin altitude is 10,000 feet. First C-133B flight was October 31, 1959. The C-133B, developed for the Military Airlift Command, was built at the Douglas Long Beach plant.

Specifications

Wingspan 179 feet 7.86 inches; length 157 feet 6.44 inches; height 48 feet 9 inches; empty weight 120,363 pounds; wing loading 107 pounds per square foot; power loading 9.75 pounds per shaft horsepower; engines T34-P-9W, 5,650 shaft horsepower normal rated; fuel capacity 18,112 gallons.

Performance

Maximum speed 312 knots, military power, 286,000 pounds gross weight at 8,700 feet; cruise speed 284 knots, approximately 90 percent normal rated power, from 17,000 feet at 280,000 pounds to 35,000 feet at 130,000 pounds; landing speed 117 knots at 250,500 pounds; rate of climb 1,280 feet per minute; range with maximum payload 1,973 nautical miles.



DC-6, C-118 LIFTMASTER

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

First of the modern, post-World War II airliners, the propeller-driven DC-6 series and their military counterparts are still giving service throughout the world. Powered by 4 Pratt & Whitney Aircraft R2800 engines, the DC-6 repeatedly set commercial records with its cruising speed of 315 miles an hour. It also introduced new levels of comfort to air travel with cabin pressurization and air conditioning. With an overall fuselage length of 100 feet 7 inches, the DC-6 carries up to 74 passengers. After 174 were produced, an enlarged version 5 feet longer to seat up to 102 was designed and designated the DC-6B. This design was the basis of the first commercial airfreighter, the DC-6A, and the military C-118 Liftmaster, ordered by the Air Force and the Navy for cargo and troop transport and medical evacuation purposes. More than 700 DC-6 aircraft of all types were produced. First DC-6 flight was February 15, 1946; first delivery was March 28, 1947.



DC-7 COMMERCIAL TRANSPORT

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

The DC-7, the most advanced piston-powered commercial transport built by Douglas, is in extensive use on long-range airways of the world. The first airliner with the speed and range to fly nonstop in both directions between California and New York, it also pioneered polar routes between the U.S. West Coast and Europe and between Europe and Asia. Three models were built, in approximately equal numbers, for a total of 336, culminating in the DC-7C. Dubbed the "Seven Seas" because of its extended-range, overwater capabilities, the DC-7C is powered by 4 Wright R3350 compound engines which give it a maximum speed in excess of 400 miles per hour. It carries up to 99 passengers and their baggage on nonstop flights of 4,000 miles with ample fuel reserves. First DC-7 flight was December 20, 1955; certification was May 15, 1956.



DC-8 JET TRANSPORT

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

The DC-8 jet is being manufactured in 3 basic models of the new extended-fuselage Super Sixty series. Each model is also made in a cargo or combination cargo-passenger version. Super 61, first of the Super Sixty series, has a fuselage extension of 440 inches for a total of 187.4 feet and carries up to 259 passengers. Super 62, an ultralong-range transport, seats up to 189 passengers in a fuselage extended 80 inches to 157.4 feet and has a 6-foot increase in wingspan, increased fuel capacity, and redesigned engine pylons and ducted fan nacelles. Super 63 (photo) is a combination of the full fuselage extension of Super 61, with pylon and engine pod modifications of the Super 62. First flight of Super 61 was March 14, 1966; Super 62, August 29, 1966; Super 63, April 10, 1967. Certification of all Super Sixty series models was in 1967.

Specifications (Super 63)

Span 148.4 feet; length 187.4 feet; height 42 feet 4 inches; wing area 2,926 square feet; crew 3 to 5 plus cabin attendants; engines 4 Pratt & Whitney Aircraft JT3D-7, 19,000 pounds thrust each; design gross weight 353,000 pounds.

Performance

Level flight speed 600 miles per hour; maximum range 7,700 statute miles.



DC-9 JET TRANSPORT

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

The short- to medium-range DC-9 twin-jet is produced in 3 versions: Series 20, Series 30, and Series 40 (photo). Series 20, capable of operating from very short runways, is 104.4 feet long and accommodates up to 90 passengers. Series 30, 119.3 feet long, carries a maximum of 115 passengers. Series 40, with more powerful engines, is 125.6 feet long and accommodates up to 125 passengers. The DC-9 is designed to operate from short runways. In normal operations, all versions will take off on a 600-mile flight with 50 passengers and baggage from a runway of less than 5,000 feet and make 2 intermediate stops without refueling. The Series 20, 30, and 40 have the high-lift wing system of leading-edge slats and trailing-edge flaps for excellent short-field performance. Production of an earlier Series 10 was discontinued in 1968. Its exterior dimensions and passenger capacity are the same as those of the Series 20.

Specifications (Series 30)

Span 93.4 feet; length 119.3 feet; height 27.4 feet; wing area 1,000.7 square feet; crew 2 plus cabin attendants; engines 2 Pratt & Whitney Aircraft JT8D-7 ducted turbofans, takeoff thrust 14,000 pounds; maximum takeoff weight 77,700 pounds.

Performance (Series 30)

Level flight speed 557 miles per hour; range at optimum cruise speed 1,430 nautical miles.



C-9A AEROMEDICAL AIRLIFT TRANSPORT

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

The first of 12 C-9A Nightingales was delivered to the Air Force on August 10, 1968, less than a year after Douglas Aircraft received a contract from the Air Force Systems Command's Aeronautical Systems Division. More than 40 ambulatory patients, 30 to 40 litter patients, or a combination of ambulatory and litter patients can be accommodated in a C-9A on 500-mile-per-hour flights between military hospitals. The transports, equipped to provide passengers with the same medical care and attention they would receive in a hospital ward, are operated by the 375th Aeromedical Wing of the Military Airlift Command. The Nightingale is basically a standard DC-9 Series 30, but it has an 11-foot-wide cargo door and a special ramp for boarding patients on litters. Special features include accommodation of patients in either aft-facing seats or rigidly suspended litters of 3 or 4 tiers, provision for therapeutic oxygen, a medical suction system for use in keeping patients' air passages clear, an isolated special-care section, a central control station for the flight nurse, and medical attendant stations. The boarding ramp and large door (81 by 136 inches) for boarding patients are hydraulically operated.

Specifications

Other than special features, the craft is an off-the-line DC-9 Series 30, with standard dimensions: wingspan 93.4 feet; overall length 119.3 feet; overall height 27.4 feet.

Performance

Cruise speed 500-plus miles per hour; range 2,000-plus miles.



DC-10 JET TRANSPORT

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

The DC-10 is a 3-engine, multirange, advanced-technology jetliner produced in 3 basic models: Series 10 for routes of 300 to 3,500 statute miles and Series 20 and 30 for ranges up to 5,600 miles. All have identical dimensions, including accommodations for 270 to 345 passengers in a spacious cabin nearly 19 feet wide and over 8 feet high. The DC-10F is a convertible passenger-cargo version. Two of the high bypass ratio engines are mounted conventionally on pylons beneath the wings; the third is above the aft fuselage at the base of the vertical stabilizer.

Specifications

Length 180 feet; span 155 feet 4 inches; height 58 feet 1 inch; diameter nearly 20 feet; engines General Electric CF6-6, 40,000 pounds takeoff thrust (10), Pratt & Whitney Aircraft JT9D-17, 49,800 pounds thrust (20), General Electric CF6-50A, 49,000 pounds thrust (30); maximum gross takeoff weight 410,000 pounds (10), 530,000 pounds (20 and 30).

Performance

Level flight speed 600-plus miles per hour; payload 80,435 pounds (10), 103,035 pounds (20), 104,704 pounds (30), 158,000 pounds (Series 20 and 30 DC-10F); maximum range 3,500 statute miles (10), 5,610 statute miles (20), 5,560 statute miles (30).



EC-135N APOLLO RANGE INSTRUMENTED AIRCRAFT

Program Direction: Electronics Systems Division, Air Force Systems Command
Contractors: McDonnell Douglas Corporation's Douglas Aircraft Company (prime contractor for Apollo Range Instrumented Aircraft Program); The Bendix Corporation (major subcontractor for electronics); The Boeing Company (basic airframe)

Remarks

The EC-135N is an Air Force jet transport modified to play an important role in the Apollo lunar landing program. A fleet of 8 Apollo Range Instrumented Aircraft (ARIA) provides a highly mobile communications network which can be shifted quickly to allow coverage in areas where ground or sea stations cannot afford maximum radio and telemetry contact with Apollo astronauts. Most prominent addition to the transport is a huge protruding radome attached at the nose. The 10-foot-long bulb houses a 7-foot VHF and S-band parabolic dish antenna which will scan for a spacecraft, lock on it, and then transmit and receive voice and telemetry communications. The first EC-135N made its initial flight September 19, 1966.



RANGER

Prime Contractor: Mooney Aircraft Corporation

Remarks

The 4-place, retractable-gear Ranger features positive control for wings-level flight attitude. Its 4-cylinder, 180-horsepower engine uses 91/96 octane fuel which is contained in 2 integral sealed tanks. A full-trim tail gives maximum stability at low speeds and minimum drag at high speeds. Cabin construction features a welded chrome-moly steel tube frame structure. Electric gear retraction system is standard.

Specifications

Span 35 feet; length 23 feet 2 inches; height 8 feet 4.5 inches; gross weight 2,575 pounds; empty weight 1,566 pounds; useful load 1,009 pounds; baggage 120 pounds; wing loading 15.4 pounds per square foot; power loading 14.3 pounds per horsepower; wing area 167 square feet; tread 9 feet .75 inch; engine 1 Lycoming O-360, 180 horsepower; propeller 74 inches, constant speed; fuel capacity 52 gallons.

Performance

Maximum level speed 179 miles per hour; maximum cruise speed at 75 percent power 172 miles per hour at 7,500 feet; stall speed 57 miles per hour; rate of climb 1,000 feet per minute at gross weight; maximum range 1,043 miles; service ceiling 17,200 feet.



M-22

Prime Contractor: Mooney Aircraft Corporation

Remarks

The M-22 is an advanced single-engine business aircraft with pressurized cabin seating 4 or 5. It was designed as a high-performance airplane capable of going anywhere, anytime, at a practical price. With a self-imposed operational ceiling of 24,000 feet, the M-22 will fly above virtually any en route weather. The 310-horsepower engine is turbo-charged. The M-22 will fly at speeds up to 250 miles per hour.

Specifications

Span 35 feet; length 27 feet; height 9 feet 10 inches; gross weight 3,680 pounds; useful load 1,240 pounds; engine 1 Lycoming TIO-541-A1A; usable fuel 92 gallons.

Performance

Maximum level speed 256 miles per hour; maximum recommended cruise 230 miles per hour; stall speed 67 miles per hour; gross weight rate of climb at sea level 1,125 feet per minute; takeoff over 50-foot obstacle 2,079 feet; maximum certificated operational ceiling 24,000 feet; maximum range over 1,100 statute miles.



MU-2

Prime Contractor (United States, Mexico, Canada): Mooney Aircraft Corporation

Remarks

The Mooney MU-2 is a new 7-place, twin turbo-prop, executive transport featuring exceptionally high speeds with good short-field capabilities at a practical investment and operating cost. It can cruise at 340 miles per hour and has a 26,500-foot ceiling. Passengers enjoy air-conditioned and pressurized comfort. Its 2 705-shaft-horsepower engines, full-span, double-slotted flaps, and reversible propellers allow the Mooney MU-2 to get in and out of short airstrips.

Specifications

Span 38 feet 9 inches; length 33 feet 3 inches; height 13 feet; gross weight 8,930 pounds; useful load 3,600 pounds; engines 2 AiResearch TPE 331; fuel 295 gallons.

Performance

Maximum cruise speed at 10,000 feet 340 miles per hour; stall speed 74 miles per hour; rate of climb 2,000 feet per minute; maximum range 1,200 miles.



EXECUTIVE 21

Prime Contractor: Mooney Aircraft Corporation

Remarks

The Mooney Executive 21 combines all the high-performance features of the Chaparral with a longer fuselage that allows more leg room for both front- and back-seat passengers. It has individually reclining seats and a longer range.

Specifications

Span 35 feet; length 24 feet 3.1 inches; height 8 feet 4.5 inches; gross weight 2,740 pounds; empty weight 1,622 pounds; useful load 1,118 pounds; baggage 120 pounds; wing loading 15.4 pounds per square foot; wing area 167 square feet; engine 1 Lycoming IO-360, 200 horsepower.

Performance

Maximum level speed 184 miles per hour; maximum cruise speed, 75 percent power, 179 miles per hour; stall speed 64 miles per hour; rate of climb 1,330 feet per minute; maximum range 1,147 miles with 45-minute reserve; service ceiling 17,900 feet.

STATESMAN

Prime Contractor: Mooney Aircraft Corporation

Remarks

The Mooney Statesman offers the economy of a 180-horsepower engine combined with the stretch-out comfort of the Executive 21. The Statesman has a restyled instrument panel, improved instrument and interior lighting, and an easily operated manual gear-retraction system.



CHAPARRAL

Prime Contractor: Mooney Aircraft Corporation

Remarks

A new addition to the Mooney line, the Chaparral features electric gear (up in 3 seconds, down in 2), a power quadrant which sets up power, propeller, and mixture controls in ideal arrangement, electrically operated flaps, a completely new instrument panel, and an annunciator panel to monitor the aircraft's vital systems.

Specifications

Wingspan 35 feet; length 23 feet 2 inches; height 8 feet 4.5 inches; wing area 167 square feet; maximum gross weight 2,575 pounds; empty weight 1,578 pounds; useful load 997 pounds; maximum baggage 120 pounds; engine Lycoming IO-360-A1A, 200 horsepower.

Performance

Maximum speed 197 miles per hour; maximum cruise, 75 percent, 193 miles per hour; rate of climb sea level 1,400 feet per minute; service ceiling 18,800 feet; stall speed, gear and flaps down, power off, 57 miles per hour; range 1,060 miles.



CADET

Prime Contractor: Mooney Aircraft Corporation

Specifications

Wingspan 30 feet; length 20 feet 8 inches; height at tail 7 feet 8 inches; gross weight 1,450 pounds; empty weight 950 pounds; useful load 500 pounds; baggage capacity 90 pounds; wing loading 10.17 pounds per square foot; engine Continental C-90-16F of 90 horsepower.

Performance

Maximum speed 118 miles per hour; maximum cruise, 75 percent, optimum altitude 114 miles per hour; service ceiling 15,500 feet; takeoff run 334 feet; landing roll 430 feet; rate of climb 835 feet per minute; stall speed, power off, 46 miles per hour; maximum range 559 miles.



XB-70A RESEARCH AIRCRAFT

Prime Contractor: Los Angeles Division, Aerospace & Systems Group, North American Rockwell Corporation

Associate Contractor: General Electric Company

Remarks

The XB-70A was a high-speed, high-altitude, 6-engine experimental aircraft flown in research programs at Edwards Air Force Base, California, under NASA management. Originally conceived as an intercontinental bomber, its development began in 1956 following a 2-company study competition. In 1963 the decision was made to produce only 2 aircraft, both to be used only for research programs. The first XB-70A was rolled out on May 11, 1964, and made its first flight on September 21 of that year. The second aircraft was completed on May 29, 1965, and made its maiden flight on July 17. On October 14, the No. 1 airplane first reached its design goal of Mach 3 at 70,000 feet. The No. 2 aircraft flew sustained Mach 3 for 32 minutes on May 19, 1966. On June 8, 1966, it crashed after a midair collision with one of its chase planes. The 2 XB-70 airplanes had accumulated 123 flights totaling more than 239 hours as of August 21, 1968. The program was terminated at year-end 1968.

Specifications

Span 105 feet; length 185 feet; height 30 feet; weight over 500,000 pounds; engines 6 General Electric YJ93, 30,000-pound-thrust class; crew pilot and copilot.

Performance

Speed 2,000 miles per hour; altitude over 70,000 feet.



T-39 SABRELINER

Prime Contractor: Los Angeles Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The T-39 Sabreliner was developed to meet USAF requirements for a utility aircraft which could be certificated by the FAA under Part 4b. Following completion of a prototype in May 1958, it was placed in production for the Air Force in October of that year. Delivery of the first aircraft was in October 1960. Three models were manufactured for military use: the T-39A, with a basic configuration for 4 passengers and crew of 2, for use as a trainer or utility aircraft; the T-39B, a radar navigation trainer for the Air Force; and the T-39D, a radar navigation trainer for the Navy. The T-39 was placed on the civilian market in October 1962. It is currently produced in 2 versions: the Series 40, which carries up to 8 passengers and a crew of 2, and the stretched Series 60, which carries up to 10 passengers and a crew of 2. Both models are equipped with the Pratt & Whitney Aircraft JT12A-8 engine which develops 3,300 pounds of thrust. In photo, Series 60 left, Series 40 right.

Specifications

Span 44.5 feet; length 44 feet (40), 46.9 feet (60); height 16 feet; maximum gross takeoff weight 18,650 pounds (40), 20,000 pounds (60).

Performance

Speed 560 miles per hour plus; range over 2,100 miles (40), over 2,000 miles (60); altitude 40,000 feet, certified to 45,000 feet (business version) with passengers.



X-15 RESEARCH AIRCRAFT

Prime Contractor: Los Angeles Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The X-15 was a special-purpose research airplane; its initial development was funded jointly by the Air Force, the Navy, and the National Aeronautics and Space Administration. Three aircraft were built, and the first to fly took to the air on June 8, 1959. In the course of its long career, the X-15 made many contributions to research, particularly in the hypersonic area. It attained speeds of over Mach 6 and altitudes above 350,000 feet. The No. 1 plane, now in the Smithsonian Institution, was used for research in high-altitude brightness, micrometeorite collection, ultraviolet stellar photography, heat exchangers, atmospheric density measurements, horizon scanning and definition, advanced integrated data systems, air-breathing propulsion, supersonic decelerators, and high-temperature leading edges. The No. 2 airplane (photo), which was fitted with twin droppable fuel tanks, coated with ablative material, and modified as a ramjet test-bed, set an unofficial speed record of Mach 6.7, or 4,520 miles per hour, on October 3, 1967. The pilot was Major Pete Knight. Subsequently the aircraft was overhauled and placed in storage at the NASA facility at Edwards Air Force Base. The No. 3 aircraft was destroyed in an accident on November 11, 1967, in which Major M. J. Adams lost his life. More than 10 years of flight research had been completed by the 3 aircraft without a fatality prior to the No. 3 crash. The X-15 made 197 flights.



OV-10A BRONCO LIGHT ARMED RECONNAISSANCE AIRCRAFT

Prime Contractor: Columbus Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The OV-10A was the first aircraft designed specifically for counterinsurgency and limited-war operations. It is intended for use by the military services, allied foreign countries, and the Military Assistance Program. Its mission capabilities include observation and reconnaissance, helicopter escort, light ground attack, gunfire spotting, liaison, transport, and training. The Bronco can operate from rough clearings and primitive roads as well as from prepared airfields and small carriers. The fuselage is mounted below the wing, providing unobstructed visibility well ahead of the propellers for pilot and observer. Cockpits are equipped with the North American Rockwell LW3-B escape system which allows ejection at zero airspeed and ground level. The 111-cubic-foot fuselage cargo compartment can carry loads up to 3,200 pounds. Bombs, rockets, and napalm can be mounted on fuselage sponsons which contain 4 fixed 7.62-millimeter machine guns and 5 ordnance stations. External fuel can be carried on a centerline station.

Specifications

Span 40 feet; length 41 feet 7 inches; height 15 feet; engines AiResearch T76-G-10 (left) and T76-G-12 (right), 715 shaft horsepower each; trailing arm articulating landing gear.

Performance

Speed 245 knots; range 1,200 nautical miles; service ceiling 28,000 feet.



RA-5C TACTICAL RECONNAISSANCE WEAPON SYSTEM

Prime Contractor: Columbus Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The RA-5C is a carrier-based tactical reconnaissance weapon system with all-weather multisensor capability. Attack provisions are contained as alternate mission capabilities. The RA-5C, named the Vigilante, can perform supersonic missions at low or high altitudes; it has a top speed in the Mach 2 range. Reconnaissance equipment includes serial frame and panoramic cameras, side-looking radar, and passive electronic countermeasures. Four wing stations provide for external carriage of fuel tanks. The RA-5C Tactical Reconnaissance Weapon System is one part of the Navy's Integrated Operational Intelligence System; the aircraft carrier processing centers, known as the Integrated Operational Intelligence Centers, are the other part.

Specifications

Span 53 feet; length 76 feet; height 20 feet; wing, tail, nose hinged for folding aboard carriers; normal takeoff gross weight 65,600 pounds; landing weight 46,175 pounds; engines 2 General Electric J79-10 turbojets, 11,110 pounds thrust each, 17,857 pounds with afterburner; landing gear tricycle.

Performance

Speed Mach 2; range 2,000-plus nautical miles.



AIRCRAFT

T-2A BASIC JET TRAINER

Prime Contractor: Columbus Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The T-2A Buckeye, standard basic jet trainer of the Navy, is in wide use throughout the Naval Air Basic Training Command. Designed to operate from land and carrier bases, the T-2A is utilized to train Navy and Marine Corps student pilots in aerial gunnery, instrument flying, formation flying and tactics, and carrier operations. The Buckeye has stepped, tandem seating and a clamshell-type canopy for maximum visibility and low-altitude ejection provisions. It is equipped with the rocket-propelled crew escape system, manufactured by the Columbus Division of North American Rockwell, which is effective throughout the trainer's flight envelope.

Specifications

Span 36 feet; length 38 feet 3 inches; height 14 feet 9 inches; takeoff gross weight 11,498 pounds; engine Westinghouse J34-WE-48, 3,400 pounds thrust; landing gear tricycle.

Performance

Speed 400 knots; range 795 nautical miles; service ceiling 36,500 feet.

T-2B, T-2C BASIC JET TRAINERS

Prime Contractor: Columbus Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The T-2B Buckeye, an improved version of the T-2A, entered production in 1965. It is used as a land- or carrier-based trainer to instruct Navy and Marine Corps student pilots from first jet flight to the advanced training phase. The 2-engine configuration gives the T-2B performance and safety characteristics superior to those of the T-2A. Waist-level engine compartments and equipment bays are easily accessible for ground maintenance and servicing. Fuel is carried in the fuselage, in the inboard wing leading edges, and in 100-gallon tanks on each wing tip. The T-2C is an improved and more economical version of the T-2B. Incorporated into the production line in January 1969, it features a different engine but performs the same role and mission as the T-2B.

Specifications

Span 38 feet 2 inches; length 38 feet 3 inches; height 14 feet 9 inches; takeoff gross weight 13,284 pounds (T-2B), 13,179 pounds (T-2C); engines 2 Pratt & Whitney Aircraft J60-P-6 turbojets, 3,000 pounds thrust each (T-2B), 2 General Electric J85-GE-4 turbojets, 2,950 pounds thrust each (T-2C).

Performance

Speed 453 knots; range 960 nautical miles (T-2B), 909 nautical miles (T-2C); service ceiling 40,700 feet (T-2B), 40,414 feet (T-2C).



F-100 SUPER SABRE

Prime Contractor: Los Angeles Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The F-100 Super Sabre was the first supersonic fighter in the Air Force's Tactical Air Command. The first production model, the F-100A, was delivered in October 1953. It was produced in 4 models, the A, C, D, and F. The F-100A, an air superiority fighter, is flown by the Air National Guard. The F-100C, with inflight refueling and bombing capabilities, is assigned to the Air Force's tactical fighter wings. The D and F fighter-bomber models are providing the Tactical Air Command with long-range striking power and supersonic air-to-air combat ability. In addition to its bomb armament and 4 20-millimeter cannons, the Super Sabre can be equipped to fire rockets and missiles, including the heat-seeking Sidewinder.

Specifications

Span 38 feet; length 47 feet; height 16 feet; weight 18,239 to 22,337 pounds according to model; engine J57, 10,000-pound-thrust class; crew, pilot (F model, pilot and observer or student).

Performance

Speed over 800 miles per hour; range over 1,000 miles; altitude over 50,000 feet.



LARK COMMANDER

Prime Contractor: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

The Lark Commander is a 4-place, single-engine, high-wing, all-metal aircraft designed for the businessman-pilot and for the leisure market. Several paint combinations and interior decor selections are offered as standard.

Specifications

Span 35 feet; length 24 feet 11 inches; height 10 feet 1 inch; gross weight 2,450 pounds; empty weight with standard equipment 1,532 pounds; useful load 918 pounds; cabin length 8 feet 2 inches; cabin width 3 feet 4 inches; baggage 120 pounds; fuel capacity 44 gallons standard; engine Lycoming O-360-A2F rated at 180 horsepower at 2,700 revolutions per minute at sea level, 1,500 hours time between overhauls.

Performance*

Speed at best altitude 138 miles per hour; takeoff over 50-foot obstacle 1,650 feet; takeoff run 1,050 feet; initial rate of climb 648 feet per minute; stall speed 63 miles per hour; range 470 statute miles.

*All performances shown are based on full gross, standard atmospheric conditions at sea level unless otherwise shown.



SHRIKE, SHRIKE ESQUIRE COMMANDERS

Prime Contractor: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

The Shrike (photo) and Shrike Esquire twin-engine Commanders are designed for the businessman-pilot. Standard installations include separate pilot and passenger entry doors. Principal differences between the 2 models are in interior styling and decor and exterior designs.

Specifications

Span 49 feet .5 inch; length 36 feet 7 inches; height 14 feet 6 inches; tread 12 feet 11 inches; takeoff weight 6,750 pounds; empty weight 4,635 pounds (Shrike), 4,741 pounds (Shrike Esquire); useful load 2,115 pounds (Shrike), 2,009 pounds (Shrike Esquire); fuel capacity 156 gallons; engines 2 Lycoming IO-540, 290 horsepower each; baggage capacity 500 pounds; seating, 4 to 7 (Shrike), 6 (Shrike Esquire).

Performance*

Maximum speed at sea level 215 miles per hour; cruise speed, 75 percent power 9,000 feet, 203 miles per hour; takeoff distance over 50-foot obstacle 1,915 feet; landing distance over 50-foot obstacle 2,235 feet; range at 15,000 feet, TAS 170, 1,078 statute miles; service ceiling 21,000 feet.

*All performances shown are based on full gross, standard atmospheric conditions at sea level unless otherwise noted.



HAWK COMMANDER

Prime Contractor: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

The Hawk Commander is a pressurized turboprop aircraft with standard executive seating for 8 occupants or as many as 10. It has IFR capabilities and features fully reversible propellers as standard installation. A 500-pound-capacity baggage compartment is separated from the passenger cabin. Four interior color combinations are available as standard installations. Special interior arrangements and styles are also available.

Specifications

Span 44 feet .7 inch; length 42 feet 11.72 inches; height 14 feet 6 inches; maximum takeoff weight 9,400 pounds; empty weight with standard equipment 5,647 pounds; useful load 3,803 pounds; maximum fuel capacity 286.5 gallons (standard), 337.5 gallons (auxiliary); engines 2 Garrett AiResearch TPE 331-43 BL, takeoff power of 575 shaft horsepower and 605 equivalent shaft horsepower each at sea level.

Performance*

Maximum speed, best altitude, 290 miles per hour; cruise speed, normal, 278 miles per hour; takeoff roll 1,706 feet; service ceiling 25,600 feet; range, auxiliary fuel, 1,491 statute miles.

*All performances shown are based on full gross, standard atmospheric conditions at sea level unless otherwise noted.



QUAIL, SPARROW COMMANDERS

Prime Contractor: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

The Quail Commander and the Sparrow Commander aerial application aircraft are similar in airframe design and construction. They are designed for the application of liquid and solid chemicals. Quail (photo) and Sparrow differ in hopper capacity, power, and performance.

Specifications

Span 34 feet 9 inches; length 23 feet 6 inches; height 7 feet 7 inches. Quail: gross weight 3,600 pounds; useful load 2,000 pounds; hopper capacity 210 U.S. gallons or 1,600 pounds; fuel capacity 40 gallons; engine Lycoming IO-540-G1C5 fuel-injected, rated at 290 horsepower. Sparrow: gross weight 3,400 pounds; useful load 1,800 pounds; hopper capacity 170 U.S. gallons or 1,400 pounds; fuel capacity 40 gallons; engine Lycoming O-540-B2B5 rated at 235 horsepower.

Performance*

Quail: maximum speed 120 miles per hour; working speed 90 to 100 miles per hour; stall speed 46 miles per hour; takeoff distance at gross weight 650 feet; service ceiling 16,000 feet; ferry range at 70 percent power 275 statute miles. Sparrow: maximum speed 119 miles per hour; working speed 90 to 100 miles per hour; stall speed 46 miles per hour; takeoff distance 650 feet; service ceiling 14,000 feet; ferry range at 70 percent power 250 statute miles.

*Performance based on ICAO conditions unless noted.



THRUSH COMMANDER

Prime Contractor: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

The Thrush Commander is the largest agricultural aircraft in production in the United States. It is a highly maneuverable aerial application aircraft designed specifically for precise application of liquid and solid chemicals. The all-metal wing and all-metal fuselage aircraft is delivered equipped with a 70-nozzle spray boom and all basic application devices installed. The Thrush has an average 60-foot swath width at normal application altitudes and has working speeds of 105 to 115 miles per hour. The aircraft is eligible for FAR 23 and 21 certification.

Specifications

Span 44 feet 5 inches; length 29 feet 4.5 inches; height 9 feet 2 inches; gross weight 6,900 pounds; hopper capacity 400 U.S. gallons or 3,280 pounds; fuel capacity 106 gallons; engine Pratt & Whitney Aircraft Wasp R1340, 9-cylinder, supercharged, radial, rated at 600 horsepower at 2,250 revolutions per minute for takeoff.

Performance*

Maximum speed 140 miles per hour; working speed 105 to 115 miles per hour; stall speed 57 miles per hour; takeoff distance at gross weight 775 feet; service ceiling 15,000 feet; ferry range at 70 percent power 403 statute miles.

*Performance based on ICAO conditions unless noted.



F-5 TACTICAL FIGHTER

Prime Contractor: Northrop Corporation

Remarks

The F-5 is a multipurpose, twin-turbojet, supersonic fighter chosen by the Department of Defense for fighter aircraft replacement in selected allied nations under the Military Assistance Program. Fifteen free world nations have received quantities of F-5s. Single-seat F-5A fighters and twin-cockpit F-5B models are produced as well as a new RF-5A reconnaissance version. Utilizing the same basic design, the F-5B combines the combat capability of the F-5A with training capability. The aircraft provides close support of troops, interception, attacks on communications and supply lines, and armed reconnaissance missions over enemy territory. It is produced by the Aircraft Division of Northrop Corporation and, under special license, in Canada and Spain.

Specifications

Span 26 feet 7 inches with wing-tip armament; length 45 feet; height 13 feet 2 inches; weight 13,000 pounds with full internal fuel; external load 6,200 pounds of air-to-air and air-to-ground weapons, reconnaissance and surveillance equipment, and extra fuel; 2 20-millimeter cannons mounted in nose of F-5A and RF-5A; engines 2 General Electric J85-13 turbojets, 4,080 pounds thrust each (GE J85-15 engines with 4,300 pounds thrust each in Canadian and Dutch versions).

Performance

Speed Mach 1.4-plus; combat ceiling over 50,000 feet; sea-level rate of climb over 29,000 feet per minute; range over 1,500 nautical miles with external tanks dropped; tactical mission radius up to 760 nautical miles.



T-38 TALON TRAINER

Prime Contractor: Northrop Corporation

Remarks

The only U.S.-produced supersonic jet trainer, the T-38 is a twin-jet, low-wing monoplane. It is used as an advanced trainer by the Air Force and as a flight-test support aircraft by the Navy. The T-38 has been selected by NASA for astronaut space flight readiness training. A production milestone was reached in 1969 with delivery of the 1,000th T-38. A number of T-38s have been delivered to the German Air Force. Featuring a very high degree of safety, the T-38 is produced by the Aircraft Division of Northrop Corporation.

Specifications

Span 24 feet 3 inches; length 42 feet 2 inches; height 12 feet 11 inches; weight 11,550 pounds; crew 2; engines 2 General Electric J85-5 turbojets; 2 independent electrical and fuel supply systems, one for each engine.

Performance

Speed Mach 1.2 (guaranteed), Mach 1.35 (highest attained); range 990 nautical miles; rate of climb over 30,000 feet per minute; ceiling 54,000 feet.



16H-1H PATHFINDER I

Prime Contractor: Piasecki Aircraft Corporation

Remarks

The 16H-1H is a shaft-driven compound helicopter powered by a United Aircraft of Canada PT6B-16 turbine of 690 shaft horsepower. It is a 5-place aircraft utilizing a 3-bladed main rotor and a 3-bladed, controllable-pitch, ring tail ducted propeller for propulsion and antitorque control.

Specifications

Fuselage length 29 feet; wingspan 20 feet; rotor diameter 41 feet; empty weight 3,012 pounds; VTOL gross weight 4,600 pounds.

Performance

Cruise speed 174 miles per hour; range 386 statute miles.



16H-1B PATHFINDER II

Prime Contractor: Piasecki Aircraft Corporation

Remarks

The 16H-1B is an advanced developmental shaft compound helicopter with one General Electric T58-5 turbine of 1,500 shaft horsepower. The 16H-1 predecessor design was developed and tested with company funds; major modifications, made under contract to the Army, led to the 16H-1A and additional advanced ground and flight testing. The 16H-1B is an 8-place, higher-powered equivalent with 3-bladed main rotor; 3-bladed, controllable-pitch, ring tail ducted propeller for propulsion, stability, and antitorque control; stub wings; and retractable main landing gear.

Specifications

Fuselage length 37.25 feet; wingspan 20 feet; main rotor diameter 44 feet; empty weight 5,078 pounds; VTOL gross weight 8,121 pounds.

Performance

Maximum speed sea level 210 miles per hour; service ceiling 13,400 feet.



16H-3J PATHFINDER EXECUTIVE

Prime Contractor: Piasecki Aircraft Corporation

Remarks

A commercial twin-turbine configuration derived from the advanced developmental 16H-1A, the 16H-3J is a low-wing, twin-engine, shaft-driven compound helicopter powered by 2 United Aircraft of Canada PT6B-16 turbines. It features a ducted pusher propeller which provides forward thrust for fixed-wing mode flight conditions. The same propeller, working in conjunction with controllable tail vanes, provides the antitorque force for hovering. In forward flight the rotor is unloaded, transferring the propulsion function to the tail propeller and the lift function to the wing. The 16H-3J provides the executive traveler door-to-door travel at greatly increased speeds over those of present-day helicopters. Seating capacity is 14 passengers in addition to the pilot.

Specifications

Fuselage length 42.9 feet; wingspan 21.3 feet; main rotor diameter 44.2 feet; empty weight 5,925 pounds; gross weight 9,600 pounds.

Performance

Cruise speed 190 miles per hour; range 438 statute miles.



PAWNEE C

Prime Contractor: Piper Aircraft Corporation

Remarks

The Pawnee was designed specifically for safe, efficient, economical dispersal of liquid and solid agricultural chemicals, insecticides, and salt and for ease of maintenance under field conditions. The Pawnee was introduced in 1959; the present Pawnee C is equipped with a Lycoming O-540-B2B5 235-horsepower engine. In worldwide use, it has earned the universal respect of ag-operators and their customers—farmers, municipalities, and highway departments—and of ag-pilots for its handling ease and its unique safety-capsule cockpit. The Pawnee is also powered by a 260-horsepower Lycoming O-540-E engine with optional constant-speed propeller.

Specifications

Wingspan 36.2 feet; length 24.7 feet; height 7.2 feet; gross weight 2,900 pounds; empty weight sprayer 1,488 pounds, duster 1,479 pounds; wing area 183 square feet; fuel capacity 42 gallons; all-metal McCauley propeller with 84-inch diameter.

Performance

Top speed 110 miles per hour for duster, 117 for sprayer; cruise speed at 75 percent power 100 miles per hour for duster, 105 for sprayer; stall speed 61 miles per hour; takeoff run 956 feet for duster, 800 for sprayer; landing roll 850 feet; rate of climb at sea level, duster 500 feet per minute, sprayer 630 feet per minute; cruising range at 75 percent power, duster 285 miles, sprayer 300 miles.



CHEROKEE 140C

Prime Contractor: Piper Aircraft Corporation

Remarks

The Cherokee 140C is a 2- to 4-place, fixed-gear sport/trainer powered by a Lycoming O-320-E2A 150-horsepower engine. Since its introduction in 1963, the Cherokee 140 has become one of the most popular aircraft for fixed-base operators, flying clubs, flight schools, and private individuals. Its low-wing design with low center of gravity, coupled with the 10-foot-wide landing gear, has made the Cherokee 140 an extremely forgiving airplane for student work and has permitted flight operations in wind conditions heretofore considered too risky for student solo operations.

Specifications

Wingspan 30 feet; length 23.3 feet; height 7.3 feet; gross weight 2,150 pounds; empty weight 1,201 pounds; wing area 160 square feet; wing loading 13.4 pounds per square foot; power loading 14.3 pounds per horsepower; fuel capacity 50 gallons; propeller all-metal, fixed-pitch Sensenich with 74-inch diameter.

Performance

Top speed 142 miles per hour; cruise speed 75 percent power 133 miles per hour; stall speed 54 miles per hour; takeoff run 800 feet; landing roll 535 feet; rate of climb 600 feet per minute; service ceiling 14,300 feet; cruise range 725 miles.



CHEROKEE E

Prime Contractor: Piper Aircraft Corporation

Remarks

The Cherokee E is the latest version of the Cherokee line of 4-place, fixed-gear aircraft introduced in 1961.

Specifications

Wingspan 30 feet; length 23.5 feet; height 7.3 feet; wing area 160 square feet; wing loading 15 pounds per square foot; gross weight 2,400 pounds; empty weight 1,300 pounds; useful load 1,100 pounds; engine Lycoming O-360-A3A rated at 180 horsepower at 2,700 revolutions per minute.

Performance

Top speed 152 miles per hour; optimum cruise speed, 75 percent power 7,000 feet, 143 miles per hour; stall speed (flaps) 57 miles per hour; takeoff run 720 feet; rate of climb 750 feet per minute; service ceiling 16,400 feet; cruise range, 75 percent power optimum altitude, 725 miles; fuel consumption, 75 percent power, 10 gallons per hour.



CHEROKEE 235D

Prime Contractor: Piper Aircraft Corporation

Remarks

The Cherokee 235D can carry 4 passengers, 200 pounds of luggage, and 84 gallons of fuel and still have weight left over. With its Lycoming O-540-B2B5 235-horsepower engine and its modern, low-wing design, the Cherokee 235D can operate from even the shortest fields and then cruise at 156 miles per hour for a range of over 900 miles. The new Cherokee 235D incorporates many improvements, such as shock-mounted cowling, dynafocal engine mounting, increased soundproofing, a new, larger instrument panel that will accommodate even the most professional type of equipment, the Sports-Power console, and a new paint scheme.

Specifications

Wingspan 32 feet; length 23.7 feet; height 7.1 feet; gross weight 2,900 pounds; empty weight 1,467 pounds; wing area 170 square feet; wing loading 17 pounds per square foot; power loading 12.4 pounds per horsepower; fuel capacity 84 gallons; propeller either McCauley metal, fixed pitch, or Hartzell constant speed, both with 80-inch diameter.

Performance

Top speed 166 miles per hour; cruise speed at 75 percent power 156 miles per hour at 2,900 pounds gross; stall speed 60 miles per hour; takeoff run 800 feet; landing roll 680 feet; rate of climb at sea level 825 feet per minute; service ceiling 14,500 feet; cruise range at 75 percent power 935 miles.



CHEROKEE SIX

Prime Contractor: Piper Aircraft Corporation

Remarks

The Piper Cherokee Six is unique in its class. Ideal for business, pleasure, ranch, utility, or air taxi use, it is offered with a choice of horsepower, with 6- or 7-place seating, and in a seaplane configuration. The 260-horsepower version uses a Lycoming O-540-E4B5 and the 300-horsepower version uses the IO-540-K with Bendix fuel injection. Cruising speed of 160 miles per hour in the 260-horsepower model is increased to 168 miles per hour at full 3,400-pound gross in the 300-horsepower version. Both models carry 6 passengers, 200 pounds of luggage, and full fuel of 84 gallons, with a seventh seat optional.

Specifications

Wingspan 32.8 feet; length 27.7 feet; height 7.9 feet; gross weight 3,400 pounds; empty weight 1,655 pounds; wing area 174.5 square feet; wing loading 19.5 pounds per square foot; power loading 13.1 pounds per horsepower; fuel capacity 84 gallons; propeller either fixed-pitch, metal McCauley or Hartzell constant speed with 82-inch diameter.

Performance

Top speed 166 and 174 miles per hour (260- and 300-horsepower versions, respectively); cruise speed at 75 percent power 160 and 168 miles per hour; stall speed 63 miles per hour; takeoff run 740 and 700 feet; landing roll 630 feet; rate of climb at sea level 850 and 1,050 feet per minute; service ceiling 14,500 feet; cruise range at 75 percent power 960 and 880 miles.



CHEROKEE ARROW 200

Prime Contractor: Piper Aircraft Corporation

Remarks

The Arrow 200 has a number of features which distinguish it from its companion craft, the Cherokee E. It has 3 instead of the usual 2 windows on either side, providing additional visibility for the 4 occupants. A new power control arrangement groups the throttle, propeller, and mixture controls in a quadrant similar to that found in multi-engine aircraft. Gear is retractable by a hydraulic system that employs an electrically operated pump.

Specifications

Wingspan 30 feet; wing area 160 square feet; length 24.2 feet; height 8 feet; wing loading 16.3 pounds per square foot; baggage 200 pounds; fuel capacity 50 gallons; gross weight 2,600 pounds; empty weight 1,459 pounds; engine Lycoming IO-360-C1C, 200 horsepower at 2,700 revolutions per minute.

Performance

Top speed 176 miles per hour; optimum cruise speed, 75 percent power optimum altitude, 166 miles per hour; stall speed, flaps and gear down, 64 miles per hour; rate of climb 910 feet per minute; service ceiling 16,000 feet; cruise range, 75 percent power, 810 miles; optimum cruise range, 55 percent power, 950 miles.



SUPER CUB

Prime Contractor: Piper Aircraft Corporation

Remarks

The Super Cub reflects the sound aerodynamic design proven and refined in more than 27,000 planes of this basic model produced by Piper Aircraft since its introduction in 1937. The Super Cub is powered by a Lycoming O-320 150-horsepower engine; it holds the world's altitude record for piston-powered light aircraft by attaining 30,203 feet. The Super Cub is certified on floats and skis and is used throughout the world for pleasure and for training, patrol, survey, agricultural, and general utility work.

Specifications

Wingspan 35.3 feet; length 22.5 feet; height 6.7 feet; gross weight 1,750 pounds; overload gross weight 2,070 pounds; empty weight 930 pounds; wing area 178.5 square feet; wing loading 10 pounds per square foot; power loading 11.6 pounds per horsepower; fuel capacity 36 gallons; propeller all-metal Sensenich with 74-inch diameter.

Performance

Top speed 130 miles per hour; cruise speed at 75 percent power 115 miles per hour; stall speed 43 miles per hour; takeoff run 200 feet; landing roll 350 feet; rate of climb at sea level 960 feet per minute; service ceiling 19,000 feet; cruise range at 75 percent power 460 miles.



POCONO

Prime Contractor: Piper Aircraft Corporation

Remarks

Designed specifically for the commuter market, Piper's new Pocono is an 18-place, short-haul airliner which has attracted more-than-anticipated interest as an executive transport. Cabin height is 5 feet 8 inches; normal seating is 3 abreast, 2 on the right side of the aisle and one on the left. Standard airline-type floor mounting channels permit positioning of seats or cargo fasteners in any desired location.

Specifications

Wingspan 51 feet; length 39.25 feet; height 15.75 feet; gross weight 9,500 pounds; empty weight 4,900 pounds; useful load 4,600 pounds (18-place), 4,350 pounds (cargo configuration); engines 2 Lycoming TIO-720, 500 horsepower.

Performance

Top speed at 10,000 feet 242 miles per hour; cruise speed, 75 percent power 10,000 feet, 216 miles per hour; stall speed 74 miles per hour; rate of climb 1,630 feet per minute; single-engine ceiling 14,000 feet; range, economy cruise (55 percent) 810 miles.



COMANCHE C

Prime Contractor: Piper Aircraft Corporation

Remarks

The Comanche C is the latest version of the proven Comanche line of airplanes. The new Comanche C has a longer cabin that seats up to 6 people, more luxurious styling, and a maximum gross weight of 3,100 pounds. Powered by either a Lycoming O-540-E carburetor induction engine or a Lycoming IO-540-D fuel-injection engine, the Comanche C cruises at over 180 miles per hour and has a range of 1,100 miles at 75 percent power.

Specifications

Wingspan 35.98 feet; length 25.29 feet; height 7.47 feet; gross weight for takeoff 3,100 pounds; gross weight for landing 2,945 pounds; empty weight 1,728 pounds; wing area 178 square feet; wing loading 17.42 pounds per square foot; power loading 11.92 pounds per horsepower; fuel capacity 90 gallons; propeller Hartzell constant speed with 77-inch diameter.

Performance

Top speed 194 miles per hour; cruise speed at 75 percent power 182 miles per hour; stall speed 66 miles per hour; takeoff run 760 feet; landing roll 655 feet; rate of climb at sea level 1,370 feet per minute; service ceiling 20,000 feet; cruise range at 75 percent power 1,108 miles.



**TWIN COMANCHE C,
TURBO TWIN COMANCHE C**

Prime Contractor: Piper Aircraft Corporation

Remarks

A longer cabin that seats 6 passengers, new luxurious styling, and even quieter operation are added to the already proven design of the Twin Comanche to make the Twin Comanche C. Powered by 2 Lycoming IO-320-B fuel-injection engines developing 160 horsepower each, the Twin Comanche C cruises at over 190 miles per hour at 75 percent power. If even better performance is desired for high altitude, the Turbo Twin Comanche C can cruise at 24,000 feet at 223 miles per hour at 75 percent power. It holds the light twin nonstop distance record. In photo, Turbo Twin Comanche C.

Specifications

Wingspan 35.98 feet; length 25.2 feet; height 8.2 feet; gross weight 3,600 pounds (3,725, Turbo); empty weight 2,210 pounds (2,408, Turbo); wing area 178 square feet; power loading 11.3 pounds per horsepower; fuel capacity 120 gallons; propellers Hartzell constant speed, full feathering, 72-inch diameter.

Performance

Top speed 205 miles per hour (246, Turbo); cruise speed, 75 percent power, 198 miles per hour (240, Turbo); takeoff run 940 feet; landing roll 1,215 feet; rate of climb at sea level 1,460 feet per minute (1,290 at 10,000 feet, Turbo); service ceiling 18,600 feet (30,000-plus, Turbo); single-engine ceiling 7,100 feet (17,000, Turbo); cruise range at 75 percent power 1,200 miles (1,535, Turbo).



AZTEC D, TURBO AZTEC D

Prime Contractor: Piper Aircraft Corporation

Remarks

The Aztec D is powered by 2 Lycoming fuel-injection IO-540-C4B5 engines developing 250 horsepower each. It cruises at 210 miles per hour at its maximum gross weight of 5,200 pounds and will travel nonstop well over 1,000 miles. For even better, high-altitude performance, the Turbo Aztec D is equipped with 2 Lycoming fully modified IO-540-J4A5 engines which increase cruise speed to 250 miles per hour at 24,000 feet and give the Turbo Aztec D a ceiling of over 30,000 feet.

Specifications

Wingspan 37 feet; length 30.2 feet; height 10.3 feet; gross weight 5,200 pounds; empty weight 2,933 pounds (3,023 pounds, Turbo Aztec); wing area 207.56 square feet; fuel capacity 144 gallons; propellers Hartzell constant speed, full feathering, 77-inch diameter.

Performance

Aztec D: top speed 216 miles per hour; normal cruise, 4,000 feet, 210 miles per hour; intermediate cruise, 6,000 feet, 208 miles per hour; economy cruise, 6,400 feet, 204 miles per hour; long-range cruise, 10,200 feet, 195 miles per hour. Turbo Aztec D: top speed 256 miles per hour; turbo cruise, 24,000 feet, 250 miles per hour; intermediate cruise, 24,000 feet, 236 miles per hour; economy cruise, 24,000 feet, 218 miles per hour; long-range cruise, 24,000 feet, 199 miles per hour.



NAVAJO 300, TURBO NAVAJO

Prime Contractor: Piper Aircraft Corporation

Remarks

Piper offers 2 models of the Navajo: the Turbo Navajo with 310-horsepower turbocharged Lycoming TIO-540-A engines and the Navajo 300 with IO-540-K engines. At full gross of 6,200 pounds, the Turbo Navajo will cruise at 247 miles per hour at 23,500 feet; the Navajo 300, 210 miles per hour at 6,400 feet. Accelerate-stop distance is just over 2,000 feet for both models, and short-field characteristics are similar to those of the Aztec.

Specifications

Wingspan 40.67 feet; length 32.63 feet; height 13 feet; gross weight 6,200 pounds; empty weight 3,603 pounds (Navajo 300), 3,759 pounds (Turbo Navajo); wing area 229 square feet; fuel capacity 190 gallons; propellers full-feathering, constant-speed Hartzells.

Performance

Top speed 224 miles per hour (260, Turbo); cruise speed, 75 percent power, 210 miles per hour at 6,400 feet (247 at 23,500 feet, Turbo); stall speed 71 miles per hour; takeoff run 1,080 feet (1,066, Turbo); landing roll 1,725 feet; rate of climb at sea level 1,440 feet per minute (1,395, Turbo); service ceiling 20,500 feet (26,300, Turbo); absolute ceiling 30,000-plus feet (Turbo); cruise range, 75 percent power, 1,240 miles (1,305, Turbo); single-engine ceiling 5,750 feet (15,800, Turbo).



S-58 TRANSPORT HELICOPTER

Prime Contractor: Sikorsky Aircraft

Remarks

The S-58 is an all-purpose transport flown by the U.S. Navy, Marine Corps, and Army, by many foreign countries, and by domestic and foreign commercial operators. More than 1,800 S-58s have been manufactured. The S-58 has a seating capacity of crew (pilot and copilot) and 12 to 18 passengers or 8 litters, or a net payload of 4,000 pounds for a distance of 100 miles. It has an alternate cargo capacity of 405 cubic feet. A 5,000-pound-capacity automatic touchdown release cargo sling for carrying external loads and a 600-pound-capacity hydraulically operated utility hoist are provided as desired. Automatic stabilization equipment, installed on Navy, Marine, and Army versions of the aircraft, has been certified by the FAA for use on commercial S-58s. Four-bladed main rotor and 4-bladed tail rotor are all-metal. The first flight took place March 8, 1954.

Specifications

Empty weight 7,900 pounds; normal gross weight 13,000 pounds; useful load 5,100 pounds; engine Wright R1820, 1,525 horsepower.

Performance

Maximum speed 123 miles per hour; service ceiling 9,500 feet; range 280 miles.



SH-3A/D ANTISUBMARINE HELICOPTER

Prime Contractor: Sikorsky Aircraft

Remarks

The SH-3A antisubmarine warfare helicopter made its first flight March 11, 1959, after development under the Navy's weapons system program. It was the first helicopter in the world to exceed 200 miles per hour in a sanctioned speed test, and the first to make a nonstop coast-to-coast helicopter flight in the United States. The SH-3A gave the Navy a helicopter able to both search out and destroy enemy submarines. The SH-3D, with more powerful engines and improved avionics and sonar equipment, has increased range and ability. The SH-3A/D is produced not only for the U.S. Navy but also for the Canadian, English, Spanish, Italian, and Brazilian navies and for the Japanese Self Defense Forces. The S-61A, without the antisubmarine warfare gear, has been produced for the Danish Air Force, for the Malaysian Air Force, and for commercial use. The RH-3A, a version of the SH-3A fitted with towing hook, is used by the U.S. Navy as a mine countermeasures aircraft. Still another version, the VH-3A, is used to transport the President of the United States and other government officials.

Specifications

Empty weight 11,865 pounds; useful load 6,761 pounds; engines 2 General Electric T58-10, 1,400 horsepower each.

Performance

Maximum speed 166 miles per hour; service ceiling 14,700 feet; range, with 10 percent reserve, 624 miles.



S-61L/N HELICOPTER AIRLINER

Prime Contractor: Sikorsky Aircraft

Remarks

The S-61N is the amphibious version of the S-61L, first helicopter designed specifically for airline use and to airline standards. It carries from 25 to 30 passengers. The aircraft is powered by twin turbine engines and can continue flight to normal landing with one engine inoperative. The S-61L has been flown in scheduled passenger service by Los Angeles Airways since 1962. S-61Ns have been delivered to San Francisco & Oakland Helicopter Airlines in the United States, BEA Helicopters Ltd. in England, Greenlandair in Greenland, and Ansett-ANA in Australia. In addition, S-61Ns are in passenger service in Pakistan and in Japan. S-61Ns are used in construction and oil rig work in the United States and abroad; they fly crews and supplies to offshore rigs in the Gulf of Mexico, the North Sea, and the waters off Malaysia. The Canadian Coast Guard also uses the S-61N.

Specifications

Empty weight 12,256 pounds; normal gross weight 19,000 pounds; useful load 6,744 pounds; engines 2 General Electric CT58-140-2, 1,500 horsepower each.

Performance

Maximum speed 150 miles per hour; service ceiling 12,200 feet; range 265 miles.



S-61R HELICOPTER

Prime Contractor: Sikorsky Aircraft

Remarks

The S-61R, a member of the S-61 series marked by a rear cargo door, made its first flight June 17, 1963. The S-61R was selected by the Air Force as both transport and rescue vehicle, the former called CH-3E and the latter HH-3E. The HH-3E is equipped with external, jettisonable fuel tanks; it has a telescopic air-refueling probe for extended flights. In 1967, 2 HH-3Es made the first nonstop transatlantic helicopter flight, refueling 9 times from New York to Paris. Assigned to the Aerospace Rescue and Recovery Service, the HH-3E's prime combat mission is recovery of downed airmen. For this mission the HH-3E is both armor plated and armed for protection from hostile forces while in the combat area. A rear ramp and rear cargo door make rapid loading and unloading possible. Power is supplied by 2 gas turbine engines. Primary mission of the CH-3E is cargo and troop transport. It has approximately the same performance as the HH-3E but is not equipped with tip tanks, armor plating, or aerial refueling probe. Another search and rescue version of the S-61R, the HH-3F, is being produced for the Coast Guard. It is equipped with sophisticated communications and navigation equipment.

Specifications

Empty weight 14,426 pounds; normal gross weight 19,500 pounds; alternate gross weight 22,050 pounds; useful load 5,074 pounds; engines 2 General Electric T58-5, 1,500 horsepower each.

Performance

Maximum speed 165 miles per hour; cruise speed 154 miles per hour; service ceiling 11,700 feet; range, with 2 tip tanks, 748 miles.



S-62 SEARCH-RESCUE HELICOPTER

Prime Contractor: Sikorsky Aircraft

Remarks

The single-turbine S-62, first amphibious helicopter built with a flying boat type hull, is used by the Coast Guard as its search and rescue helicopter. The S-62 was the first American turbine-powered helicopter to be certified by the Federal Aviation Administration for commercial operations. The FAA certificate permits it to carry a pilot, a copilot, and 11 passengers. It can operate from land, water, ice, snow, swamp, mud, or almost any other surface. The first flight took place May 22, 1958. Besides its Coast Guard application, the S-62 is used in airline and industrial operations. It is especially useful to the oil industry in supplying offshore drilling platforms.

Specifications

Empty weight 5,083 pounds; normal gross weight 8,100 pounds; useful load 3,017 pounds; engine General Electric T58-8, 1,250 horsepower.

Performance

Maximum speed 110 miles per hour; service ceiling 11,200 feet; range 463 miles.



S-64 SKYCRANE

Prime Contractor: Sikorsky Aircraft

Remarks

First flight of the twin-turbine-powered S-64 Skycrane, a universal transport vehicle with a 10-ton payload, was May 9, 1962. A newer version, the CH-54B, with a 12.5-ton payload, went into production in 1969 for the Army. First deliveries of the Skycrane were to the West German Ministry of Defense, followed by deliveries to the U.S. Army beginning in 1964. The S-64 is designed for both military and commercial operations. It has a rear-facing pilot's seat to provide a clear view of loads during pickups and deliveries. All cargo is carried externally. By means of a hoist, the S-64 can accomplish cargo transfer missions without landing. A lightweight van, for use as a field hospital, command post, or repair shop, can be attached to the S-64 fuselage. The Skycrane is produced also for commercial operations in such fields as oil drilling, ship-to-shore loading and unloading, moving prefabricated housing, and transmission line construction. The S-64 was certified for commercial use in August 1969; it is the largest helicopter ever certified by the FAA.

Specifications

Empty weight 18,969 pounds; normal gross weight 38,000 pounds; alternate gross weight 42,000 pounds; useful load 19,031 pounds; engines 2 Pratt & Whitney Aircraft JFTD-12A, 4,500 horsepower each.

Performance

Cruise speed 110 miles per hour; maximum speed 124 miles per hour; service ceiling 13,000 feet; range 253 miles.



S-65 HEAVY ASSAULT TRANSPORT

Prime Contractor: Sikorsky Aircraft

Remarks

The Sikorsky S-65 was designed for the Marine Corps as a heavy assault transport helicopter, the CH-53A. First flight was October 14, 1964. First delivery to a Marine Corps squadron was in September 1966. The CH-53A has flown at speeds exceeding 200 miles an hour and has carried loads, both internally and externally, exceeding 12 tons. The CH-53A, with a crew of 3, can accommodate 38 troops. It has been used to retrieve other aircraft and to deliver equipment and supplies. The HH-53B and the HH-53C, rescue and recovery versions produced for the Air Force, have a rescue hoist, auxiliary fuel tanks, and an aerial refueling probe that allows almost unlimited range.

Specifications

Empty weight 22,444 pounds; gross weight 42,000 pounds; engines 2 General Electric T64-12, 3,435 horsepower each (CH-53A), 2 GE T64-3, 3,080 horsepower each (HH-53B), 2 GE T64-7, 3,435 horsepower each (HH-53C).

Performance

Cruise speed 172 miles per hour; maximum speed 195 miles per hour; service ceiling 22,000 feet; range 250 miles (with auxiliary tanks 780 miles).



SA-26AT CORPORATE AIRCRAFT

Prime Contractor: Swearingen Aircraft

Remarks

The SA-26AT, or Merlin IIB, is an 8- to 10-place, pressurized, twin-engine airplane designed for corporate use. It has a cylindrical fuselage with a pressure differential of 7 pounds per square inch. The Merlin IIB is powered by 2 Garrett AiResearch TPE 331-1-151G turbine engines equipped with propeller reversing and synchronization features and rated at 665 shaft horsepower. The Merlin IIB made its initial flight August 25, 1967, and was type certified June 12, 1968.

Specifications

Span 45 feet 10.5 inches; length 40 feet 1.3 inches; height 14 feet 4 inches; cabin dimensions: length 128 inches, width 62 inches, height 59 inches; fuel capacity 386 gallons; design gross weight 10,000 pounds; design empty weight 6,150 pounds; design landing weight 9,300 pounds.

Performance

Speed at 15,000 feet 295 miles per hour; range at 27,500 feet 1,785 miles with 45-minute reserve; rate of climb at sea level 2,570 feet per minute; service ceiling at full gross weight 29,900 feet; single-engine service ceiling 12,500 feet with pressurization and full accessory load; stall speed 87 miles per hour.



SA-226TC COMMUTER AIRLINER

Prime Contractor: Swearingen Aircraft

Remarks

The SA-226TC, the Swearingen Metro, is a 22-place (20 passengers plus crew), pressurized, air-conditioned, twin-engine airplane designed for use as an airline aircraft and arranged to readily accommodate passengers, cargo, or a mixed configuration. It has a cylindrical fuselage with a pressure differential of 7 pounds per square inch. The Metro is powered by 2 Garrett AiResearch TPE 331-303 turbine engines equipped with propeller reversing and automatic synchronization and rated at 840 shaft horsepower. The production prototype made its initial flight on August 26, 1969. Certification was expected in January 1970; first delivery, in February 1970.

Specifications

Span 46.25 feet; length 59.35 feet; height 16.66 feet; cabin dimensions: length (excluding aft baggage area) 305 inches, width 62 inches, height 57 inches; overall length (pressurized area) 562 inches; cockpit length 62 inches; passenger cabin volume 463 cubic feet; usable rear baggage compartment volume 136 cubic feet; nose baggage compartment volume 45 cubic feet; fuel capacity 550 gallons; design gross weight 12,500 pounds; empty weight 7,000 pounds; design landing weight 12,500 pounds.

Performance

Speed, 10,000 feet ISA, 265 knots; rate of climb 2,580 feet per minute at sea level; useful load 5,000 pounds.



XV-5B V/STOL VERTIFAN

Prime Contractor: Teledyne Ryan Aeronautical

Remarks

The Ryan XV-5B Vertifan V/STOL jet utilizes 5-foot-diameter fans submerged in its wings for vertical flight. Powered by 2 General Electric J85 engines, the aircraft's speed range includes capabilities of zero speed in hover to over 450 knots in conventional jet mode. Under NASA contract, the XV-5B was renovated and modified by Ryan and commenced ground tests June 24, 1968, at San Diego. First conventional flight was made July 15, 1968; ferry flight to NASA's Ames Research Center was on July 18, 1968. First vertical flight was August 2, 1968. After initial flight testing by Ryan, the XV-5B was delivered to Ames Research Center for use in V/STOL research programs. Major modification for NASA use was movement of landing gear outboard of wing fans. The aircraft was formerly the Army XV-5A, which accomplished a highly successful flight test program.

Specifications

Span 29.83 feet; length 44.52 feet; height 14.75 feet; empty weight including instrumentation 9,150 pounds; maximum gross weight 12,326 pounds; engines 2 General Electric J85.

Performance

Maximum speed in jet mode (demonstrated) 456 knots; maximum speed in fan mode (demonstrated) 90 knots; maximum sideward speed in fan mode 29 knots.



WREN 460 STOL AIRPLANE

Prime Contractor: Wren Aircraft Corporation

Remarks

The Wren 460 is a 4-place, high-wing, single-engine airplane which derives its STOL and slow-speed capabilities from aerodynamic devices. New Cessna 182 airframes are utilized in the manufacture of the Wren for economy and in order to assure the user of parts and service availability in most of the free world. The Wren 460 is capable of sustained patrol for 15 hours at speeds of 45 to 60 miles per hour using less than 35 percent power while maintaining level flight attitude and maneuverability with slow-speed control devices. The prototype Wren 460 first flew in January 1963; FAA certification was received in June 1964.

Specifications

Span 36 feet 6 inches; length 27 feet 4 inches; height 8 feet 9 inches; all metal; high wing; fixed gear; empty weight 1,710 pounds; useful load 1,090 pounds; gross weight 2,800 pounds; fuel capacity 65 to 84 gallons; engine Continental O-470-R, 230 horsepower.

Performance

Maximum speed 193 miles per hour; cruise speed, 75 percent power at 6,500 feet, 156 miles per hour; takeoff and landing speed 40 miles per hour; rate of climb at sea level 1,080 feet per minute; service ceiling 19,200 feet; cruise range 785 miles; maximum range 1,000 miles; takeoff distance to clear 50-foot obstacle 560 feet; landing distance to clear 50-foot obstacle 555 feet.

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MINUTEMAN ICBM

Weapon System Integrator: The Boeing Company; systems engineering and technical direction by Systems Group of TRW Inc.

Associate Contractors: Thiokol Chemical Corporation (first-stage engine); Aerojet-General Corporation (second-stage engine, all models; third-stage engine, Minuteman III); Hercules Incorporated (third-stage engine, Minuteman I and II); Autonetics Division, Aerospace & Systems Group, North American Rockwell Corporation, and Aerospace Division, Honeywell Inc. (guidance and control system); Avco Corporation or General Electric Company (reentry vehicles); Sylvania Electronics (ground communications)

Remarks

Minuteman is an intercontinental ballistic missile operated by the Air Force's Strategic Air Command. One thousand Minuteman missiles are on strategic alert in 6 wings deployed in 7 western states. The force, which now consists of a mix of Minuteman I and II missiles, will evolve to a mix of Minuteman II and III missiles over the next few years. Minuteman is a 3-stage, solid-fuel missile which can be launched from blast-proof underground launch facilities within seconds after a command is received. Multiple-channel communications connect an underground launch control center, manned by 2 SAC officers, with 10 launch facilities. Minuteman II (photo) has a larger second-stage engine, improved guidance system, greater range and payload capabilities, more flexible targeting, and increased survivability. Minuteman III has an improved third stage and a new reentry system, providing greater accuracy and payload. Minuteman carries a nuclear warhead.

Specifications

Minuteman I (WS-133A): Model LGM-30A, length 54 feet, Model LGM-30B, length 55.9 feet; weight approximately 65,000 pounds; diameter approximately 6 feet at first-stage interstage.

Minuteman II (WS-133B): Model LGM-30F, length 59.8 feet; weight approximately 70,000 pounds.

Minuteman III: Model LGM-30G, length 59.8 feet; weight approximately 76,000 pounds.

Performance

Minuteman I: range over 6,300 nautical miles; speed over 15,000 miles per hour.

Minuteman II: range over 7,000 nautical miles; speed over 15,000 miles per hour.

Minuteman III: range improved.





TITAN II ICBM

Program Management: Ballistic Systems Division, Space and Missile Systems Organization (SAMSO), Air Force Systems Command

Prime Contractor: Martin Marietta Corporation, Denver Division (systems integration, base integration, airframe)

Associate Contractors: Aerojet-General Corporation (propulsion); AC Electronics Division, General Motors Corporation (guidance); Missile and Space Vehicle Division, General Electric Company (re-entry vehicle); Systems Group of TRW Inc. (technical direction)

Remarks

Titan II is an intercontinental ballistic missile operated by the USAF's Strategic Air Command. SAC has 54 operational missiles at 3 bases. Largest of the U.S. ICBMs, Titan II is equipped with sophisticated penetration aids. It is a 2-stage weapon with 430,000 pounds of rocket thrust in its first stage and 100,000 pounds in the second stage. Both stages burn storable liquid propellants (nitrogen tetroxide and a 50/50 mixture of hydrazine and unsymmetrical dimethyl hydrazine). Titan II carries a nuclear warhead and is inertially guided. Earlier Titan I ICBM was phased out of service in 1965.

Specifications

Length 103 feet; diameter 10 feet; weight 330,000 pounds.

Performance

Range 6,300 nautical miles with Mark VI reentry vehicle.

POSEIDON FLEET BALLISTIC MISSILE

Prime Contractor: Lockheed Missiles & Space Company

Associate Contractors: Hercules Incorporated and Thiokol Chemical Corporation (power plants); General Electric Company and Sperry Rand Corporation (guidance and fire control); Nortronics Division of Northrop Corporation (missile check-out)

Remarks

The Poseidon C3 missile has its roots in Polaris technology, but it is larger and much more advanced. It is 6 feet in diameter as opposed to Polaris' 4.5 feet, and, at 34 feet, it is 3 feet longer than the A3 Polaris. Poseidon, at 65,000 pounds, weighs about twice as much as its predecessor. Despite the increase in size, the weapon will fit into the submarine tubes designed for Polaris. Poseidon will have double the payload of the A3 Polaris and will be twice as accurate. These factors, coupled with the use of new penetration aids, will make Poseidon 8 times as effective as Polaris. Plans call for equipping 31 of the 41 Fleet Ballistic Missile (FBM) submarines with Poseidon C3 and the remaining 10 with Polaris A3. The first flight test of Poseidon (C3X-1), on August 16, 1968, was a "complete success," according to the Navy, and all test objectives were met. By September 1969, the Navy had flown 10 land-launched test missiles.

POLARIS FLEET BALLISTIC MISSILE

Prime Contractor: Lockheed Missiles & Space Company

Associate Contractors: Aerojet-General Corporation and Hercules Incorporated (power plants); General Electric Company and Hughes Aircraft Company (guidance and fire control); Nortronics Division of Northrop Corporation (missile check-out)

Remarks

The third-generation Polaris A3 became operational with the Navy in September 1964. It was preceded into service by the A1 version, which had a range of 1,200 nautical miles, and the A2, with a 1,500-nautical-mile range. While A2 was an outgrowth of A1, the A3 is a 90 percent new missile. Among many innovations was a switch from the champagne-bottle shape of the earlier missiles to a simple, bullet-shaped configuration. The A3, with a range of 2,500 nautical miles, arms 28 of the 41 Polaris submarines; the remaining 13 will carry the A2 weapon. The A1, operational since November 1960, has been retired from fleet duty but will find utility as a booster in developing and testing missile and space programs. All 3 versions of the Polaris are 2-stage, solid-propellant, inertially guided ballistic missiles which can be fired from submerged or surfaced submarines, from surface ships, or from land bases. There are 336 A3 and 208 A2 missiles assigned to the Atlantic Fleet, which operates 34 Fleet Ballistic Missile (FBM) submarines. An additional 112 A3s are assigned to the Pacific Fleet.



R-121



PERSHING SURFACE-TO-SURFACE WEAPON SYSTEM

Prime Contractor: Martin Marietta Corporation, Orlando Division

Remarks

Pershing is a 2-stage, surface-to-surface ballistic missile operational with U.S. Army artillery battalions. It is also in the hands of Federal Republic of Germany Air Force units, within the framework of NATO. It has the longest range and greatest fire-power of all weapons in the Army's arsenal. In the original system, 4 tracked vehicles carried the firing equipment to the firing position in the ground-mobile mode. The system can also be airlifted. The missile is transported in a horizontal position on its unique erector-launcher, which contains its own launch pad and leveling jacks and raises the missile to vertical firing position. In 1966 the Army awarded a contract to Martin Marietta for development of new-generation ground-support equipment to increase system reliability and firing rate. Production contracts followed in 1967 and 1968. Mounted on wheels instead of tracks, the new system, Pershing 1-A, includes major improvements: a new programmer/test station, a fast-reacting erector-launcher, automatic countdown and fault isolation, and a battery control central. There is no change in the missile itself. In 1969, under an Army logistics program known as SWAP, Pershing 1-A equipment began replacing the original Pershing 1 hardware in the field.

Specifications

Length 34.5 feet; diameter 3.3 feet; weight approximately 10,000 pounds; speed supersonic; trajectory ballistic; propulsion 2 stage, solid propellant; guidance inertial; warhead nuclear.

Performance

Range 100 to 400 nautical miles.

SERGEANT SURFACE-TO-SURFACE MISSILE

Prime Contractor: Univac-Salt Lake City, a division of Sperry Rand Corporation

Remarks

The Sergeant is reliable, mobile, and simple to operate; with its ease of maintenance and degree of immunity to countermeasures, it represents an Army weapon system comparable in general field worthiness to the shorter-range unguided rockets. Sergeant has been purchased and deployed with U.S. and Federal Republic of Germany troops. Status: operational.

Specifications

Length 35 feet; diameter 31 inches; weight 10,000 pounds.



R-122



MACE SURFACE-TO-SURFACE MISSILE

Prime Contractor: Martin Marietta Corporation, Baltimore Division

Associate Contractors: Allison Division of General Motors Corporation (engine); Thiokol Chemical Corporation (booster); Goodyear Aerospace Corporation (ATRAN guidance, A version); AC Spark Plug Division, General Motors Corporation (inertial guidance, B version)

Remarks

Mace is an improved version of Matador first launched in 1959. Mace TM-76A is fired from a truck-drawn, zero-length launcher; Mace TM-76B, from hardened underground bases.

Specifications

Sweptwing missile; length 44 feet; span 23 feet; diameter 54 inches; guidance self-contained ATRAN (Automatic Terrain Radar and Navigator) map-matching system (Mace A), all inertial (Mace B); warhead nuclear or conventional; power Allison J33 jet engine, booster Thiokol motor.

Performance

Speed over 650 miles per hour, supersonic in terminal dives; range over 650 miles (Mace A), over 1,200 nautical miles (Mace B); thrust 5,200 pounds (engine), 100,000 pounds (booster).

LANCE SURFACE-TO-SURFACE MISSILE

Prime Contractor: LTV Aerospace Corporation, a subsidiary of Ling-Temco-Vought, Inc.

Associate Contractors: American Bosch Arma Corporation (gyroscope); Systron-Donner Corporation (guidance components); Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (propulsion); Whittaker Controls and Guidance (gyroscope); F. M. C. Corporation (vehicles); Hawker Siddeley (lightweight launcher)

Remarks

The Army's Lance surface-to-surface field artillery missile, in advanced testing stages and moving toward production, is a highly mobile general-support weapon system which will permit Army commanders to place strategic fire on enemy troop concentrations, supply depots, and transportation routes quickly and accurately. Lance is built by the Michigan facility of LTV Aerospace's Missiles and Space Division. It is the first Army missile to use packaged, storable liquid propellants. Major components of the missile are a warhead section, a guidance package, fuel tankage, and an engine. Major ground-support equipment includes self-propelled launcher, fully mobile lightweight launcher, transporter-loader, and prefire tester and fire pack. Guidance is a simplified inertial unit developed in the Army Missile Command's Guidance and Control Laboratory. Development of a longer-range version is under way for the Army, and the company has performed exploratory work for the Navy to determine whether Lance can be used as a ship-launched, amphibious support system.



**SHILLELAGH ANTI-ARMOR
GUIDED MISSILE SYSTEM**

Prime Contractor: Aeronutronic Division, Philco-Ford Corporation

Remarks

Shillelagh is a tank-fired, surface-to-surface, anti-armor guided missile system which is standard armament on the Army's General Sheridan armored reconnaissance vehicle. A lightweight guided missile system, Shillelagh is designed to give U.S. armor field superiority over enemy armored vehicles, tanks, troops, and field fortifications. Aeronutronic is producing Shillelagh for the Army Missile Command. A "fifth buy" production contract for \$100,000,000 was awarded to Aeronutronic in 1968. Shillelagh utilizes an infrared command guidance system which gives it extremely high accuracy against either stationary or moving targets and a high first-round kill probability. The system includes the guided missile system and conventional ammunition, both fired from a 152-millimeter combination gun/launcher. Shillelagh is handled in the field with the ease of a conventional round of ammunition. It has been tested under extreme environmental conditions ranging from desert heat to arctic cold to high tropical humidity. Shillelagh is used also in the compact turret version of the Army's M60 A1E2 Main battle tank and will be standard armament on the U.S./Federal Republic of Germany Main battle tank, to be operational in the 1970s. Shillelagh is in its sixth year of production by Aeronutronic at the Army's Lawndale, California, Missile Plant. Aeronutronic also produces the tank-mounted Shillelagh guidance and control equipment.

Specifications

Length approximately 45 inches; diameter 152 millimeters; weight approximately 60 pounds; warhead, shaped charge.

TOW ANTITANK MISSILE

Prime Contractor: Hughes Aircraft Company
Associate Contractor: Army Munitions Command,
Picatinny Arsenal (warhead development)

Remarks

TOW is the first supersonic missile guided in flight by means of a 2-wire link between launcher and missile. TOW's name is derived from its description: Tube-launched, Optically tracked, Wire-guided. A major improvement of this weapon over earlier antitank missiles is the simplified and highly accurate aiming device. To fire at a stationary object or a moving target, the gunner simply aligns the crosshairs of his telescopic sight on the target and then launches the missile, which automatically flies along his line of sight. With TOW, the gunner does not have to estimate range to the target, speed of the target, or angle between the target course and the weapon. If the gunner keeps the crosshairs centered, signals transmitted through the 2-wire link automatically correct the missile's course. TOW can be carried by troops and fired from a simple lightweight launcher mounted on a tripod. It can also be mounted on a variety of ground vehicles, including the M113 armored personnel carrier. TOW is in production.



R-124



DRAGON MEDIUM ANTITANK ASSAULT WEAPON

Prime Contractor: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation

Remarks

Dragon is a medium antitank assault weapon for use by the infantryman of the Army and the Marine Corps. Light enough to be carried by one man and shoulder-fired, Dragon has a warhead lethal enough to knock out most armor and other infantry targets. It is far superior in range, accuracy, and hit probability to the 90-millimeter recoilless rifle it will replace. Weighing 28.5 pounds complete, the system employs command-to-line-of-sight guidance and consists of 3 main items: a tracker, a recoilless launcher, and a missile. In operation, the gunner sights the target through a telescopic sight, then fires the missile. While the gunner holds his sight on the target, the tracker senses missile position relative to the gunner's line of sight and sends command signals over wire to the missile. This causes rocket side thrusters to fire, applying corrective control forces. The thrusters are fired at appropriate roll angles so that the missile is automatically guided throughout flight. In photo, sight and launcher (missile is enclosed within the launcher and is never seen by the gunner). An Army contract calling for production engineering and production of the Dragon, with a planned total value of \$133,000,000, has been awarded to McDonnell Douglas Astronautics Company. First manned firing was conducted successfully on July 5, 1968; in later tests, successful operation was demonstrated in both very hot and very cold environments.

SUBROC ANTISUBMARINE MISSILE

Prime Contractor: Goodyear Aerospace Corporation
Subcontractors: Kearfott Division, Singer-General Precision, Inc. (major portion of guidance system); AiResearch Division, The Garrett Corporation (auxiliary power system); Thiokol Chemical Corporation (manufacture and loading of propellant)

Remarks

Subroc, an underwater-to-air-to-underwater antisubmarine missile, has been developed by Goodyear Aerospace Corporation for the Naval Ordnance Systems Command under technical direction of the Naval Ordnance Laboratory, White Oak, Maryland. It is being manufactured in production quantities as a submarine-launched, rocket-propelled, inertially guided nuclear depth bomb for destruction of hostile underwater craft. Using solid-fuel propellant, its range is greater than any other ASW weapon except aircraft. The missile is launched horizontally from standard submarine tubes by conventional launch methods. The submarine can be moving and need not be pointed at the target. Utilizing a digital computer for target motion analysis, the fire-control system can solve many problems simultaneously. This system can handle other submarine-launched weapons in addition to Subroc. Subroc is operational with the fleet and has performed successfully in a number of firings.

Specifications

Weight approximately 4,000 pounds.

Performance

Classified.



R-125



MARK 46 MOD 1 ANTISUBMARINE TORPEDO

Prime Contractors: Aerojet-General Corporation and Honeywell Inc.

Subcontractors: The Bendix Corporation (subcontractor to Aerojet-General); TRW Inc. (subcontractor to Honeywell)

Remarks

The Mark 46 Mod 1 is the Navy's latest lightweight antisubmarine torpedo. It is an active-passive homing, high-speed torpedo propelled by a liquid (monopropellant) fuel, hot-gas, piston-cam engine. It can be launched from aircraft, helicopters, and ASW vessel torpedo tubes and by ASROC. It is capable of seeking, acquiring, attacking, and destroying the latest deep-diving, high-speed nuclear submarines.

Specifications

Approximate dimensions: length 101 inches; diameter 12.75 inches; weight 508 pounds.



ASROC/TERRIER

Prime Contractors: Honeywell Inc. (ASROC); General Dynamics Corporation (Terrier)

Remarks

The ASROC/Terrier system is a new concept in shipboard weaponry. It combines the ASROC (anti-submarine rocket) and Terrier supersonic guided missile weapons system in an advanced ASROC/Terrier combination aboard a new class of ship. ASROC has been modified so that it can be fired from a Terrier launcher on the forward deck of the ship. Two Terrier or 2 ASROC missiles can be alternately mounted on the launcher and fired in rapid succession. Terrier and ASROC missiles cannot be on the launcher at the same time. Combining the systems leads to several advantages, including reduced manpower requirements, greater missile storage capacity, and less topside weight and deck area. First of the new class of ships to be equipped with the system is the USS *Belknap* (DLG-26).

R-126



SPRINT ANTIMISSILE MISSILE

Prime Contractors: Western Electric Company (Safeguard system prime); Martin Marietta Corporation (Sprint missile); Bell Telephone Laboratories (system design and development)

Remarks

The Sprint missile is one of the major components being developed for the Army's Safeguard missile defense system. Its mission is to intercept ICBM warheads, or the warheads of medium-range missiles which might be launched from submarines, after they have entered the earth's atmosphere. Reaction time is a major consideration, since these missiles approach the earth at velocities over 17,000 miles per hour. Sprint's time of flight—from launch to intercept—is only a matter of seconds. The missile is designed to be popped from its launch cell rather than flown out under its own power. A gas generator placed under the missile ejects it like a dart from a blowgun. The Sprint booster ignites after the missile is aboveground. At the same time, the missile pitches over on a trajectory that takes it to the vicinity of the computer-calculated intercept point. Fine adjustments are made in flight via radar signals from the ground.

Specifications

Length 27 feet; diameter 4.5 feet at base; configuration cone-shaped; propulsion 2 stage, solid propellant; guidance command via ground radar; warhead nuclear; type surface-to-air interceptor.

Performance

Speed hypersonic; other details classified.

SPARTAN ANTIMISSILE MISSILE

Prime Contractors: Western Electric Company (Safeguard system prime); McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation (Spartan missile); Bell Telephone Laboratories (system design and development)

Remarks

Spartan is the longer-ranging of the 2 missile components of the Safeguard missile defense system, which also includes a battery of tracking radars and computers on the ground. Spartan complements the Sprint weapon to provide the Safeguard system with a wide variety of intercept ranges and altitudes. The nuclear-armed Spartan is capable of intercepting incoming missile warheads at ranges of several hundred miles; Spartan intercepts are made outside the earth's atmosphere. Spartan, like Sprint, is being developed under the supervision of a special Safeguard System Command at Huntsville, Alabama. The Army's largest missile, Spartan made its first test flight on April 1, 1968. Spartan testing continues at Meck Island, north of Kwajalein Island in the Pacific, where the first model of the Raytheon Safeguard missile site radar has been constructed.

Specifications

Three stages, all solid-propelled; first stage length 11 feet; second stage length 16 feet; overall missile length approximately 55 feet; basic stage thrust about 450,000 pounds.



R-127



NIKE HERCULES AIR DEFENSE MISSILE

Prime Contractor: Western Electric Company

Remarks

Nike Hercules is the primary U.S. high-altitude air defense weapon in operational status. The missile has proven successful against high-performance aircraft at a variety of altitudes. It has also successfully intercepted short-range ballistic missiles and other Nike Hercules missiles in tests. Ground equipment includes a low-power acquisition radar, a high-power acquisition radar which can be packaged on wheels (mobile HIPAR), a target tracking radar, a missile tracking radar, electronic and data-processing equipment, and remote-controlled launchers. The system is continually being modified to meet new threats and to incorporate advances in missile technology.

Specifications

Length 41 feet; diameter 31.5 inches; weight 10,000 pounds at launch; propulsion system 2 stage, solid propellant; command guidance; conventional or nuclear warhead.

Performance

Speed supersonic; range over 75 nautical miles; ceiling over 150,000 feet.

HAWK ANTI-AIRCRAFT MISSILE

Prime Contractor: Raytheon Company

Associate Contractors: Aerojet-General Corporation (propulsion); Northrop Corporation (launcher/loader/carrier)

Remarks

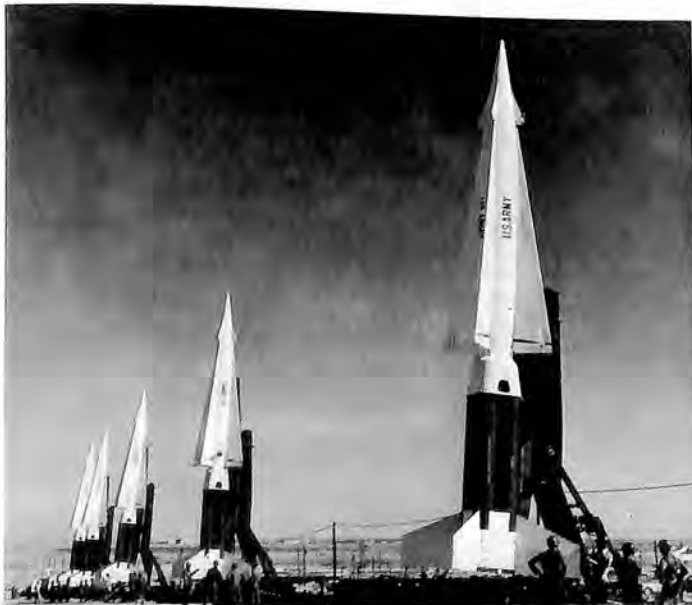
Hawk is a surface-to-air anti-aircraft missile in operational service with the Army and the Marine Corps. In addition, it is deployed in Europe, Panama, and the Far East, and is produced by 5 NATO nations for their own use. Hawk employs a radar homing system. It is effective against targets ranging from tree-top level to about 50,000 feet. Hawk is now employed in South Vietnam. Although designed primarily as an anti-aircraft missile, Hawk has had successful intercepts of tactical missiles such as Honest John, Little John, and Corporal. For more reliable and capable defense against attacking aircraft, improved and self-propelled systems are in production.

Specifications

Weight 1,275 pounds; length 198 inches; span 47.4 inches; solid propellant; high-explosive warheads.

Performance

Speed supersonic.



R-128



SAM-D AIR DEFENSE SYSTEM

Prime Contractor: Raytheon Company

Remarks

SAM-D (Surface-to-Air Missile Development) will be an Army air defense system for use in both battlefield and continental air defense against high-performance aircraft and short-range missiles. SAM-D can be deployed as a battery to provide circular defensive coverage or as a fire section to provide coverage over a sector. A fire section consists of one fire-control group and several launchers; it may be detached from the major control elements for autonomous operation. A battery is mounted on approximately 12 vehicles; it includes fire-control, launcher, battery control, and communications groups. A fire-control group contains radar, radar/weapons-control computer, communications, and prime power on the same vehicle. The multifunction phased array radar performs all the functions requiring several radars in other systems. It detects and tracks targets and issues guidance commands to the missile in flight. The battery control group coordinates firings within a battery and serves as a communications center. It houses a computer for handling high data rates, processes and coordinates information between radars, and passes on fire-control information. The launcher group can carry several single-stage, solid-propellant missiles in launching-shipping containers. The missile is cradled within the canister, or container, and is supported by Teflon-coated launch rails. At launch, the motor blast shatters the rear plastic cover and the missile breaks through the forward plastic cover. The missile can carry either a high-explosive or a nuclear warhead. It is segmented into nose, guidance, warhead, motor, and control sections. In photo, minimum fire unit in travel mode.

TARTAR SHIPBOARD ANTI-AIRCRAFT MISSILE

Prime Contractor: Pomona Division of General Dynamics Corporation

Associate Contractor: Aerojet-General Corporation (propulsion)

Remarks

Tartar is a high-performance guided missile that arms 27 destroyers and 3 cruisers of the U.S. fleet. In addition, Tartar serves the navies of France, Italy, Japan, and Australia. In a minimum of space, the missile contains a complex homing system, a dual-thrust rocket motor, and a new type auxiliary power supply. Tartar's semiactive homing guidance system is made up of several interrelated units constructed to form the basic airframe of the missile. Each unit houses a major part of the homing and control system. The auxiliary power supply uses the hot gases from solid grain fuel to generate its own electrical and hydraulic power.

Specifications

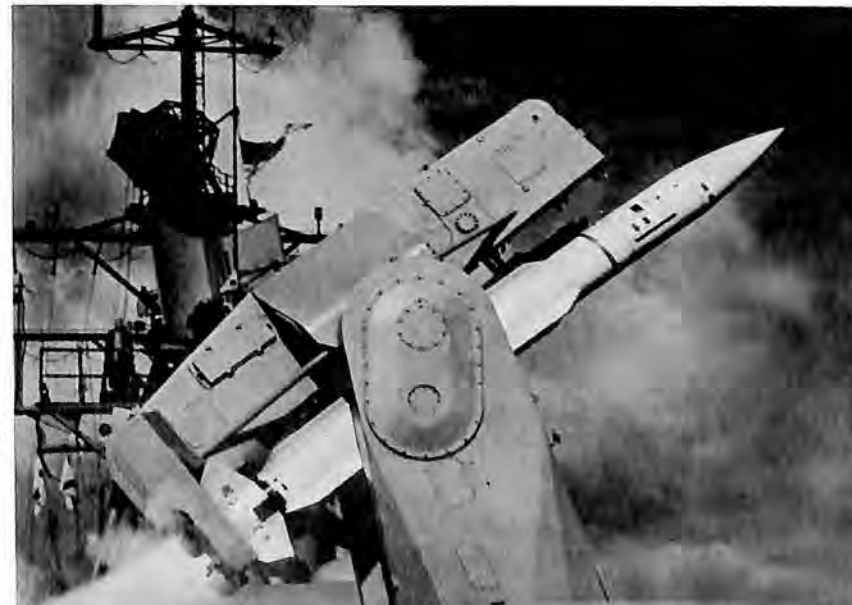
Length 15 feet; diameter 1 foot; weight 1,500 pounds.

Performance

Range over 10 miles; speed supersonic.



R-129



**ADVANCED TERRIER SHIPBOARD
ANTI-AIRCRAFT MISSILE**

Prime Contractor: Pomona Division of General Dynamics Corporation

Associate Contractor: Hercules Incorporated/Allegheny (propulsion)

Remarks

The Advanced Terrier guided missile is fulfilling its design role as a major element in the Navy's missile arsenal. This surface-to-air anti-aircraft weapon arms 40 warships. Terrier is powered by 2 stages of solid-fuel rockets. The first stage, a separate booster rocket, supplies high thrust for a short period to launch and accelerate the missile to supersonic speeds. At booster burnout, the empty booster case falls away and the second-stage rocket ignites. The second stage, the sustainer, is part of the missile proper and maintains the velocity required to match any evasive maneuver the target aircraft might take. The missile arms 3 conventional carriers, 5 cruisers, and 3 nuclear-powered warships.

Specifications

Length 27 feet, with booster; diameter 1 foot; weight 2,600 pounds.

Performance

Range over 10 miles; speed supersonic.

TALOS SHIPBOARD MISSILE

Prime Contractor: Missile Systems Division, The Bendix Corporation

Associate Contractor: Sperry Rand Corporation, Sperry Gyroscope Division (shipboard guidance and fire control)

Remarks

Talos is a supersonic surface-to-air missile designed to provide the Navy with a system of long-range, high-firepower defense against air attack. It also has a surface-to-surface capability. It is a 2-stage weapon with a solid-fuel rocket booster; the missile is powered by a 40,000-horsepower ramjet engine. It is operational with the Navy's fleet of missile cruisers which includes USS *Chicago*, USS *Galveston*, USS *Little Rock*, USS *Oklahoma City*, USS *Albany*, USS *Columbus*, and the first nuclear-powered cruiser, USS *Long Beach*.

Specifications

Length 20 feet; diameter 30 inches; weight over 3,000 pounds; booster 10 feet long.

Performance

Range over 65 nautical miles; speed classified.



R-130



REDEYE SURFACE-TO-AIR MISSILE

Prime Contractor: Pomona Division of General Dynamics Corporation
 Associate Contractor: Atlantic Research Corporation (propulsion)

Remarks

Redeye, the world's smallest guided missile, is designed to be carried into combat on a soldier's back and fired from his shoulder. Its infrared sensor is mounted in the nose of the solid-propelled missile, which is fin stabilized and aerodynamically controlled in flight. Redeye, now in production, for the first time gives the infantryman effective anti-aircraft defense against low-flying enemy aircraft. Target detection and tracking are accomplished visually by the gunner. When the aircraft is within the range of the missile and the infrared seeker has locked on the target, a simple squeeze of the trigger fires the missile.

Specifications

Length 4 feet; diameter 3 inches; weight 28 pounds.

Performance

Classified.



BOMARC B INTERCEPTOR

Prime Contractor: The Boeing Company
 Subcontractors: The Marquardt Company (ramjet engines); Thiokol Chemical Corporation (booster rocket); Westinghouse Electric Corporation (guidance)

Remarks

Bomarc B is a surface-to-air interceptor missile operated by the USAF's Air Defense Command and the Royal Canadian Air Force at 8 bases equipped with from 28 to 56 launch shelters. Bomarc B incorporates a solid-fuel rocket engine which develops some 50,000 pounds of thrust. The engine launches the missile in a vertical position. Just prior to boost burnout at approximately 30,000 feet, Bomarc's 2 flight-sustaining ramjet engines take over propulsion. Unlike other types of air defense missiles, Bomarc is guided from the ground to the immediate target area via radio signals. The missile's own target seeker pinpoints the enemy aircraft, locks on, and detonates its warhead on the closest point of pass or on impact. The missile has a nuclear warhead. Bomarc B bases are located at Kincheloe AFB, Sault Ste. Marie, Michigan; Duluth AFB, Minnesota; Niagara Falls, New York; McGuire AFB, New Jersey; Otis AFB, Massachusetts; Langley AFB, Virginia; and Canadian sites at North Bay, Ontario, and La Macaza, Quebec.

Specifications

Wingspan 18 feet 2 inches; overall length 45 feet; height 10 feet 2 inches; fuselage diameter 35 inches; width of horizontal tailplane 10 feet 6 inches.

Performance

Range well over 400 nautical miles; kill capability from sea level to altitudes above 70,000 feet; speed approximately Mach 2.5.

R-131



**CHAPARRAL AIR DEFENSE
GUIDED MISSILE SYSTEM**

Prime Contractor: Aeronutronic Division, Philco-Ford Corporation

Principal Subcontractor: Raytheon Company (guidance and control)

Remarks

Chaparral is an adaptation of the Sidewinder 1C air-to-air missile system to a ground-to-air configuration to provide maximum air defense against low and medium-flying aircraft in forward battle areas. In production by Aeronutronic at Anaheim, California, for the Army Missile Command, Chaparral utilizes the Sidewinder 1C in a multiple mount on the highly mobile M730 vehicle to insure rapid deployment for defense of forward battle areas. Production began in April 1966 under a \$6,400,000 initial tooling and production contract with the Army. Chaparral can be fired from various types of existing Army vehicles including railroad flat cars, flatbed trucks, and flatbed trailers, or it can be ground mounted. The missiles are aimed by a gunner in a turret mount; they automatically guide on the target's heat source after launch. Chaparral has completed successful test firings and guided launchings at White Sands Missile Range, New Mexico, and Naval Weapons Center, China Lake, California. It has been selected by the Army as one of 2 major weapons systems to be included in new air battalions being organized to provide field commanders with low-altitude air defense. The M730 is a lightweight, fully tracked vehicle capable of extended cross-country travel over rough terrain and of high-speed travel over improved roads. During 1969, production testing of Chaparral by the Army Test and Evaluation Command's Air Defense Board continued at Fort Bliss, Texas.

Specifications

Length 114 inches; diameter 5 inches; launch weight 185 pounds; solid propelled; infrared guided.

STANDARD SHIPBOARD MISSILE

Prime Contractors: Pomona Division of General Dynamics Corporation (guidance, control, and fuze); The Johns Hopkins University Applied Physics Laboratory (consultant to Naval Ordnance Systems Command)

Remarks

The Standard missile program implements the Navy's concept of a standardized shipboard missile system for defense of the fleet against surface and aerial threats. Primary objectives are maximum reliability and overall economy, to be achieved with simplified logistics and compatibility with existing Terrier/Tartar handling and shipboard weapon systems. There are 2 versions of Standard: extended range (ER) and medium range (MR). The principal difference between the 2 is in the propulsion systems. ER has a separable booster and integral sustainer while MR has an integral dual-thrust rocket motor. Advanced solid-state electronics and state-of-the-art miniaturization techniques have afforded space savings for functional growth potential without compromising external dimensions of this all-electric missile. The weapon is in production.

Specifications

Length 27 feet (ER), 15 feet (MR); diameter 1 foot.

Performance

Speed supersonic; range 35-plus miles (ER), 25-plus miles (MR).



R-132



SEA SPARROW SURFACE-TO-AIR MISSILE

Prime Contractor: Raytheon Company

Remarks

Sea Sparrow (AIM-7E) is in production for use by the U.S. Navy and by the armed forces of several NATO nations for shipboard point defense missile systems.

Specifications

Length 12 feet; maximum diameter .67 foot; span over fins 3.3 feet; launch weight 450 pounds; guidance semiactive radar homing.

SRAM SHORT-RANGE ATTACK MISSILE (AGM-69A)

Weapon System Integration Contractor: The Boeing Company

Major Subcontractors: Lockheed Propulsion Company; Singer-General Precision, Inc.; Litton Industries; Autonetics Division, Aerospace & Systems Group, North American Rockwell Corporation; Sylvania Electronics; Unidynamics; Stewart-Warner Electronics Division

Remarks

SRAM (Short-Range Attack Missile) is a supersonic air-to-ground missile with nuclear capability. It will be carried by FB-111 fighter-bombers and late-model B-52 strategic bombers. The missile will be capable of penetrating sophisticated enemy defenses after launch from its carrier aircraft. The program is in developmental status; early testing was initiated in 1968.



R-133



STANDARD ARM

Prime Contractor: Pomona Division of General Dynamics Corporation

Remarks

Standard ARM is an air-launched guided missile system deployed by the Navy and the Air Force to locate and destroy hostile ground-based radar installations. The system consists of a modified medium-range Standard missile delivered by high-performance aircraft—including the Navy A-6 and the Air Force F-105—equipped to detect, identify, and acquire the radar target. Initial version of Standard ARM is in production.

Specifications

Length 14-plus feet; diameter 1 foot.

Performance

Speed supersonic; range classified.

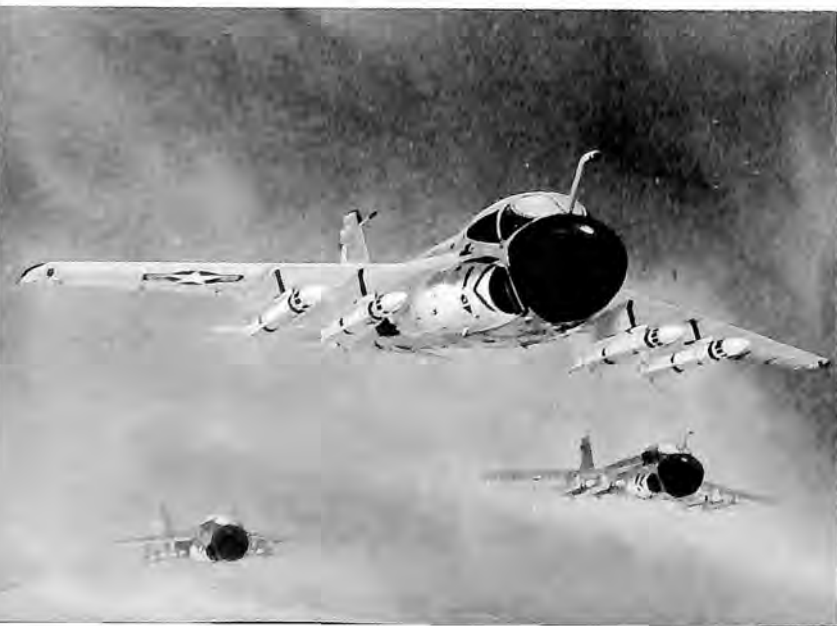
SHRIKE ANTIRADAR MISSILE

Prime Contractors: Texas Instruments, Inc.; Univac-Salt Lake City, a division of Sperry Rand Corporation

Subcontractor: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (propulsion elements)

Remarks

Shrike is an air-to-ground missile designed as a countermeasure to enemy radar. Developed by the Naval Weapons Center, China Lake, California, it was turned over to civilian contractors for production. Shrike takes its name from the small, lightning-quick bird which attacks the eyes of its enemies; in similar fashion, Shrike blinds the long-range eyes of military radar. Launched either individually or in battery from Air Force or Navy aircraft, Shrike missiles home on the radiations from radar systems and carry a high-explosive warhead to destroy their targets. A simple, lightweight missile of low unit cost, Shrike is powered by a solid-fuel rocket. In photo, Shrike in underwing mount on Navy A-4.



R-134



QUAIL (ADM-20C)

Prime Contractor: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation
Associate Contractor: General Electric Company (propulsion system)

Remarks

ADM-20C Quail is a decoy missile used by the B-52 as a penetration aid during strategic bombing missions. Carried in quick-load clip-in packages, Quail degrades hostile air defense systems by its ability to simulate the flight and radar signature characteristics of the parent aircraft. Powered by the General Electric J85 turbojet engine, the missile is guided by a preprogrammed autopilot. Quail was integrated into the Strategic Air Command inventory in 1961 and declared combat ready. It is standing strategic alert with the B-52.

Specifications

Length 13 feet; span 5.5 feet; weight 1,200 pounds.

Performance

Same operating envelope as the B-52.

HOUND DOG MISSILE (AGM-28)

Prime Contractor: Tulsa Division, Aerospace & Systems Group, North American Rockwell Corporation
Principal Subcontractors: Pratt & Whitney Aircraft (J52 turbojet engines); Autonetics Division, Aerospace & Systems Group, North American Rockwell Corporation (guidance and controls)

Remarks

The AGM-28 Hound Dog is a B-52-launched air-to-surface strategic missile operated by the Strategic Air Command. Nearly 30 SAC bases throughout the United States are equipped with the double-sonic missile. The B-52 carries 2 inertially guided Hound Dogs—one under each wing. Capable of carrying a nuclear payload, the Hound Dog can be used as a penetration aid for the bombers or it can be directed to strike at primary targets. The Hound Dog engines, using the same fuel as the mother bomber, can be used to supplement the thrust of the B-52.

Specifications

Length 43 feet; fuselage diameter 30 inches; weight approximately 5 tons.

Performance

Range 700-plus miles; speed over Mach 2.



R-135



BULLPUP MISSILES (AGM-12B, AGM-12C)

Prime Contractor: Maxson Electronics Corporation

Remarks

Extremely accurate and reliable, the Bullpup is launched over 2 miles away from surface targets such as airfield installations, train or truck convoys, tanks, and bridges. Tracking flares in the tail enable the pilot to "follow" the missiles while sending commands for changes in direction. Bullpup reaches speeds near Mach 2. Simplified design and production reliability permit the missile to be handled as a round of ammunition, with no prefiring check-out required. Very little ground support is required. The missile can be loaded on aircraft and ready for firing in about 5 minutes using only normal bomb-handling equipment or special ground-handling equipment.

Specifications

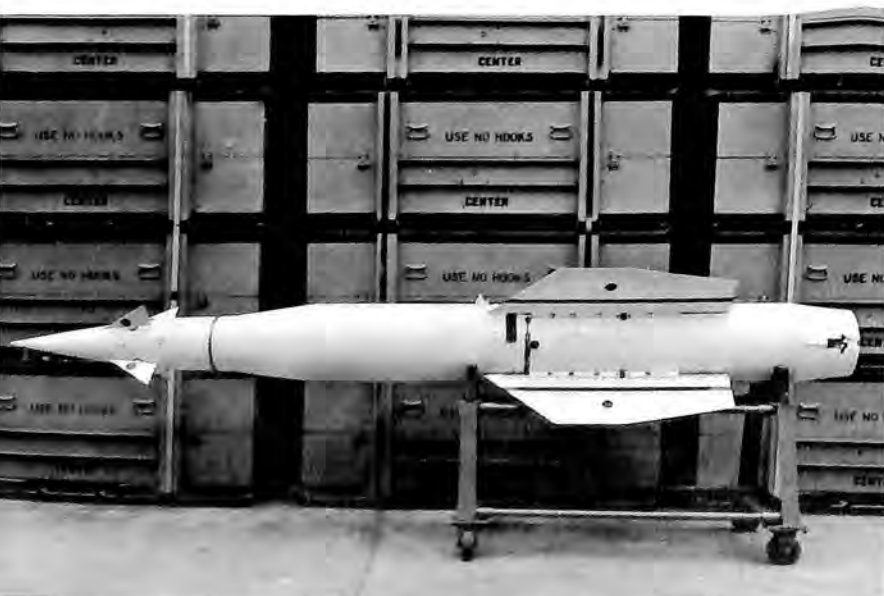
Length 10.5 feet (AGM-12B), 13.6 feet (AGM-12C); diameter 1 foot (AGM-12B); weight 571 pounds including warhead (AGM-12B), 1,785 pounds (AGM-12C); 250-pound conventional warhead (AGM-12B), 1,000-pound conventional warhead (AGM-12C); range 3 to 6 miles (AGM-12B), over 6 miles (AGM-12C); propulsion prepackaged liquid rocket; guidance radio command, controlled by pilot.

CONDOR AIR-TO-SURFACE MISSILE

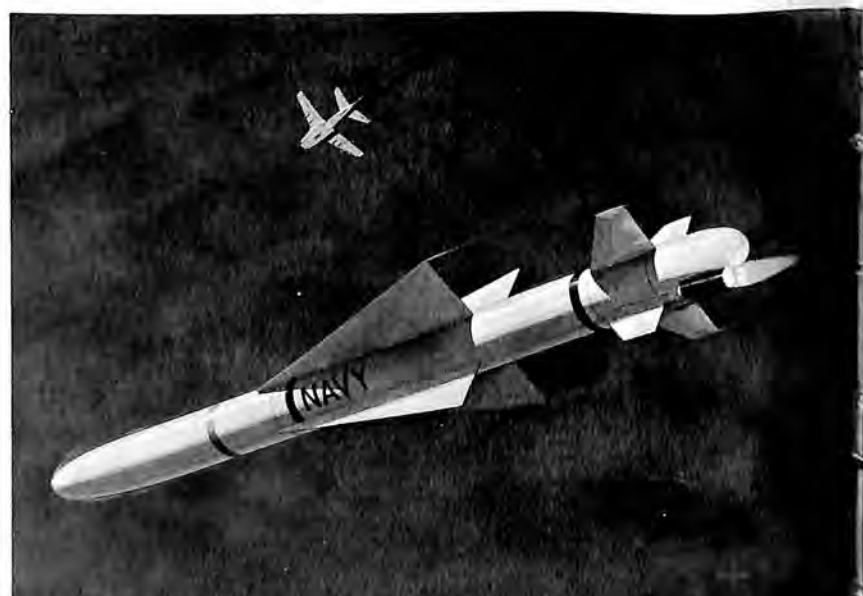
Prime Contractor: Columbus Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

Condor, designated AGM-53A, is a rocket-powered conventional-warhead guided missile designed for use with current and future Navy aircraft to destroy large, hard targets such as bridges and railroads. The Condor system relies on closed-circuit television and a command link between missile and airplane for guidance which will provide Navy pilots with a standoff capability. Navy officials say the Condor represents a quantum jump in range over other missiles and will be the first missile to use the "ready, fire, aim" rather than the "ready, aim, fire" mode of operation. The Condor weapon system has unique capabilities as compared with weapons presently in Air Force and Navy arsenals.



R-136

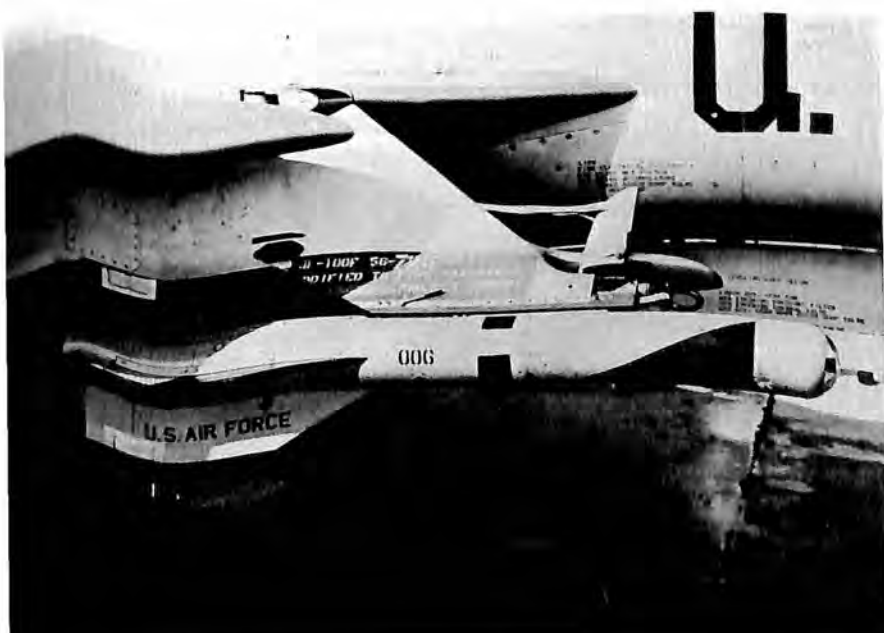


HORNET AIR-TO-SURFACE MISSILE

Prime Contractor: Columbus Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

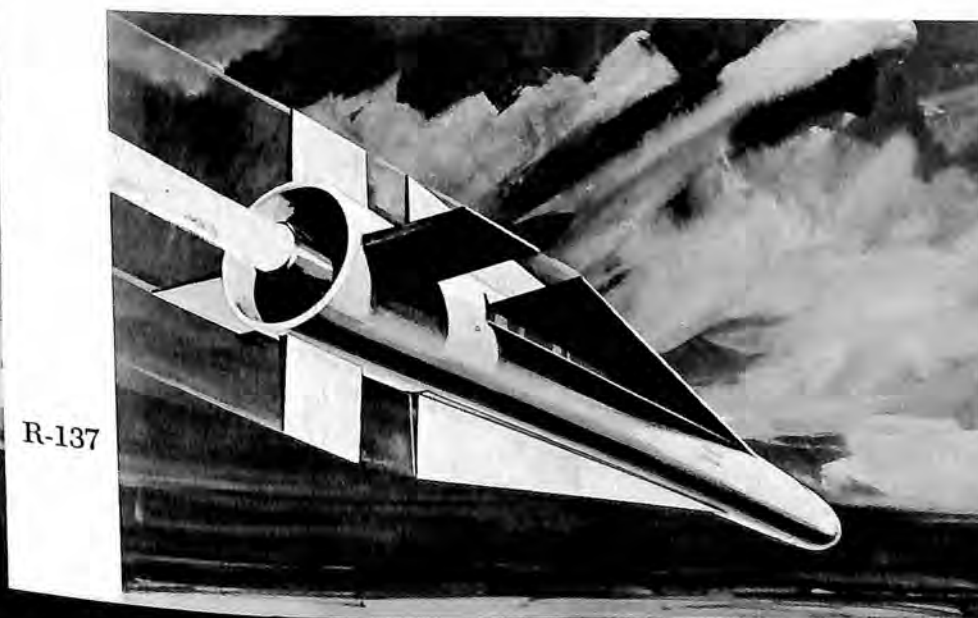
Hornet is a rocket-powered air-to-surface missile system designed for use on tactical aircraft. The missile depends on a television guidance system which locks on previously identified mobile or stationary targets and automatically guides it to those targets.

**MAVERICK AIR-TO-SURFACE MISSILE**

Prime Contractor: Hughes Aircraft Company

Remarks

Maverick is a highly accurate, TV-guided air-to-surface weapon designed to knock out enemy tanks, armored vehicles, and field fortifications. In operation, the pilot selects a target on a TV screen in his cockpit, locks the missile's guidance system on it, and launches the weapon. The pilot can then leave the area while Maverick continues on its way to the target, guided by an electrooptical TV homing device in its nose. Maverick is being developed for use by Air Force tactical aircraft, including the A-7, the F-4, and the F-111.



ZUNI AIR-TO-SURFACE MISSILE

Prime Contractor: Naval Weapons Center

Remarks

One of the earlier Navy missiles, Zuni is used on fighter and attack aircraft as a ground-strafting weapon. It is an unguided rocket, 5 inches in diameter, with a range of about 5 miles. Its warhead is a conventional high-explosive charge.

WALLEYE TELEVISION-GUIDED GLIDE BOMB

Prime Contractor: Martin Marietta Corporation, Orlando Division

Remarks

An operational guided bomb with a range of several miles, Walleye weighs approximately 1,000 pounds and is television guided. Developed by the Naval Weapons Center, China Lake, California, the missile is being produced by Martin Marietta's Orlando Division. In artist's conception, Walleye is launched from Navy A-4 aircraft.

SPARROW AIR-TO-AIR MISSILE

Prime Contractor: Raytheon Company

Remarks

Developed and produced by Raytheon's Missile Systems Division, Sparrow is a supersonic, radar homing weapon which can be launched from aircraft flying at subsonic or supersonic speed. The original model became operational with Navy squadrons in 1958; the missile is now being used as primary defensive armament on Air Force, Navy, and Marine Corps fighters. Current models have greater performance capabilities than the original model because of a series of engineering and design changes. Sparrow has an advanced fire-control system which consists essentially of a radar in the nose of the aircraft, a fire-control computer, and cockpit displays and controls. The radar searches for, acquires, and tracks the target; the information is supplied to the computer to generate signals that will enable the pilot to attack targets successfully. The missile is operational with the United Kingdom's Royal Air Force and Royal Navy and with the Imperial Iranian Air Force, and it is in production for the Italian Air Force. Other countries are planning to employ the system. An advanced version is under development.

Specifications

Weight 450 pounds; length 12 feet; diameter 8 inches.

Performance

Speed supersonic; all-weather, all-aspect, all-altitude capability.



R-138



SIDEWINDER AIR-TO-AIR MISSILE

Prime Contractor: Missile Systems Division, Raytheon Company
 Associate Contractors: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (propulsion); General Electric Company (guidance)

Remarks

The Sidewinder AIM-9D is a second-generation, supersonic, infrared target detection, air-to-air missile. It can be launched from aircraft flying at subsonic or supersonic speed. The original Sidewinder AIM-9B became operational in Navy carrier jet squadrons in June 1956. Advanced engineering and design have led to a more advanced missile with greater capabilities than the earlier models. The Sidewinder AIM-9D missile is used on Marine Corps and Navy aircraft, including the McDonnell Douglas F-4B/F-4C supersonic dual-purpose fighter. Sidewinder AIM-9D system capabilities provide the pilot a number of combat advantages previously unobtainable with air-to-air weapons.

Specifications

Overall length 9.5 feet; maximum diameter .42 foot; span over fins 2.1 feet; launch weight 185 pounds.

Performance

Speed Mach 2.5.

AIM-9E SIDEWINDER

Prime Contractor: Aeronutronic Division, Philco-Ford Corporation
 Major Subcontractor: Communications and Technical Services Division, Philco-Ford Corporation

Remarks

The USAF AIM-9E guided missile is an advanced version of the AIM-9B (Sidewinder 1A) obtained by a modification to the missile infrared guidance and control unit. The AIM-9E, which can be carried on any aircraft equipped to fire AIM-9B or AIM-9D, provides improvements in air-to-air missile capability against highly maneuverable targets. The modified guidance and control unit is in volume production. The missile configuration is completed by utilization of existing warhead, fuze, rocket motor, and wings of the AIM-9B missile.

FALCON AIR-TO-AIR MISSILES

Prime Contractor: Hughes Aircraft Company
 Associate Contractors: Thiokol Chemical Corporation and Lockheed Propulsion Company (propulsion)

Remarks

Among the smallest missiles in service, the Air Force's Falcon family consists of several different types of air-to-air missiles which are guided either by radar or by a heat-seeking (infrared) homing device. Among the later versions are the AIM-26, which has a nuclear warhead; the AIM-47, which arms the YF-12A interceptor; and the AIM-4D, which is carried by the F-4C. Several other versions are operational on F-101, F-102, and F-106 aircraft. All of the weapons are solid propelled and supersonic.



R-139



PHOENIX AIR-TO-AIR MISSILE

Prime Contractor: Hughes Aircraft Company
Associate Contractors: Control Data Corporation (computer); Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (propulsion)

Remarks

The Navy's Phoenix missile system is designed for capabilities exceeding those of any operational air-to-air weapon. The system consists of the missile itself, designated XAIM-54A, an advanced AN/AWG-9 radar and missile control system, and the MAU-48A missile/bomb launcher. Under development for use on the F-14A aircraft, the missile is a long-range, high-performance, solid-propelled weapon.

GENIE AIR-TO-AIR ROCKET

Prime Contractor: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation
Associate Contractors: Aerojet-General Corporation; Thiokol Chemical Corporation

Remarks

The AIR-2A Genie is an air-to-air rocket with a solid-propellant motor capable of carrying a nuclear warhead. McDonnell Douglas builds the Genie weapon system for the USAF's Air Defense Command. It is carried on the F-101B Voodoo and the F-106 Delta Dart.

Specifications

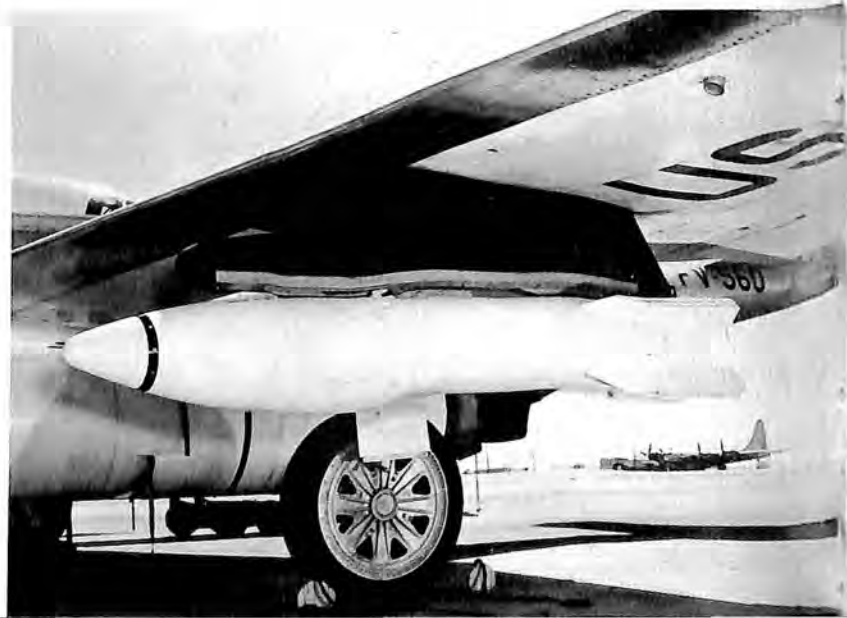
Length 9 feet; width 1 foot 5 inches; weight 830 pounds.

Performance

Classified.



R-140





GUNRUNNER BALLISTIC AERIAL TARGET SYSTEM

Prime Contractor: Atlantic Research Corporation, a division of The Susquehanna Corporation

Remarks

The Gunrunner ballistic aerial target system was developed for Army and Navy use as a low-cost, expendable target for air defense weapon training, including Redeye and Chaparral. The system consists of a 27-square-foot cross section body, 3-target launcher assembly, and remote firing circuit. A unique molded foam fabrication process is used to construct the large, lightweight body. A recess is provided at the target aft end for installation of either HVAR or HVARI sustainer propulsion units. Plywood fins for inflight stability and nose cone/ballast for center of gravity positioning are field-installed. The 3-target launcher, with leveling, elevation, and azimuth jacks, was designed to satisfy the high launch rate requirement. Fifty-eight flights have been accomplished including 39 launches in support of the Redeye training program at Twenty-nine Palms, California.

Specifications

Length 16 feet; diameter 20 inches; propulsion HVAR (0.86ES5800), sustainer (10KS300); launch weight 290 pounds.

Performance

Speed 300 to 500 knots; range 6,000 to 16,000 feet; flight time 10 to 33 seconds.

DRONES AND TARGETS



MODELS 1025, 1025-TJ TARGET MISSILES

Prime Contractor: Beech Aircraft Corporation

Remarks

The Model 1025 was designed principally for programs involving developmental and evaluation testing and personnel training in surface-to-air and air-to-air weapon systems. Model 1025 has been employed successfully with such systems as Hawk, Sparrow, Terrier, Tartar, Sidewinder, Nike Hercules, Nike Ajax, and Redeye. Model 1025-TJ (photo) is a newer, turbojet system which provides out-of-sight targets for surface-to-air and air-to-air weapon systems. It is a remote-controlled, recoverable target missile capable of speeds of over 400 knots for a duration of over 90 minutes. It was designed for such weapons as Hawk, Mauler, and Redeye.

Specifications (Model 1025)

Span 155 inches; length 181 inches; diameter 17.75 inches; weight 664 pounds; engine McCulloch turbosupercharged, 125 horsepower, with Beech constant-speed propeller.

Specifications (Model 1025-TJ)

Span 142.8 inches; length 204 inches; diameter 17.75 inches; weight 999 pounds without launch booster; engine 1 Continental 321-2 turbojet.

Performance (Model 1025)

Maximum speed 305 knots; service ceiling 40,000 feet; endurance 82 minutes on station.

Performance (Model 1025-TJ)

Maximum speed Mach .8; service ceiling in excess of 40,000 feet; endurance 1 hour-plus.



AQM-37A TARGET MISSILE

Prime Contractor: Beech Aircraft Corporation

Remarks

This supersonic target missile simulates enemy threat systems for air-to-air and surface-to-air missile evaluation and training. The target provides active or passive radar area augmentation for simulating threat systems by means of an optical Luneberg lens or traveling wave tube installation. A chemical flare is provided for missions which require infrared augmentation. Two miss-distance indication systems are also available. The target is normally air launched, but it has surface launch capability from shipboard or land-based launcher systems. The target's universal launch capability and high performance suit it uniquely to a number of tactical and support missions. The target utilizes a liquid bipropellant rocket engine. The engine is a prepackaged system consisting of a booster and sustainer thrust chamber; an orifice selector valve for propellant flow control; fuel, oxidizer, and nitrogen tankage; regulator and start valves; and the necessary interconnecting structure and plumbing.

Specifications

Span 39 inches; length 162.67 inches; diameter 13 inches; weight 565 pounds; frame swept delta wings with canard controls; cylindrical centerbody, tangent ogive nose; engine 1 Rocketdyne liquid-propellant engine with 630 pounds thrust.

Performance

Maximum speed Mach 3; service ceiling 90,000 feet.



SANDPIPER TARGET MISSILE MODEL 1069

Prime Contractors: Beech Aircraft Corporation; United Technology Center

Remarks

This new supersonic target missile system is designed to simulate a wide variety of aircraft and missile threats of the 1970s. Beech Aircraft is under contract to the Air Force to demonstrate the feasibility of a hybrid engine, built by United Technology Center, that utilizes both solid and liquid propellants. The engine uses Plexiglas with a magnesium compound as the solid propellant and a mixture of oxides as the liquid. The oxidizer is forced through a low-cost injector into the solid-fuel combustion chambers and is touched off by a conventional pyrotechnic igniter. Thrust is controlled by the amount of oxidizer programmed through the injector. The system is inherently safe, as neither of the propellants will burn unless external ignition is supplied. The test-bed vehicle combines the newly developed engine system with the airframe of the Beech Aircraft-built AQM-37A supersonic target missile. Sandpiper development is being conducted in 2 phases. Phase I will verify the propulsion system technology, airframe, and components; Phase II includes development of the production model Sandpiper and establishment of aircraft compatibility. Test launches are to be from the F-4 series aircraft.

Specifications (production Sandpiper)

Body diameter 10 inches; length 180 inches; weight 600 pounds; highly swept, clipped delta wing and forward-mounted canards for pitch control; full-span ailerons; symmetrical vertical stabilizers on each wing tip.

Performance

Maximum speed Mach 4; service ceiling 90,000 feet.



BIKINI SURVEILLANCE SYSTEM

Prime Contractor: Fairchild Hiller Corporation, Republic Aviation Division

Remarks

The Bikini aerial drone surveillance system was developed for the Marine Corps to provide combat units with quick-response, short-range reconnaissance. Designed to be operated from unprepared advanced positions by battalion or brigade personnel with a minimum of special training, the highly mobile system can supply intelligence on enemy vehicles, emplacements, troops, and terrain. A Bikini system consists of a small, radio-controlled reconnaissance aircraft and supporting launch and control ground equipment. An entire system, including 2 drones, fits into the jeep-drawn M100 trailer. A 2-man team can put the system in operation within 10 minutes from arrival at the launch site and provide finished 9 by 9 reconnaissance photographs 20 minutes later. The drone is a conventional high-wing, propeller-driven aircraft. Lightweight yet rugged, it is launched by a trailer-mounted pneumatic catapult to flying speed in a distance of 6 feet.

Specifications

Wingspan 96 inches; length 76 inches; weight 50 pounds normal, 60 pounds maximum; engine 4.5 horsepower, 2 cycle, driving tandem 28-volt generator.

Performance

Rate of climb 1,000 feet per minute; speed 80 to 100 miles per hour; service ceiling 10,000 feet; flight duration 30 minutes.



QH-50 DASH DRONE HELICOPTERS

Prime Contractor: Gyrodyne Company of America

Remarks

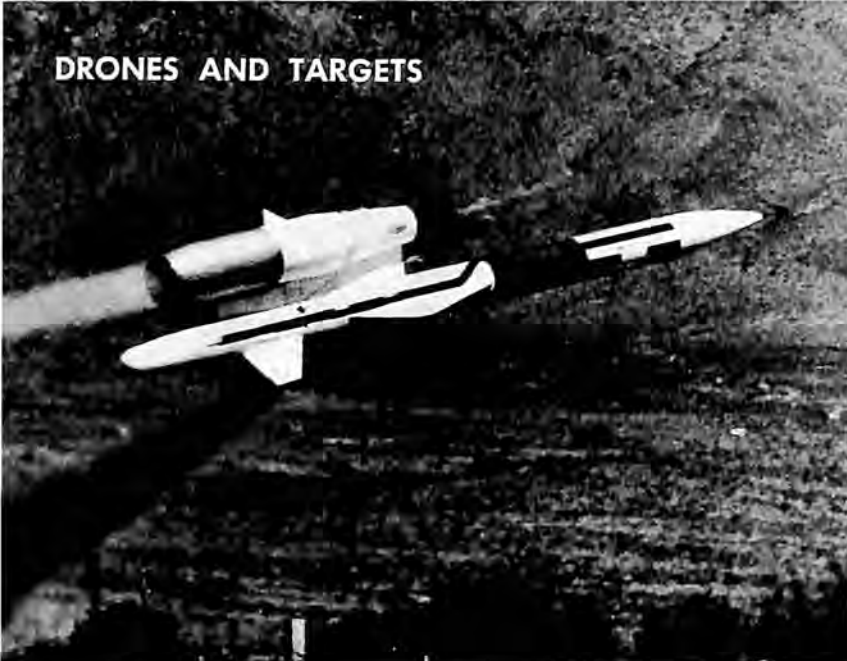
The DASH (Drone Antisubmarine Helicopter) weapons system provides destroyers with a flexible, deliberate, long-range attack capability against submarines. An unmanned helicopter, DASH permits a destroyer to attack a submarine without itself coming into lethal range. The series included the QH-50A, original evaluation prototype for the DASH system, first flown in 1960 and later used as an aerial target; the QH-50B, a manned version built only as a developmental aircraft; the QH-50C, first of the operational drones, which was introduced to the fleet beginning in 1962; and the final model of the series, the QH-50D, which has simplified avionics and greatly increased range capability and load-carrying capacity. Deliveries to the Japanese Maritime Self-Defense Force commenced in 1967. In 1968 the D successfully performed surveillance/reconnaissance missions by means of a TV camera. Auxiliary fuel tanks provide a flight endurance of 4 hours. The addition of weapons and sensing devices gives a multimission capability.

Specifications (D)

Rotor system coaxial; fuselage length 7 feet 3 inches; height 9 feet 8.5 inches; rotor diameter 20 feet; rotor blades molded fiber glass; weight 1,035 pounds; normal gross weight 2,350 pounds; power plant 1 T50-BO-12 turboshaft, normal rating 300 horsepower.

Performance (D)

Maximum speed at sea level 92 knots; hover ceiling 11,500 feet; service ceiling 16,000 feet; vertical rate of climb at sea level 1,230 feet per minute; operational radius over 30 nautical miles.



MQM-42A GUIDED TARGET MISSILE

Prime Contractors: Columbus Division, Aerospace & Systems Group, North American Rockwell Corporation (airframe and guidance/control); Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (booster rocket)
Associate Contractor: The Marquardt Company (ramjet engine)

Remarks

The MQM-42A Roadrunner was developed for the Army Missile Command as a low-unit-cost, dual-purpose target missile capable of operation at up to twice the speed of sound and at very low and very high altitudes. It is used primarily for realistic training of crews of the Hawk-type anti-air warfare batteries of the Army Air Defense System. Roadrunner can simulate the speeds and flight patterns of a wide variety of attack missiles and high-performance aircraft. Launch and flight are controlled electronically from a ground control station. Power is provided by a Rocketdyne solid-propellant booster which drops away after burnout; inflight propulsion is furnished by a top-mounted ramjet engine. Recovery is effected by activation of a parachute/retrorocket system housed in the rear equipment section. Roadrunner completed a successful operational program at White Sands Missile Range in mid-1969, providing evaluation flights for an air defense system undergoing operational tests.

Specifications

Length 24.8 feet; diameter 12 inches; gross weight 861 pounds.

Performance

Speed Mach .9 to 2.1; service ceiling 60,000 feet.



MQM-74A TARGET DRONE

Prime Contractor: Northrop Corporation

Remarks

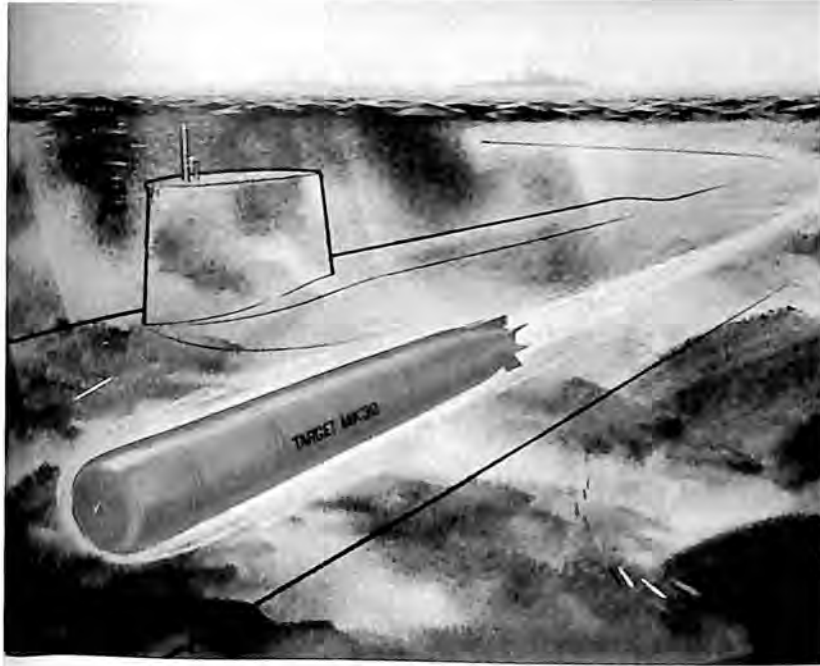
A new, low-cost, variable-speed target drone aircraft, the MQM-74A was designed by Northrop Corporation's Ventura Division for Navy use to fill the gap between low-speed and supersonic targets now in service. The small, jet-powered aircraft provides realistic training to increase the proficiency of military gunnery and antiaircraft missile crews and is suitable for exercising a wide range of operational missiles. It provides realistic simulation of limited-warfare aircraft speeds and maneuvers. Featuring ease of handling and high reliability, the MQM-74A is capable of flying both visual and out-of-sight missions. The Luneberg lens passive radar augments, which provides radar cross section of an actual aircraft, increases the realism of training for gun and missile crews. Provisions are included for radar tracking beacons, visual augmentation, infrared augmentation, and distance indicator.

Specifications

Length 135.9 inches; height 27.7 inches; wingspan 66.7 inches; weight 248 pounds empty, 322 pounds fully fueled for flight with provisions for adding 2 15-pound wing-tip pods; launch standard zero-length from ground or shipboard; guidance radio control; power plant 29-pound-weight, 121-pound-thrust turbojet Williams engine.

Performance

Variable speed 200 to 400 knots; service ceiling 40,000 feet; endurance .5 to 1.5 hours; recovery by parachute.



MARK 30 MOBILE ASW TARGET

Prime Contractor: Northrop Corporation

Remarks

The Mark 30 Mobile ASW Target, to be used for antisubmarine warfare training, is under development for the Naval Ordnance Systems Command by Northrop Corporation's Ventura Division. The target will simulate the size, sound, and performance of a full-scale submarine. It is torpedo-shaped. The underwater target is intended to free fully manned submarines from use as targets during mock antisubmarine warfare exercises. It can be launched from surface ships or submarines. An acoustic transducer will be towed behind the vehicle itself so that live torpedoes can be exercised against the system without destroying the target vehicle. During an exercise, the preprogrammed target will travel at changing speeds, directions, and depths; it is capable of operating for as long as 7 hours, the length of time depending on the speed required. Upon conclusion of its target run, the vehicle will surface for recovery by surface ship or helicopter. It will be powered by batteries which drive an electric motor coupled to propeller shafts.



MQM-33, MQM-36 TARGET DRONE

Prime Contractor: Northrop Corporation

Remarks

This aerial target is a propeller-driven, all-metal, high-wing monoplane used by the Army (MQM-33), the Navy (MQM-36), and the Air Force as a target for antiaircraft training. Under its general, international designation, KD2R-5, it is being used by 18 free world countries. It has been the standard target for worldwide antiaircraft weapons training for many years. It is available with various operational equipment, including speed-up kit, tow darts, altitude hold device, and auxiliary decoder, in addition to beacons, smoke cylinders, and flares. Rugged construction and simplicity of maintenance permit multiple missions in rapid sequence. All versions are recoverable by parachute, and the target contains flotation equipment for operation at sea.

Specifications

Span 11 feet 6 inches; length 12 feet 7 inches; height 2 feet 7 inches; launch rotary, zero-length, or catapult; power plant 2-cycle, 4-cylinder, air-cooled McCulloch engine.

Performance

Speed 175 to 207 knots; rate of climb 3,060 feet per minute; ceiling 24,000 feet; flight endurance 60 minutes.

DRONES AND TARGETS



LOCAT (LOW-COST AIR TARGET)

Prime Contractor: Aeronutronic Division, Philco-Ford Corporation

Remarks

LOCAT (Low-Cost Air Target) is an extremely low-cost, high-speed, rocket-powered military air target. The expendable air target pops up from its ground launch site like a clay pigeon at a shooting range and attains speeds in excess of 500 miles per hour within seconds. The 15-foot-long LOCAT fuselage is made of rolled paper tubing; the nose cone and fins, of glass-reinforced plastic. The paper fuselage is coated with aluminum to provide a radar signature for missile tracking and targeting purposes. The LOCAT booster motor consists of 3 2.75-inch Folding-Fin Aircraft Rockets (FFAR) of the type used as armament on some military aircraft.

Specifications

Length 15 feet; weight 155 pounds; outside diameter 9.6 inches; tri-fin configuration provides 20.5-square-foot target when viewed by the gunner during flight.

Performance

Designed for altitude of 1,000 feet, range of 10,000 feet, flight time of 17 seconds; use of different launch angles will vary range from 2,000 to 11,000 feet, altitude from 300 to 2,000 feet, flight time from 4 to 24 seconds; speed 345 to 520 miles per hour; IR signature provided for use with low-altitude air defense systems employing infrared homing missiles.



TDU-9B BANDITO

Prime Contractor: Univac-Salt Lake City, a division of Sperry Rand Corporation

Remarks

In 1967 Sperry won a contract from the U.S. Air Force for a new, lightweight, supersonic tow target. Called the "Bandito," the target was given the designation TDU-9B. Contract value was \$1,900,000. The contract was won by Sperry Utah, which, later in 1967, was incorporated into the company's Univac Division. The major advantage in Bandito is the electrical constant infrared developed by Sperry as a target for heat-seeking missiles. CIR is an electrical heater which emits radiant energy in the infrared spectrum. Power is supplied by a Ram Air Turbine (RAT) capable of producing 28 volts direct current at a constant power rating of 1,700 watts. The entire target system is provided with electrical interlocks to prohibit target operation while in the stowed position under the tractor aircraft.



**RYAN FIREBEE JET TARGET DRONE
(MQM-34D ARMY; BQM-34A NAVY,
AIR FORCE)**

Prime Contractor: Teledyne Ryan Aeronautical

Remarks

The Ryan Firebee is a remotely controlled, variable-speed, highly maneuverable, subsonic aerial target. It is a multipurpose vehicle, having heavy payload and target-towing capability. Towbee, long-burning infrared tow, and banner tow targets can be streamed behind Firebee for surface-to-air missile and automatic weapons firings. Increased Maneuverability Kits added to the basic Firebee make possible 6 g turns at bank angles up to 78 degrees. Low-altitude performance down to 50 feet over water and 100 feet over land is accomplished with addition of the Radar Altimeter Low-Altitude Control System (RALACS). Ryan has delivered more than 4,000 Firebee target systems to the military services since 1947. Firebees have supported development of nearly every surface-to-air and air-to-air missile weapon system in the U.S. military arsenal.

Specifications

Speed 175 to 600 knots TAS; altitude 50 feet to 60,000 feet; endurance up to 114 minutes; range over 1,200 kilometers; payload up to 1,000 pounds; reliability over 12,000 flights; air or ground launchable, parachute recovery system; active and passive radar augmentation; infrared flares; scoring systems; traveling wave tube for radar size variation.



**RYAN SUPERSONIC FIREBEE II
JET DRONE (BQM-34E NAVY)**

Prime Contractor: Teledyne Ryan Aeronautical

Remarks

The Ryan supersonic Firebee II, BQM-34E, developed and flight tested for the Naval Air Systems Command, is undergoing a Navy test and evaluation program at the Naval Missile Center, Point Mugu, California. The operational version of Firebee II performs missions in excess of 60,000 feet at speeds exceeding Mach 1.5 and has 5 g maneuverability. The Continental J69-T-406 turbojet engine, a modification of the power plant used in the subsonic BQM-34A Firebee, develops 1,920 pounds of static sea-level thrust. Firebee II is designed to carry 400 pounds of fuel in an external, jettisonable fuel tank. After completion of subsonic missions, the tank is jettisoned for higher-performance, supersonic flight. The new target carries active and passive augmentation as employed in the subsonic Firebee.

Specifications

Operational supersonic configuration: empty weight 1,446 pounds; gross weight 1,880.5 pounds; useful load includes 147.6 pounds augmentation equipment and 278.6 pounds internal fuel and oil. Subsonic configuration: empty weight 1,509.5 pounds; gross weight 2,344 pounds; useful load includes 147.6 pounds augmentation equipment and 678.6 pounds internal and external fuel and oil.

Performance

Speed at sea level Mach 1.1, at 45,000 feet Mach 1.9, above 60,000 feet Mach 1.5; 5 g capability at altitudes in excess of 20,000 feet.

LAUNCH VEHICLES

SATURN V

Contractors: Marshall Space Flight Center, NASA (assembly); The Boeing Company (systems engineering and integration and S-IC stage); Space Division, Aerospace & Systems Group, North American Rockwell Corporation (S-II stage); McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation (S-IVB stage); IBM Corporation (instrument unit); Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (propulsion, all stages)

Remarks

The superbooster used to send American astronauts to the moon under NASA's Project Apollo, Saturn V is a 3-stage vehicle, 363 feet tall, which is capable of placing a 285,000-pound payload in earth orbit or sending 100,000 pounds into a lunar trajectory. The first, or basic, stage, known as S-IC, is 33 feet in diameter and 138 feet long. Its key component is the mighty F-1 rocket engine which develops 1,522,000 pounds of thrust in a single chamber. Five such engines, fueled with kerosene and liquid oxygen, give the first stage a launch output of 7,600,000 pounds to start the 6,400,000-pound vehicle on its journey. The lunar mission profile begins with launching of the Saturn V space vehicle at Cape Kennedy, Florida. The first stage reaches full thrust 9 seconds after ignition. S-IC engine cutoff occurs 150 seconds later, 50 miles downrange at an altitude of approximately 40 miles and a velocity of about 6,000 miles an hour. After engine cutoff, the S-IC stage is jettisoned and the S-II stage takes over. After S-II burnout at near-orbital altitude, the S-IVB third stage provides the final kick into earth parking orbit.

S-IC STAGE

Prime Contractor: The Boeing Company

Remarks

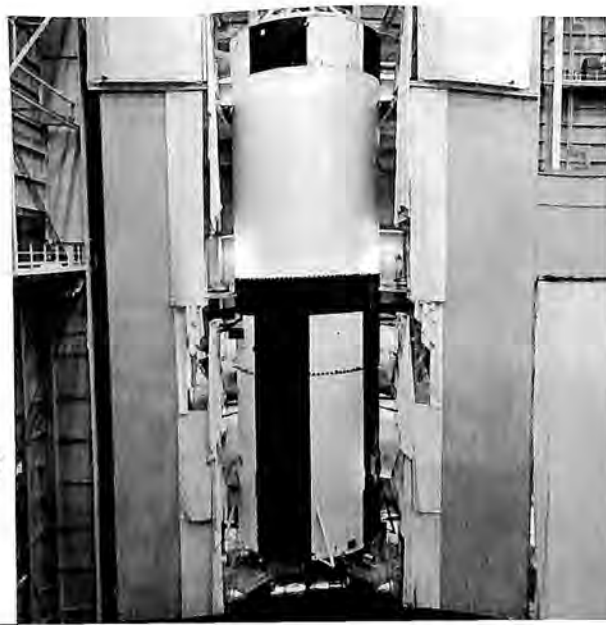
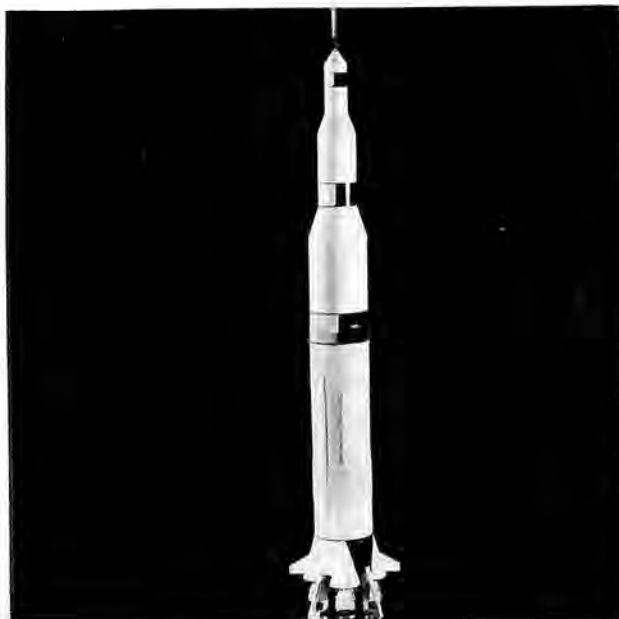
The S-IC is the first-stage booster for the Saturn V launch vehicle. Close to 10,000 Boeing employees are working at 6 sites in the United States on this largest and most powerful booster stage in the free world. Most of the major subassembly and vertical assembly tasks are accomplished at NASA's Michoud Assembly Facility in New Orleans. Burning liquid oxygen and kerosene, the S-IC propels the 3-stage Saturn V and the Apollo spacecraft during the first 2.5 minutes of flight. Initial stages produced were the S-IC-D (for "dynamic test"), S-IC-F (for "facilities test"), S-IC-T (for "static test"), and S-IC-S (for "structural test"). All were ground-test versions. Seven production versions had flown by the end of 1969.

Specifications

Length 138 feet; diameter 33 feet.

Performance

Thrust 7,600,000 pounds, produced by 5 Rocketdyne F-1 engines; lunar voyage firing endurance 150 seconds.



S-II STAGE

Prime Contractor: Space Division, Aerospace & Systems Group, North American Rockwell Corporation
 Major Subcontractors: Acoustica Associates (controllers); American Brake Shoe Company (hydraulic pumps); Consolidated Electrodynamics Corporation (tape recorder); Electrada Corporation (test conductor console); Electroplex, subsidiary Borg-Warner Corporation (logic modules, power supplies); Fairchild Precision Metal Products and Solar Division of International Harvester Company (cryogenic lines); B. H. Hadley (disconnects); W. O. Leonard, Inc. (vent valves); Parker Aircraft Company (hydraulic systems)

Remarks

The S-II is the second stage of NASA's Apollo launch vehicle—the giant Saturn V. Most powerful hydrogen-fueled booster in production, the S-II is used for Apollo manned lunar missions to help power the 3-man spacecraft to the moon. The S-II is being developed and manufactured at Seal Beach, California, under the technical direction of NASA's Marshall Space Flight Center, Huntsville, Alabama. The S-II is constructed primarily of an aluminum alloy (2014-T6 aluminum). With its 5 Rocketdyne J-2 engines of 225,000 pounds thrust each, the S-II develops a total thrust of 1,125,000 pounds. The S-II is powered by a combination of liquid hydrogen and liquid oxygen propellants. The 4 outer engines gimbal. The fifth engine, which is centered, is fixed.

Specifications

Height 81.5 feet; diameter 33 feet; weight 95,000 pounds empty and 1,037,000 pounds loaded.

Performance

Thrust (combined engines) 1,125,000 pounds.

S-IVB STAGE

Prime Contractor: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation

Remarks

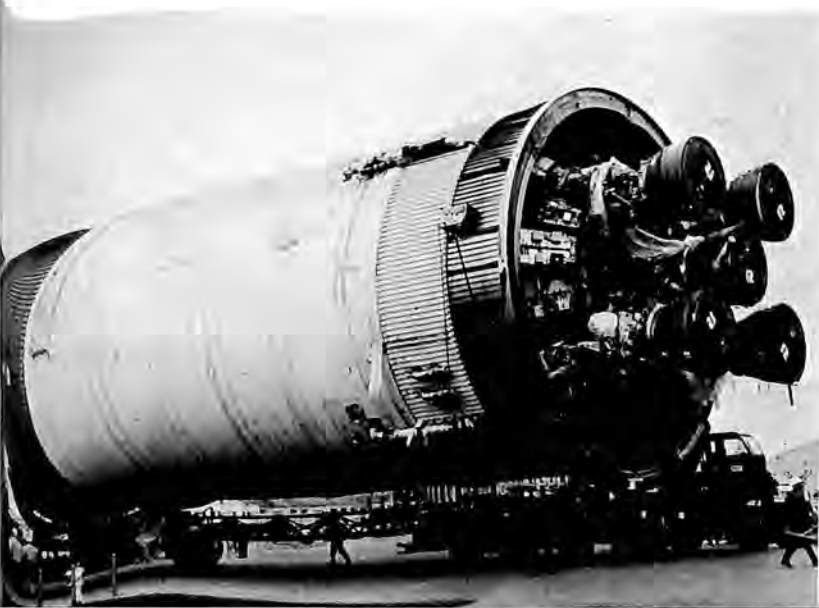
The S-IVB, upper stage of the Saturn V launch vehicle, fires on a lunar voyage after the S-II stage has burned about 6 minutes. It sends the Apollo spacecraft into earth orbit but, unlike the 2 lower stages, does not fall back to earth; it remains with the spacecraft for a later assignment: provision of thrust for the final kick into lunar trajectory. The 12-ton stage is fabricated of lightweight aluminum except for battleship, or ground-test, versions which were made of heavy stainless steel. In addition to its use as topmost stage of the Saturn V stack, the S-IVB serves as the upper stage of the Saturn IB vehicle. Propellant capacity is the same for both versions. In the Apollo Applications Program, an S-IVB stage will be used as the manned Orbital Workshop for missions lasting up to 56 days. The earlier S-IV stage, powered by 6 Pratt & Whitney Aircraft RL10 engines producing 90,000 pounds thrust, was used on Saturn I.

Specifications

Length 58 feet 7 inches; diameter 21 feet 8 inches; engine Rocketdyne J-2; propellants liquid oxygen/liquid hydrogen; propellant capacity 230,000 pounds.

Performance

Thrust 225,000 pounds maximum.



R-149



LAUNCH VEHICLES

SATURN IB

Contractors: Marshall Space Flight Center, NASA (engineering and systems assembly); Chrysler Corporation Space Division (first stage, S-IB); McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation (second stage, S-IVB); Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (propulsion, first and second stages)

Remarks

Saturn IB was used in the early test phase of the Apollo lunar landing program through Apollo 7, the first manned mission, in October 1968. It also figures in NASA's plans for the follow-on Apollo Applications Program. The 2-stage Saturn IB is larger and more powerful than Saturn I. Major changes are in the first stage (S-IB), which has been redesigned by Chrysler to eliminate 10 tons of weight, and in the use of the McDonnell Douglas S-IVB as top stage in place of the earlier S-IV stage.

Specifications

Length 224 feet with Apollo payload and escape tower; weight approximately 1,300,000 pounds; first stage (S-IB) 80.3 feet long, 21.4 feet in diameter; second stage (S-IVB) 58 feet 7 inches long, 21 feet 8 inches in diameter.

Performance

First stage (S-IB) powered by 8 Rocketdyne H-1 engines, each producing 200,000 pounds of thrust, or a total of 1,600,000 pounds; second stage (S-IVB) powered by a single Rocketdyne J-2 engine which generates 225,000 pounds of thrust at altitude. Saturn IB is capable of placing approximately 20 tons in earth orbit and 2.5 tons in lunar orbit.



TITAN IIIC

Program Management: Air Force Systems Command's Space Systems Division of the Space and Missile Systems Organization (SAMSO)

Major Contractors: Martin Marietta Corporation, Denver Division (systems integration, airframe, flight test); Aerojet-General Corporation (liquid propulsion); AC Electronics Division, General Motors Corporation (guidance); United Technology Center (solid-propellant boosters); The Ralph M. Parsons Company (launch facilities design and engineering); The Aerospace Corporation (technical direction)

Remarks

Titan IIIC is the standard military heavy-duty launch vehicle. It consists of a 3-stage common core vehicle with 5-segment, solid-propellant United Technology Center zero-stage boosters (the core vehicle is essentially the same as the Titan IIIA, first of the family, which flew 4 test missions in 1964-65). The solid boosters have a combined lift-off thrust of 2,400,000 pounds. The core's Aerojet liquid propulsion system, ignited at altitude, produces 470,000 pounds thrust. The IIIC is about 130 feet tall with a standard payload fairing and weighs 1,400,000 pounds; diameter of all stages is 10 feet. Titan IIIC can send as much as 26,500 pounds into earth orbit or 5,000 pounds into escape trajectory. One of the most successful of all space programs, Titan IIIC was launched 17 times without a failure in the research and development phase. First flight was June 18, 1965, and the last R&D mission was launched February 7, 1969. Titan IIIC has sent into space such payloads as the complete Initial Defense Satellite Communications System, the LES experimental comsats, a variety of USAF OV's (Orbiting Vehicles), Dodge, DATS-1, and, in 1969, the Hughes-built TACSAT. In photo, IIIC moves on its mobile launch platform to the launch complex, where the payload and nose fairing are attached.



R-150

TITAN IIIB, IIID, IIID/CENTAUR

Program Management: Air Force Systems Command's Space Systems Division of the Space and Missile Systems Organization (SAMSO)

Major Contractors: Martin Marietta Corporation, Denver Division (systems integration, airframe, flight test); Aerojet-General Corporation (liquid propulsion); AC Electronics Division, General Motors Corporation (guidance); United Technology Center (solid-propellant boosters); The Ralph M. Parsons Company (launch facilities design and engineering); The Aerospace Corporation (technical direction)

Remarks

Although it bears an earlier alphabetical designation, Titan IIIB actually came later than the IIIC in the development of the Titan III family of military launch vehicles. Known officially as SLV-5B, the Titan IIIB is essentially an advanced version of the original IIIA core vehicle with a different upper stage. The launch vehicle consists of the basic 2 stages plus a third stage, which may be Transtage, Burner II, Centaur, or Agena D. The latter configuration was first flown on July 29, 1966; by year-end 1969, it had been used approximately 20 times to orbit classified USAF payloads. Topped by Agena D, Titan IIIB is about 145 feet tall and 10 feet in diameter. First-stage thrust is 430,000 pounds. Martin Marietta's Denver Division builds the airframe, supplies the flight control system, and serves as systems integrating contractor for the first 2 stages; the USAF's Space Systems Division is responsible for executive management. In development status are 2 other versions of the Titan III: the Titan IIID, which employs strap-on solid rockets like the IIIC but has a different upper-stage configuration, and the Titan IIID/Centaur, an intermediate-class launch vehicle for the 1970s, to be used primarily for planetary exploration.

TITAN III TRANSTAGE

Program Management: Air Force Systems Command's Space Systems Division of the Space and Missile Systems Organization (SAMSO)

Major Contractors: Martin Marietta Corporation, Denver Division (systems integration and airframe); Aerojet-General Corporation (propulsion); AC Electronics Division, General Motors Corporation (guidance)

Remarks

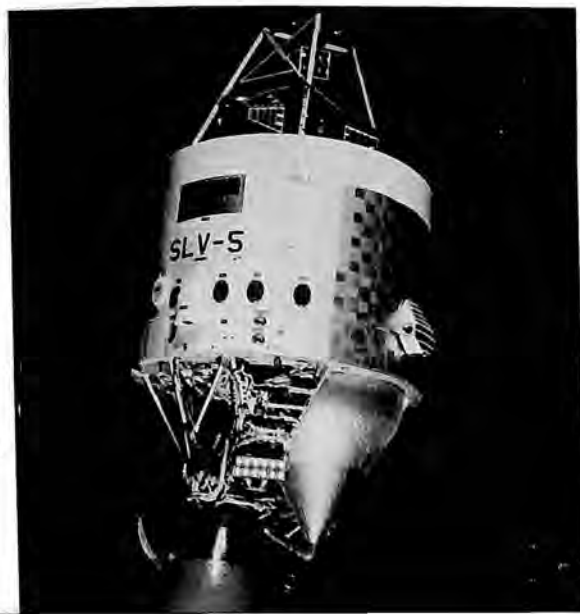
Transtage is a switch engine spacecraft capable of delivering multiple payloads to multiple destinations as needed. Its missions have included deployment of 33 satellites in near-synchronous, equatorial orbit as the vanguard of a worldwide military communications network, and stationing twin Vela nuclear detection satellites in 70,000-mile orbits.

Specifications

Diameter 10 feet; length 33 feet with the standard payload fairing utilized for unmanned missions; weight, fueled but not including payload, 27,000 pounds; capable of 10 or more starts in space.



R-151



ABRES ATLAS (E AND F)

Prime Contractor: Convair Division of General Dynamics Corporation

Associate Contractors: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (engines); General Electric Company, Burroughs Corporation, and American Bosch Arma Corporation (guidance)

Remarks

The E and F models of the Atlas ICBM, the free world's first intercontinental ballistic missile, were the last produced in missile configuration. Phased out of the weapons arsenal in 1965, they found utility as launch vehicles and are being used in a continuing USAF program known as ABRES (Advanced Ballistic Reentry Systems). Initiated in 1963 and scheduled to continue at least through 1971, ABRES involves a thorough investigation of reentry phenomena and the evaluation and test of new reentry vehicles. The reentry systems are fired from Vandenberg Air Force Base, California, to a reentry near Kwajalein Atoll in the Pacific. The Series E and F missiles have propulsion systems of 390,000 pounds thrust and all-inertial guidance; they have sent reentry packages over 9,000 miles.

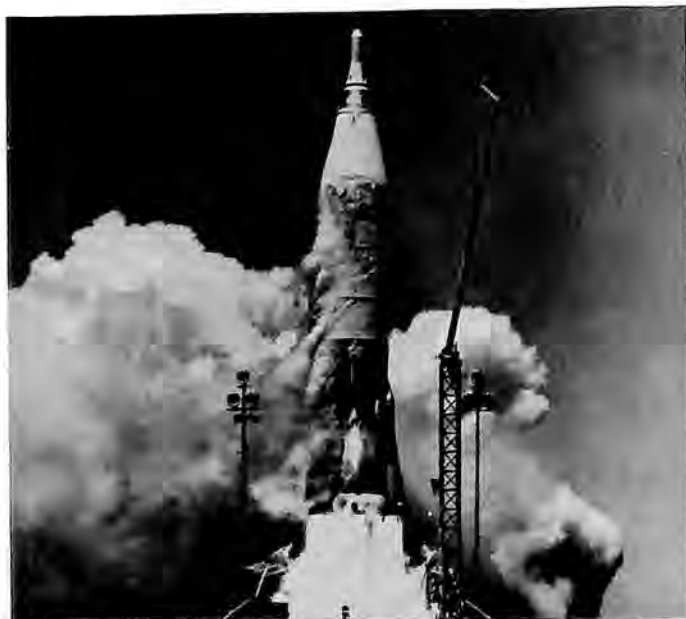
ATLAS SLV-3, SLV-3A, SLV-3C

Prime Contractor: Convair Division of General Dynamics Corporation

Associate Contractors: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation; General Electric Company; Acoustica Corporation

Remarks

The SLV-3 was the original launch vehicle version of the Atlas missile. Of 54 flown, 42 were successful. The SLV-3A is an uprated version of the SLV-3 vehicle. Increased performance is achieved by modifying existing systems, thereby retaining the inherent, flight-proven reliability of the SLV-3. The new tank is 117 inches longer and holds an additional 48,000 pounds of usable propellants. The MA-5 engine system is uprated by changing the settings of the engine reference regulators, causing an increased operating pressure in the gas generators. These and other modifications increase booster engine thrust to 168,000 pounds each; sustainer engine thrust is 58,000 pounds. The SLV-3A, with an Agena second stage, can inject a 7,950-pound payload into a 100-nautical-mile orbit. The SLV-3C, an uprated version of the constant 10-foot-diameter LV-3C, is used to launch the Centaur upper stage. The first uprated SLV-3C was flown as Atlas/Centaur 13 for the Surveyor 5 mission. The new booster incorporates a 51-inch tank extension, resulting in the addition of approximately 21,000 pounds of usable propellants; thrust ratings are the same as for SLV-3A. Assigned missions include Surveyor, Applications Technology Satellite, Orbiting Astronomical Observatory, and a Mariner Mars flyby. The SLV-3C, with a Centaur upper stage, can carry a 2,900-pound payload to escape or a 2,200-pound payload to Venus or Mars. In photo, SLV-3A (foreground), SLV-3C (second from front).



R-152



CENTAUR

Prime Contractor: Convair Division of General Dynamics Corporation

Associate Contractors: Pratt & Whitney Aircraft Division of United Aircraft Corporation (main propulsion system); Honeywell Inc. (all-inertial guidance system)

Major Subcontractors: Pesco Products Division of Borg-Warner Corporation and General Electric Company (hydrogen boost pumps); Bell Aerospace Company (hydrogen peroxide, ullage, and attitude control system)

Remarks

Centaur is a high-energy upper stage currently using an Atlas first stage of similar diameter and construction. Centaur's first mission was Surveyor, to soft-land instruments on the moon prior to manned landings. Centaur is a high-specific-impulse vehicle powered by 2 15,000-pound-thrust liquid hydrogen and liquid oxygen engines. The Centaur vehicle is 46 feet long and has used nose fairings up to 35 feet long. Centaur weighs about 37,500 pounds at launch. Atlas vehicles used as the first stage employ the 390,000-pound-thrust Rocketdyne propulsion system. Centaur tank structure, like Atlas, is fabricated from thin-gauge stainless steel. Centaur features unique jettisonable insulation to protect its payload, flight control equipment, and fuel from aerodynamic forces during ascent through the atmosphere. Insulation is jettisoned, allowing Centaur to shed unnecessary weight early in flight—a concept that buys 14 pounds of payload capability for every 15 pounds of discarded insulation. Centaur is capable of boosting 2,700 pounds to escape with an Atlas first stage and 11,000 pounds to escape atop a Titan IIID booster. Using a Saturn IB in combination with Centaur, 15,800-pound payloads can be boosted to escape velocity.

THOR, LONG TANK THOR

Prime Contractor: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation

Associate Contractors: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (liquid propulsion); Thiokol Chemical Corporation (solid propulsion); Western Electric Company (guidance)

Remarks

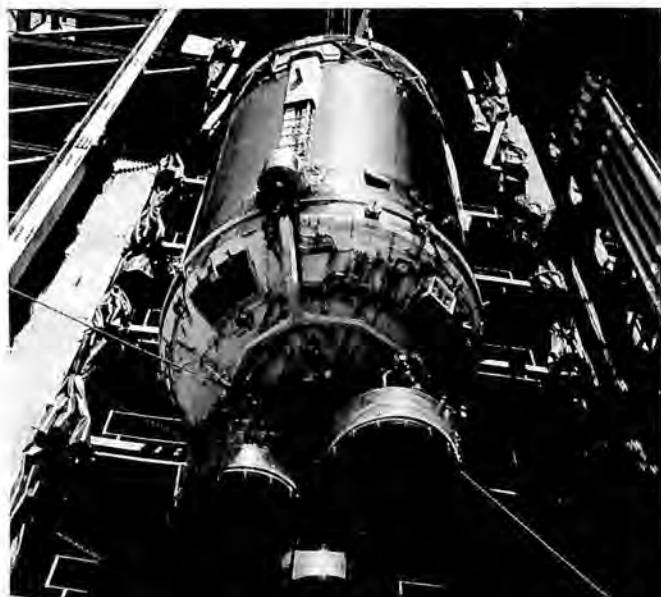
The Thor family of launch vehicles has included more than 2 dozen configurations, and the vehicle has earned the title "workhorse of the space age" with demonstrated reliability and versatility in more than 200 firings. Newest version is the Long Tank Thor, which is expected to boost the majority of USAF space programs. Long Tank Thor offers added payload capability by increasing the volume of the liquid-propellant tanks. The new vehicle is a constant diameter (8 feet), whereas its predecessor was conical. Total thrust is essentially the same as that for the Thrust Augmented Thor, but Long Tank Thor gets its increased payload capability from a burn time of 216 seconds, as compared with 146 for the earlier Thor. In photo, Long Tank Thor at right, standard model at left.

Specifications (Long Tank Thor)

Length 70.5 feet (compared with 56 in standard version); diameter 8 feet constant (compared with 8 feet maximum).

Performance

Thrust 330,000 pounds; payload varies with upper stage; Long Tank Thor has 3,000-pound low-altitude orbit capability.



R-153



DELTA

Prime Contractor: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation
Associate Contractors: Aerojet-General Corporation (propulsion system, second stage); Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (first-stage propulsion); Allegany Ballistics Laboratories (third-stage propellant motor); Western Electric Company (first- and second-stage guidance)

Remarks

The Delta launch vehicle is an economical, reliable, and accurate 3-stage vehicle used for launching space probes and earth-orbital missions. Its first stage is a modified Thor. Liquid propellants are used in the first and second stages; the third stage is powered by solid propellants. Delta has placed in orbit the majority of U.S. scientific and communications satellites, including Tiros, OSO, Explorer, Telstar, Relay, Syncom, ESSA, and BIOS payloads.

Specifications (DSV-3C Delta)

Length about 93 feet; diameter 8 feet; lift-off weight 114,000 pounds; thrust 172,000 pounds (first stage), 7,575 pounds (second stage), 6,100 pounds (third stage).

Performance

Payload 875 pounds in a 500-nautical-mile circular orbit.

THRUST AUGMENTED DELTA

Prime Contractor: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation
Associate Contractors: Aerojet-General Corporation (second-stage propulsion); Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (first-stage propulsion); Thiokol Chemical Corporation (strap-on propulsion)

Remarks

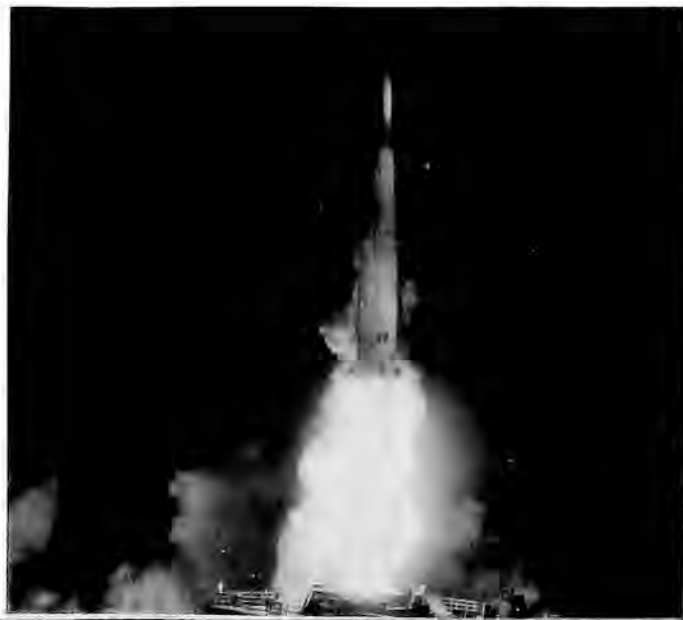
The Thrust Augmented Delta (TAD) was introduced in 1964 as a more advanced, more powerful version of the standard Delta. Its added performance is derived from 3 strap-on solid-propellant rocket motors that bring TAD's first-stage lift-off thrust to 330,000 pounds—almost double the 172,000-pound-thrust capability of the standard Delta. Addition of the solids enables TAD to boost heavier payloads higher and farther. TAD launched the Syncom C satellite that relayed on-the-spot television pictures of the Olympic Games from Japan to the United States and the Communications Satellite Corporation's history-making Early Bird, first link in a proposed worldwide communications network.

Specifications

Length about 90 feet; diameter (maximum including solid boosters) 14 feet 2 inches; lift-off weight 143,164 pounds; thrust 330,000 pounds (first stage), 7,575 pounds (second stage), 6,100 pounds (third stage).

Performance

Payload 1,000 pounds in a 500-nautical-mile circular orbit.



R-154



THRUST AUGMENTED IMPROVED DELTA

Prime Contractor: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation
 Associate Contractors: Aerojet-General Corporation (second-stage propulsion); Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (first-stage propulsion); Thiokol Chemical Corporation (strap-on propulsion)

Remarks

The Thrust Augmented Improved Delta (TAID), introduced in 1965, is an advanced version of earlier Delta models. Adaptable as either a 2-stage or a 3-stage vehicle, the TAID can carry a wide range of spacecraft, including communication satellites, specialized scientific capsules, and navigational, meteorological, experimental, and other types of payloads, into near-earth orbits, moon orbits, or deep space. Both the 2-stage and the 3-stage TAID can be used with or without strap-on thrust augmentation boosters.

Specifications

Length about 90 feet; diameter (maximum including solid boosters) 14 feet 2 inches; lift-off weight (with solid boosters) 149,461 pounds; thrust 333,000 pounds (first stage), 7,550 pounds (second stage), 5,650 pounds (third stage).

Performance

Payload 1,120 pounds in a 500-nautical-mile circular orbit.

LONG TANK DELTA

Prime Contractor: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation
 Associate Contractors: Aerojet-General Corporation (second-stage propulsion); Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (first-stage propulsion); Thiokol Chemical Corporation (strap-on propulsion)

Remarks

The Long Tank Delta (LTD), which made its debut August 16, 1968, when it orbited the ESSA 7 weather satellite, is the latest and most powerful version of the Delta series of launch vehicles introduced in 1960. This model is launched as either a 2-stage or a 3-stage vehicle with 3, 6, or 9 thrust augmentation boosters. As a result, the overall vehicle length is 14.5 feet greater than that of the Thrust Augmented Improved Delta and propellant capacity is increased. The LTD also includes a new, higher-energy third-stage motor. Space assignments for the LTD include the lofting of communication, meteorological, scientific, navigational, and experimental payloads into near-earth orbits, moon orbits, or deep space.

Specifications (DSV-3L Long Tank Delta)

Length about 106 feet; diameter (maximum including solid thrust augmentation) 14 feet 2 inches; lift-off weight (with solid thrust augmentation) 199,416 pounds; thrust 330,000 pounds (first stage), 7,550 pounds (second stage), 10,000 pounds (third stage).

Performance

Payload 1,580 pounds in a 500-nautical-mile circular orbit.



R-155



REDSTONE

Prime Contractor: Chrysler Corporation Missile Division

Remarks

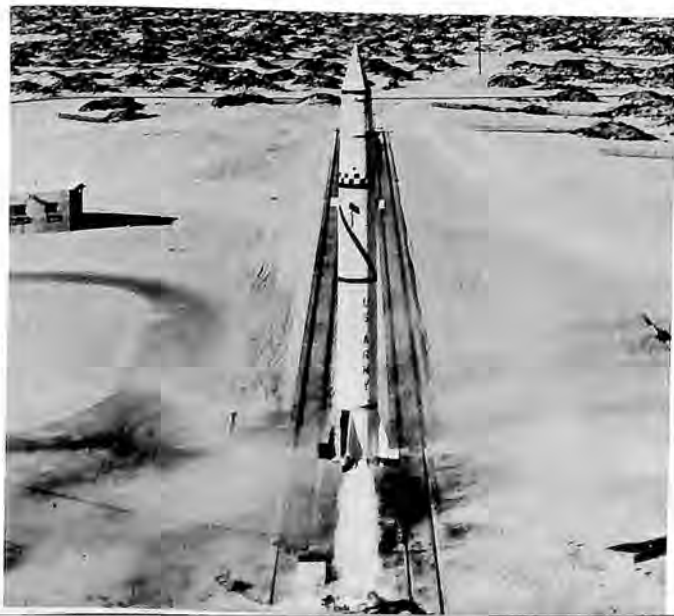
The first ballistic missile to be deployed overseas, Redstone is no longer being built as a weapons system, but it has research utility. Chrysler Missile Division, as a major subcontractor to Systems Group of TRW Inc., has made major modifications to a number of Redstones for use in the SPARTA (Special Antimissile Research Tests in Australia) program. SPARTA is part of Project Defender, sponsored by the Defense Department's Advanced Research Projects Agency. Equipped with solid-propellant upper stages and with reentry payloads, the Redstones were assembled and launched at Woomera, Australia. Chrysler also provided the payloads and assisted in launch support. Other Redstones have been reactivated for Project Defender. Programs utilizing Redstone for new missions are under consideration.

Specifications

Length 69 feet; diameter 70 inches; weight 60,970 pounds.

Performance

Range 200 nautical miles; thrust 75,000 pounds.



R-156

SCOUT

Prime Contractor: LTV Aerospace Corporation, a subsidiary of Ling-Temco-Vought, Inc.

Associate Contractors: Aerojet-General (first stage); Thiokol Chemical (second stage); Hercules Powder Company (third stage); United Technology Center (fourth stage); Honeywell Inc. (guidance)

Remarks

Scout is a 4-stage, solid-fueled rocket developed to provide the United States with a reliable, versatile, cost-effective launch vehicle for a variety of space exploration tasks—orbital, high-altitude probe, and high-speed reentry. Developed by NASA, the vehicle is produced by LTV Aerospace's Missiles and Space Division, which also provides systems management. The first U.S. solid-propellant rocket capable of placing payloads in orbit, Scout has important roles in the space programs of NASA and the Department of Defense plus those of the United Kingdom, Italy, France, Germany, and the 10-nation European Space Research Organization (ESRO). Scout is launched in the United States from NASA's Wallops Island, Virginia, and by Air Force crews from the Western Test Range in California. A third site, the Italian San Marco sea-based platform off the east coast of Africa, makes possible launches along the equator. Scout is capable of boosting 320 pounds into a nominal 300-mile orbit. Performance is expected to be increased still further by development of a fifth-stage velocity package.

Specifications

Length 72 feet; weight 20 tons. Stages: Algol IIB, 105,000 pounds thrust, controlled by fins and jet vanes impinging in rocket exhaust, 30 feet long; Castor II, 60,000 pounds thrust, controlled by hydrogen peroxide jets, 20 feet long; Antares II, 21,000 pounds thrust, controlled by hydrogen peroxide jets, 10 feet long; FW-4S, 6,000 pounds thrust, spin stabilized, 6 feet long.



AGENA

Prime Contractor: Lockheed Missiles & Space Company

Associate Contractors: Bell Aerospace (primary and secondary power plants); Honeywell Inc. (guidance)

Remarks

One of the workhorses of U.S. space exploration, Agena is an upper stage which is also employed as a spacecraft, the whole vehicle going into orbit. Agena played a key role in manned space flight; it was the target vehicle for rendezvous and docking maneuvers in NASA's Gemini project. Agena has a main rocket engine capable of multiple restarts in space; in the modified target vehicle version, it also had 2 secondary engines to provide small changes in velocity and position in orbit. In the Gemini Agena, a control system could handle 96 commands from the astronauts or from ground stations. Agena is used as an upper stage with the Thor, Augmented Thor, Atlas, and Titan boosters; it has played important roles in such military and NASA programs as Discoverer, Samos, Mariner, OGO, Lunar Orbiter, Ranger, Nimbus, and Orbiting Astronomical Observatory.

Specifications

Length 19 to 40 feet depending on version, Gemini version 25 feet; diameter 5 feet; all-inertial guidance.

Performance

Atlas/Agena 5,000 pounds in 300-mile orbit.

BURNER II

Prime Contractor: The Boeing Company

Major Subcontractors: Thiokol Chemical Corporation (solid rocket motor); Honeywell Inc. (preprogrammed inertial guidance system); Walter Kidde & Company (reaction control system)

Remarks

Burner II is a launch vehicle upper stage developed by Boeing for the Air Force Space Systems Division. It is the first solid-fuel upper stage with full control and guidance capability developed for general space applications. Burner II was designed for use with the Thor booster, but it can be readily adapted for use on the complete range of standard launch vehicles. Its general assignment is to place small- and medium-size payloads in orbit. The Burner II motor, guidance system, and reaction control system are integrated to provide attitude stability and precise control of flight rate and burnout velocity for orbital injection and earth-escape missions. Boeing has delivered 8 flight vehicles and, under terms of a follow-on contract, is building 6 additional flight models. Six Thor/Burner II combinations have been launched successfully from Vandenberg Air Force Base, California. The third launch placed 2 unclassified satellites in earth orbit. A SECOR satellite, built for the Army Corps of Engineers by Cubic Corporation, and an Aurora satellite, developed by Rice University for the Office of Naval Research, were placed in circular orbits 2,100 miles above the earth. As integration contractor for the Air Force Space Experiment Support Program Office, Boeing designed, built, and tested the injection stage, or "payload dispenser," which carried the 2 satellites on top of a standard Burner II stage and placed them in precise orbits. The satellites were mounted on opposite sides of the injection stage, which housed a 1,400-pound-thrust, solid-propellant rocket motor.



R-157



LAUNCH VEHICLES

ATHENA REENTRY TEST VEHICLE (STANDARD)

Prime Contractor: Atlantic Research Missile Systems Division

Associate Contractors: Thiokol Chemical Corporation (first-stage propulsion); Thiokol Chemical Corporation and Hercules Incorporated (second-stage propulsion); Aerojet-General Corporation (third-stage propulsion); Hercules Incorporated (fourth-stage propulsion); Atlantic Research Corporation (spin rockets); Hercules Incorporated (boost-assist motors and retro motors)

Remarks

The Athena reentry vehicle simulates the reentry environment of intercontinental ballistic missiles. It has proved to be one of the Air Force's most important research and development programs. Begun in February 1964, the Athena program christened what was to become the first U.S. inland range for overland test of multistage vehicles. Athena is launched from Green River, Utah, along the Army's White Sands Missile Range, reaching altitudes of over 1,000,000 feet before descending some 470 miles downrange. The Army's highly instrumented range had monitored 118 flights by the end of July 1969, in a program of 149 launches. The program is under the direction of the Space and Missile Systems Organization (SAMSO), Air Force Systems Command.

Specifications

Three or 4 stages, all solid propellant; overall length 50 feet; diameter 31 inches; weight 16,000 pounds at launch; unguided boost, midcourse correction.

Performance

Velocity over 15,000 miles per hour at reentry; range over 470 miles; ceiling over 1,000,000 feet; successfully yielding high degree of reentry space physics data and subscale systems test data.

ATHENA H REENTRY TEST VEHICLE

Prime Contractor: Atlantic Research Missile Systems Division

Associate Contractors: Thiokol Chemical Corporation or Aerojet-General Corporation (first-stage propulsion); Thiokol Chemical Corporation and Hercules Incorporated (second-stage propulsion); Aerojet-General Corporation (third-stage propulsion); Atlantic Research Corporation and Thiokol Chemical Corporation (spin rockets); Hercules Incorporated (boost-assist motors and retro motors)

Remarks

The Athena H reentry vehicle is an uprated version of the Standard Athena, capable of flying larger payloads at ICBM velocities over the inland test range from Green River, Utah, to White Sands Missile Range, New Mexico. The program is under the direction of Air Force Systems Command, Space and Missile Systems Organization (SAMSO).

Specifications

Two or 3 stages, all solid propellant; overall length 61 feet; diameter 40 inches; weight 32,000 pounds at launch; unguided boost, midcourse correction.

Performance

ICBM reentry environments for payloads up to 400 pounds, IRBM environments for payloads up to 1,000 pounds; apogees in excess of 1,000,000 feet will be obtained over the 470-mile range.



R-158



APOLLO

Prime Contractor: North American Rockwell Corporation's Space Division

Major Subcontractors: Aerojet-General Corporation (Service Module propulsion engine); Aeronca, Inc. (honeycomb panels); Avco Corporation (ablative heat shield); Beech Aircraft Corporation (super-critical gas storage system); Bell Aerospace Company (positive expulsion tanks for reaction control system); Beckman Instruments, Inc. (data acquisition equipment); Collins Radio Company (communications and data); Control Data Corporation (digital test command system); Dalmo Victor Company (main communications antenna systems); Electro-Optical Systems, Inc., Micro Systems, Inc. subsidiary (temperature and pressure transducer instrumentation); The Garrett Corporation, AiResearch Manufacturing Division (environmental control system); General Motors Corporation (fuel and oxidizer tanks); Singer-General Precision, Inc. (mission simulator trainer); General Time Corporation (central timing system); Honeywell Inc. (stabilization and control); Lockheed Propulsion Company (launch escape and pitch control motors); Micro Systems, Inc., Electro-Optical Systems (pressure and temperature transducers); Motorola, Inc. (up-data link digital); The Marquardt Company (reaction control motors, Service Module); Northrop Corporation (earth landing system); Remanco, Inc. (rocket engine test set); Sciaky Brothers, Inc. (tooling, welding, and machinery); Simmonds Precision Products (propellant gauging mixture ratio control); Thiokol Chemical Corporation (escape system jettison motors); Transco Products, Inc. (telemetry antenna system); United Aircraft Corporation, Pratt & Whitney Aircraft Division (fuel cell); Westinghouse Electric Corporation, Aerospace Electrical Division (static inverter conversion unit); Weber Aircraft (spacecraft couches)

Remarks

Project Apollo, the U.S. program to send men to the moon for scientific exploration and return them safely to earth, reached its apogee in July 1969 with the first lunar landing, accomplished by the astronauts of Apollo 11 (see Events). Plans called for a total of 10 such landings running through calendar year 1972. The spacecraft that makes possible such visits to the moon, certainly the most reliable and most complex machine ever built, is made up of 3 major separable segments, called "modules." They

are the Command and Service Modules, built by North American Rockwell, and the Lunar Module, built by Grumman Aerospace Corporation. Details of each module are covered on the next 2 pages. Design of the Apollo spacecraft got under way in July 1960, some 10 months before President Kennedy formally committed the United States to the goal of a lunar landing within the decade of the sixties. In November 1961, after a series of feasibility studies, the National Aeronautics and Space Administration awarded the basic Apollo contract to North American Rockwell (then North American Aviation). Technical management of the project was assigned to NASA's Manned Spacecraft Center, Houston, Texas. On January 22, 1962, the first Apollo engineering order was issued and 14 months later, on March 12, 1963, the first "boiler-plate" (test model) Command Module was completed and shipped to Marshall Space Flight Center for ground testing. In November 1963, flight tests employing boiler-plate models got under way; the first, a pad abort test, was conducted at White Sands, New Mexico. The first actual Apollo spacecraft was accepted by NASA on October 20, 1965, and was subsequently shipped to Cape Kennedy. There it was launched, on February 26, 1966, on an unmanned test designed primarily to check out the Apollo engine, the Service Module's thrusters, and the Command Module's heat shield. A second unmanned Apollo spacecraft test was conducted in 1966 as was a separate test of the launch vehicle's upper stage without spacecraft (these first 3 flights would have been designated Apollo 1, 2, and 3 under the current system, but NASA used more complicated designations at the time). Apollo 4, an unmanned mission and the first using the Saturn V booster, was a complete success on November 9, 1967. On January 22, 1968, NASA flew the Lunar Module on a solo test (Apollo 5) and followed with Apollo 6 on April 4, 1968, essentially a double check of Apollo 4. On October 11-22, 1967, the first human crew thoroughly checked out a Command and Service Module basic spacecraft on Apollo 7. On Apollo 8, December 21-27, 1968, another crew made the first lunar orbit mission, again using the 2-module combination. The first test of the complete 3-module spacecraft came on Apollo 9, March 3-13, 1969; it was followed by a 3-module lunar orbit mission without landing, Apollo 10, May 18-26, 1969. The epochal Apollo 11 was followed in November 1969 by a second manned lunar landing.



COMMAND MODULE

Prime Contractor: North American Rockwell Corporation's Space Division

Remarks

The Command Module is the control center of the Apollo spacecraft, the living, working, and leisure-time quarters for the 3-man crew. The astronauts remain in the Command Module throughout a mission except for the lunar exploration period during which the spacecraft commander and the Lunar Module pilot descend to the moon while the Command Module pilot flies his basic spacecraft (Command and Service Modules) solo. The structure consists of 2 basic structures joined together: an inner structure, or pressure shell, encasing the crew compartment; and an outer shell, or heat shield, covered with ablative material and capable of withstanding friction temperatures of over 5,000 degrees Fahrenheit. The crew compartment has a habitable volume of 210 cubic feet. Focal point of the module is the 3-position console complex containing flight controls and informational displays.

Specifications

Shape conical; height 10 feet 7 inches; diameter (at base) 12 feet 10 inches; launch weight (approximate, varies with mission) 12,200 pounds including crew; splashdown weight 11,700 pounds; outer structure stainless steel honeycomb bonded between stainless steel alloy sheets; inner structure primarily aluminum honeycomb bonded between aluminum alloy sheets; insulation 2-layer microquartz fiber insulation separating the walls of the inner and outer structures; environment shirt-sleeve temperature of about 70 degrees, 100 percent oxygen during flight; 12 thrusters (fuel monomethyl hydrazine, oxidizer nitrogen tetroxide), used only for reentry; thruster propellant load 270 pounds.



SERVICE MODULE

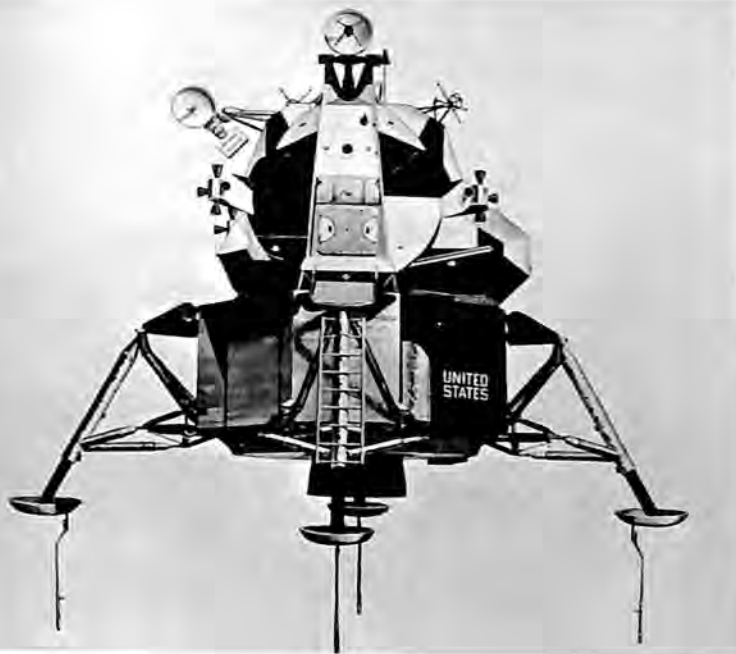
Prime Contractor: North American Rockwell Corporation's Space Division

Remarks

The Service Module, nonhabitable, is the support element of the basic spacecraft, containing the main propulsion system and supplying most of the spacecraft's consumables (oxygen, water, propellants, hydrogen). The Service Module remains attached to the Command Module until just before reentry, when it is jettisoned to be destroyed by atmospheric heating. The structure is a simple one, consisting of a center section, or tunnel, surrounded by 6 wedge-shaped sectors. The bell-shaped nozzle of the main Apollo engine (details under Engines, Rocket) protrudes below the cylindrical frame. Contained within the wedge-shaped sectors are the various fuel and oxidizer tanks and the electrical power, environmental control, and telecommunications systems. On the exterior of the frame are 16 thrusters used throughout the mission for attitude changes and minor course corrections.

Specifications

Height 24 feet 9 inches; diameter 12 feet 10 inches; launch weight 52,800 pounds; weight (less propellants) 10,500 pounds; construction mostly of aluminum alloy; outside skin honeycomb bonded between aluminum sheets, interior radial beams solid aluminum chemically milled to thicknesses from .018 inch to 2 inches; propellant load for main engine (known officially as the Service Propulsion System) 15,750 pounds fuel (aerozine 50), 25,200 pounds oxidizer (nitrogen tetroxide); propellants hypergolic (ignite on contact); propellant load for thrusters 1,350 pounds.



LUNAR MODULE

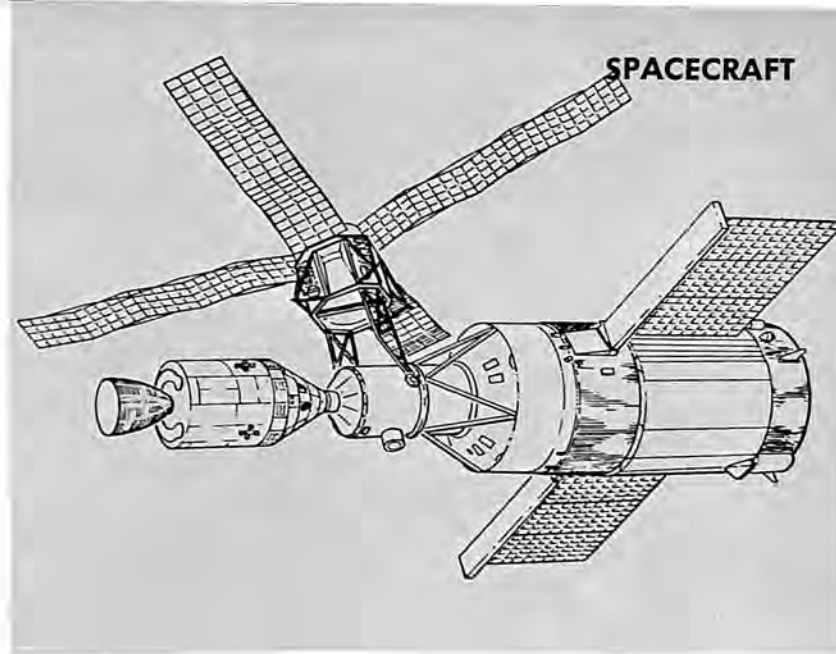
Prime Contractor: Grumman Aerospace Corporation

Remarks

The Lunar Module is a 2-stage vehicle used by Apollo astronauts for the descent from lunar orbit to the surface of the moon, and for the ascent from the lunar surface back to the orbiting Command Module. Unsymmetrical, and with no aerodynamic considerations imposed upon its structural design, LM lands by use of a main descent engine which is throttleable and capable of developing approximately 10,000 pounds of thrust. Vehicle orientation is provided by 16 100-pound-thrust rocket engines located in quads at 4 locations on the ascent stage. The LM can land in the automated mode, using a landing radar as the sensing device and a computer to update engine thrust; or it can be controlled by the astronauts, either completely or in conjunction with the automated devices. Its landing gear consists of 4 padded legs. The lower portion of the legs telescopes into the upper portion, crushing a honey-comb structure which absorbs the energy of the landing impact. When LM is ready to return to the Command Module, its 3,500-pound-thrust ascent engine carries the ascent stage into lunar orbit, leaving the descent stage on the lunar surface.

Specifications

Height 23 feet 1 inch; width 31 feet diagonally across landing legs; launch weight (approximate, varies with mission) 32,500 pounds; dry weight 9,150 pounds; pressurized volume 235 cubic feet; habitable volume 160 cubic feet; dry weight 4,850 pounds (ascent stage), 4,300 pounds (descent stage); propellants 5,186 pounds (ascent stage), 18,049 pounds (descent stage), 606 pounds (thruster).



APOLLO APPLICATIONS PROGRAM

Program Direction: Marshall Space Flight Center, NASA (launch vehicles and cluster elements); Manned Spacecraft Center, NASA (Apollo Command/Service Modules)

Prime Contractors: Martin Marietta Corporation (integration contractor to Marshall SFC for cluster); McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation (manufacture of Orbital Workshop and airlock)

Remarks

Apollo Applications, a follow-on to the lunar landing program, is designed to make maximum use of the hardware and techniques developed in the Apollo project. The program involves manned habitation and experimentation in an earth-orbital cluster of spacecraft which is in effect a space station. Prime element of the cluster is the Orbital Workshop (photo), a modified S-IVB stage. Attached to the workshop is a Multiple Docking Adapter and an Airlock Module which will permit the crew to exit without depressurizing the workshop. The Multiple Docking Adapter has ports for the workshop, for the Apollo Telescope Mount, and for the Apollo Command/Service Module spacecraft which will ferry the astronauts. The Apollo Telescope Mount includes a rack of several telescopes mounted in a 7-foot-diameter cylindrical structure. Mission sequence is as follows: a Saturn V will launch the entire cluster, weighing 130,000 pounds, as an unmanned space station; a day later a 3-man crew in an Apollo spacecraft will be launched into similar orbit for rendezvous and hookup with the Multiple Docking Adapter; the crew will occupy the workshop, conduct experiments, and man the ATM for 28 days, then return to earth in the Command Module. Later there will be 2 revisits to the cluster of up to 56 days duration. First launch will be in 1972.



BIOSATELLITE

Prime Contractor: General Electric Company, Reentry and Environmental Systems Division
 Associate Contractors: Garrett AiResearch (cryogenics system); Hamilton Standard (gas management); GE Direct Energy Conversion Operation (fuel cells)

Remarks

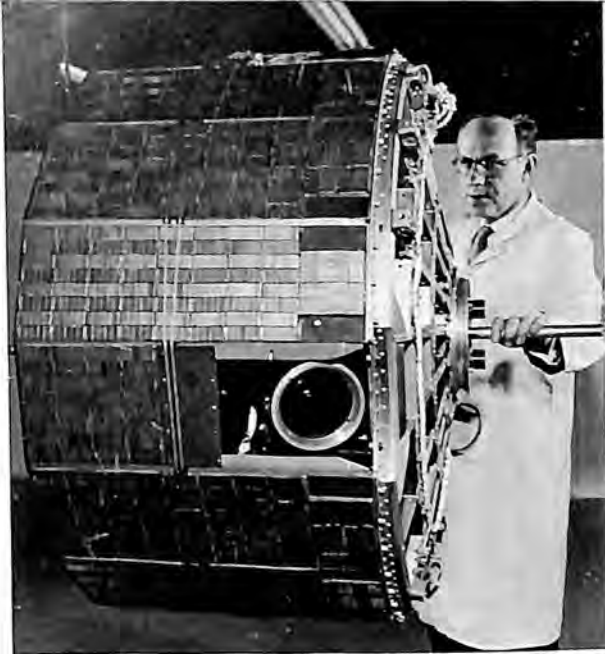
Biosatellite is the first U.S. spacecraft designed to demonstrate the effects of prolonged space travel on terrestrial life. NASA's Ames Research Center selected General Electric to develop and build the Biosatellite vehicles. The program is aimed at studying the effects of extended exposure to weightlessness and radiation on a variety of biological specimens ranging from tiny single-cell organisms to monkeys. All payloads are recoverable. Payload weights range from 940 to 1,535 pounds depending on the specific mission. A Thrust Augmented Improved Delta booster is the launch vehicle. Rate gyros and cold gas jets provide attitude control in all 3 axes; telemetry is real time and tape recording readout; power is by batteries and Gemini-type fuel cells; an ablating heat shield protects the vehicle through reentry. Initial 3-day flight was in December 1966, but the payload was not recovered. The second flight, a 2-day mission in September 1967, was successful; the payload was recovered by USAF air snatch. In June 1969, Biosatellite 3, carrying a monkey, was launched for an intended 15- to 30-day orbit. The recovery capsule was called down after 9 days, however, and the monkey died shortly thereafter. A major portion of the Biosatellite remained in orbit and provided long-duration (38 days) data for such spacecraft functions as fuel cell power, attitude control, telemetry, and tracking and command.

NIMBUS

Program Direction: Goddard Space Flight Center, NASA
 Spacecraft Contractor: General Electric Company, Space Systems Organization

Remarks

Nimbus is a second-generation research and development atmospheric observatory; Nimbus 3 (photo) is the latest version. Launched April 14, 1969, Nimbus 3 is butterfly-shaped, measures 10 feet by 11 feet, and weighs 1,268 pounds. From its nearly polar sun-synchronous circular orbit 690 miles above the earth, Nimbus 3 studies the earth's atmospheric structure. Its mission is to study spatial and temporal distribution of the atmospheric structure, particularly temperature; to determine temporal variations in the solar radiation in the near ultraviolet; and to demonstrate the spacecraft's capability of handling multiple experiments. Experiments aboard the satellite are designed to measure the atmosphere's vertical temperature, water vapor, and ozone distribution; to demonstrate the feasibility of using a satellite to locate and interrogate sensors (located on balloons, buoys, aircraft, animals, and fixed platforms); to take infrared photos of the earth in darkness with a resolution of about 5 miles at picture center; to measure the earth's radiation balance, which could affect weather, and the ultraviolet radiation flux from the sun in 5 relatively broad bands; and to take daytime pictures of the entire earth. Nimbus 3 is also conducting experiments to evaluate the performance of a nuclear power system (SNAP-19). Scientists believe that information from Nimbus 3 and future Nimbus satellites may hold the key to reliable, long-range computerized weather prediction. Nimbus 3 was preceded into orbit by Nimbus 1, launched August 28, 1964, and Nimbus 2, orbited May 15, 1966.



TIROS

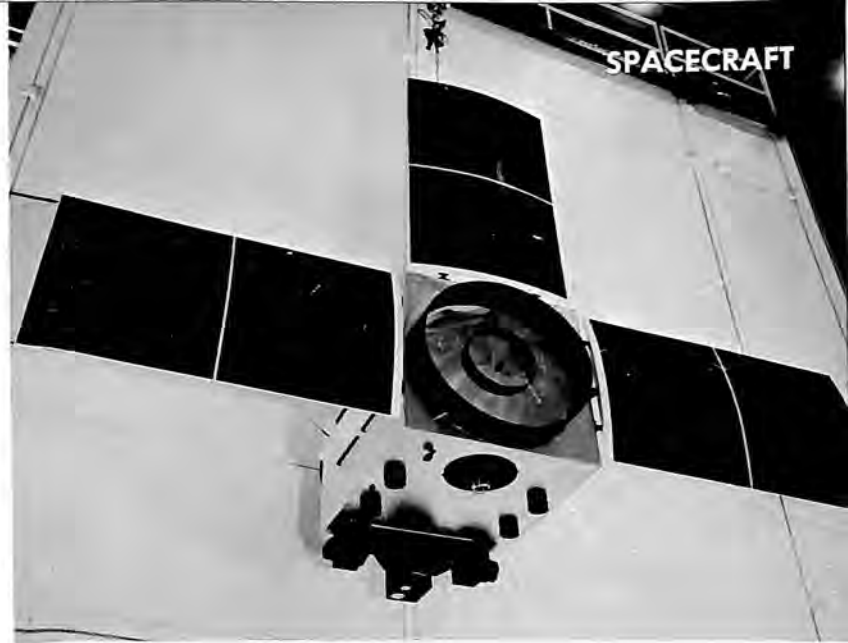
Prime Contractor: RCA, Defense Electronic Products, Astro-Electronics Division

Remarks

One of the most successful of all U.S. space programs, Tiros paved the way for operational observation of the weather from space. Equipped with TV cameras and infrared equipment, Tiros took photos of the earth's cloud cover and relayed them to earth stations. A later version was the Tiros "wheel," which was maneuvered to roll in orbit like a drum rolling downhill; its 2 TV cameras were positioned radially so that with each half turn of the wheel one of the cameras looked down at earth. Tiros led to the present generation of ESSA satellites.

Specifications

Diameter 42 inches; weight approximately 300 pounds.



TIROS M

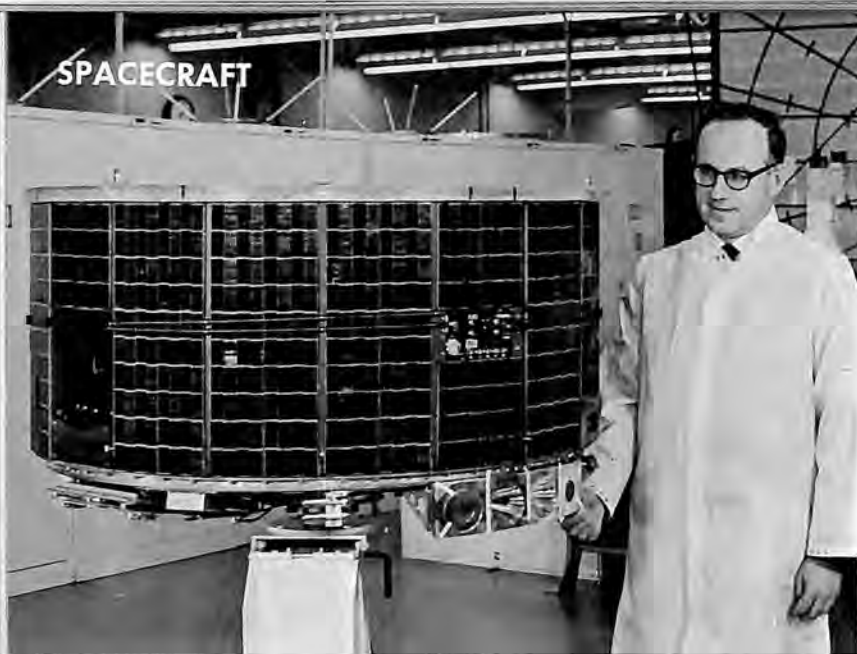
Prime Contractor: RCA, Defense Electronic Products, Astro-Electronics Division

Remarks

A second-generation follow-on to the Tiros Operational System (TOS) weather satellites, Tiros M is being developed by RCA for NASA's Goddard Space Flight Center. Eventual user and sponsor of the satellite after it becomes operational will be the Environmental Science Services Administration. The first Tiros M research and development flight was scheduled for 1970. One Tiros M carries both Automatic Picture Transmission (APT) systems for direct readout of local weather pictures and Advanced Vidicon Camera Systems (AVCS) for global coverage. A stable platform that keeps its sensors pointed always toward earth, Tiros M also carries high-resolution infrared radiometers for nighttime views of cloud cover, 2 secondary sensors, a flat-plate radiometer, and a solar proton monitor. A single Tiros M will provide the coverage offered by 2 present TOS/ESSA spacecraft. Tiros M is also designed as a space bus that can accommodate a wide variety of other sensors and instrumentation.

Specifications

Dimensions 48 by 40 by 40 inches, with 3 solar panels, each 36 by 63 inches; weight approximately 670 pounds.



ESSA

Prime Contractor: RCA, Defense Electronic Products, Astro-Electronics Division

Remarks

ESSA (Environmental Survey Satellite), the world's first global operational weather satellite, is designed and built by RCA under the technical direction of NASA's Goddard Space Flight Center for the Environmental Science Services Administration, of which the U.S. Weather Bureau is a division. The first ESSA satellite was launched successfully on February 3, 1966. It carried 2 conventional Tiros-type television cameras in a rolling-wheel configuration. ESSA 2 was launched successfully February 28, 1966, using 2 Automatic Picture Transmission (APT) cameras which enabled it to broadcast weather pictures to local stations around the world. It also rolled like a wheel in its orbital path. ESSA 3, launched October 2, 1966, replaced ESSA 1 and featured an Advanced Vidicon Camera System (AVCS); it, too, operates in a wheel mode. ESSA 4 (APT), ESSA 5 (AVCS), and ESSA 6 through ESSA 9 have also joined the operational system. The satellites are known as Tiros Operational System (TOS) satellites until they achieve orbit, when they acquire the ESSA designation.

Specifications

Right circular cylinder 42 inches in diameter, 22.5 inches high; weight 325 pounds.



EARTH RESOURCES TECHNOLOGY SATELLITE (ERTS-A AND -B)

Program Direction: Goddard Space Flight Center, NASA

Remarks

Potentially one of the most important of all spacecraft projects, the Earth Resources Technology Satellite is the first step in a research and development program leading toward an operational system of earth resources survey satellites. Such a system will offer tremendous practical benefits in hydrology, agriculture, public health, oceanography, mineral exploration, and a wide variety of other fields. In addition to NASA, the Navy and the Departments of Agriculture, Interior, and Commerce are involved in the ERTS program. At year-end 1969, ERTS was still in design competition status with selection of a contractor for first hardware expected by the end of fiscal 1970. Initial program includes construction of 2 experimental spacecraft known as ERTS-A and -B, the first to be launched early in 1972. Specifications call for a sun-synchronous satellite operating in a circular orbit at an altitude of 496 nautical miles. To be launched by a Long Tank Delta, ERTS-A and -B will have an overall weight of about 1,000 pounds, including at least 450 pounds of payload including sensors and other electronic equipment. Externally, ERTS may resemble existing spacecraft, since competing contractors based some of their designs on contemporary satellites. In photo, ERTS based on a modified Nimbus, a design submitted by General Electric Company.

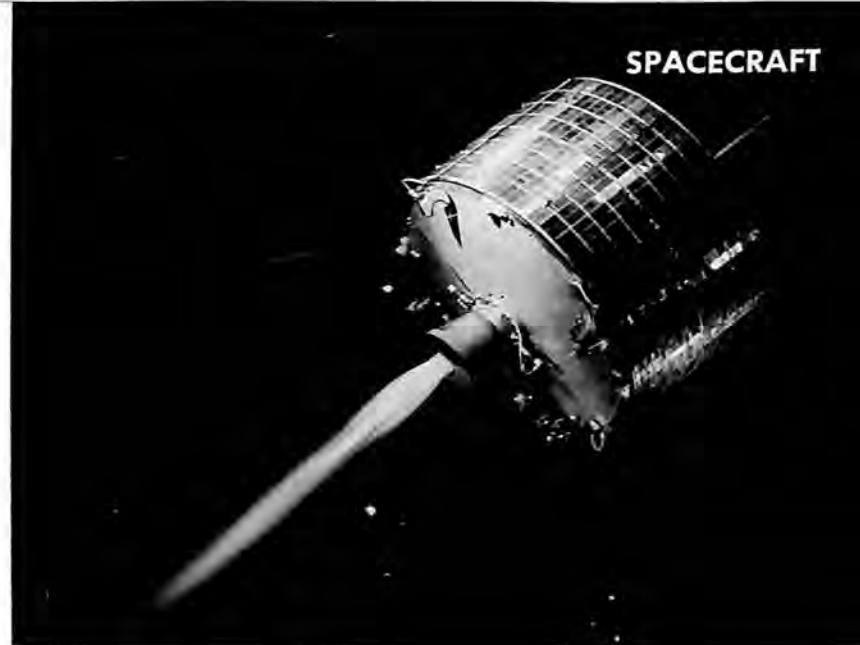


EARLY BIRD

Prime Contractor: Hughes Aircraft Company

Remarks

A synchronous communications satellite, Early Bird was launched April 6, 1965, by the Communications Satellite Corporation as agent for a world consortium of more than 40 participating nations. The satellite was injected into a synchronous orbit 22,300 miles above the equator over the Atlantic Ocean. The 85-pound spacecraft has capacity for 240 2-way telephone channels or simultaneous 2-way television between Europe and North America on a 24-hour-day basis. It can also handle teletype and facsimile and carry telephone conversations at the same time. Power is supplied by some 6,000 solar cells. The satellite is a later version of the NASA/Hughes Syncom. Early Bird is kept on standby status. It was reactivated on June 30, 1969, when an Intelsat 3 malfunctioned temporarily; it was used to handle traffic between North America and Europe. Early Bird was retired again when the Intelsat 3 resumed normal service.



SYNCOM

Prime Contractor: Hughes Aircraft Company

Remarks

A second-generation active-repeater communications satellite, Syncom is a synchronous orbiting spacecraft, one with an orbital speed just matching that of the earth's rotation so that the satellite remains in a fixed position with respect to a point on earth. To achieve the proper velocity, the satellite is sent into orbit at an altitude of 22,300 miles. From that altitude, over a third of the earth can be "seen"; thus, 3 of the spacecraft can form a TV-telephone network providing 24-hour-a-day service. Syncom 1, launched February 14, 1963, was unsuccessful. Syncom 2, launched July 26, 1963, was completely successful and was the first spacecraft to achieve synchronous orbit. Syncom 3, launched August 19, 1964, was placed in stationary orbit over the International Date Line; it relayed the Olympic Games from Japan to the United States.



INTELSAT 2

Prime Contractor: Hughes Aircraft Company

Remarks

Intelsat 2 is a new communications satellite designed to provide the first regular transpacific communications by satellite as well as communications support for the Apollo program. Hughes built 5 spacecraft under an \$11,700,000 contract awarded by the Communications Satellite Corporation, which acts as manager for the International Telecommunications Satellite Consortium. Intelsat 2 is twice the size and weight of the Hughes Early Bird and has 3 times the power of Early Bird. Early Bird's antenna concentrated its beam in a narrow band between Europe and the United States, whereas Intelsat 2 offers broader antenna coverage over a wider global area and has the ability to carry multiple conversations among ground stations simultaneously. Two of the satellites are now in commercial service, one over the Pacific and one over the Atlantic. The first Pacific satellite, F-2, launched January 11, 1967, was retired from service by Comsat on February 20, 1969. A fifth spacecraft, F-5, is in storage at a Comsat facility in Maryland.

Specifications

Diameter 56 inches; height 26 inches.

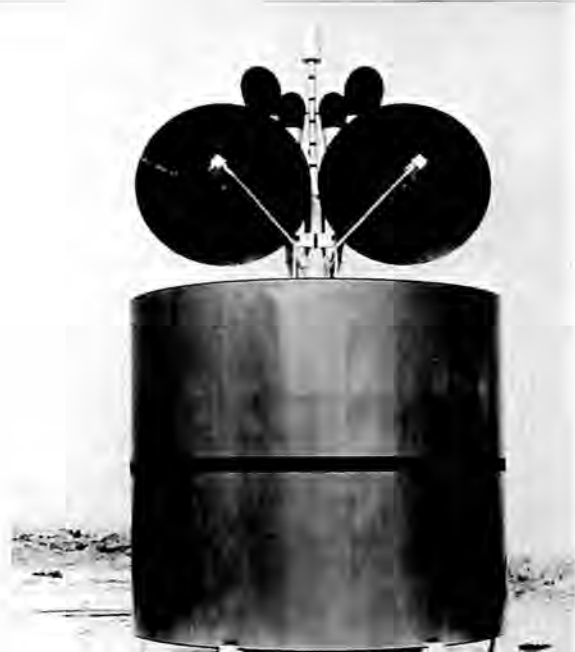
INTELSAT 3

Prime Contractor: Systems Group of TRW Inc., for Communications Satellite Corporation (Comsat)

International Participants: Aerojet-General Corporation, United States; Contraves AG, Switzerland; Engins MATRA SA, France; Entwicklungsring Nord (ERNO), West Germany; Hawker Siddeley Dynamics Ltd. (HSD), United Kingdom; ITT Defense Communications Division, United States; Lockheed Aircraft Corporation, United States; Mitsubishi Electric Corporation (MEC), Japan; Société Anonyme de Telecommunications (SAT), France; Sylvania Electronic Systems, United States

Remarks

Intelsat 3 is the first wholly commercial communications satellite system to operate on a global scale; it began operational service in 1969. TRW was assigned contracts for 8 flight spacecraft. Each spacecraft handles a maximum of 1,200 2-way voice channels or 4 high-quality television channels. The spin-stabilized spacecraft are positioned in synchronous orbit (22,300 miles) over the Pacific, Atlantic, and Indian oceans, as required. They are 56 inches in diameter and 78 inches high and weigh about 270 pounds, not including the apogee motor. At year-end, the operational network included 4 Intelsat 3 spacecraft.



INTELSAT 4

Prime Contractor: Hughes Aircraft Company

Remarks

Intelsat 4, the world's largest commercial communications satellite, is scheduled for launch from Cape Kennedy, Florida, in 1971. The new satellite will be nearly 8 feet in diameter and 17.5 feet high. Four flight spacecraft and one prototype will be constructed under direction of the Communications Satellite Corporation, which acts as manager for the 68-nation International Telecommunications Satellite Consortium. The satellite will be launched into a 22,300-mile synchronous orbit by an Atlas/Centaur rocket. Companies from 10 nations have been enrolled as major subcontractors to assist Hughes in the fabrication and testing of the satellites. Intelsat 4 offers 25 times more potential communication volume than any satellite in service and more capacity than all comsats in combined operation. The spacecraft is designed to carry more than 5,000 2-way telephone calls, transmit 12 simultaneous color TV broadcasts, or handle any combination of different kinds of communication transmissions.

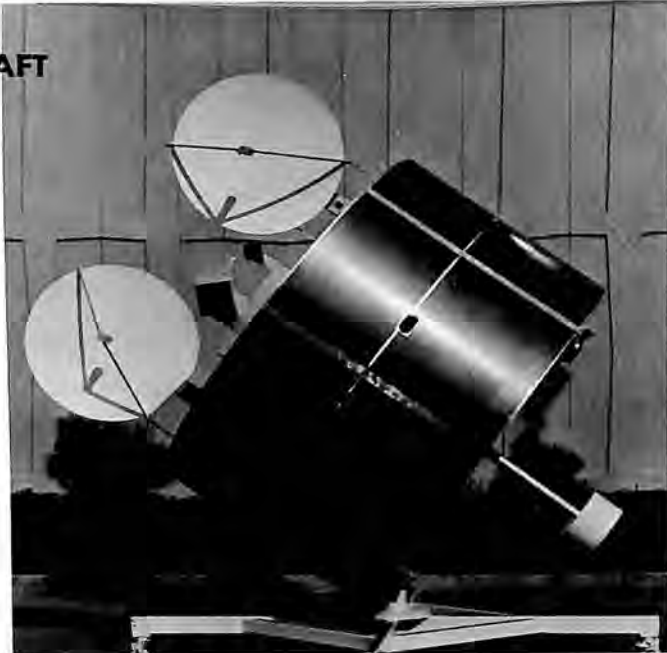


INITIAL DEFENSE SATELLITE COMMUNICATIONS SYSTEM

Prime Contractor: Space and Re-Entry Systems Division, Philco-Ford Corporation

Remarks

In late October 1964, Philco-Ford Corporation was assigned prime contractor responsibilities for designing, developing, and assembling the satellites and the multiple-launch dispensers for the Initial Defense Satellite Communications System. Overall program direction is by the Defense Communications Agency; the space hardware portion of the program is the responsibility of the Air Force Space Systems Division, assisted by The Aerospace Corporation. On June 16, 1966, an Air Force Titan IIC rocket launched 7 IDSCS satellites (plus a gravity-gradient experimental satellite) into near-synchronous equatorial orbit at an altitude of approximately 21,000 statute miles to initiate the network—19 months from the start of hardware design. On January 18, 1967, 8 additional satellites were launched and on July 1, 1967, 4 more were sent into orbit. On June 13, 1968, 8 more satellites were placed in orbit, bringing the total in space to 26. In photo, Titan IIC Transtage kicks satellites into orbit, one at a time.



DEFENSE SATELLITE COMMUNICATIONS SYSTEM PHASE II

Prime Contractor: Systems Group of TRW Inc.

Remarks

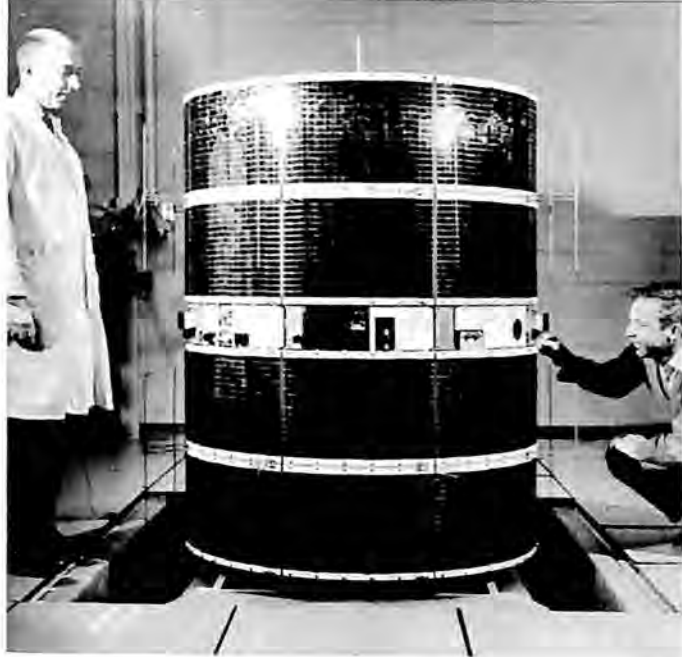
In 1969, the Air Force Space and Missile Systems Organization contracted with TRW Inc. for development of a new series of military comsats for Phase II of the Defense Satellite Communications System. The satellites will eventually replace those in the Initial Defense Satellite Communications System. The Phase II satellites will operate at synchronous altitude—22,300 miles—and will provide the Department of Defense with 2 significant capabilities not available in the initial comsat system: they will enable continuous and instantaneous communications around the earth and they will enable large volume communications between small transportable ground terminals operating in a theater or contingency area. The satellites will be launched in pairs. Each will weigh about 980 pounds and measure 9 feet in diameter and 12 feet in height. Outer perimeters will be covered with solar cells to generate 520 watts of power. The spacecraft will be spin-stabilized with an internal despun platform which mounts the communications repeaters and antennas. Four communication antennas will be mounted atop each satellite with a command/telemetry antenna on a boom extending from the bottom. Two large dish antennas will provide narrow beams for communications between and within regions of high traffic density. TRW is building 6 flight satellites. Although the USAF announced no launch target date, effective continuance of the comsat network dictates first launch in 1971-72 because of the 6-year maximum life of the satellites in the Initial Defense Satellite Communications System. This means that, of the 26 IDSCS satellites launched, only the last 8 (launched in 1968) will be operating by 1972-73.

TACSAT

Prime Contractor: Hughes Aircraft Company

Remarks

TACSAT is an experimental tactical communications satellite built for the Air Force by Hughes. The satellite is designed to provide tactical communications among military units in the field, aircraft, and ships at sea. As tall as a 2-story house, TACSAT is the largest communications satellite built; it weighs 1,600 pounds. The spacecraft carries a cluster of antennas whose powerful signals can be picked up by all types of terminals, including those with antennas as small as 1 foot in diameter. The spin-stabilized satellite carries 3 antenna systems: 5 helical UHF antennas, 2 microwave horns for X-band communications, and a biconical horn for telemetry and command. Built under contract with the USAF's Space and Missile Systems Organization, TACSAT was launched February 9, 1969, into a 22,300-mile synchronous orbit by a Titan IIC launch vehicle. It is in geo-stationary orbit above the Pacific. The satellite was used as a communications relay during the Apollo 11 lunar-landing mission and relayed television coverage of the moon landing to Alaska via a portable earth station at Anchorage.



LINCOLN EXPERIMENTAL SATELLITES

Prime Contractor: Massachusetts Institute of Technology Lincoln Laboratory

Remarks

The LES (Lincoln Experimental Satellite) spacecraft are designed and built by the MIT Lincoln Laboratory, Lexington, Massachusetts, as a part of the laboratory's Air Force-sponsored program in space communications. The spacecraft test realistically, in orbit, advanced devices and techniques developed for possible use in military satellite communication systems. LES-1, LES-2, and LES-4, launched in 1965, operated at X-band (approximately 8,000 MHz) and included the first all-solid-state communication satellite transmitters and the first "electronically despun" (earth-sensing and antenna beam switching) systems. LES-3, a UHF-band radio signal generator launched in December 1965, helped to establish design criteria for LES-5 and LES-6, the first communication satellites to operate entirely in the government-allocated UHF band (225 to 400 MHz). Their UHF-band satellite antenna systems are the first to generate circularly polarized radio signals for minimizing fading and communications dropouts; the surface terminal can use a very small, simple antenna such as a whip or stub monopole. LES-5, launched in July 1967, and LES-6, launched in September 1968, are used in triservice test programs in the development of a Tactical Satellite Communications (TACSATCOM) system for the Department of Defense. LES-6 (photo) has the first UHF-band switched-beam, electronically despun antenna system; a unique power-optimized UHF-band power amplifier chain; and the first completely autonomous east-west station-keeping system with the first useful long-life electrically powered thruster system to operate on a satellite or space vehicle.



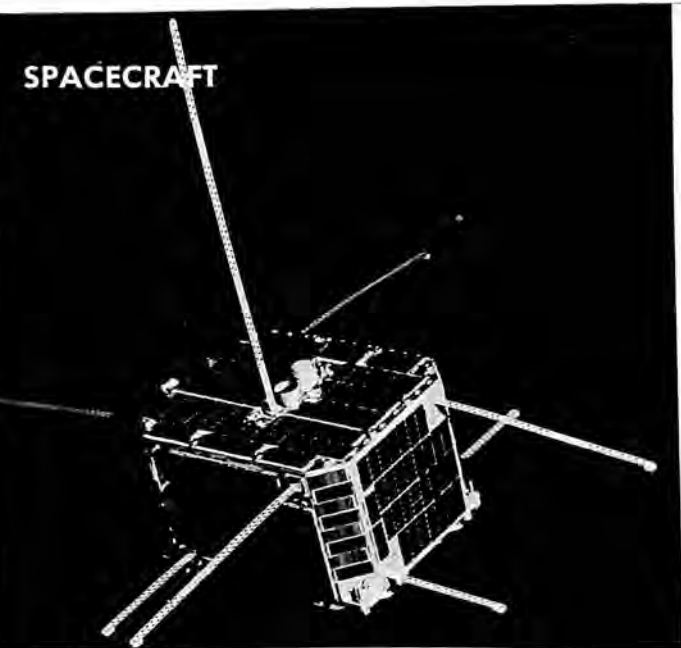
SPACECRAFT

NAVIGATION SATELLITE

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory
Associate Contractor: RCA, Defense Electronic Products, Astro-Electronics Division

Remarks

A system of satellites in a 600-nautical-mile polar orbit, the Navigation Satellites provide precise navigation fixes for Navy fleet vessels and for commercial ships. The satellites enable vessels equipped with shipboard user equipment to compute their positions with accuracy to within 600 feet, as compared with 2 to 4 miles when conventional navigation techniques are used. Worldwide position fixes are also possible with the satellites regardless of time of day or weather conditions. In addition to the spacecraft, the system consists of ground tracking stations and the shipboard receiving equipment and associated computer. The ground stations track and compute the orbit of the satellites and send the data to the orbiting spacecraft, which stores the information and then broadcasts it to earth once every 2 minutes. As the satellite passes within the range of a ship, the signals it sends earthward are received by the shipboard equipment. The change in frequency of the signals is measured and, along with the satellite position data, is fed into the computer which in turn calculates the ship's position. A constellation of several Navigation Satellites in different orbits is maintained by the Navy to provide navigation fixes to any given ship anywhere on the world's seas at intervals no more than 90 minutes apart.

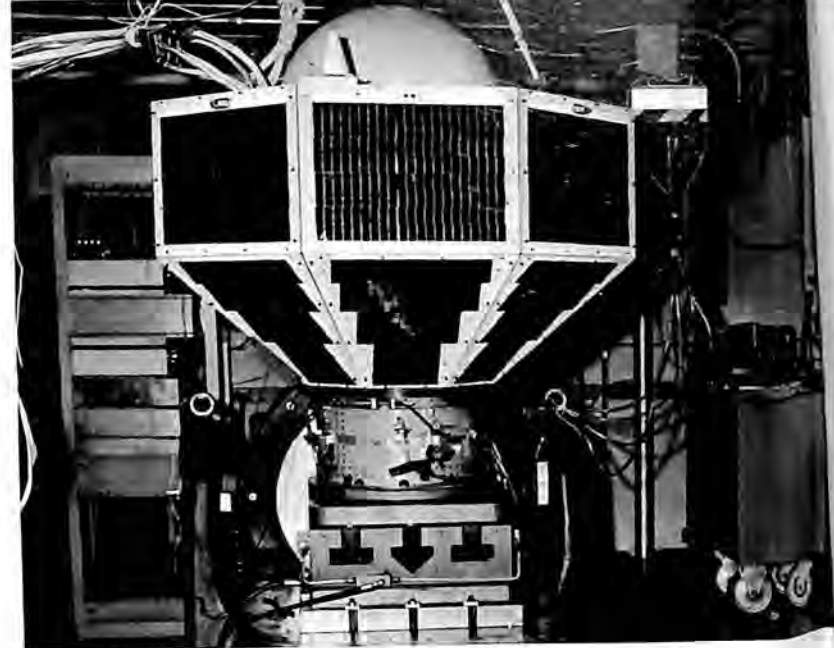


GEODETIC SECOR

Prime Contractor: Cubic Corporation

Remarks

Geodetic SECOR (Sequential Collation of Range) is an all-weather geodetic survey system in operational use for establishing a global survey network. It uses the successive positions of artificial satellites in space to determine locations on the earth's surface with exactness over long distances. The system consists of a satellite and 4 ground stations, 3 at geographical points whose coordinates have been surveyed accurately and the fourth at an unknown location. Radio waves are flashed from the ground stations to the satellite and returned. The position of the satellite at any given time is fixed by the measured ranges from the 3 known stations. With precisely established satellite positions as a base, ranges from the satellite to the unknown station are used to compute the position of the unknown station. Geodetic SECOR allows continents and islands to be brought within the same geodetic global grid. Each ground station is entirely portable and contains 3 units: a radio-frequency shelter, a data-handling shelter, and a storage shelter. Lighter-weight, solid-state equipment is being developed to replace these units. The present satellite has a volume of 1 cubic foot, weighs approximately 39 pounds, and contains a transponder, a telemetry system to monitor temperature and operating voltages, and a power unit consisting of solar panels and batteries.



GEOS 2

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

GEOS 2 is designed to contribute to the development of a more precise model of earth's gravitational field and to improve knowledge of the size and shape of the earth by establishing the location of a set of worldwide tracking stations whose positions are known with an accuracy of 36 feet or better in a unified geocentric coordinate system. The 52-inch-diameter, 460-pound satellite was launched January 11, 1968, from the Western Test Range aboard an Improved Delta launch vehicle. It carries 6 geodetic systems: flashing light beacons, Navy radio Doppler system, Army radio range transponder, NASA range and range rate transponder, 2 C-band transponders, and laser corner reflector panels. The satellite is gravity-gradient stabilized. Heat pipes are used to balance temperatures between the transponders. GEOS 2 was launched to contribute to the completion of the NASA-managed National Geodetic Satellite Program (NGSP). The program was designed to satisfy the nation's requirements in satellite geodesy. It is a coordinated undertaking involving NASA, the Department of Commerce (Coast and Geodetic Survey), and the Department of Defense as well as many nongovernmental scientists and organizations. Scientists of other nations also participate in NGSP. NASA's Office of Space Science and Applications has overall responsibility for GEOS 2.



LINCOLN CALIBRATION SPHERE (LCS)

Prime Contractor: Massachusetts Institute of Technology Lincoln Laboratory
Associate Contractor: Rohr Corporation

Remarks

The Lincoln Calibration Sphere is a rigid, hollow aluminum sphere with a projected area of exactly 1 square meter and a polished surface that is exactly spherical to within a few thousandths of an inch. In orbit, it serves as a durable, stable primary standard for direct calibration of large radio and radar systems, reducing uncertainties in estimated system sensitivity from several decibels to a few tenths of a decibel. LCS weighs 75 pounds and is made of $\frac{1}{8}$ -inch aluminum sheet stock, spun into 2 hemispheres which are joined to an internal equatorial band by 440 equally spaced aluminum screws and then machined from a precision template and hand polished to a high gloss. LCS was designed by the MIT Lincoln Laboratory, Lexington, Massachusetts, under Air Force contract with support from the Advanced Research Projects Agency of the Department of Defense; it was fabricated by Rohr Corporation. LCS-1 was launched from Cape Kennedy May 6, 1965, aboard a USAF Titan IIIA into a circular, 32-degree-inclination orbit at an altitude of 1,500 nautical miles. Post-launch radar observations confirmed pre-launch measurements. Launch problems have frustrated subsequent efforts to place LCS-2 and LCS-3 in lower-altitude orbits, where they would be accessible and useful to a larger number of radar facilities than is LCS-1.



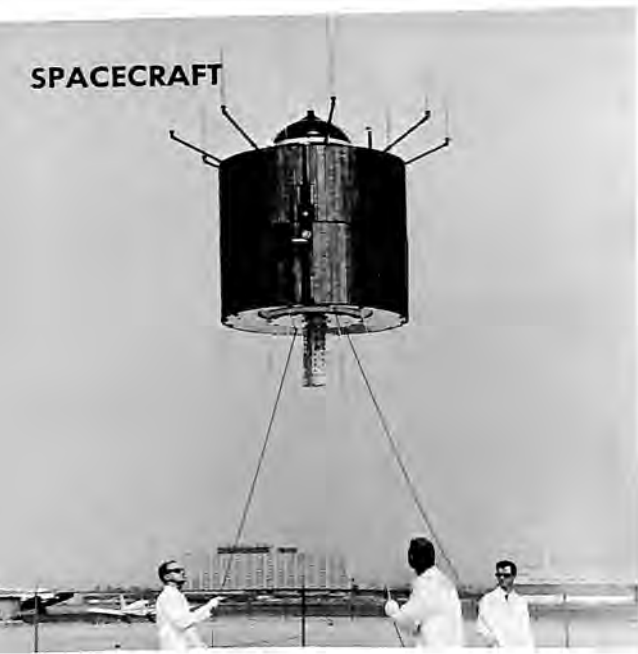
NUCLEAR DETECTION SATELLITES (VELA)

Prime Contractor: Systems Group of TRW Inc.

Remarks

Vela Nuclear Detection Satellites are launched in pairs into high-altitude orbits to detect possible nuclear explosions in space and on earth. The project is directed by the Advanced Research Projects Agency of the Department of Defense; the USAF Space and Missile Systems Organization is responsible for development of the spacecraft. The first pair of satellites was launched in October 1963, the second in July 1964, and the third in July 1965. The fourth launch, in April 1967, was the first of an advanced pair of Velas. These identical, 26-sided polygons, 56 inches in diameter and 46 inches high, weigh 509 pounds in orbit. Another Vela pair, with further improvements to the payload, was launched June 21, 1969. A sixth pair was scheduled for 1970 launch.

SPACECRAFT

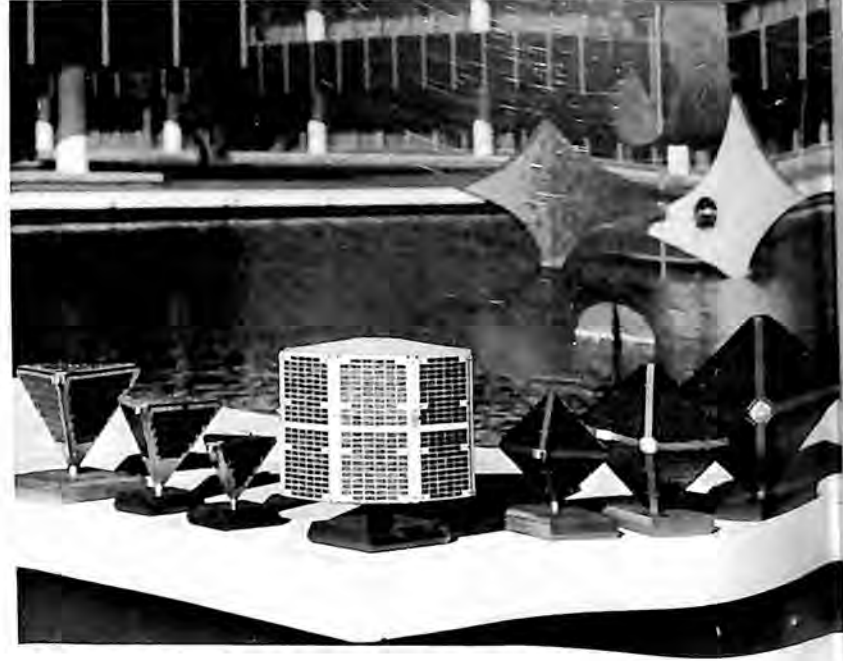


APPLICATIONS TECHNOLOGY SATELLITES

Prime Contractor: Hughes Aircraft Company

Remarks

The Applications Technology Satellites are spacecraft whose mission is to improve the capabilities of other spacecraft, specifically the ability of future satellites to provide weather, communications, earth resources survey, navigational, and other types of informational services. The first-generation ATS consisted of 5 satellites, launched between December 1966 and August 1969; some of them were still returning data at year-end 1969 and were expected to do so for some time. The Hughes-built spacecraft were launched into both synchronous (22,300 miles) and medium-altitude orbits. The spacecraft are of 2 basic types, one spin-stabilized, the other stabilized by gravity-gradient systems. The latter are equipped with 100-foot booms. The first-generation spacecraft are barrel-shaped, with a diameter of 56 inches; they weigh from 650 to 790 pounds. The second-generation spacecraft, known tentatively as ATS-F and -G, were in design status at year-end 1969. To be built by a different contractor, they will pursue the same general line of research in advanced areas. The spacecraft will carry a very large in-space antenna measuring 30 feet in diameter; they will weigh approximately 1,500 pounds. Launches were scheduled for 1972 and 1973.

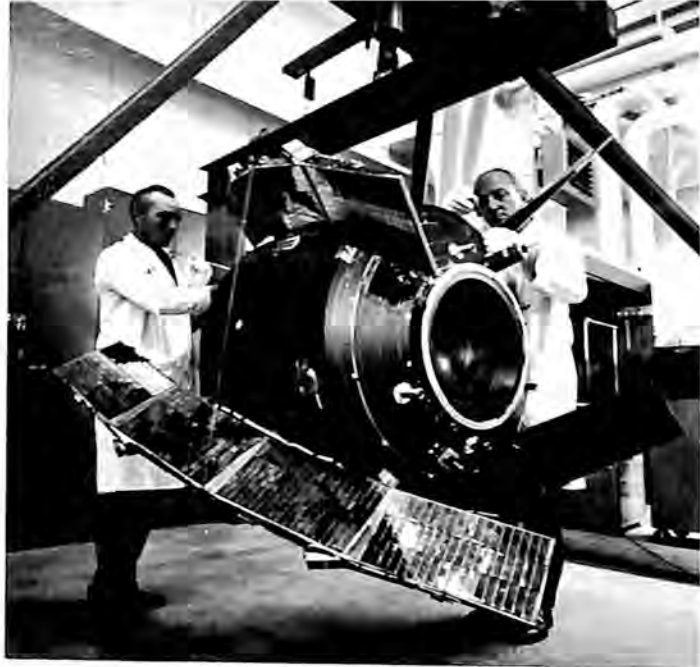


ENVIRONMENTAL RESEARCH SATELLITES

Prime Contractor: Systems Group of TRW Inc.

Remarks

The Environmental Research Satellites were designed especially for piggyback launching from large primary-mission vehicles. Ranging in weight from 1.5 to 100 pounds and carrying from one to 14 experiments, these ERS hitch-hiker spacecraft provide an inexpensive, flexible vehicle capable of making scientific and engineering measurements in space. A major role of the ERS satellites is to act as a test-bed to determine the reliability of unproven components and subsystems destined for use in later generations of spacecraft. An example is the Testing and Training Satellite for the Apollo manned program. One unique feature of the satellites is their capability of functioning without a battery on some missions. The key to this advantage is the design, which permits solar cells—fastened to all exterior surfaces of the vehicle—to maintain a nearly constant exposure to the sun within about 15 percent. One of the small satellites measures only 6.5 inches on a side and weighs 1.5 pounds; the largest version is a 20-inch cylinder weighing 100 pounds. Some 27 satellites have been launched since 1962 for a variety of missions and sponsors. The 8-sided version has been designated OV5 and has become part of a program conducted by the Air Force Office of Aerospace Research.

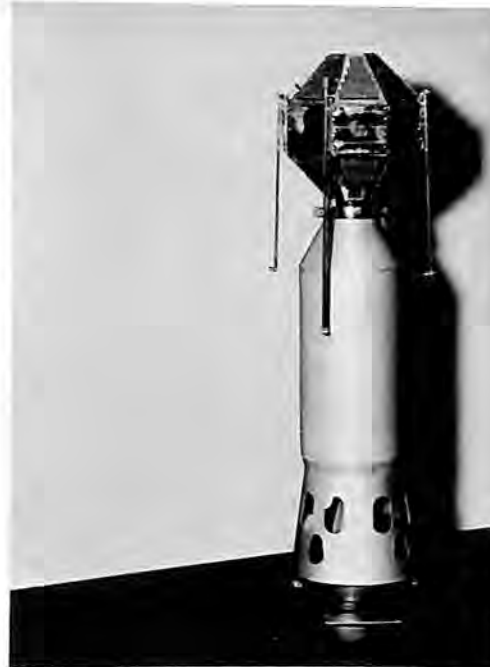


RADIO ASTRONOMY EXPLORER

Program Direction: Goddard Space Flight Center, NASA

Remarks

The Radio Astronomy Explorer program is designed to investigate low-frequency (long wavelength) radio emissions from the sun and its planets as well as from galactic and extragalactic sources. The spacecraft is a cylinder 36 inches in diameter and 31 inches high, weighing 414 pounds; it also has a 175-pound Thiokol apogee kick motor and a 14-pound motor adapter. The main appendages are 4 solar paddles, 2 elements forming a dipole antenna 120 feet long, and 4 750-foot antennas which form an X, with the spacecraft structure in the middle. The approved program, as of late 1969, consisted of 2 flight projects, one of them already launched; 2 additional spacecraft are contemplated. Initial launch of RAE-A, which became Explorer 38 upon achieving orbit, was on July 4, 1968. Explorer 38 is operating in a circular orbit at 3,640 miles. This spacecraft provided the discovery that earth, like Jupiter, emits low-frequency radio signals. Goddard officials said that the signals, still a mystery to scientists, appear to be sharply beamed or directed in a narrow cone, are quite intense and increase in intensity very rapidly when observed toward the lower frequencies, and are impulsive, occurring in rapid but sporadic bursts.



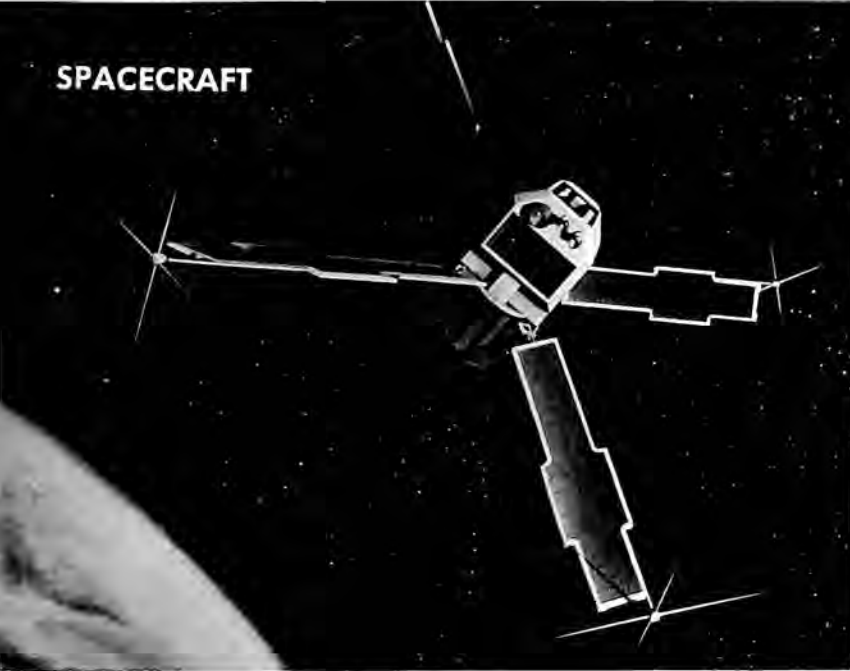
SMALL SCIENTIFIC SATELLITE

Program Direction: Goddard Space Flight Center, NASA

Remarks

The Small Scientific Satellite program was established to provide experimenters with the opportunity of flying a well-integrated set of detectors aimed at specific investigations within the magnetosphere. As of late 1969, the program embraced one funded spacecraft, scheduled for launch in the third quarter of 1970. SSS-A, as it is called, will investigate the dynamic processes which occur in the inner magnetosphere from 2 to 5 earth radii. A second objective is to flight-demonstrate the performance of the lightweight, general-purpose SSS. SSS-A has a polyhedral-shaped structure which approximates a 27-inch sphere with 26 flat surfaces; it weighs 108 pounds. There are a number of appendages to the main structure: a 30-inch pole, atop the body, on which is mounted a flux-gate magnetometer; 2 100-inch radial booms containing electric field spheres; 2 24-inch radial booms containing 2 search coil magnetometers; and an antenna turnstile array consisting of 4 22-inch elements canted 22 degrees from the upper pole. Experiment detectors include 3 for energetic particles (experiment provided by Goddard SFC), 2 for magnetic fields (University of Minnesota), and 2 for electric fields (Goddard and the University of Iowa jointly). SSS-A is to be launched from the San Marco Range, the floating man-made platform anchored off East Africa.

SPACECRAFT



SMALL ASTRONOMY SATELLITE

Program Direction: Goddard Space Flight Center, NASA

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

One of the newest of NASA's Explorer-class programs, the Small Astronomy Satellite was designed, fabricated, integrated, and tested at Johns Hopkins. SAS has the capability of providing, at relatively low cost, much basic, previously unavailable information concerning low- and high-energy radiation from sources both inside and outside our galaxy. The objective of the program is to study the celestial sphere above the earth's atmosphere and to search for sources radiating in the X-ray, gamma ray, ultraviolet, visible, and infrared regions of the spectrum. The first satellite, SAS-A, will concentrate on sources emitting X-ray energy. On-board instrumentation will provide valuable data on the position, strength, and time variation of sources radiating in that region. The collected data could lead to the selection of the more interesting sources for detailed study on later missions, either by advanced SAS or by more sophisticated spacecraft. SAS-A is to be launched in mid-1970 from the San Marco launch platform 3 miles off the coast of Kenya in the Indian Ocean. Launch vehicle is the Scout. The basic spacecraft is a cylinder approximately 22 inches in diameter and 20 inches high. The lightweight cylindrical shell acts as support for the experiments; 4 solar paddles provide power for spacecraft and experiments. Total weight is about 330 pounds.



SAN MARCO

Program Direction: Goddard Space Flight Center, NASA, jointly with Centro Ricerche Aerospaziali (CRA) of the University of Rome

Remarks

San Marco is a cooperative scientific effort between NASA and the Space Commission of the Italian National Council. The satellite is designed and built in Italy, with assistance from the United States; it is launched by a U.S. 4-stage Scout vehicle from Italy's floating launch platform anchored off the African coast in the Indian Ocean. San Marco's assignment is to make atmospheric drag and ionospheric measurements along the equator. The currently active program, designated San Marco C until launch, is the third in the series, which included San Marco 1, launched December 15, 1964, from Wallops Island, Virginia, and San Marco 2 (photo), launched April 26, 1967, from the towable floating launch platform. San Marco C, scheduled for 1970 launch, is similar to its predecessors. It will continue use of drag force balance to measure the local density of the equatorial upper atmosphere by measuring the instantaneous aerodynamic drag on the satellite. By means of mass spectrometry, it will measure the densities of molecular nitrogen, molecular oxygen, atomic oxygen, and helium.



INTERNATIONAL PROGRAMS

U.S. Participation: National Aeronautics and Space Administration; Goddard Space Flight Center, NASA (technical support)

Remarks

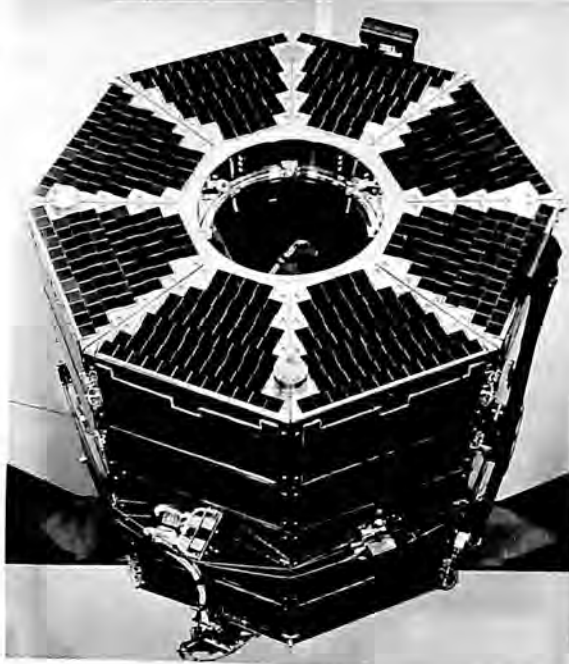
To stimulate scientific interest and technical competence in other nations and to enlarge thereby the general flow of space data, NASA conducts a broad program of international cooperation involving associations with 74 countries. Most of these nations are participating only in ground-based programs, but there are approximately a score of countries working with the United States on cooperative flight projects. Some of the projects involve foreign-designed experiments placed aboard U.S. spacecraft. Others involve NASA participation in spacecraft projects of other nations. In addition to Italy's San Marco, major cooperative projects include ISIS 1 (photo) (International Satellite for Ionosphere Studies), Canada, launched January 30, 1969, 4 U.S., 4 Canadian experiments; ISIS-B and -C, Canada, scheduled for launch in 1970 and 1971; Eole (also known as Cooperative Applications Satellite), France, an experiment in satellite/balloon meteorological data gathering, scheduled for late 1970 launch; Azur, Germany, a wide range of experiments to acquire further knowledge of the earth's radiation belts, launched late in 1969; Helios, Germany, a solar probe, 2 flights planned for 1974-75; and UK-4, a United Kingdom scientific satellite, scheduled for 1971 launch. NASA is also a participant in the European Space Research Organization's projects Iris, Aurorae, and HEOS-1, launched in 1968 and still returning radiation/solar wind and other data at year-end 1969, and ESRO-1B, a duplicate of Aurorae, launched in 1969.

OVI AEROSPACE RESEARCH SATELLITE

Prime Contractor: Convair Division of General Dynamics Corporation
Associate Contractor: Allegany Ballistics Laboratory (propulsion system)

Remarks

OVI is a simple, versatile vehicle designed to place scientific experiment packages in near-earth orbits at minimum cost and on a typical 12-month schedule from experiment assignment to orbit. Convair has integrated experimental packages into suborbital and orbital research vehicles since 1960. The first of 50 Scientific Passenger Pods were flown in 1961. These purely ballistic vehicles carried experimental packages on suborbital flights lasting as long as 40 minutes. Both recoverable and nonrecoverable pods were flown; several recoverable pods were flown a second time. Experiment integration continues to be an important aspect of the OVI program. OVI requires no specialized booster; it can be flown on Scout, Thor, Atlas, Titan, or Saturn launch vehicles. Atlas, for example, can launch 3 individually programmed OVIs in one flight, resulting in distinct orbits tailored to the demands of the scientific experiments aboard each satellite. OVI is equipped with its own rocket motor and control subsystem; each satellite can orbit up to 220 pounds of scientific experiments. Standard electronic subsystems handle all payload power, data storage, and telemetry requirements. Other payloads, up to 600 pounds, are also being flown on the OVI propulsion module.

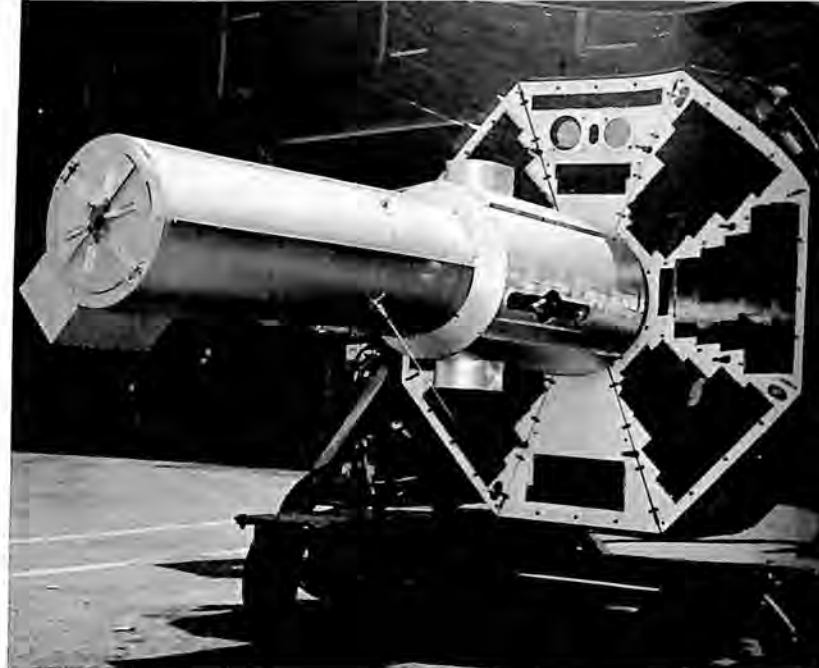


OV3 GENERAL UTILITY SATELLITE

Prime Contractor: Aerojet-General Corporation, Space Division

Remarks

Another of USAF's Orbiting Vehicle series of low-cost military/scientific satellites, the OV3 General Utility Satellite is a right octagonal cylinder measuring 29 inches in diameter and 29 inches high. Depending upon the mission, the spacecraft weighs from 150 to about 175 pounds. Solar cells supply power; OV3 has a cell volume of 540 square inches for experiment power and 9,000 square inches for support subsystems. Launch vehicle is the Scout. As of late 1969, USAF had launched 5 successful OV3s. OV3 1, April 22, 1966; OV3 4, June 10, 1966; OV3 3, August 4, 1966; and OV3 2, October 28, 1966, were radiation explorers. OV3 5, an atmospheric research satellite, failed to orbit after launch on January 31, 1967. OV3 6, December 4, 1967, conducted ionospheric studies.

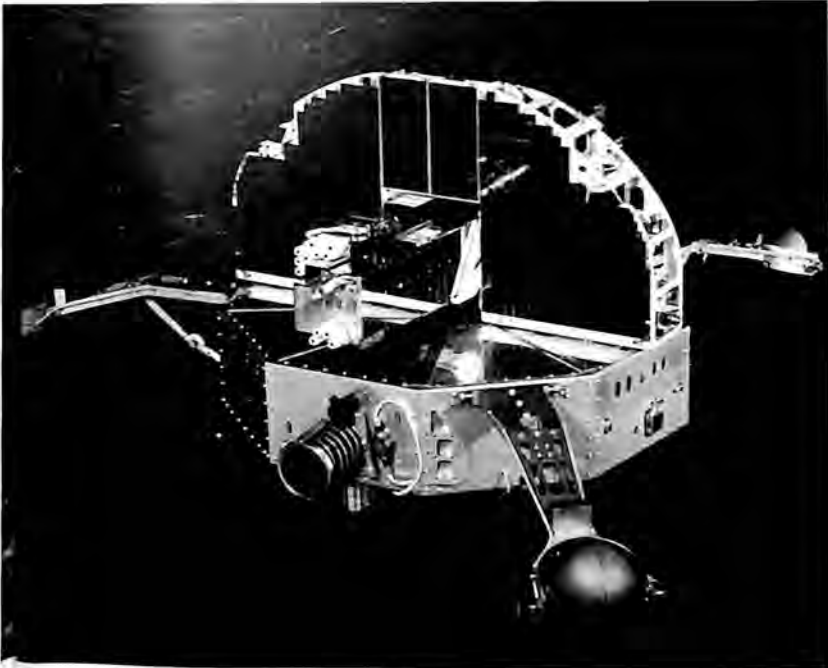


DODGE (DEPARTMENT OF DEFENSE GRAVITY EXPERIMENT)

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

The Navy's 430-pound Dodge satellite, whose primary mission is to explore gravity-gradient stabilization at near-synchronous altitude, was launched successfully from Cape Kennedy on July 1, 1967, aboard a Titan IIIC rocket. Dodge carries 10 booms that can be radio commanded to extend or retract along 3 different axes. Data from in-orbit experiments are providing fundamental constants to determine satellite attitude with respect to the earth. Dodge also carries a number of commandable magnetic damping devices and 2 television cameras to determine satellite attitude. Less than a month after launch, the satellite was stabilized in space by means of gravity-gradient boom and damping systems. On July 25, 1967, one of the satellite-borne cameras (22-degree field of view vidicon) took the first color pictures of the full earth ever made, from a near-synchronous altitude of 18,700 nautical miles. The color photograph, a composite of 3 pictures made through red, green, and blue filters, was transmitted by the satellite to the Applied Physics Laboratory's Howard County, Maryland, communications station. Now in its third year of operation, Dodge remains stabilized and performs experiments by means of several on-board systems. More than 25,000 pictures have been made since Dodge was launched. The pictures indicate that the silver-plated, paper-thin beryllium copper booms have been effective in minimizing the thermal bending induced by solar radiation. Computer techniques continue to be used to automate data from the satellite and, when required, to enhance picture quality.



ORBITING SOLAR OBSERVATORIES

Prime Contractor: Ball Brothers Research Corporation

Remarks

Orbiting Solar Observatories, developed for NASA's Goddard Space Flight Center, are designed primarily as stabilized platforms for solar-oriented scientific instruments. The OSOs permitted the first extended study of the sun (from above the earth's filtering atmosphere) with accurate positioning. Experiments on the satellites studied the sun, flares and other solar activities, X-ray, gamma, and ultraviolet radiation, and radiation from extrasolar sources. The 2-section space observatory is stabilized because the lower section, the "wheel," spins as a gyroscope at a near-constant 30 revolutions per minute. The upper, fan-shaped section, the "sail," is joined to the wheel by a connecting shaft and remains pointed toward the sun during the OSO daytime. Experiments in the sail point continuously at the solar disc when the OSO is in sunlight; instruments in the wheel scan the sun every 2 seconds and, in 6 months, view the celestial sphere. A Delta launch vehicle injects the OSO into a 350-mile-high orbit, where it circles the earth in 96 minutes. Six OSOs were placed in orbit, 2 of them in 1969, and all were rated successful. OSO 1, March 7, 1962, and OSO 2, February 3, 1965, provided over 8,600 hours of scientific information. OSO 3, March 8, 1967, and OSO 4, October 18, 1967, are returning real-time data. OSO 5, January 22, 1969, surpassed its 6-month design goal, as did the previous OSOs. OSO 6 (photo), August 9, 1969, was the first OSO to enable experimenters to study developing solar activity in local areas by making small raster scans about any one of 16,384 points on the solar disc. OSO-H, to be launched in late 1970, will continue studies of the current 11-year solar cycle.



SPACECRAFT

ORBITING GEOPHYSICAL OBSERVATORY

Prime Contractor: Systems Group of TRW Inc.

Remarks

The Orbiting Geophysical Observatory is a large standardized spacecraft capable of carrying approximately 20 different scientific experiments, utilizing an identical structure and identical basic spacecraft systems irrespective of mission. The program has 2 objectives: to conduct large numbers of experiments designed to take scientific and technological measurements within the earth's atmosphere, the magnetosphere, and cislunar space in order to attain a better understanding of earth/sun relationships and of earth itself; and to design and develop a standard observatory-type spacecraft of a basic system design that can be used repeatedly for various missions. OGO has a main body 6 feet long, 3 feet wide, and 3 feet deep, weighing 1,200 pounds. It has 2 solar paddles, each 6 feet wide and 7.5 feet long, and 6 booms on which experiments can be mounted to avoid possible electrical interference from the main body. With booms extended, OGO has an overall length of 49 feet. Power is supplied by 32,000 solar cells. Six OGOs have been launched.



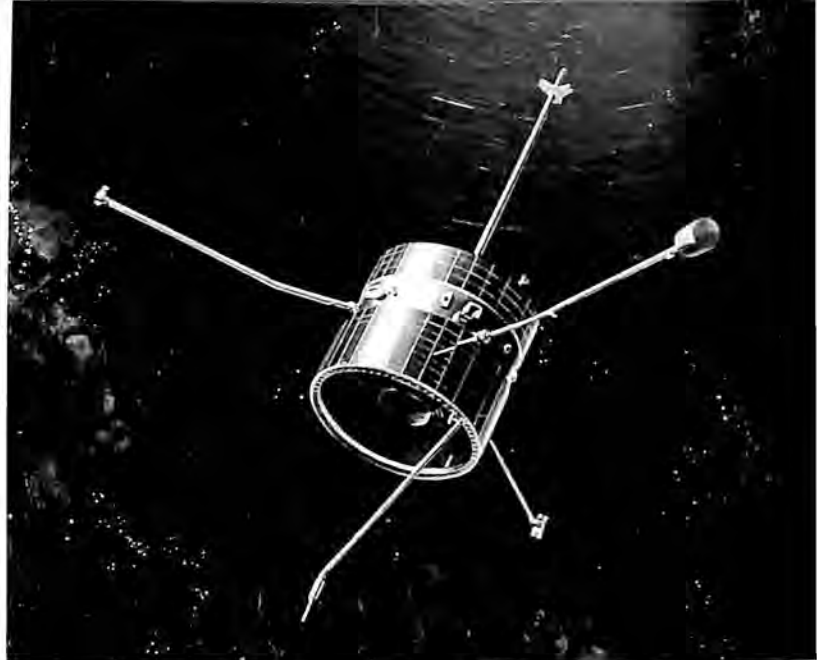
ORBITING ASTRONOMICAL OBSERVATORY

Prime Contractor: Grumman Aerospace Corporation

Associate Contractors: Westinghouse Electric Corporation (electronic components); General Electric Company (stabilization and control); Kollsman Instrument Corporation (star trackers); International Business Machines Corporation (data processor); Hughes Aircraft Company and Avco Corporation (communications equipment)

Remarks

The Orbiting Astronomical Observatory is a large (4,500 pounds) earth-orbiting satellite capable of lifting a number of telescopes and astronomical experiments above the earth's atmosphere, which obscures cosmic radiations of interest to astronomers. Solar paddles provide up to 1,800 watts of power. OAO is launched by Atlas/Centaur. The second of 4 OAOs was launched December 7, 1968; at the end of 1969, it was still operating successfully.

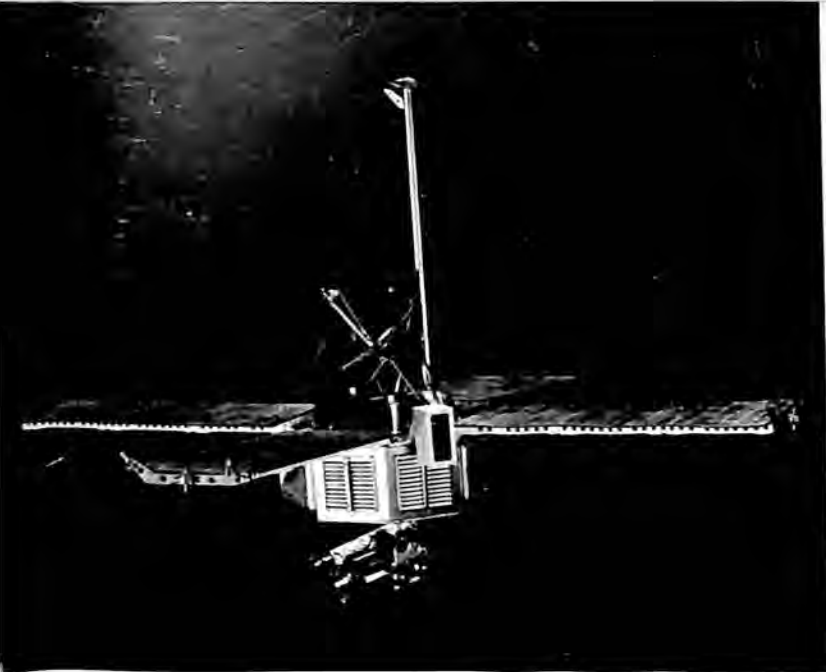


PIONEER

Prime Contractor: Systems Group of TRW Inc.

Remarks

Pioneer is an interplanetary spacecraft designed to operate in solar orbit and return data on interplanetary magnetic fields, radio propagation effects of the sun, plasma spectrometry, ionization levels, and solar, high-energy, and medium-energy particles. Pioneer is cylindrical, 35 inches long and 37 inches in diameter; it weighs 140 pounds. High- and low-gain antennas are mounted on a boom extending from the top of the satellite, and experiments are mounted on other booms projecting from the mid-section and the base of the spacecraft. A nitrogen gas jet attitude control system, with input from 4 sun sensors, orients the spin-stabilized spacecraft normal to the ecliptic plane. More than 10,000 solar cells provide 60 watts of electrical power. Pioneer 6, launched December 16, 1965, went into a solar orbit some 20,000,000 miles closer to the sun than is the earth's orbit. Pioneer 7, launched August 17, 1966, attained an orbit over 13,000,000 miles farther from the sun than is the earth's orbit. Pioneer 8 was launched December 13, 1967; it provided new insights into the earth's magnetic tail. Pioneer 9 was launched successfully November 8, 1968. The spacecraft were performing exceptionally well and returning vast amounts of valuable data on the solar environment. Pioneer 10 was launched August 27, 1969, but it did not orbit.

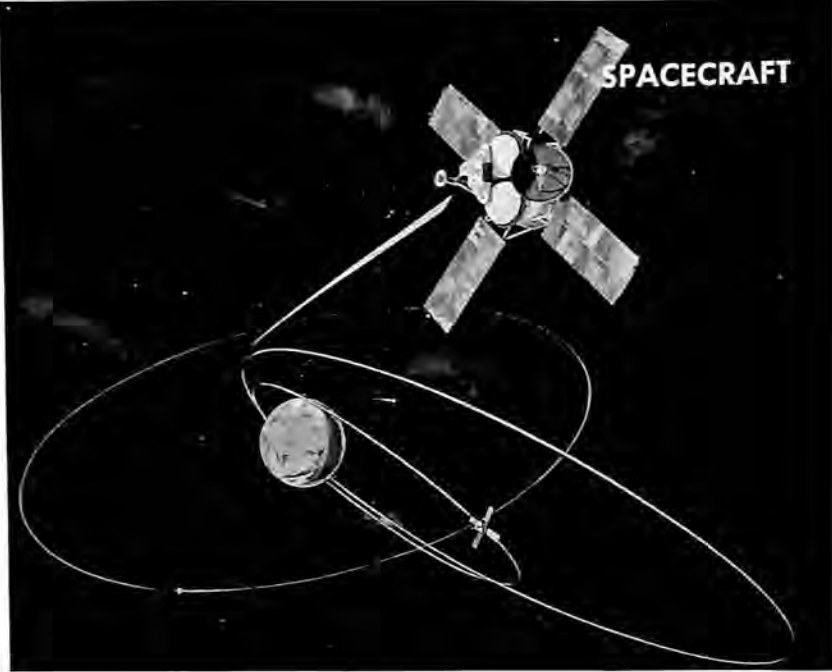


MARINER MARS 1969

Prime Contractor: Jet Propulsion Laboratory, California Institute of Technology
Associate Contractor: General Dynamics/Astronautics (prime contractor to Lewis Research Center for Atlas/Centaur launch vehicle system)

Remarks

The National Aeronautics and Space Administration launched 2 850-pound Mariner unmanned spacecraft, 6 and 7, on flyby missions to Mars in 1969. The first spacecraft was launched February 24; the second, March 27. Arrival dates were 5 days apart, July 30 and August 4. All scientific experiments aboard the Mariners '69 were planet-oriented with particular emphasis on providing data on the atmosphere and surface of Mars. The experiments measured the infrared spectral energy from the lower atmosphere, measured thermally emitted energy from the surface of Mars, detected the presence and scale height of atmosphere constituents, photographed the Mars disc and surface, determined atmospheric surface pressure and density, and refined the accuracy of earth and Mars orbits, Mars mass, earth-moon mass ratio, and the astronomical unit. The 2 spacecraft flew by Mars at a closest approach distance of approximately 2,000 miles. Two camera systems, wide angle and narrow angle, were aboard each spacecraft. They provided narrow-angle photographs of the disc of Mars as it revolved in front of the spacecraft during the near-encounter flyby.



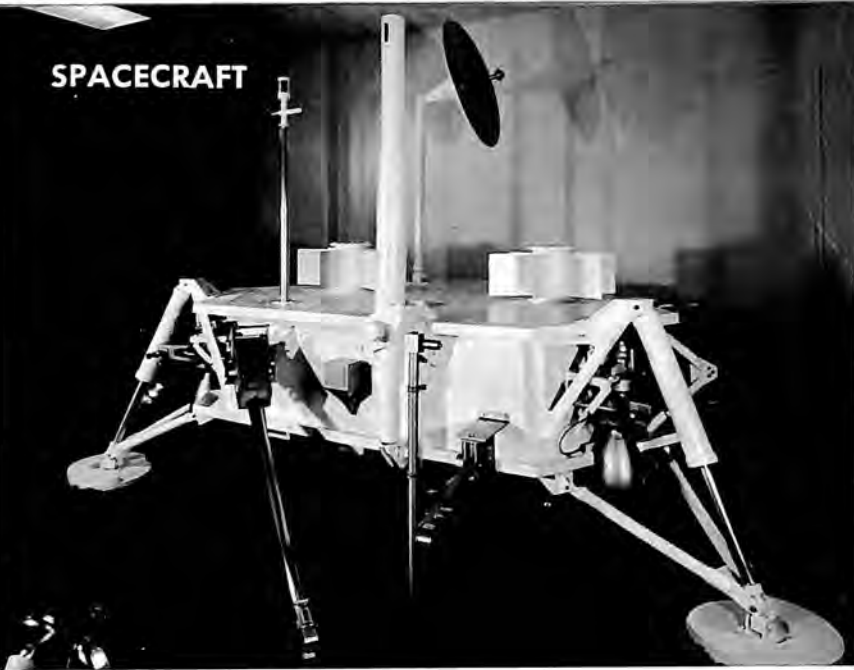
MARINER MARS 1971

Prime Contractor: Jet Propulsion Laboratory, California Institute of Technology

Remarks

Two Mariner-class spacecraft will be launched in early spring of 1971. They will arrive at Mars in mid-fall and will be inserted into Mars orbit. The spacecraft, which will weigh about 2,000 pounds each, will be launched by Atlas/Centaur. They will be equipped with scientific experiments to take measurements in the infrared and ultraviolet regions and to photograph the surface of Mars. Occultation experiments will be performed utilizing the S-band radio transmitters aboard each spacecraft. A celestial mechanics experiment will utilize tracking data for refining astronomical data. Approximately 70 percent of the Martian surface will be observed during a minimum of 90 days of orbital operations at an altitude of approximately 1,500 miles.

SPACECRAFT



VIKING

Prime Contractor: Martin Marietta Corporation, Denver Division

Remarks

Viking, the latest in NASA's series of unmanned planetary explorers, is scheduled for a 1975 mission to Mars. The program calls for insertion of 2 spacecraft into Mars orbit, each spacecraft sending a separate landing craft to the surface. Both orbiter and lander will gather scientific data, using various experiments, and will return information to earth by means of advanced telecommunications systems that will minimize transmission losses. Viking objectives are to search for evidence of active biota on Mars, using an integrated instrument; to determine the visual and thermal characteristics of the landing sites (the landers are camera-equipped); to ascertain the organic composition of the atmosphere, using a surface sampler pyrolyzer-gas analyzer; to determine the atmospheric composition and structure during the descent phase of the lander's flight, using direct measurement instruments, indirect techniques (remote sensing and radio), and information from engineering and housekeeping sensors aboard the entry vehicle; and to establish the meteorological parameters of the atmosphere from the lander, using direct-measurement instruments and applicable data from engineering and housekeeping sensors.



X-24A PILOT (PILOTED LOW-SPEED TEST)

Prime Contractor: Martin Marietta Corporation, Baltimore Division

Remarks

The rocket-powered X-24A is designed to explore flight characteristics of lifting bodies at supersonic speeds of Mach 2 down to normal jet landing speeds. It is carried aloft to 45,000 feet under the wing of a B-52, then released to rocket up to 100,000 feet before maneuvering to a landing at Edwards Air Force Base, California. Power is supplied by the Thiokol XLR11 engine. The X-24A has 8 aerodynamic control surfaces: 2 upper and 2 lower flaps and 4 rudders, or 2 split rudders on each of the 2 outside vertical fins. The vehicle is 24 feet long and 13 feet wide and weighs about 5,000 pounds unfueled. Flight testing began in 1969.



HL-10 LIFTING BODY VEHICLE

Prime Contractor: Northrop Corporation

Remarks

The HL-10 was designed and manufactured by Northrop's Aircraft Division under contract to NASA and was configured at NASA's Langley Research Center. It is an experimental wingless lifting body designed for high-altitude flights within the earth's atmosphere. It is flat on the bottom and has 3 vertical fins. The modified half-cone shape of the HL-10 lifting body provides a useful volume-to-surface area and achieves aerodynamic stability and lift from the body alone, eliminating the need for wings. The HL-10 was first flown successfully in late 1966; it was later equipped with a rocket engine for powered flights, which started late in 1968. As of August 1969, 23 flights had been made, including 11 powered and 5 supersonic flights.

Specifications

Length 22 feet 2 inches; width 15 feet 1 inch; height 11 feet 5 inches; minimum weight 5,265 pounds; maximum weight 10,000 pounds; controls, a thick elevon between each outer fin and the center fin for pitch and roll control, a split rudder on center fin for yaw and speed brake control. All surfaces are used in the 3-axis stability augmenter system. Each elevon has a flap on the upper surface; each outer fin has 2 trailing edge surfaces; 2 rudder surfaces can be controlled to vary the base drag.

Performance

Glide to landing from 45,000-foot altitude approximately 3.5 minutes; flare for landing performed at an altitude of 1,000 feet; speed 200 to 300 knots; landing speed 140 to 210 knots; landing rockets (optional use) 1,000 pounds thrust for 12 seconds.



SPACECRAFT

M2-F2 LIFTING BODY VEHICLE

Prime Contractor: Northrop Corporation

Remarks

The M2-F2 is an experimental wingless lifting body designed for high-altitude flights within the earth's atmosphere. It was designed and manufactured by Northrop's Aircraft Division under contract to NASA for flight research in the art of controlling future manned space flights in the earth's atmosphere during the critical terminal approach and landing phase. The M2 configuration design was created at NASA's Ames Research Center. The basic lifting body is a half-cone altered by blunting the nose and adding tail fins. The M2-F2 was first dropped successfully on July 12, 1966; it was dropped from a special pylon attachment on the wing of a B-52 bomber flying at 45,000 feet and was piloted to a conventional airplane-type landing at Edwards, California. Fifteen successful flights were made before a landing accident on the 16th flight. The craft was repaired and a center fin was added; it was scheduled to return to service late in 1969.

Specifications

Length 22 feet 2 inches; width 9 feet 7 inches; height 8 feet 10 inches; minimum weight 4,600 pounds; maximum weight 9,600 pounds; controls 1 pair thick rudders, 1 pair flaps on upper surface of boat-tail, 1 full-span pitch flap on lower surface of boat-tail. Upper flaps aid in pitch control and are interconnected with rudders for roll control.

Performance

Average flight time approximately 4 minutes from 45,000 feet; first flight touchdown speed approximately 195 miles per hour.

SERVO-CONTROLLED HYDRAULIC PUMP

Prime Contractor: Aerospace Division, Abex Corporation

Remarks

The Abex Corporation servo-controlled hydraulic pump provides a load-sensitive, bi-directional hydraulic power supply for aerospace hydraulic subsystems such as hoists and self-contained pump-actuator packages. The pump combines 2 standard Abex product lines, a jet pipe electrohydraulic servovalve and an over-center, piston-type hydraulic pump; both products have been in service for many years and have gained widespread acceptance in the aerospace industry. Any desired characteristics of flow versus input current can be obtained by this integration of both components into a single package with mechanical feedback from the pump to the servovalve. This type of power supply has the advantage of being load sensitive, so that flow is supplied to the actuator, whether of linear or rotary type, at only that pressure level required by the actuator load. Thus, the amount of power loss due to system inefficiency is minimized, with a consequent reduction in heat rejection and system complexity. The unit shown incorporates an auxiliary positive displacement pump of low output to supply the control pressure for the servovalve. Weighing less than 22 pounds, this model is capable of an output approaching 100 horsepower, yet it can be controlled with an input as low as 8 milliamperes.

SNAP-8 NUCLEAR ELECTRICAL POWER GENERATING SYSTEM

Prime Contractor: Aerojet-General Corporation

Remarks

The SNAP-8 system is under development for NASA's Lewis Research Center for use in converting nuclear reactor heat into electrical power for future large manned space stations, lunar bases, and deep space probes. The system is designed to generate 35 kilowatts and to operate for 10,000 hours (nearly 14 months). Heat from a nuclear reactor is used to operate conversion equipment and generate electrical power. In photo, artist's conception of a moon base with electrical power supplied by SNAP-8 generator in foreground.



R-182



AUTOMATIC VACUUM DEPOSITION SYSTEM

Prime Contractor: Aerojet-General Corporation, Electronics Division

Remarks

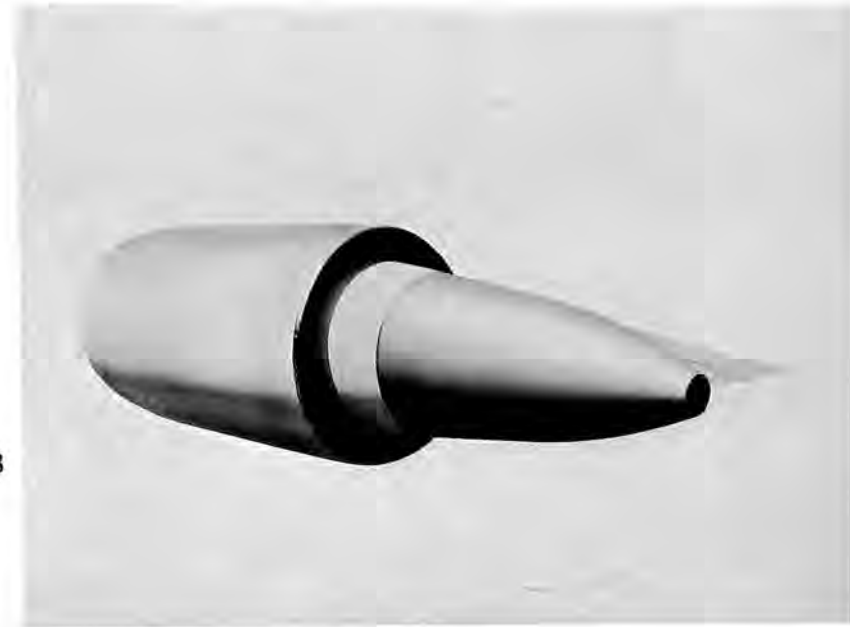
Aerojet-General's Electronics Division has activated an Automatic Vacuum Deposition System (AVDS), one of the most advanced facilities in existence for fabrication of thin-film microelectronics. A computerized vacuum deposition system with a capacity of 10,000 circuits in a single cycle, AVDS contains a mechanism for handling multiple substrates and masks in high vacuum, with multiple sources for the volatilization of resistive, insulating, and conductive thin-film material. Production quantities of microcircuits containing thin-film resistors, capacitors, interconnections, crossovers, distributed parameter filters, inductors, and passivating films can be deposited in this system in a single 12- to 16-hour pump-down sequence. The system permits volume production of complex linear circuits which can be priced competitively with other methods of producing thin and thick film circuits. The 150-cubic-foot system is an ion-pumped, high-vacuum chamber containing 4 deposition stations, each capable of handling 8 electron-beam-gun source evaporation mechanisms; it also permits mounting 120 4- by 5-inch substrates on a continuous belt which is mounted over 4 mask carrier turntables, each capable of handling 8 mask set combinations. Each source carousel contains 8 different materials which can be evaporated from continuous rods by individual servo-controlled electron beam guns. All functions are monitored remotely, and logic has been integrated into the system to permit computer programming and real-time monitoring of source materials, substrate and mask positions, deposition rates, film thickness, and resistor values.

ATF 3 NACELLE/THRUST REVERSER

Prime Contractor: Aeronca, Inc.

Remarks

Utilizing experience with lightweight, high-strength structures and high-temperature materials gained in a number of aerospace programs, Aeronca entered the jet engine nacelle and thrust reverser field with a contract for the design, test, and production of a power package for the Garrett AiResearch ATF 3 turbofan engine. Initial application of the engine will be on the North American Rockwell Sabreliner 60, increasing the aircraft range to transcontinental. Aeronca's responsibility includes the nacelle, the cowling, and the electrical, bleed air, anti-icing, reversing, and fuel systems. Brazed honeycomb structures will be utilized in the reverser blocker doors, and much of the afterbody fairing and Aeronca's portion of the pylon will be made of titanium. The Aeronca-developed thrust reverser is similar to those being used with the 747, the L-1011, and the DC-10 jet aircraft, but it is more sophisticated in some aspects because of the smaller size of the power package, the severe weight limitations, and certain design features. For example, in the ATF 3, gas and fan airstreams are mixed prior to being reversed. Working closely with AiResearch, Aeronca was able to achieve thrust reverser operation which does not alter pressure relationships between the 2 streams and provides uniform gas flow. The reverser is flexible and basically simple in design. It achieves maximum control of exhaust gas direction and minimizes both reingestion of exhaust gases and impingement of the fuselage. The reverser system is pneumatically driven, removing all commonality with the brakes, which are hydraulic, for maximum reliability and safety. The pod and reverser system can be adapted to other aircraft with only minor modification. Flight test of the first power package was scheduled for early 1970 with certification to follow within a year.



R-183

RESISTOJET SPACECRAFT CONTROL SYSTEM

Prime Contractor: Avco Corporation, Applied Technology Division

Remarks

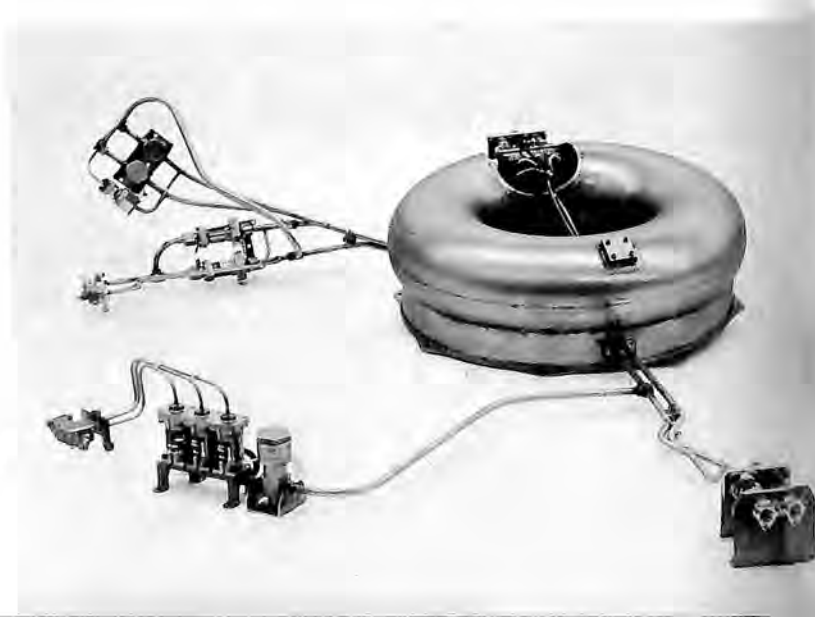
The Resistojet spacecraft control system was developed for NASA for attitude and orbit control of satellites. Two experimental models have been tested on NASA-Goddard Space Flight Center's Applications Technology Satellites B and C, launched December 1966 and November 1967. Operational low-thrust (50 micropounds) engines were launched on board the ATS-D and -E spacecraft August 1968 and August 1969, respectively. The ATS-D Resistojets performed successfully in nearly continuous operation for the orbital life of the spacecraft. The ATS-E Resistojets commenced operation in the latter part of 1969 to maintain this gravity-gradient stabilized spacecraft on station. This station-keeping system is fueled with 3 pounds of liquid ammonia for 3 years of operation. The Resistojet experiment on the ATS-C provided the first high-accuracy measurements of micropound thrust in space. The measurements compared well with ground thrust calibrations. The propellant used in each of these systems was ammonia. A Resistojet system developed for NASA's Lewis Research Center, capable of 3-axis attitude control and multidirectional station keeping, has a 60-pound ammonia storage capability.

COLD GAS AMMONIA CONTROL SYSTEM

Prime Contractor: Avco Corporation, Applied Technology Division

Remarks

An operational cold gas (specific impulse of 105 seconds) ammonia control system, developed for the MIT Lincoln Laboratory, is continuing successful operation on the LES-6 Air Force spacecraft launched in 1968. The system was designed to provide spacecraft spin-up, spin control, attitude control, and station keeping. Thrust levels were .1 pound and 20 millipounds. This represents the highest thrust level flown for an ammonia-fueled system. Use of the low-pressure (125 pounds per square inch) liquid-ammonia propellant offered significant system weight savings over the standard-type cold gas nitrogen systems. A principal system feature was the zero g propellant feed and control system which provided plus or minus 10 percent thrust pressure control without using any mechanism to obtain liquid-gas propellant separation in the toroidal supply tank. This type of feed system was successfully used on NASA's ATS-C, -D, and -E spacecraft.



R-184

AIR-CUSHION LANDING SYSTEM

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

The Air-Cushion Landing System (ACLS) is designed to replace conventional aircraft landing gear with an annular jet air cushion. First flown on August 4, 1967, on a modified Lake LA-4 amphibian, it embodies a pneumatic bag mounted beneath the fuselage. A continuous air feed from an on-board power source maintains bag inflation while producing a distributed jet flow at the base of the bag. The escaping jets create cushion pressure within the bag whenever the bag is close to the takeoff or landing surface. Air clearance beneath the bag is minimal, but considerable surface irregularities are tolerable because of the resilience of the material. The bag is retractable, and total system weight is less than that of high flotation wheel gear. The ACLS provides improved tolerance to the take-off and landing maneuvers and environments with no compromise of performance while enabling aircraft to land on or take off from a surface of any softness including water. Footprint pressure is in the region of 1 to 2 psi. Other significant features are crosswind capability, kneeling, distributed support, high energy absorption and damping, and cushion braking.

JET FLYING BELT

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

The Jet Flying Belt, a jet-powered version of Bell's famed Rocket Belt, began its preliminary flight test program in August 1968. The program included an extensive series of man-rating and preliminary endurance, speed, and range tests conducted in tethered and free flight modes. Sponsored by the Defense Department's Advanced Research Projects Agency under an Army Aviation Materiel Command contract, development of the Jet Belt began in January 1966. The system is powered by a high bypass turbojet engine mounted vertically on a fiber glass corset which, when strapped to the operator's back, distributes the weight comfortably on his hips. Thrust from the engine is channeled equally through 2 nozzles pointed downward behind the operator's back. The operator has complete freedom of flight, including forward, backward, sideward, rotating, and hovering maneuvers. The power plant, believed to be the world's smallest fanjet engine, has a high thrust-to-weight ratio and low specific fuel consumption which give the Jet Belt a range and an endurance substantially greater than those of its rocket-powered predecessor. The Jet Belt's range and endurance are being measured in miles and minutes.

Specifications

Power plant 1 Williams Research Corporation WR-19 bypass turbojet approximately 2 feet long and 1 foot in diameter; fuel JP-4; control motorcycle-type hand grips giving varying degrees of thrust and deflection to the thrust nozzles; ignition solid-propellant cartridge.



R-185



AN/SPN-42 CARRIER LANDING SYSTEM

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

Bell Aerospace developed the AN/SPN-42 All-Weather Carrier Landing System for the Naval Ship Systems Command. This electronic system permits pilots to make hands-off landings on the pitching and rolling decks of aircraft carriers regardless of weather conditions. The Bell automatic landing concept has been proven by more than 10,000 hands-off landings at airports and on aircraft carriers at sea. The AN/SPN-42 is a closed-loop controlled system which maintains control of the aircraft from acquisition (4 to 8 miles) to touchdown. For an automatic hands-off landing, the aircraft is flown to the traffic pattern altitude 4 to 8 miles behind the ship. The ship transmits landing system messages addressed to a particular aircraft and a checkoff light is illuminated in the cockpit, reminding the pilot to make his landing configuration checks and to couple his autothrottle. The aircraft enters the acquisition window (10,000 feet wide by 630 feet high) and the radar locks on the aircraft, tracking its position. The cross-pointer instrumentation in the cockpit begins functioning, telling the pilot where he is relative to the ideal flight path to the carrier. If the aircraft is positioned to permit an automatic landing, the pilot couples his autopilot. The computer compares the aircraft's position with the ideal flight path and generates pitch and bank commands to maintain the aircraft on this path. If the aircraft deviates from the path, the autopilot is uncoupled and the pilot is informed of the situation on cockpit instruments. When he returns to the safe funnel, he can recouple. Ten seconds from touchdown, the pilot is notified by light indication that he is entering the deck motion compensation phase which puts the aircraft in synchronous motion with the carrier deck for landing.

LUNAR FLYING VEHICLE

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

Under study for the National Aeronautics and Space Administration, the Lunar Flying Vehicle concept is designed to provide astronauts with the mobility required for extended manned lunar exploration missions over the relatively rough and jagged terrain. Simplicity and light weight are key design factors. NASA has studied the possibility of transporting 2 lunar flyers to the moon aboard the Apollo Lunar Module. As currently conceived, each flyer would weigh no more than 180 earth pounds. Gross system weight, including allowances for weight of the astronaut and his equipment, as well as payload and propellants, is being limited to 1,220 earth pounds. The rocket-powered Lunar Flying Vehicle must also be capable of 10- to 15-mile minimum flight range and of performing at least 30 sorties, using the residual propellants from the LM descent stage for fuel.



R-186



STABILIZED PLATFORM SYSTEM FOR SATURN VEHICLES

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

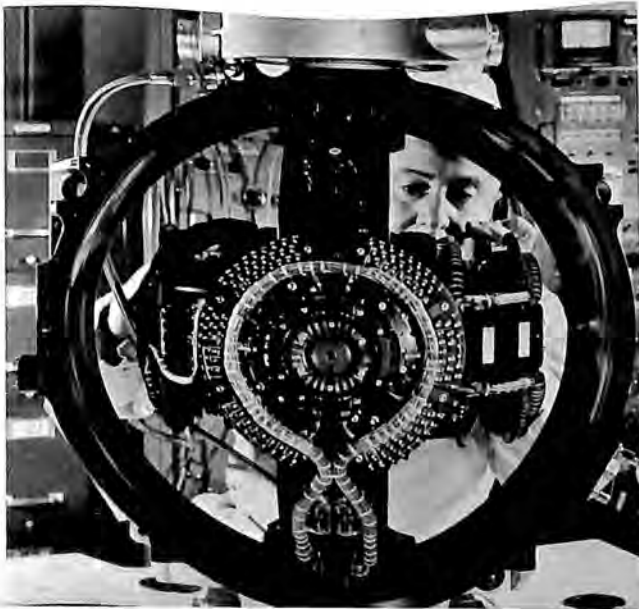
The Saturn rocket's ST-124 stable platform provides guidance and second-stage cutoff information, and velocity and attitude control signals. The platform operates in conjunction with 2 other major subsystems—a general-purpose digital guidance computer and an analog control computer with associated sensors and actuators—to form the complete Saturn guidance and control system. An on-board data adapter handles interface requirements. The system uses either 3-gimbal or 4-gimbal platforms, depending upon the particular Saturn mission. Mounted to the stable inner element, or inertial gimbal, are 3 single-degree-of-freedom gyros, 3 pendulous gyro accelerometers, and 2 preflight leveling pendulums. Gyros and accelerometers are gas floated. The gyro wheel is supported in the beryllium cylinder, which, in turn, is supported by the hydrostatic gas-bearing, with both radial and axial centering. All platform structural members and most of the components are made of beryllium, which affords considerable weight saving as well as greatly improved stability over a wide range of temperatures. The system has performed successfully on Saturn I, IB, and V launches.

CONTROL MOMENT GYRO

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

Three Bendix Control Moment Gyros (CMG) will stabilize and control the pointing and positioning (attitude) of the Apollo Telescope Mount (ATM) in NASA's Apollo Applications mission of 1972. The CMG is a 2-degree-of-freedom gyroscopic device. A heavy wheel suspended within the inner gimbal spins at a constant speed to provide a constant magnitude of angular momentum. This tends to maintain a fixed line (axis) of rotation. Swinging the gimbals in a calculated direction changes the direction of momentum, thus causing the ATM to swing in the opposite direction. Three Control Moment Gyros can control ATM attitude in all directions.



RANGE INDICATOR FOR LUNAR MODULE

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

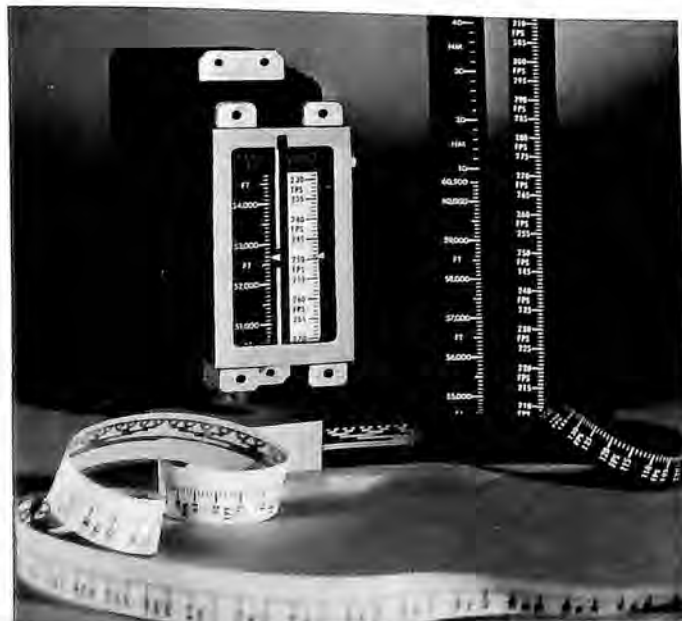
The Lunar Module (LM) range indicator provides LM astronauts with altitude and rate-of-altitude-change information during descent from the Apollo Command and Service Modules to the lunar surface. During the ascent and rendezvous with the Apollo spacecraft, it displays the distance between the 2 lunar orbiting vehicles and the rate at which the distance closes. The indicator features a pair of specially developed digitized display tapes which cover a flight profile of 400 nautical miles. The front, or viewing side, of the spool-wound tapes displays altitude, range, and rate information to the astronauts in terms of miles, feet, and feet per second. The reverse side contains corresponding information in the form of digital code, by means of which the tapes are continuously programmed to the mission profile as the flight progresses. The 4-pound indicator incorporates the latest features of integrated microcircuit design and has an accuracy of better than 1 mile at its maximum range and better than 5 feet during the lunar landing maneuver.

PRECISION APPROACH AND LANDING SYSTEM

Prime Contractors: The Bendix Corporation, Navigation & Control Division; The Boeing Company, Commercial Airplane Division

Remarks

In 1965 the Precision Approach and Landing System won Federal Aviation Administration approval for use in fully automatic landings by large commercial jet aircraft; later, approval was given for use in Category II conditions. The system makes extensive use of transistorized equipment and microelectronics. A complete system for automatic landings comprises an improved autopilot coupler (which locks the aircraft's autopilot on the instrument landing system beam at the airport), amplifier computer, 2 radio altimeters, monitored flare computer, standby gyro horizon, improved yaw damper, and a series of monitors to check the operation of the autopilot and instruments. The sensitivity of the autopilot coupler permits a longitudinal dispersion of plus or minus 500 feet from intended touchdown point and a lateral dispersion of plus or minus 50 feet from the beam. Two radio altimeters provide height-above-terrain signals for the autopilot and the indicator on the pilot's panel. At an altitude of 60 feet, the flare computer takes pitch control of the airplane. Upon receiving the appropriate signals from the altimeters, it puts the airplane in the landing attitude and reduces its rate of descent to 2 feet per second for the touchdown. The yaw damper and automatic throttle system, tied in to the autopilot, provide precise lateral and airspeed control. Operation of all components is monitored constantly during final approach; should there be any error, the monitor disconnects the autopilot in trim, ready for pilot take-over.



R-188



1. APPROACH CONTROL PANEL 5. AIRSPEED IND. (AUTO THROTTLE CONTROL)
 2. APPROACH PROGRESS DISPLAY 6. LOW RANGE RADIO ALTIMETER No. 2
 3. LOW RANGE RADIO ALTIMETER No. 1
 4. AIRCRAFT 4. WING TIP WARNING LIGHTS

MICROVISION

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

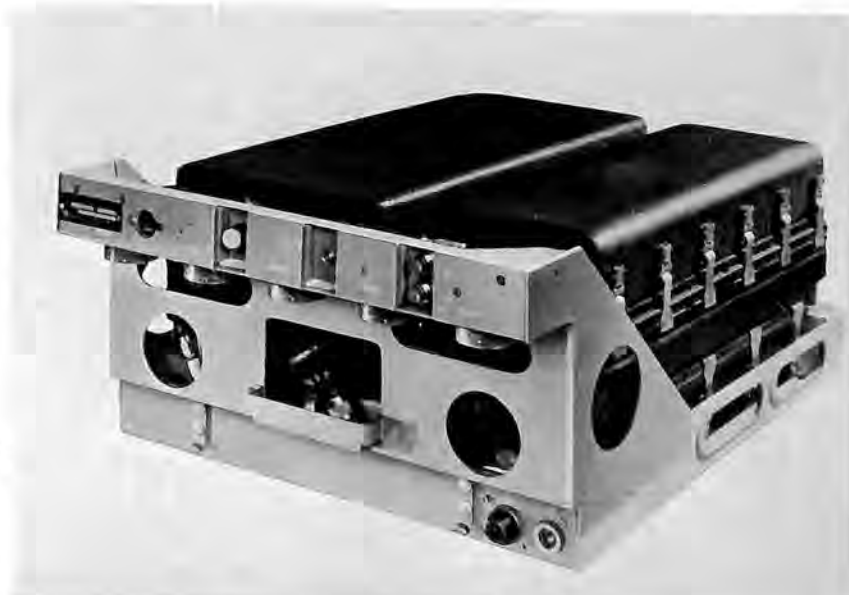
Microvision is an all-weather landing aid that outlines an airport runway so that it appears similar to the way a pilot would see it in a normal clear-weather night landing. The system has been installed by the Federal Aviation Administration at its research center in Atlantic City, New Jersey. Microwave radio signals—beamed to the plane from both sides of the landing strip—put an electronic image, or “picture,” of the runway on a semitransparent screen in the cockpit. The pilot “sees” the runway through his normal line of vision from a distance of about 10 miles with the plane at an altitude of some 5,000 feet. At a distance of about 7 miles from touchdown, the runway, appearing as a pattern of separate beacons resembling runway lights, comes into focus on the screen and becomes increasingly defined as the distance decreases. The system comprises a series of ground-based microwave beacon-transmitters, airborne direction-finding equipment, and the head-up display. The beacons, along each side of the runway, form a pattern similar to runway lights. Each beacon transmits 1-microsecond pulses approximately 120 times per second to small, fixed, wide-angle microwave antennas installed in the aircraft nose. The airborne direction-finding receiver determines the immediate angular position of all the beacons with respect to the longitudinal and lateral axes of the aircraft, and simultaneously presents these positions on the aircraft’s head-up display. The display consists of a cathode ray tube, which presents the processed beacon pulses as coordinated images; an optical system, which collimates the images at infinity; and a combining mirror, which is positioned in the pilot’s line of sight.

ADC-600 AIR DATA COMPUTER FOR F-111

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

The ADC-600 air data computer for the supersonic F-111 immediately and precisely converts information on the physical properties of the air through which the plane is flying into data for operation of such subsystems as autopilots, flight instruments, and navigation systems. The highly refined, analog, central air data computer exhibits controlled dynamic response, high accuracy, and static probe error compensation capability in providing the F-111 aircraft systems with a wide range of information. The basic computing mechanism and repeater modules provide shaft rotations for 88 electromechanical devices such as conductive plastic potentiometers, synchros, encoders, and switches. Shaft outputs include altitude, Mach number, true airspeed, total pressure, dynamic pressure, indicated airspeed, true temperature, pressure altitude, and angle of attack, all corrected for probe errors. Of 88 output provisions, 66 are implemented and 22 are reserved for growth potential. The unique design philosophy applied to the ADC-600 makes the sensors and the entire computer relatively immune to position and acceleration errors. Consequently, the computer provides precision outputs of fine sensitivity, required particularly at high altitudes. The computer is flexible in design, reliable, and easily maintained; it incorporates monitoring and self-test capabilities. It achieves good balance between the weight and size economy of single packaging, on the one hand, and the design flexibility of modular construction and separate packaging, on the other hand.



R-189

C-5 ATTITUDE DIRECTOR INDICATOR

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

A new Attitude Director Indicator (ADI) with dual display capability has been designed for commercial and military aircraft. The ADI's initial application is on the USAF/Lockheed C-5 heavy logistics transport. The indicator provides a pilot with either a precise bull's-eye display—in 3-dimensional form—of an instrument landing system (ILS) approach gate or, alternatively, a conventional type of display during cruise mode. An integral component of a flight director system, the ADI utilizes the commands from a flight steering computer for control of the aircraft to a selected flight path for cross-country navigation or landing approach.



HEAD-UP DISPLAY SYSTEM

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

The Head-Up Display System (Specto System) takes essential flight information out of the cockpit and puts it on a transparent viewer right in front of the pilot, in line with his vision through the windshield. The system eliminates head motion and hurried eye refocusing from the instrument panel to the real world and reduces fatigue by allowing the pilot to view outside objects while reading essential flight data. The heart of the system is a cathode ray tube similar to a television set tube. It projects symbols representing flight and engine characteristics on a transparent display screen 2 feet in front of the pilot's eyes. The pilot pushes a button and gets all the data he needs to perform a particular function, such as landing, en route flying, or tactical maneuvering. The system operates in wide application from executive, helicopter, and fighter aircraft to large military and commercial supersonic transports. The Head-Up Display System consists of 4 units: pilot's display, 3-axis adjustable mount, electronic assembly package, and control panel.



AN/GSM-133 PROGRAMMER COMPARATOR

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

The AN/GSM-133 is a versatile, automatic, programmable testing system that provides, for the first time, consistent automatic checking of avionic systems for aircraft, missiles, and space vehicles at all levels from factory and depot to flight line and on-site maintenance. This second-generation programmer-comparator incorporates micrologic techniques that reduce its size by 30 percent and its weight by 50 percent over current models. It can be transported either by air or over land. The system performs serial-type evaluations on both analog and digital signals, utilizing integrated (micrologic) elements for all logic functions. It evaluates voltage levels and measures time, events, frequencies, and resistances to high orders of accuracy; it is compatible with testing requirements anticipated through 1975. The wide interfacing capability of the set permits the direct coupling of alternate programming sources, manual controls, displays, recorders, and measurement devices, and provides all the basic input/output lines for connections with computational devices in either on-line or off-line configurations. The general-purpose configuration of the set can be readily altered for special applications. The set provides for a variety of multiple, independent, and simultaneous evaluations. This capability greatly enhances the versatility of the set and allows for combining continuous monitoring techniques with sequential evaluations of related parameters and for directly accommodating a variety of dynamic test procedures.

AN/APX-72 TRANSPONDER

Prime Contractor: The Bendix Corporation, Communications Division

Remarks

This transponder is the smallest, lightest, most reliable, and most advanced airborne IFF transponder presently available in high-volume production. Despite its small size and light weight, the AN/APX-72 has far greater capability than previous transponders. It can store thousands of secure codes for identifying military aircraft, and it is compatible with the commercial system for FAA air traffic control. Built for the Naval Air Systems Command for use by the 3 military services, it meets all triservice and FAA operational requirements of the AIMS program. The transponder is being used in new aircraft and is being retrofitted into aircraft in service. The AN/APX-72 is capable of using 5 operational modes and a test mode. Three special signals can be superimposed on these replies. The transponder provides 32 reply codes on Mode 1 and 4,096 reply codes on Mode 2 for discrete aircraft identification, 4,096 reply codes on Mode 3/2 for air traffic control, 4,096 reply codes on Test Mode for testing interrogator and transponder, Mode C for altitude information encoding, and the additional AIMS Mode.



R-192



AN/FPS-85 SPACE TRACK RADAR SYSTEM

Prime Contractor: The Bendix Corporation, Communications Division

Remarks

This new radar facility (original destroyed by fire January 1965), located at Eglin Air Force Base, Florida, is a major element in the U.S. aerospace surveillance and warning system. The building housing the space track radar is 13 stories high and over a city block long. The radar system uses an electronic scanning technique called "phased array," a method of scanning large volumes of space with radar beams without any mechanical movement of the radar. The space track radar has thousands of small, individual receivers and transmitters fixed in the face of the antenna structure. Through the high speeds available with electronic—rather than mechanical—beam steering, it is possible to track many satellites to altitudes of several thousand miles in one "glance." Design, technical, and contractual direction of the project is by the Air Force Systems Command's Rome Air Development Center. Development was under the sponsorship of the Electronic Systems Division; the facility is operated by the Air Defense Command.

MULTIPLE ADDRESS SEGREGATOR

Prime Contractor: The Bendix Corporation, Communications Division

Remarks

The Bendix MAS-101B unit is an accurate, dependable, low-cost, completely automatic multiple address segregator which operates in an AMASS digital communications system. By making routing line segregation completely automatic, the MAS-101 unit appreciably increases the message-handling capacity and accuracy of teletype relay centers which presently use a manual segregation procedure. MAS-101B is an all-solid-state unit which automatically performs routing line segregation for any messages prepared in accordance with COI-101 and MIL-STD-188B. The ACP 127 format can be accepted with minor changes. The equipment processes the 5-level (7, 7.45, or 8 unit) teletypewriter code in serial form, but it can be altered for parallel operation if required. Since it is not designed around any specific reader or reperforator equipment, the system provides versatility and allows maximum use of presently available equipment.



R-193



AN/PRC-72 RADIO SET

Prime Contractor: The Bendix Corporation, Communications Division

Remarks

Combining the best features of previous radios and utilizing experience gained in Southeast Asia, the Bendix Communications Division has developed for the Air Force a light and very flexible manpack radio set for forward air control in tactical situations. Conceived to bridge the interservice communications gap, this radio set, designated AN/PRC-72, provides absolute operational flexibility. Combined in one compact, open frame rucksack are 4 self-contained, independently operating radio sets that cover the high, very-high, and ultrahigh frequencies in AM, FM, and single sideband modes. The radios can be used independently or in combinations for repeater service. The microcircuit design and advanced packaging techniques used in the AN/PRC-72 have achieved significant size and weight reduction and reliability improvements over conventional miniaturization techniques. The division has completed extensive tests and has delivered developmental models to the Air Force.

**FUEL GAUGE CONNECTOR/CABLE ASSEMBLIES**

Prime Contractor: Amphenol Space and Missile Systems, Amphenol Connector Division, The Bunker-Ramo Corporation

Remarks

Accurate measurement of the amount of fuel in jet aircraft fuel tanks can be made using high impedance type capacitance bridge networks. This system measures the capacitance of the fuel with multiple probes in each fuel tank along with compensators that correct for variations due to changes in temperature and types of fuel. It is used on all Boeing jet aircraft of the 700 series. The problem of passing wires carrying fuel data through the tank to a point where the data could be collected and transmitted to the cockpit for display was solved by engineers at Amphenol Connector Division with a fuel gauge cable assembly. The assemblies are produced at the division's Space and Missile Systems facility in Chatsworth, California. Each fuel gauge connector has 25 contacts: 12 shielded outputs and 13 signal inputs. Individual lead wires have a Teflon outer coating; some wires are shielded and recovered with Teflon. Shrink tubing at various intervals is used to hold the wire bundle in place. The Boeing 747 has 7 fuel tanks and uses 15 different fuel gauge cable assemblies; maximum capacity of the fuel tanks is 46,700 gallons.



E8100 AUTOMATIC TEST SYSTEMS

Prime Contractor: Electronics and Space Division,
Emerson Electric Company

Remarks

E8100 designates a new family of computer-controlled, automatic test systems capable of testing times which are as much as 90 percent less than those required by conventional methods. Designed to fulfill the requirements of manufacturers and users of electronic/avionic systems, the E8100 systems perform go/no-go acceptance tests and diagnostic tests in any testing environment. Tailoring E8100 configurations for specific testing needs is accomplished through building-block options which also permit expanding a particular system's capabilities to meet future requirements at minimum cost. E8100 systems feature an Emerson-designed computer using a test-oriented language that eliminates the need for a compiler in most testing situations. The machine uses standard tape ASCII code, allowing programs to be generated easily on any teletypewriter. The flexibility of the product line is particularly evident in the E810, one of the smaller systems of the E8100 family. The E810 tests analog, radio-frequency, and digital circuitry as well as pneumatic assemblies. It utilizes the same test-oriented computer as the larger E8100, and features a unique load/stimuli drawer with interchangeable plug-in stimuli or loads, allowing it to be reconfigured to specific testing requirements in a matter of minutes.

AN/APQ-137 MOVING TARGET FIRE-CONTROL RADAR

Prime Contractor: Electronics and Space Division,
Emerson Electric Company

Remarks

The AN/APQ-137, based on the Emerson Moving Target Detection System (MOTARDES), is capable of extending weapon effectiveness and day-night assault capability against enemy personnel and vehicular targets in the presence of heavy clutter. The system has been flight-tested in the nose-mount configuration aboard the Army UH-1 helicopter as shown in photo; in these flight tests, the system directed the fire of the Emerson-produced M-21 pylon-mounted armament system. The AN/APQ-137 has also been developed in a pod version for mounting under the wings of the Army AH-1G HueyCobra helicopter and of fixed-wing aircraft. The AN/APQ-137 fire-control system consists of an antenna/electronics unit, an indicator unit, and a control panel interfaced with the armament system. In operation, a wide-angle forward sector is searched continually as the helicopter flies above the effective range of enemy small arms ground fire. Moving targets are detected at extended ranges and are displayed on the indicator unit. As the range to the target closes, the copilot expands the display and positions a cursor over the target indicator to perform the gunlaying action.



R-195

**INTEGRATED RADOME, ANTENNA,
AND RF CIRCUITRY (RARF)**

Prime Contractor: Electronics and Space Division,
Emerson Electric Company

Remarks

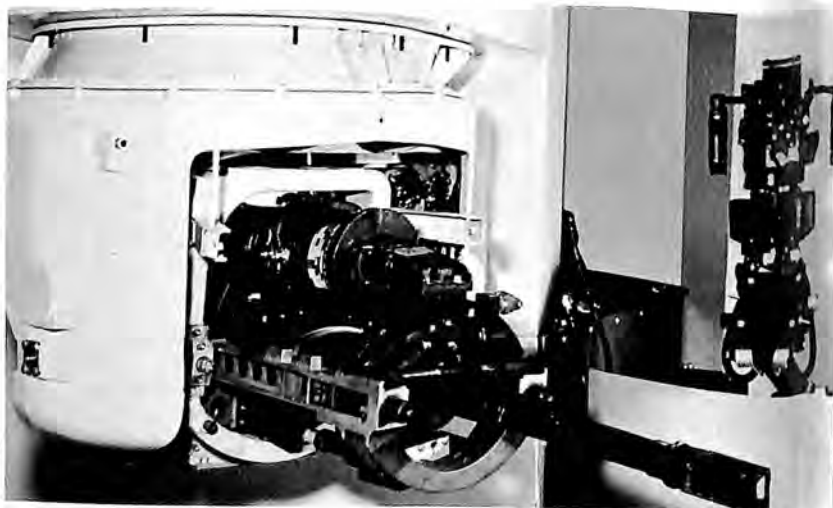
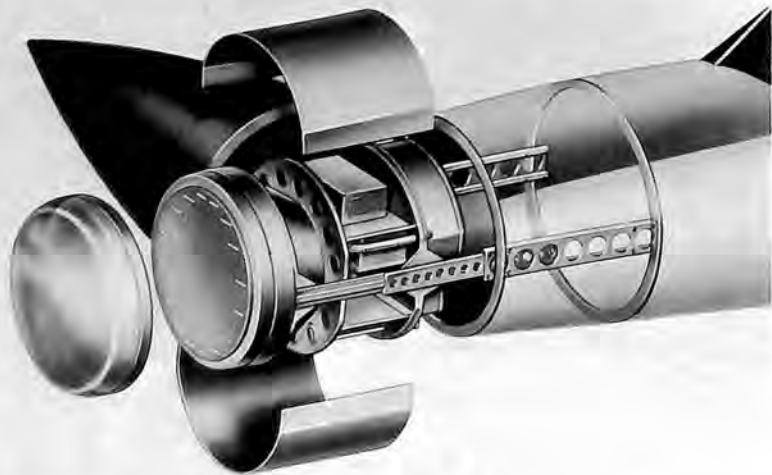
The Emerson RARF radar subsystem is designed to perform all target illumination and data-gathering functions required for future high-performance tactical and strategic aircraft missions. The design is compatible with advanced techniques planned for use in airborne radar systems during the 1970s. The electronically scanned radar system is based on the use of reciprocal latching ferrite phase shifters in a lens array controlled by a special-purpose, lightweight digital computer. RARF performs multi-mode radar functions with one antenna on a time-shared, noninterference basis. Integrated circuits, thick film techniques, and advanced packaging concepts are used to minimize weight and volume.

TAT-140 ARMAMENT SYSTEM

Prime Contractor: Electronics and Space Division,
Emerson Electric Company

Remarks

The TAT-140 is a flexible, remotely controlled armament system designed by Emerson for application to both rotary- and fixed-wing aircraft. The system mounts the XM140 30-millimeter automatic gun and provides rapid and accurate suppressive and point fire on soft and semi-hard targets. Firing rate of the rapid-turnaround 30-millimeter weapon system is 425 shots per minute. The TAT-140 has been built in a chin-turret configuration but can be reconfigured as a belly turret. As a chin turret, the TAT-140 is interchangeable with the Emerson XM-28 armament system used aboard Army HueyCobra helicopters. Commonality of certain TAT-140 and XM-28 components and subsystems makes possible introduction of the TAT-140 into inventory with minimum logistics impact. Major components of the TAT-140 are the turret, weapon, fire controls, ammunition storage and feed system, and sighting station.



R-196

AUXILIARY DATA ANNOTATION SYSTEM

Prime Contractor: Fairchild Hiller Corporation,
Space & Electronics Systems Division

Remarks

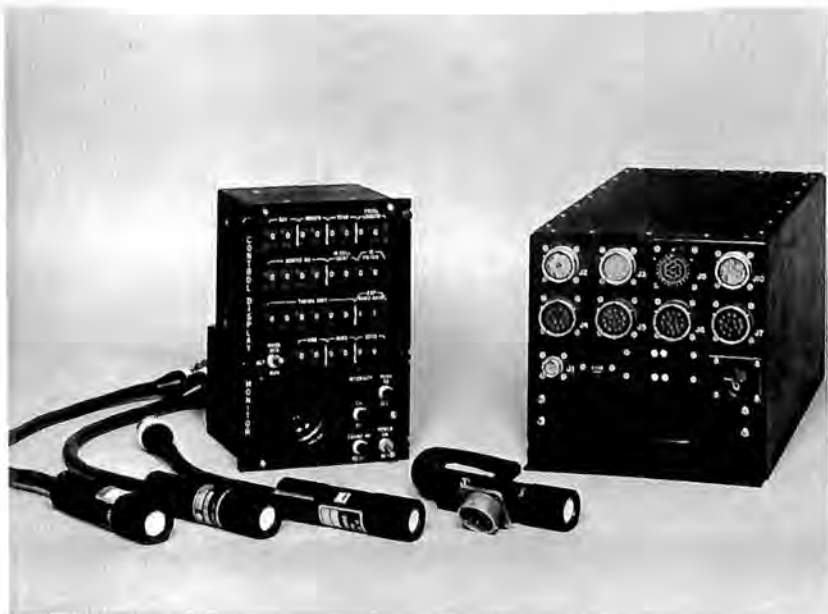
The Auxiliary Data Annotation System (ADAS) provides mission data annotation capability to airborne reconnaissance film recording systems. Flight information such as time, latitude, longitude, speed, barometric and radar altitude, heading, pitch, roll, drift, date, sortie number, detachment, radar mode, electronic data, sensor/station identification, and taking unit identification can be marked automatically on the sensor film. Fairchild Hiller has produced the following ADAS equipment: AN/ASQ-90 for the RF-4B/C, AN/ASQ-92 for the AN/USQ-28 in the KC-135, AN/ASQ-94 for the RF-101, MAS-1 for the RF-104G, AN/AYA-5 (shown), and AN/AYA-15. Each of these sets has been designed for compliance with MIL-STD-782B and can provide an alternate mode of operation to record data in MIL-STD-782B, alphanumeric, or BCD/numerical alternating forms. Information is recorded on film by means of a cathode ray tube contained in each recording head assembly. Fixed program data (date, sortie number, etc.) are inserted prior to flight. An earlier alphanumeric ADAS system was designed for the AN/USD-5 reconnaissance drone.

SERT 2 SPACECRAFT SUPPORT UNIT

Prime Contractor: Fairchild Hiller Corporation,
Space & Electronics Systems Division

Remarks

Under a program for NASA's Lewis Research Center, the Space & Electronics Systems Division designed and delivered 3 (experimental, prototype, flight unit) Spacecraft Support Units (SSU) for the SERT 2 (Space Electric Rocket Test) spacecraft. Located between the Agena D and the spacecraft unit that contains the ion engines and associated experiments, the SSU includes the communication, control, and data-handling subsystems for SERT 2. The SSU is 5 feet in diameter and 3 feet high; it weighs 460 pounds. Major subsystems are the command link, telemetry, acquisition and tracking beacon, power and gyro operation control, instrumentation, and signal conditioning. In addition to the SSU, the division was developing as part of the same contract 2 mobile ground telemetry data-processing systems. In photo, Spacecraft Support Unit is checked over by Fairchild Hiller and Lewis Research Center engineers prior to acceptance.



R-197



THERMAL CONTROL SYSTEMS

Prime Contractor: Fairchild Hiller Corporation, Space & Electronics Systems Division

Remarks

Fairchild Hiller thermal control systems include thermal louvers and heat pipes. Thermal control louver assemblies were manufactured for operation on Pegasus, on the Nimbus D attitude control subsystem, and on the Orbiting Astronomical Observatory (OAO). The assemblies were qualified for operation in an environmental temperature range of plus 120 degrees to plus 180 degrees Fahrenheit with a minimum operating capability (open-to-close/close-to-open) of 15,000 times over an environmental life of 21,000 hours. Flight data obtained from the Pegasus satellites showed that the battery temperature for all 3 spacecraft was maintained within a band of 15 degrees Centigrade during a flight period of 3 years. For the NASA/Grumman OAO program (spacecraft 2, 3, and 4), Fairchild Hiller designed and produced over 40 thermal louvers. Photo shows the 13.5-inch by 24.5-inch OAO louver, self-activating at the slightest temperature change. The thermal louvers consume no power. Fairchild Hiller is also active in the design and development of heat pipes to be used in spacecraft thermal control. The heat pipe efficiently utilizes saturated vapor convection and condensation to transport heat over long distances. Fluid refluxing at the hot end of the pipe is accomplished by the capillary action of a wick which lines the interior of the pipe.

CONTINUOUS ENLARGER

Prime Contractor: Fairchild Hiller Corporation, Space & Electronics Systems Division

Remarks

The Fairchild Hiller Model 702 continuous enlarger, military designation EN-95 (XA-2), combines versatility with high optical precision in handling continuous strips of photographic negatives for enlargement and printing. The unit has a paper transport rate of 60 feet per minute and an exposure rate of one print per second. A high-speed xenon flash lamp exposes the negative and the print material as they move past, insuring freedom from linear distortion and image smear. The 50/200-microsecond exposure time eliminates the need to match precisely both negative and print speeds. This innovation permits, for the first time, the combining in a single instrument of 3 modes of operation: continuous, panoramic, and step and repeat. In the continuous mode, negative and print material move continuously, with the xenon flash triggered to expose each successive frame. The panoramic mode accommodates negatives too long for a single-frame exposure. The long negative is exposed in sections with adequate format overlap to establish the relationship of adjacent prints. In step-and-repeat mode, the print material moves continuously, while the desired negative frame remains stationary. Paper motion distance and the required number of prints are preset. The xenon flash is triggered until the preselected number of identical prints are exposed. The entire operation is continuous, with no need for stopping the print material for each exposure. Access for quick change of photographic paper is provided by large double doors in the front of the unit. All principal controls are sequentially illuminated to guide the operator.



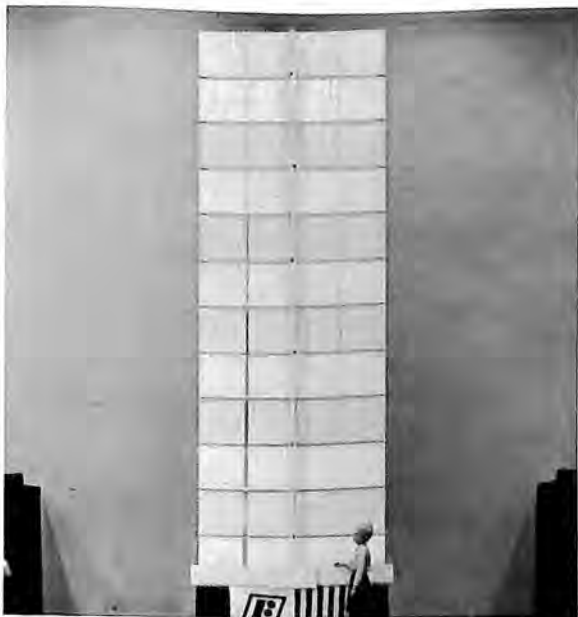
R-198

SOLAR PANELS

Prime Contractor: Fairchild Hiller Corporation, Space & Electronics Systems Division

Remarks

Fairchild Hiller has been actively engaged for a number of years in the development of large extendible solar arrays. The photo shows a full-scale working mock-up of panels for the S-IVB workshop program. The design consists of 12 accordion-folded panels driven by a cross linkage. The extended length is 27 feet; width is 8 feet. This panel is one-eighth of the total array proposed for the workshop. The Radio Astronomy Explorer (RAE 1) satellite, launched July 4, 1968, carries solar arrays designed, developed, and produced by Fairchild Hiller. For the past several years, Fairchild Hiller has conducted development programs on flexible deployable solar arrays for NASA and for the Jet Propulsion Laboratory. A notable accomplishment was the successful completion of 30-watt/pound, 270-square-foot solar array programs for JPL. Fairchild Hiller is also developing a 2-degree-of-freedom system for the Nimbus advanced solar array. With the acquisition of S. J. Industries, one of the few companies in the United States specializing in the installation of solar cells on array panels, Fairchild Hiller became a leading designer and fabricator of solar panels.



AN/TPS-41 MOBILE WEATHER RADAR

Prime Contractor: Fairchild Hiller Corporation, Space & Electronics Systems Division

Remarks

Fairchild Hiller has developed 2 successive generations of mobile weather radars for the Army. The initial development in 1965 resulted in a van-housed radar system, capable of being placed in operation on a self-supporting basis in less than 20 minutes. The latest development, the AN/TPS-41 (XE-2), is a highly flexible, lightweight system that can be transported by jeep or carried by one man. Major system features are ISO-Echo capability; RHI, PPI, A/R, and Nixie displays; lightweight antenna pedestal (158 pounds); and 250-kilowatt peak power X-band transmitter and remote indicator operation. The mobile weather radars provide a completely automatic processing, reduction, and display system for rapid presentation of fresh meteorological data from a mobile position. Battle commanders can locate and measure precipitation and natural or nuclear clouds for tactical purposes at ranges up to 150 miles.



R-199

RECEIVER TEST BENCH SUBSYSTEM

Prime Contractor: Fairchild Hiller Corporation, Space & Electronics Systems Division

Remarks

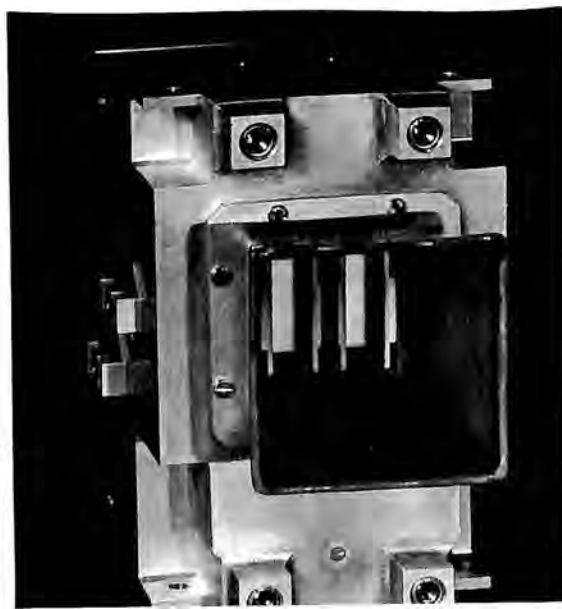
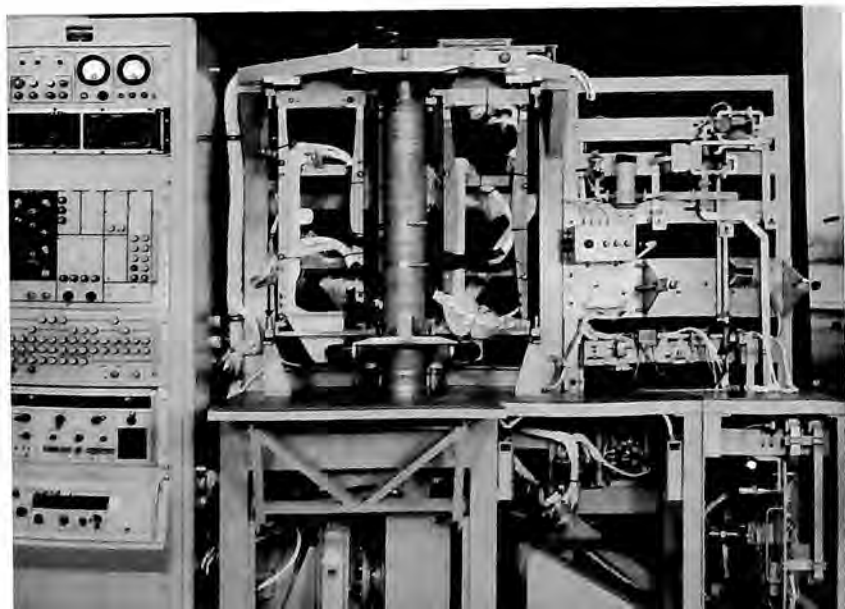
The AN/AWG-10 receiver test bench subsystem is a ground-support equipment designed to provide for test and maintenance of the receiver section of the AN/APG-59 pulse-Doppler fire-control radar. The AN/AWG-10 is a multimission weapons-control system for the F-4B/J/K/M aircraft using the Sparrow missile system. It is built almost entirely from solid-state components. Under contract from Westinghouse Electric Corporation, Fairchild Hiller-SESD shared in the design and is the producer of the receiver test bench subsystem, consisting of a receiver bench assembly and a test and control rack assembly. The bench assembly contains provisions for mounting and operating the radar receiver subsystem. It also provides work space, cooling air, interconnection to the test and control rack, and the microwave calibration package. The test and control rack is a single cabinet which contains the necessary controls for primary power system control, simulated test inputs and loads, system controls, and test equipment. Built-in characteristics of the receiver test bench include capability for calibrating receiver gain over the complete radar band. A self-calibration capability permits balance of 2 parallel paths to within .1 db. Insertion of radar components, such as the BIT target generator, into one of the balanced paths permits calibration by a modified substitution method. Maximum height of the AN/AWG-10 receiver test bench subsystem is 76 inches. The subsystem is designed to be fastened to the deck and bulkhead of a ship or to the floor and wall of a shelter, with the rack shock-mounted. Floor space required for the subsystem is 29 by 96 inches.

PULSED PLASMA MICROTHRUSTER

Prime Contractor: Fairchild Hiller Corporation, Republic Aviation Division

Remarks

The pulsed plasma microthruster developed by Republic Aviation has applicability to satellites for use in attitude stabilization and station keeping. The system is in space on the MIT Lincoln Laboratory LES-6 synchronous-orbit, spin-stabilized experimental communications satellite, launched September 26, 1968; by July 1969, the system had accumulated approximately 3,500 hours of continuous, trouble-free operation. The microthruster utilizes a solid propellant and operates in the 50- to 200-micro-pound thrust range. The propellant is easily measurable in zero gravity. Specific design features include high specific thrust; zero warm-up time; elimination of all valves; fail-safe operation; repeatable, discrete impulse bits compatible with digital logic control; low weight; variable thrust capability; and essentially off-the-shelf availability.



R-200

747 AIR TURBINE DRIVE

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

In production at Stratos is the air turbine drive for the Boeing 747. The TP85-1 air turbine is utilized to drive a hydraulic pump that furnishes, under high load conditions, auxiliary boost power for selected control functions of the aircraft. In addition, air-turbine-driven pumps provide continuous system hydraulic power in case of a malfunction of engine-driven pumps. Nominally rated at 85 horsepower, the Stratos turbine utilizes the bleed air of the jet engine for operating power. There are 4 turbine drives per aircraft. The TP85-1 control circuits are pneumatic and operate on the primary supply air source. They require no quiescent flow, minimizing contamination. They are protected by water separators, filters, and $\frac{3}{8}$ -inch-minimum-diameter lines to preclude any contamination or freezing. The speed-regulation and overspeed sensing/shutdown functions are each performed by a completely independent circuit. The control circuits are adaptive to the environment; i.e., if supply pressure increases, the level of force balance at the control valve actuators increases. No pressure regulators are required in either the control circuits or the air supply to the turbine. Normal speed regulation is accomplished by an isochronous governor which is capable of controlling turbine steady-state speed to within plus or minus 1 percent of its design point.

TOTAL ENVIRONMENT FACILITY (TEF)

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

Under development, the Total Environment Facility (TEF) is a lightweight, highly mobile shelter that contains provisions for the installation of electronic and photographic equipment and for the housing of personnel associated with the processing of reconnaissance data. The heart of the TEF is a utilities section capable of supplying electrical power, air conditioning, heating, water heating and circulation, humidity control, and ventilation for the TEF equipment and occupants. Included in the utilities section, which occupies only the rear 2 feet of the 20- by 8- by 8-foot shelter, are a gas turbine-generator set with 50-kilowatt capacity and an environmental control system powered by utilizing the gas turbine exhaust gases, which are usually vented overboard. The exhaust gas from the turbine-generator set is utilized in the Stratos-designed and -developed Rankine cycle waste heat recovery system for energy conversion. System efficiency increases to a point at which 50 kilowatts of usable refined electrical power are developed at the same fuel consumption rate as that of a 30-kilowatt set without the waste heat recovery feature. The net result is a substantial fuel saving (up to 60 percent), which represents a significant reduction in logistic support required. The TEF will be deployed as part of the TIPI (Tactical Information Processing and Interpretation System), a triservice-sponsored reconnaissance program.

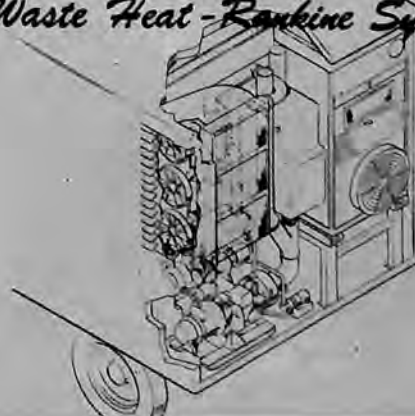


R-201

TIPI/TEF

Total Environmental Facility

Waste Heat-Rankine System



APOLLO ENVIRONMENTAL CONTROL SYSTEM

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Division, Los Angeles

Remarks

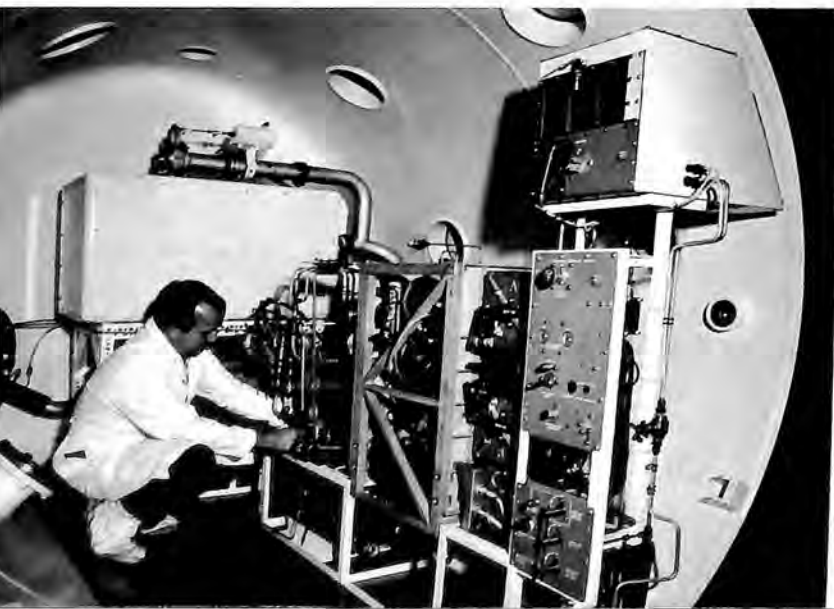
The Apollo Command Module environmental control system (ECS) establishes a safe environment for 3 astronauts and various cabin equipment throughout all mission phases. It provides the crew with oxygen and with hot and cold water; removes carbon dioxide, odors, waste water, and solids from the breathing gas; and controls suit/cabin pressure and temperature. In addition, the ECS regulates certain equipment temperatures by heat dissipation to heat transport coolant loops and provides instrumentation to assess system performance. The system is designed to minimize crew attention during normal operation. Automatic and/or manually actuated component redundancies are incorporated to enhance reliability. Originally designed for a 14-day mission, the ECS is readily capable of significantly longer missions because of an inherent ease of adding expendables. In flight, the nominal cabin environment consists of 100 percent oxygen at 5 pounds per square inch, 75 degrees Fahrenheit temperature, and 50 percent relative humidity. Basic ECS flexibility permits mixed-gas launches and various emergency operations to insure crew safety without mission compromise.

AIRBORNE SPECIAL-PURPOSE DIGITAL COMPUTERS

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Division, Los Angeles

Remarks

Under development at Garrett-AiResearch are a number of airborne special-purpose digital computers. Particularly noteworthy are the central air data computer (CADC) and air inlet control system (AICS) for the Navy's multimission, supersonic F-14 aircraft. Employing advanced electronic technology, the CADC is the first military air data system incorporating all-solid-state electronics and a fully digital computational technique. Extensive use of MOS-LSI circuit logic substantially increases reliability and maintainability with reduced size and weight. The CADC employs a newly developed solid-state quartz pressure sensor (on the left in photo, compared with analog sensor on the right) which converts directly from pneumatic to electrical parameters with greater accuracy and reliability than previously employed electromechanical transducers. The CADC provides more than 50 outputs, both analog and digital, to cockpit instruments and other aircraft subsystems. The AICS, also employing MOS-LSI electronics, senses, computes, and programs the amount and the speed of air entering the aircraft's engines for optimum performance in all flight regimes. Prototypes of both systems were scheduled for delivery in 1970.



R-202



AIRCRAFT ENGINE AND CABIN TURBOCHARGING SYSTEM

Prime Contractor: The Garrett Corporation, AiResearch Industrial Division

Remarks

Turbocharging light business and utility aircraft engines enables quick ascent and cruise above the weather at altitudes of 20,000 to 30,000 feet. Cabin pressurization for flight at those altitudes is accomplished by direct bleed of air from the compressor of the engine turbocharger. Combining cabin and engine supercharging from the compressor of one turbocharger provides simplicity, low cost, and light weight. The basic AiResearch system consists of turbocharger, compressor discharge pressure sensing controller, turbine bypass waste-gate valve, and cabin bleed flow limiting sonic venturi. The system is fully automatic and requires no special attention from the pilot for normal operation. AiResearch turbochargers are used on 3 Beech, 7 Cessna, and 3 Piper models and on the Bell 47G-3B and the Hiller E-4 helicopters. Beech, Cessna, and Mooney also have models incorporating the combined engine and cabin turbocharging system.

AUXILIARY POWER UNITS

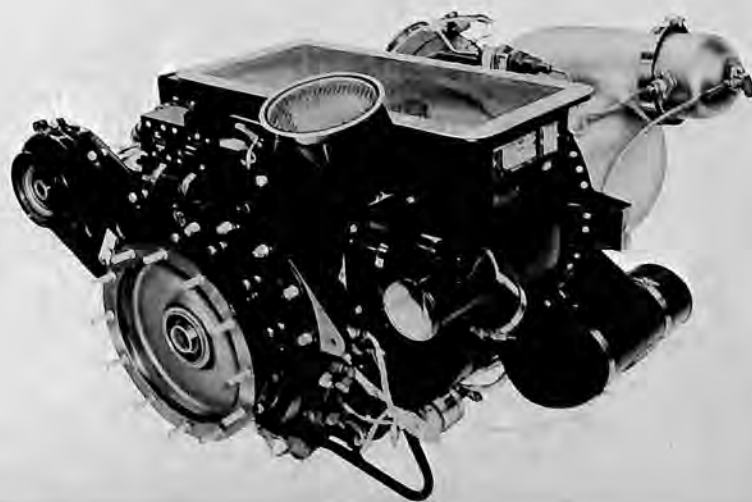
Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Company of Arizona

Remarks

AiResearch-Arizona manufactures 3 series of auxiliary power units. Smallest is the GTP 30 series gas turbine, models of which weigh approximately 75 pounds and produce shaft power in a range from 60 to 150 horsepower. Typical applications include business aircraft auxiliary power units, generator sets for ground power, and pump drives. The GTCP 85 series gas turbine (photo) has the largest production history and the widest variety of applications; models in this series are used as ground and on-board auxiliary power units for airline and military transport aircraft and as generator sets for ground power. Models in the 85 series develop power in the 200- to 350-equivalent-horsepower range and weigh about 275 pounds. Most applications utilize the power in a combination of varying amounts of shaft power and compressed air energy. The shaft power is used for driving generators, alternators, pumps, compressors, and other driven equipment. The pneumatic energy is used in such applications as jet engine starting systems, air-conditioning systems, and anti-ice and heating systems. Newest of the AiResearch line, and the largest of its kind available, is the GTCP 660 series gas turbine, which produces about 300 shaft horsepower, 825 pounds of bleed air per minute, or varying combinations of both at the same time. The system is 73 inches long and weighs 550 pounds. Typical applications include large transport aircraft on-board auxiliary power units and aircraft ground-support equipment.



R-203



CONTINUOUS NONEQUILIBRIUM MHD POWER GENERATOR

Prime Contractor: General Electric Company,
Space Sciences Laboratory

Remarks

A magnetohydrodynamic generator was continuously operated without high heating, for the first time, in a series of basic experiments at the GE Space Sciences Laboratory. The Department of Defense and GE cosponsored the work under the Independent Research & Development Program. Steady electric power of several watts was continuously extracted at 93 percent of the theoretically attainable level of induced voltage. Running times, effectively limited only by the experimental gas supply, were typically about an hour. The success depended on raising the working plasma's level of ionization far above the equilibrium value for the relatively low temperature. (The transverse conductivity during power extraction was approximately 150 times the thermal equilibrium value at 1,500 degrees Kelvin.) The nonequilibrium MHD generator, perhaps as a topping device on a ground-based system, should be capable of exploiting the higher efficiencies at cycle temperatures approaching 2,000 degrees. A nonequilibrium MHD generator, using a condensable alkali metal vapor as the working fluid, promises high reliability because of the complete absence of moving mechanical parts; thus, it is attractive for long-term space nuclear power applications—for electric propulsion, communications, or planet-based needs. In photo, test section of MHD facility with 11 electrode pairs.

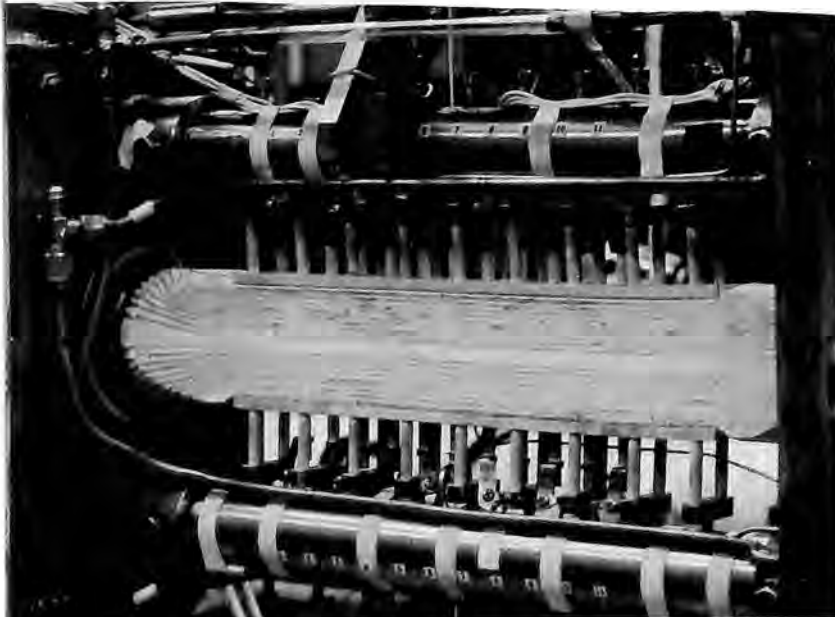
SNAP-27

Prime Contractor: General Electric Company, Missile and Space Division

Principal Subcontractors: 3M Company (thermopile); Solar Division of International Harvester Company (beryllium fabrication)

Remarks

SNAP-27 is a plutonium-238-fueled power supply developed under contract to the Atomic Energy Commission. The complete system weighs 42.7 pounds and produces a minimum of 64 watts (DC) at a nominal 16 volts. It is the power source for the Apollo Lunar Surface Experiments Package (ALSEP), developed for NASA's Manned Spacecraft Center and used for the first time on Apollo 12. The package is transported to the lunar surface within the scientific equipment bay of the Lunar Module (LM). The fuel capsule is transported in a separate protective cask mounted on the external surface of the LM. This fuel cask provides the heat shielding necessary to assure intact reentry of the fuel capsule in the event of an aborted mission. After landing, the fuel capsule is removed from the cask and is inserted into the generator by one of the astronauts. The ALSEP is then deployed on the lunar surface, with the SNAP-27 power source connected to a central station containing the data management and power distribution equipment. Data on the lunar environment will be transmitted to earth for a period of at least one year following departure of the astronauts. The illustration shows an electrically heated fuel capsule being inserted prior to thermal vacuum testing.



R-204



COMPUTED VISUAL SIMULATOR

Prime Contractor: General Electric Company, Electronics Laboratory

Remarks

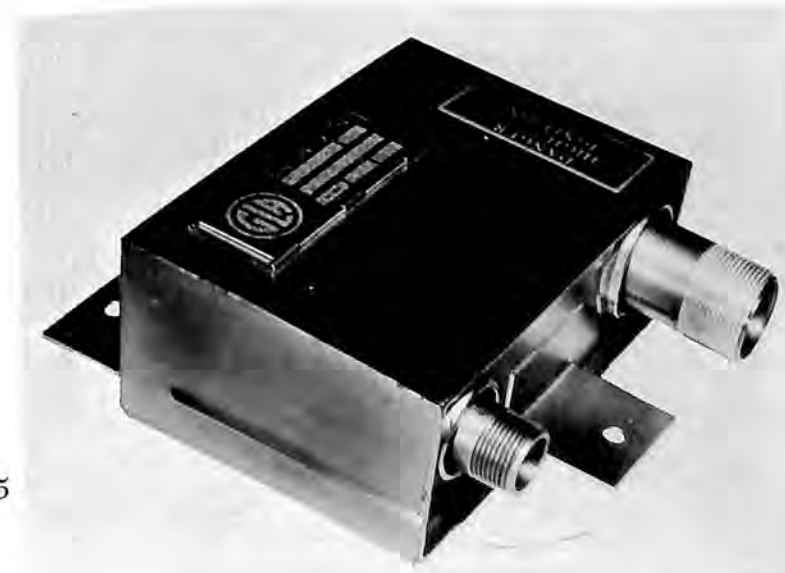
The Computed Visual Simulator, built for NASA's Manned Spacecraft Center, is a special-purpose digital computer that generates real-time television pictures of solid objects and scenes from numerical models stored in the computer's memory. There are no cameras, physical models, slides, or films in the system. The computer updates the television display of the scene in exact perspective 20 times per second. The only external inputs required by the system are data describing the vehicle attitude and position with respect to the scene. The numerical models of various scenes, such as airports, spacecraft, and the lunar surface, are stored on punched tape and fed to the memory prior to running a simulation. The display is in color and scenes are described by straight edges up to a total of 240. GE has developed techniques for increasing the number of edges to 1,500. The Computed Visual Simulator can be used for training or engineering design and evaluation. In training, it overcomes most of the problems associated with TV camera/physical model techniques such as depth of focus, model scaling, lighting, and gimbaling. For design and evaluation, the computed approach presents visual impressions of the characteristics and behavior of a design long before it is built.

ENGINE IGNITION SYSTEMS

Prime Contractor: General Laboratory Associates, Inc.

Remarks

General Laboratory Associates has, over the past 2 decades, attained prominence in the field of gas turbine accessory systems for commercial, military, and business jet aircraft. The photo shows the exciter portion of the GLA ignition system used on the Pratt & Whitney Aircraft JT9D turbofan engines for the Boeing 747 aircraft. This ignition system features 2 separately mounted exciters on each JT9D engine; they supply energy to a recess gap igniter plug through an air-cooled high-tension lead. Other commercial programs utilizing GLA ignition equipment include the Boeing 707, 720, 727, and 737, the McDonnell Douglas DC-8 and DC-9, the Convair 600, 880, and 990, and the Lockheed Electra II. Military programs include the General Dynamics F-111A, the Ling-Temco-Vought A-7, and the Boeing B-52.



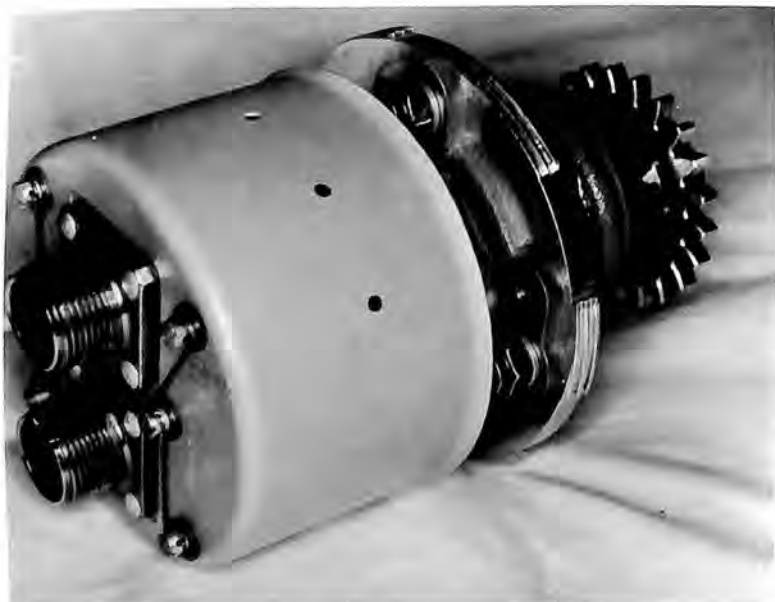
R-205

ENGINE IGNITION ALTERNATORS

Prime Contractor: General Laboratory Associates, Inc.

Remarks

The requirements of advanced aircraft for highly sophisticated electrical systems stressed the need for an engine electrical system separate from the aircraft's main electrical supply. At General Laboratory Associates, the initial task of fulfilling this need was the development of specially designed, lightweight, high-speed alternators as an electrical power source for engine ignition. In production at GLA are alternators with built-in capability of supplying power requirements in a range from 10 percent of full engine speed to full engine speed. Technical developments—particularly military—in advanced engine controls have created additional applications for an independently reliable source of power.



JET ENGINE TEMPERATURE SENSING SYSTEMS

Prime Contractor: General Laboratory Associates, Inc.

Remarks

Demands for a high-integrity and functional means of sensing jet engine temperatures resulted in the application of the thermocouple principle to a system as shown in photo. Specifically, the system is designed to monitor temperatures in the exhaust area of the jet engine. The electrical signal emitted by the system represents the average gas temperature in the searched area. Provisions for engine mounting and for ease of installation or replacement of individual system components are incorporated into the system, as well as features which permit ground check-out of engine functions and of the temperature sensing system. Lightweight, approximately 5 pounds, the system has a life expectancy in excess of 15,000 hours.

R-206

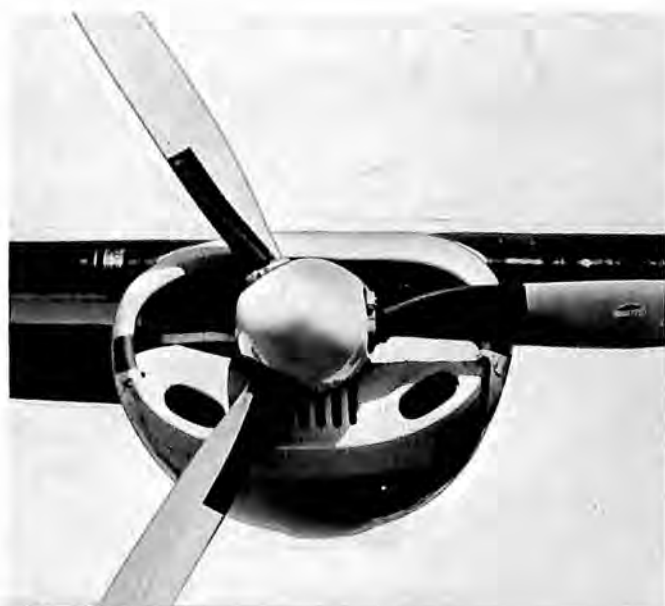


LIGHTWEIGHT PNEUMATIC DE-ICING SYSTEM, ELECTRICAL PROPELLER DE-ICING SYSTEM

Prime Contractor: B. F. Goodrich Aerospace and Defense Products

Remarks

The B. F. Goodrich lightweight pneumatic de-icing system gives inflight protection from the hazards of ice formation on wing and empennage leading edges. It can be put into operation instantly with flip-of-the-switch convenience and will operate continuously if necessary. Engine-driven air pumps or turbine engine compressors are dependable sources of energy for de-icer operation. Spanwise tubes built into the lightweight, reinforced rubber boots are automatically cycled for inflation and deflation, thus cracking the ice and shedding it into the airstream. Electrical propeller de-icers consist of heating elements sandwiched in rubber and bonded to propeller blades. Electrical energy is cycled automatically through a slip ring-brush assembly for an effective and efficient heat pattern on prop blades. BFG lightweight pneumatic and electrical propeller de-icers are available for most popular single- and twin-engine general aircraft. The systems can be installed at the factory as optional original equipment, or later as field installations. Total system weights depend upon make and model of aircraft. Ranges are approximately as follows: pneumatic de-icers, 20 to 60 pounds; electrical prop de-icers, 5 to 15 pounds.



R-207

463L CARGO PALLETS

Prime Contractor: Goodyear Aerospace Corporation

Remarks

Standard Air Force 463L cargo pallets are used to transport goods and material throughout the free world; a large number are being used in Vietnam and Southeast Asia. During the first 7 months of 1969, the Air Force ordered 15,438 of the pallets from Goodyear Aerospace. The pallets, ordered by the Air Materiel Command at Warner-Robins Air Force Base, Georgia, measure approximately 7 feet by 9 feet and are 2.25 inches thick. They have a lightweight, end-grain balsa core surfaced with aluminum and enclosed in aluminum side rails. Although weighing less than 300 pounds each, they can handle cargo loads weighing up to 10,000 pounds. They are so rugged that in emergencies they can be air- or runway-dropped. Tie-down fittings secure cargo from warehouse to the final destination. The pallets fit on lift trucks, slide into transport aircraft on rollers, and lock into place either sideways or lengthways. They are used in a variety of planes including the C-124, C-130, C-130E, C-133, C-135, and C-141. Prior to 1969, Goodyear Aerospace had supplied 36,000 of the 463L pallets to the Air Force.

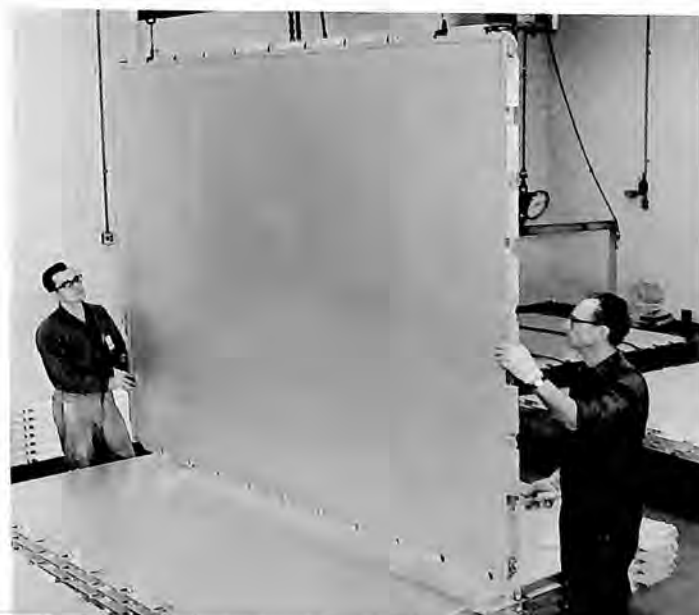


PHOTO PROCESSING AND INTERPRETATION (PPI) SYSTEMS

Prime Contractor: Goodyear Aerospace Corporation

Remarks

Completely mobile color or black-and-white photography processing and interpretation facilities, capable of rapid processing of aerial reconnaissance film, help reduce the critical time between Tactical Air Command reconnaissance flights and possible retaliatory measures in forward tactical areas. Color printing equipment included in the system can process and dry 3,200 feet of 5-inch-wide color aerial reconnaissance film in an 8-hour period. It can also duplicate standard 70-millimeter, 5-inch, and 9.5-inch reconnaissance film in continuous lengths up to 1,000 feet at rates from 20 to 60 feet per minute. Enlargements up to 30 inches by 30 inches are possible. Eight photo shelters are included in the color units, which are completely air mobile for use in forward combat areas, including those with arctic cold or jungle heat conditions. The shelters are linked by intercoms and passageways and are served by electrical, water, drainage, and air-conditioning systems. The PPI systems provide tactical aerial reconnaissance units with a number of services: processing and interpreting aerial color film records; preparing and releasing flash and immediate reports; exposing and processing color aerial film duplicates for immediate use or distribution to other users; printing and processing enlarged color prints to support reconnaissance reports; and support functions, including administration, quality control, water conditioning, chemical mixing, distribution, storage, and maintenance. Two ES-75 (XA-1) color processor units built in 1968-69 are an outgrowth of black-and-white film processing units, designated WS430A and WS430B, used around the world.



PARAWING PRECISION AERIAL DELIVERY SYSTEM

Prime Contractor: Goodyear Aerospace Corporation

Remarks

The parawing is a parachute-like gliding device that eliminates 3 combat-area problems of parachutes: exposing airplanes and crews to enemy gunfire, revealing the ground location of troops receiving food and supplies, and delivering supplies inaccurately. Guided by a radio no larger than a GI walkie-talkie, the controlled airdrop cargo system is accurate to within 200 feet of a target when released from airplanes flying up to 6 miles high and 15 miles away. Silent and capable of flying day or night in all types of weather, a 25-foot-wide parawing can carry payloads ranging from 100 to 500 pounds. It is highly maneuverable and can be steered by pushing "left" or "right" buttons on the ground transmitter; it will also automatically home to the transmitter. The device was developed under contract with the Army Aviation Material Laboratories, Fort Eustis, Virginia. Twenty units have been tested extensively at Yuma Proving Ground, Arizona. The parawing remotely resembles a parachute in that it is made of flexible cloth and its load is carried at the end of suspension lines. Actually, however, it is a triangular-shaped glider that is steerable. It can be folded into a compact package weighing 80 pounds and less than 3 cubic feet in volume. Both parawings and parachutes can be released from as high as 30,000 feet, but parachutes lack the range and accuracy of parawings. The parawing lets the payload hit the ground with about the same impact as a parachute-dropped load, providing protection for such items as fuel, medical supplies, food, ammunition, and survival gear.



R-208

METAL MATRIX CONTINUOUS FILAMENT COMPOSITES

Prime Contractor: Harvey Engineering Laboratories, a division of Harvey Aluminum, Inc.

Remarks

A family of materials consisting of aluminum or titanium alloy as a matrix, reinforced by continuous filaments of boron, beryllium, silicon carbide, stainless steel, or alumina, has been developed by Harvey Engineering Laboratories. These materials possess heretofore unavailable combinations of high strength/weight and stiffness/weight ratios together with high endurance limit, good corrosion resistance, and other desirable properties. Weight savings of 25 to 40 percent are possible with these materials as compared with high-strength homogeneous metals and alloys. Applications are being made in aerospace and airframe structures and in components of propulsion units. Forms available are sheet and plate in any thickness from .003 to 1 inch, monolayer or multilayer tape, simple forged shapes, and die forgings and structural shapes such as hat sections, angles, zees, channels, and tees.



DIGITAL AIR DATA COMPUTER

Prime Contractor: Honeywell Inc.

Remarks

The digital air data computer constantly measures critical parameters to provide real-time inputs to aircraft flight data displays and control systems. It incorporates a completely solid-state pressure transducer (photo) capable of converting pressure inputs into frequency-modulated outputs. Key element of the transducer is a single crystal silicon diaphragm on the face of which are diffused 2 piezo-resistive elements that control 2 oscillators. The oscillators in turn produce frequency-modulated outputs that are fed directly to the computer. The computer was designed to meet ARINC specification 576 and is readily adaptable to ARINC 575 and 565 requirements. These specifications require altitude measurement accuracy of 15 feet and sensitivity of 1 foot of altitude change at sea level. Integrated circuitry is used extensively in the computer to reduce complexity and increase reliability. The computer's compact central processor was designed to handle 18-bit word length and 12-bit instruction word length; it employs a nonvolatile fixed memory. The processor also incorporates a scratch-pad memory and a repertoire covering multiplication, addition, division, square root, branching, and transfer functions. Another feature is a built-in test capability that provides a continuous inflight check of the system and a ground self-test capable of detecting better than 98 percent of all potential failures.

R-209



HELMET SIGHT SYSTEM

Prime Contractor: Honeywell Inc.

Remarks

The Honeywell helmet sight system permits the pilot of an aircraft to acquire air or ground targets, without interfering with the pilot's primary task of flying the aircraft. The system was developed as a fire-control aid for the Lockheed-built Army AH-56A Cheyenne helicopter, and it is being utilized in an Air Force reconnaissance project and in an Air Force camera direction experiment. The helmet-mounted eyepiece eliminates the pilot's need for a hand-held sight, and an electrooptical positioning concept eliminates restrictive mechanical linkages between helmet and cockpit. Once determined by computer, the helmet's position is fed by electronic signals to command gun or camera direction. Helmet-mounted CRT displays have been developed to provide critical information to the helmet sight operator while maintaining continuous head-up target trackings.

AGENA GUIDANCE SYSTEM

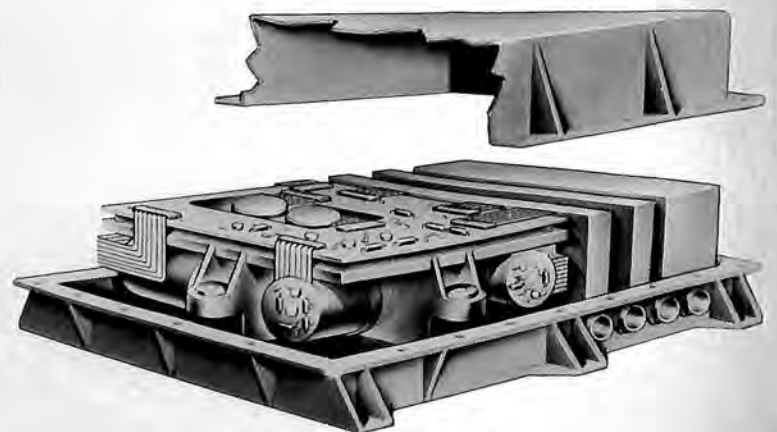
Prime Contractor: Honeywell Inc.

Remarks

The Honeywell H-448 Agena Strapdown Inertial Guidance and Navigation (SIGN) system is unique to the aerospace industry, as it is the first strapdown navigator to guide a space booster. Designed by Honeywell's Aerospace Division-Florida for increased accuracy and extremely high reliability, it provides attitude and reference information to the Agena during precise orbital insertion missions. The H-448 consists of an inertial measurement unit (photo shows artist's conception) and the Honeywell Model H-501 digital computer with an 8,000-word memory. Inertial components (gyros and accelerometers) are supplied by Honeywell's Aerospace Division-Minneapolis. The Honeywell strapdown system enhances the operational flexibility of the booster, which is capable of covering a wide range of space missions.



R-210



AN/ASN-101 GIMBALED ELECTROSTATIC AIRCRAFT NAVIGATION SYSTEM

Prime Contractor: Honeywell Inc.

Remarks

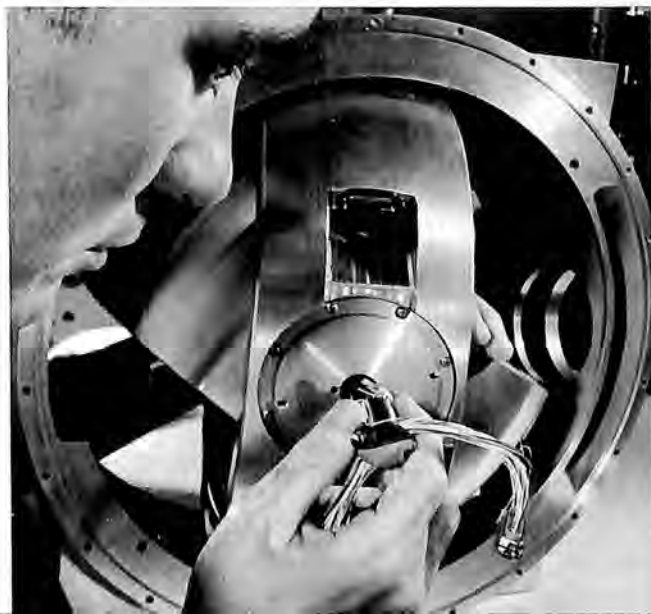
The AN/ASN-101 Gimbaled Electrostatic Aircraft Navigation System (GEANS) is an ultraprecise, self-contained, self-aligned, worldwide inertial navigator. GEANS relies on the excellent drift characteristics of the electrostatic gyro. Heart of the system is the full-freedom, 4-gimbaled inertial measuring unit which houses 2 GEANS gyro packages, an accelerometer triad, and supporting integrated circuit electronics. The platform is accompanied by a high-speed Honeywell airborne digital computer with the firm's plated wire memory, a system electronics unit, and a control display unit. The inner element of the inertial measuring unit is slaved to the electrostatic gyro spin axes to provide a space-stable base for the accelerometer triad. The system is controlled through the control display unit, which uses a modified calculator-type keyboard to provide a verbalized form of communication with the computer. Power conversion and automatic sequencing are provided by the computer and the system electronics unit. According to Honeywell, the AN/ASN-101 provides a navigational capability beyond that of other inertial systems; it will be available for duty on a wide variety of advanced strategic, tactical, and command and control aircraft now planned by the military services. GEANS is being developed by Honeywell Aerospace Division-Florida for the Air Force Avionics Laboratory, Aeronautical Systems Division.

ADVANCED DESIGN ARRAY RADAR (ADAR)

Prime Contractor: Hughes Aircraft Company

Remarks

ADAR is a radar prototype system being produced by Hughes for the Advanced Research Projects Agency and the Army as a forerunner of what could be the world's most powerful radar for defense against missile attack. The prototype, a scale version of a proposed long-range system, is in test status. The transmitting array is a planar phased array that is electronically steered by ferrite phase shifters. The antenna beam width is 3 degrees by 5 degrees. Wide-scan angle coverage is provided by the array, which is divided into sub-arrays energized by true-time delayers. The receiving array consists of a microwave optical system fed by many horns, each producing a receive beam. A microwave switching matrix selects the desired beams for reception and connects them to receivers. The receive beam width is 2 degrees. The radar is programmed to be fully automatic in scanning and tracking. Targets are automatically acquired and tracked within a selected sector of space. Controls at the radar console enable the operator to set the modes of radar operation and to carry out certain tests. Displays consist of a monitoring scope and a typewriter print-out of radar data. Magnetic tape outputs are also available. In photo, artist's conception of ADAR transmitting and receiving antennas in a subterranean installation.



R-211



NAVAL TACTICAL DATA SYSTEM

Prime Contractor: Hughes Aircraft Company

Remarks

The Naval Tactical Data System (NTDS) is an information display nerve center which exhibits instantaneous data about a tactical battle zone before the eyes of a Navy shipboard commander. In production at Hughes, NTDS consoles give tactical operations teams in the depths of a ship a comprehensive picture of ships, aircraft, and submarines, friend or foe, within reach of a fleet's electronic eyes and ears. NTDS can detect, track, and determine height, identity, and composition of a raid. Within seconds, the system can evaluate the potential threat, assign and control countering weapons, and perform other command functions for a single ship or for an entire fleet. NTDS replaces the conventional shipboard combat information center by virtually eliminating the possibility of human error and the delays that often plagued the manual system of plotting. The NTDS display can be trimmed to 3 consoles for specific missions; other installations require up to 30 consoles. In addition to providing shipboard teams with specific information, NTDS can furnish display information throughout a data network linking several ships with each other and with shore stations.

MANPACK TRANSCEIVER

Prime Contractor: Hughes Aircraft Company

Remarks

Hughes is producing for the Army the lightweight Manpack sending/receiver radio system which provides 16,000 individual voice channels and operates effectively even in dense jungle. The solid-state Manpack is a single sideband radio only 18 inches high, 12 inches wide, and 3.75 inches thick. Its 2- to 18-megacycle range and 16,000 channels offer a wide, built-in frequency flexibility, making enemy jamming efforts more difficult. Manpack's high-frequency signals reflect from the ionosphere, giving them a range beyond line of sight. Thus, the signals can traverse mountains and jungles, where VHF and UHF signals often fail. Manpack is designed to operate on ordinary flashlight-type dry cell batteries as well as wet cell batteries. Designed to be carried by one man wearing a standard Army shoulder harness, the system weighs about 29 pounds with wet cells. In field tests, the sets have operated efficiently between points over 500 miles apart, and on one occasion a Manpack clear transmission spanned 7,500 miles. Manpack uses a collapsible ship antenna, but for greater distances it can use a slant-wire antenna attached to a tree or a dipole antenna stretched between 2 vertical supports.



R-212



AIR DEFENSE GROUND ENVIRONMENT SYSTEMS

Prime Contractor: Hughes Aircraft Company

Remarks

Advanced Air Defense Ground Environment (ADGE) systems, designed by Hughes, are installed in a number of free world countries. The modular systems, which can be tailored to the requirements of the individual country, are designed to provide an electronic "umbrella" of protection against attack from the air. They are installed in Japan (BADGE system), West Germany, the Netherlands, and Belgium (IPG system). A similar Hughes system is being installed in Switzerland (Project FLORIDA). Hughes is also one of 6 international firms incorporated to design and build the \$300,000,000 NATO Air Defense Ground Environment (NADGE) system in Europe. The ADGE systems are composed of state-of-the-art general-purpose computers, electronic data display units, data-processing equipment, and communications equipment. When combined with long-range modern radars, the systems provide a modernized, quick-reacting capability of rapid detection, identification, and tracking of potential enemy air threats and to-the-target control of supersonic air defense missiles and fighter interceptors. ADGE systems are designed to meet specific air defense needs of today, but they have the capability of growth to meet new air defense challenges of tomorrow. In photo, main operations room of a NATO bunker in the IPG system.



SATURN INSTRUMENT UNIT

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

The Instrument Unit (IU)—the 3-foot-high "nerve center" stage of Saturn—was designed at NASA's Marshall Space Flight Center and is assembled at Huntsville, Alabama, by IBM Federal Systems Division. Each Saturn IB and Saturn V has one of these aluminum rings, 21.7 feet in diameter. More than 60 electrical and electronic units are integrated within each IU to provide the vehicle with guidance, navigation, control, and data-handling systems. IBM has system integration responsibility for the Saturn IUs including fabrication, assembly, check-out, and launch support. IBM also builds the on-board computer and the data adapter. During a mission, the IU's sensitive instruments process millions of bits of data every few minutes, and its guidance system measures acceleration and vehicle attitude 25 times a second. It determines velocity and position every second, then calculates and issues steering commands to keep Saturn on course. The IU samples 200 sensors that measure environment and systems performance; tests sound levels, temperatures, pressures, and vibration levels more than 7,000 times a minute; and records and relays flight information to ground stations. Before launch, the IU aids in countdown check-out. Under blockhouse control, the on-board IBM computer checks itself and the Saturn vehicle. It tests switch selectors in each stage and orders first-stage engines to gimbal for visual observation. Once in earth orbit, the IU commands engine re-ignition to put Apollo on a correct lunar trajectory. When on course, it stabilizes the stage for the turnaround and docking maneuver.

R-213



SYSTEM/4 PI

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

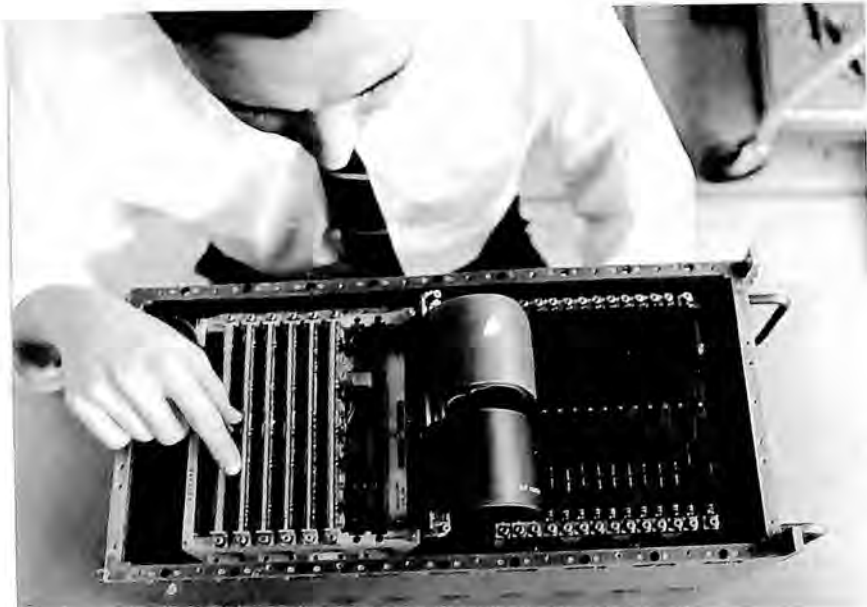
IBM System/4 Pi is a new family of general-purpose computers built for aerospace applications such as navigation and weapons delivery for aircraft, artillery fire control for battlefield systems, and spacecraft guidance. The computers range in size from .4 cubic foot to 2 cubic feet. They are "hardened" to withstand the temperature and vibration extremes common to military and space environments. System/4 Pi computers have been selected for several aerospace programs, including 2 versions of the Air Force's F-111 variable-sweeping aircraft: the F-111D tactical fighter and FB-111 strategic bomber. Each aircraft uses 2 4 Pi computers, one for navigation and one for weapons delivery. The computers are also used in the Navy EA-6B electronic warfare aircraft, in an electronic system to process and correlate enemy radar data; in the Navy Target Identification and Acquisition System, an airborne system used with Standard ARM antiradiation missile; in the Navy A-6A attack aircraft; and in Navy and Air Force versions of the A-7 fighter-bomber. System/4 Pi makes the first use of read-only storage for computer logic control in aerospace systems. There are 3 System/4 Pi models: Model TC (tactical computer) for satellites, tactical missiles, helicopters, and other applications requiring a very small, lightweight computer; Model CP (customized processor) for real-time computing applications; and Model EP (extended performance) for applications that require real-time calculation of very large amounts of data.

AN/ARN-90 AIRBORNE TACAN BEACON SYSTEM

Prime Contractor: ITT Avionics, a division of International Telephone and Telegraph Corporation

Remarks

The original TACAN AN/ARN-52(V) was designed for use by military aircraft in conjunction with a mobile or fixed beacon. The TACAN AN/ARN-90 is an airborne system which adds TACAN air-to-air bearing capability to the already existing TACAN air-to-air distance capability of the AN/ARN-52(V). The combined distance and bearing facility of an AN/ARN-90-equipped aircraft thus provides complete TACAN navigational service to user aircraft. The AN/ARN-90 equipment complement consists of a bearing data unit, a rotating antenna (new designs), and a receiver-transmitter (modified AN/ARN-52). This new system offers a wide choice of potential air-to-air applications including refueling, rendezvous, and station keeping. It is compatible with the TACAN system.



R-214

AN/URN-20 TACAN BEACON SYSTEM

Prime Contractor: ITT Avionics, a division of International Telephone and Telegraph Corporation

Remarks

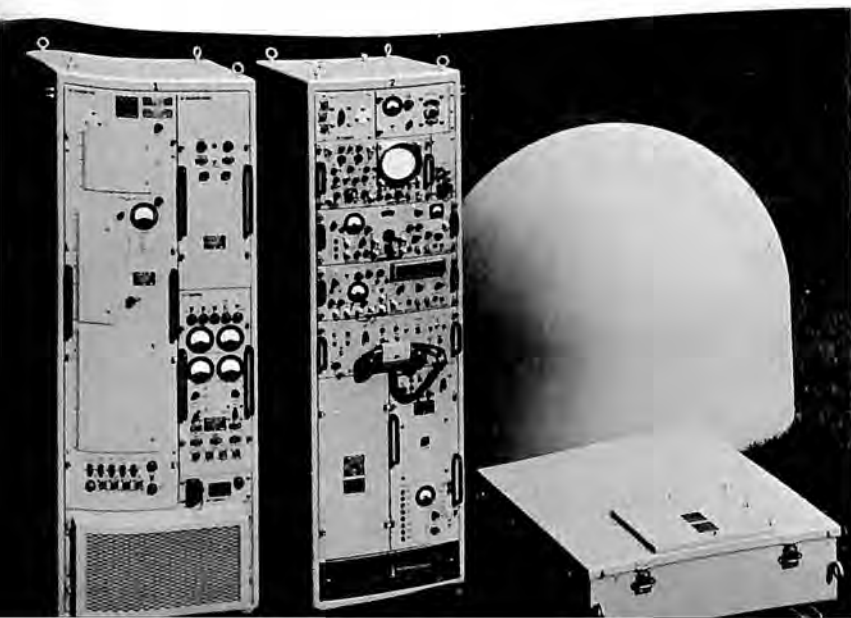
The AN/URN-20 radio set (beacon) is the latest shipboard/ground TACAN navigation aid in use. The solid-state equipment is designed for a 300-mile-range capability; it operates in a polar coordinate mode. Although designed originally for use on ships, the equipment can be applied anywhere. It can be used in a dual configuration. When the AN/URN-20 is mounted on a ship, a roll stabilizer is used. For ground station use, the same antenna without the roll stabilizer can be utilized as well as any other existing ground TACAN antenna capable of handling the RF power output. The system consists of transponder group, TMC (test-monitor-control) group, antenna group, line voltage regulators, and remote indicator. Signals transmitted by the radio set provide properly equipped aircraft with air-distance and bearing information needed by the aircraft to determine their positions with respect to the beacon.

SATELLITE COMMUNICATION EARTH TERMINAL

Prime Contractor: ITT Defense Communications, a division of International Telephone and Telegraph Corporation

Remarks

This satellite communication earth terminal is situated in Buitrago, Spain, 50 miles north of Madrid, and was built by ITT Defense Communications Division for Compania Telefonica Nacional de Espana, the national telephone company of Spain. The terminal provides Spain with a communication gateway to North and South America via the Intelsat series of commercial communication satellites. The terminal permits simultaneous transmission over 10 message links and a television circuit.



R-215

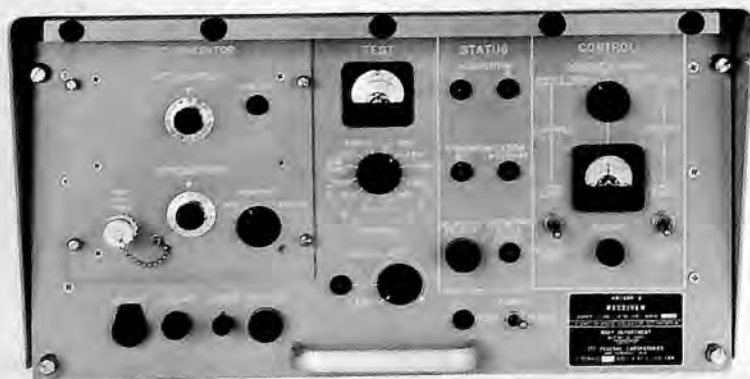


SATELLITE NAVIGATION SHIPBOARD RECEIVING EQUIPMENT

Prime Contractor: ITT Aerospace/Optical, San Fernando, a division of International Telephone and Telegraph Corporation

Remarks

The AN/SRN-9 radio navigation set was developed and produced by ITT Aerospace/Optical for shipboard use by the Navy in obtaining precise position fixes from the Navy Navigation Satellite system. The dual-channel, phase lock receiver, with its unique conical helix antenna, acquires from the satellite's signals the orbital parameters, Doppler shift, and refraction index of the satellite and formats these data to enable a digital computer to provide a position fix in direct readout of latitude and longitude with an accuracy better than .1 nautical mile. The equipment operates reliably in all weather conditions, worldwide, with an accuracy unaffected by seasonal or diurnal ionospheric shifts. The system has been in operational Navy use since 1964. Its declassification in 1967 led to the Model 4007AB commercial version for use in commercial and scientific oceanographic applications. Both the naval and the commercial versions are being produced in quantity and have been proven in operational use.



PORTABLE AUTOMATIC CALIBRATION TRACKER

Prime Contractor: ITT Aerospace/Optical, a division of International Telephone and Telegraph Corporation

Remarks

The Portable Automatic Calibration Tracker (PACT) system was developed for NASA's Goddard Space Flight Center to calibrate Space Tracking and Data Acquisition Network (STADAN) antennas. The system comprises an electrooptical sensor, X-Y mount assembly, and subsystems for mount control, data processing, display, and print-out. A 4,500-watt quartz iodine light source supplied with the system is mounted concentrically with a radar beacon antenna on a calibration aircraft. Simultaneous tracking of optical and radio-frequency targets by PACT and a STADAN antenna facilitates calibration of antenna pointing angles. Manual control is exercised during target acquisition; after the target has been acquired, the system tracks automatically.



MULTIPLIER PHOTOTUBES

Prime Contractor: ITT Electron Tube Division, a division of International Telephone and Telegraph Corporation

Remarks

Electron Tube Division is manufacturing a complete line of special-purpose multiplier phototubes providing broad spectral response range from the ultraviolet to the near infrared for the detection of moderate to very low levels of radiated energy. The line includes star tracker types characterized by low dark currents, low noise, high sensitivity, single electron counting capability, and magnetic deflection capability. The F4071 (photo) is designed specifically for laser ranging and other specialized applications in which premium performance and small size are critical considerations. Other types are being manufactured for applications involving high current operations, high ambient temperature, general scintillation counting, electron energy selection, heterodyne detection, fast gating, and detection of modulated high-frequency light beams. Ruggedized versions of many types are available.



R-217

GROUND CONTROL APPROACH QUADRADAR

Prime Contractor: ITT Gilfillan, Inc., International Telephone and Telegraph Corporation

Remarks

The Quadradar is a complete, 4-in-1 ground control approach radar which provides precision approach, surveillance, height finding, and taxi radar coverage for air traffic control. On final approach, the ITT Gilfillan Quadradar presents to the operator the range, bearing, and altitude of all aircraft within 40 miles. The data are used to keep the pilots on optimum course line and glide path to touchdown. The Quadradar provides 360-degree surveillance coverage to the 40-mile range, permitting the operator to control terminal traffic while establishing final approach patterns. Accurate altitude information on any aircraft up to 50,000 feet makes the Quadradar's height-finding system a valuable aid to complete air traffic control. The Quadradar's taxi coverage provides surface surveillance permitting an expanded view of aircraft or other objects on the runway.



FLITE-PATH DISPLAY

Prime Contractor: Kaiser Aerospace & Electronics Corporation

Remarks

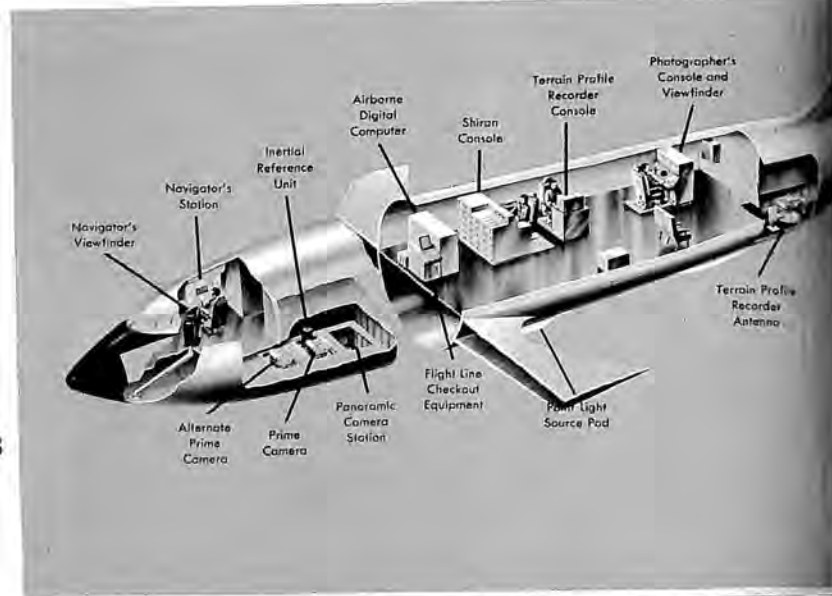
The Kaiser Flite-Path display, developed by Kaiser Aerospace & Electronics Corporation, is a revolutionary new aircraft instrumentation system for light aircraft. It is an electronic system that integrates data from many of the currently used standard instruments and converts the data into a TV picture that can be scanned by the pilot as though he were flying in visual contact with the real world. Instead of the "black ball" artificial horizon in present use, the pilot sees in his TV-type picture a realistic portrayal of a light sky, a dark ground with small symbols that represent earth features, and a highway that diminishes in perspective toward the horizon. The earth-feature symbols first appear as small fields on the horizon and increase in size as they move down the TV screen so that the pilot visualizes that his aircraft is moving over the earth below. In a turn, the symbols translate sideways, giving the real-world impression that the landmarks remain stationary and the aircraft is turning away. The "highway in the sky" is superimposed over the basic display and directs the pilot to his destination. The path is positioned by information that has been processed from radios, a gyro compass, and an altitude sensor.

AN/USQ-28 AERIAL SURVEYING AND MAPPING SYSTEM

Prime Contractor: Kollsman Instrument Corporation

Remarks

The AN/USQ-28 is the first of a new class of advanced airborne electronic photographic systems that completely integrates aerial surveying and photomapping techniques with computer control. The system includes advanced-design mapping cameras which are located, with their support equipment, in a pressurized compartment in the bottom of the forward section of the fuselage. Above this compartment is the navigator's station, with an extremely accurate navigator's viewfinder and the controls for the inertial reference unit. The other subsystems, which include the photographer's station with console and viewfinder, the Shiran operator's station and related equipment, the terrain profile recorder console, and the digital computer, are located amidship and aft in the aircraft. These subsystems are integrated to provide the fastest and most accurate means available for obtaining raw geodetic and photomapping data. The AN/USQ-28 system is capable of mapping 30,000 to 40,000 square miles a day, and it will collect data on the location, altitude, and angle at which the photographs were taken. The program is directed by the Aeronautical Systems Division, USAF, Wright-Patterson Air Force Base. Kollsman has delivered a prototype system and 3 production models for installation in Boeing RC-135A aircraft operating at Forbes AFB, Kansas, home of the 1370th Photo Mapping Wing.



INTEGRATED FLIGHT INSTRUMENT SYSTEM

Prime Contractor: Kollsman Instrument Corporation

Remarks

The heart of the Integrated Flight Instrument System for airline and executive jet use is the KS 200 central air data computer (at right in photo). The computer produces more than 50 outputs, including signals for autopilot, altitude reporting, altitude alerting, Mach trim, cabin pressurization, servo pneumatic altimeters, and servo altimeters. It has been certified for use on the Boeing 737, the McDonnell Douglas DC-8-60 series, the Grumman Gulfstream II, and the DH-125. Typical instruments in the system are at left in photo. They are (left row, top to bottom) Kollsman's altitude alert device, servo pneumatic altimeter, static air temperature and true airspeed servo indicator, (right row, top to bottom) electric altimeter, and Mach airspeed indicator. The altitude alert device provides the pilot with a series of signals as he approaches his pre-selected altitude level. The device is activated by an electric signal from the same source that supplies altitude information to the pilot, thus assuring close correlation between the alerting signal and the altitude indication used to control the aircraft. The servo pneumatic altimeter is a pressure-actuated instrument with a range of minus 1,000 to plus 50,000 feet. The static air temperature and true airspeed indicator is a dual servoed indicator with a total temperature probe to provide a combined display of both true airspeed and corrected true outside air temperature. The electric altimeter is a servoed altitude indicator. Its presentation is positioned by a 2-speed servo system which accepts an ARINC altitude output from the air data computer. The Mach airspeed indicator displays indicated airspeed, maximum allowable airspeed, and Mach number.

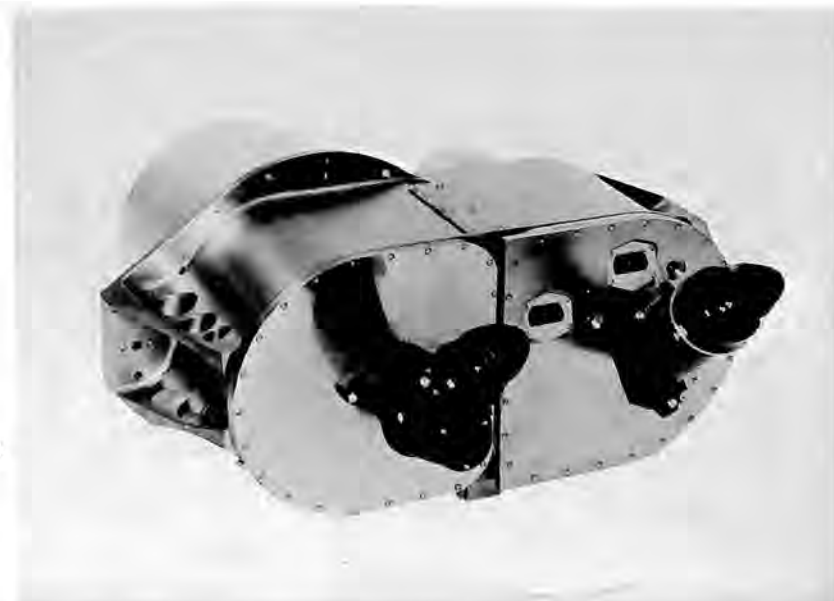


APOLLO OPTICAL UNIT ASSEMBLY AND ALIGNMENT OPTICAL TELESCOPE

Prime Contractor: Kollsman Instrument Corporation

Remarks

The Optical Unit Assembly (photo) is the primary component of the Apollo Command Module guidance and navigation optical subsystem. The assembly consists of a scanning telescope (right) and a sextant which are used in conjunction with the inertial guidance system and on-board computer to periodically establish an inertial reference for measurements and computation, to align the inertial reference by precise optical sightings, and to compute the position and velocity of the spacecraft by optical navigation and inertial guidance. Different optical measurements are made at different phases of the Apollo flight. During orbital and midcourse flight phases, optical measurements are used to provide information for determining the position of the vehicle. The sextant is a 28-power instrument with a 1.8-degree field of view. Field-of-view accuracy is 10 seconds of arc. The scanning telescope is a single-line-of-sight, unity-power, 60-degree-field-of-view instrument. It is used primarily for target acquisition and for known landmark bearing measurements. The Alignment Optical Telescope (AOT) is carried aboard the Lunar Module and mounted on a common base with the inertial measurement unit. It is used in conjunction with the guidance computer to align this stable inertial reference before descent to, and prior to launch from, the lunar surface. The AOT is a periscopic instrument which provides an instantaneous 60-degree field of view fixed in elevation, by means of an objective prism, at an angle of 45 degrees above the horizontal.



AUTOMATIC FLIGHT CONTROL SYSTEM

Prime Contractor: Lear Siegler, Inc., Astronics Division

Remarks

Automatic Flight Control System (AFCS) AN/ASW-31, designed and produced by Astronics Division for the Lockheed P-3C Orion, is a high-reliability dual-channel fail-passive autopilot replacing the single-channel system presently used in aircraft of the P-3 series. The new autopilot is an outgrowth of the AN/ASW-26 AFCS in production by Lear Siegler for the Ling-Temco-Vought A-7A/B/D/E. The AN/ASW-26 is capable of dual-channel operation only, whereas the P-3C AFCS can be operated with either dual- or single-channel control. Also, the AN/ASW-31 has expanded fault detection (monitoring) circuits, additional BITE (Built-In Test Equipment), more precise barometric altitude control, and a higher level of yaw damping. System weight (LSI furnished items only) is about 120 pounds. Besides the increased reliability afforded by the availability of single-channel control, the principal advantages of the new system, from the pilot's point of view, are full-time proportional control wheel steering, altitude capture, and independent axis engagement. With the AN/ASW-31, the control wheel can be used at will to steer the aircraft or to change altitude while the autopilot provides assistance and stabilization. With altitude hold in effect, capture is automatic (below a certain rate of climb or descent) with release of the control wheel. Pitch trim is automatic. Components of the system (in photo, clockwise from top) are pitch, roll, yaw, and monitor control amplifiers mounted in the amplifier rack; 2 identical baro altitude controls, each in its own altitude control rack; 2 identical 3-axis rate gyros; control wheels; 2 identical normal and lateral accelerometers; AFCS test panel; magnetic anomaly detection panel; and AFCS control panel.

RADAR METEOROLOGICAL SET AN/FPS-77(V)

Prime Contractor: Lear Siegler, Inc., Data and Controls Division

Remarks

The purpose of the Radar Meteorological Set is to display and record the vertical and horizontal cross section of weather phenomena such as storms, fronts, and precipitation. Accomplishment of this is based on the principle that RF energy radiated into space by the radar set is reflected by weather phenomena in varying amounts, depending on the composition of the phenomena. The return signals are processed and displayed on cathode ray tubes, which provide true range, height, and azimuth bearing information. A permanent record of the weather information is made by photographing the cathode ray tube displays with a Polaroid camera. The Radar Meteorological Set consists of a receiver-transmitter, an antenna, an operating console, and a remote indicator. Its operating characteristics are as follows: maximum range 200 nautical miles, PRF-324PPS which can be synchronized to other radars in the range of 186-324PPS, frequency 5450 to 5650 MHz, power 250 kilowatts (pulse), receiver noise figure 9.5 decibels maximum. The operating console (shown) is the heart of the Radar Meteorological Set; it contains the 3 main displays and provides all the necessary operating voltages. The upper part of the console houses the RHI and A/R scopes; the center portion houses the amplifier-detector, the PPI scope, and the reference signal generator. More than 100 Radar Meteorological Sets have been delivered to the Air Force for use as an integral part of the 433L Weather Observation and Forecasting System.



R-220



AN/TPQ-11 CLOUD HEIGHT RADAR

Prime Contractor: Lear Siegler, Inc., Data and Controls Division

Remarks

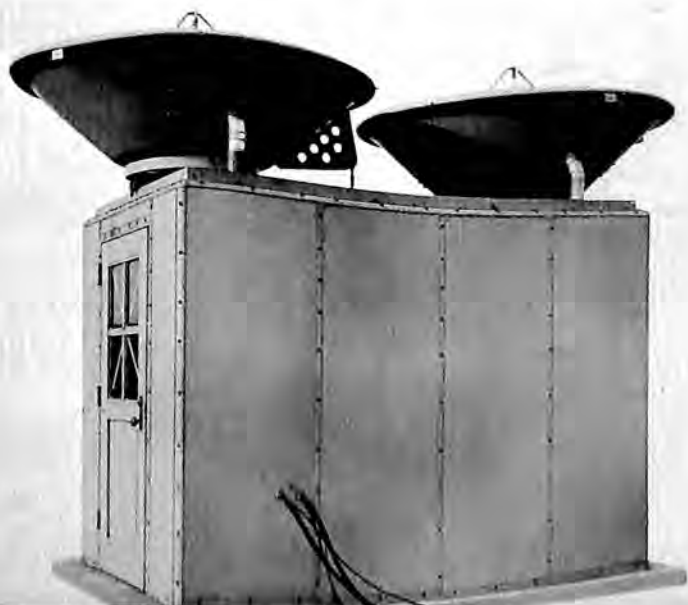
The AN/TPQ-11 Cloud Height Radar has been designed specifically to measure the profile of cloud density directly overhead between 500 and 60,000 feet, and to provide a paper tape recording with graphic indication of cloud density, altitude, and time. Equipment components can be deployed with considerable flexibility; the transmitter, antennas, and receiver are located as outdoor equipment up to 600 feet from the control console. Two major outputs are available: a modified "A" scope presentation in the control console, and a facsimile chart recording generated by a recorder that can be mounted either atop the console or up to 50 feet away. The system operates in the Ka band (34,500 to 35,600 megacycles); .5-microsecond pulses, at the rate of 100 pulses per second, are directed upward by the transmitting antenna. The radar echoes, which result because of scattering of the transmitted pulses, are intercepted by a second antenna and the radar receiver. The results are viewed on a cathode ray tube display on the console, which presents the echoes and range. In addition, the radar signals are processed so that a facsimile recording of cloud density is produced. The profile of cloud density directly overhead between 500 and 60,000 feet is thus measured and recorded on paper tape. More than 50 Cloud Height Radar Sets have been delivered to the Air Force for use as an integral part of the 433L Weather Observation and Forecasting System.

TELEMETRY DECOMMUTATION AND DISPLAY SYSTEM

Prime Contractor: Lear Siegler, Inc., Electronic Instrumentation Division

Remarks

The LSI Model 680 TDDS is capable of accepting and decommutating 4 simultaneous data links at a bit rate of 1,024,000 bits per second per link. Additional arithmetic computations are performed and messages formatted for output to the displays, the line printers, and the typewriters. The system consists of 4 telemetry processing subsystems in conjunction with one central control console and various standard computer peripheral equipments and analog quick-look equipment. The TDDS contains all the necessary equipments to accept information that is pulse code modulated (PCM), pulse amplitude modulated (PAM), and pulse duration modulated (PDM). Under the control of the instructions in the executive program, the 680 presents selected digitized data to displays, data transmission equipment, digital-to-analog converters, and IBM-compatible magnetic tape recorders. The system can accommodate any of the presently operational telemetry formats, and it is designed to provide total flexibility and anti-obsolescence for anticipated future requirements by the use of stored program equipment and program controlled peripherals throughout the system. The system utilizes 4 general-purpose digital computers, 4 special-purpose telemetry processors with the associated signal conditioning and synchronizing equipment, 12 state-of-the-art CRT display/keyboard stations, 240 10-bit digital-to-analog converters, 4 high-speed (150 ips) digital magnetic tape units, 2 medium-speed (600-line-per-minute) line printers, one digital modem buffer, 4 paper tape and teletype stations, and a complement of card processing equipment.



R-221



INTEGRATED DRIVE GENERATOR (IDG) POWER GENERATING SYSTEM

Prime Contractor: Lear Siegler, Inc., Power Equipment Division

Remarks

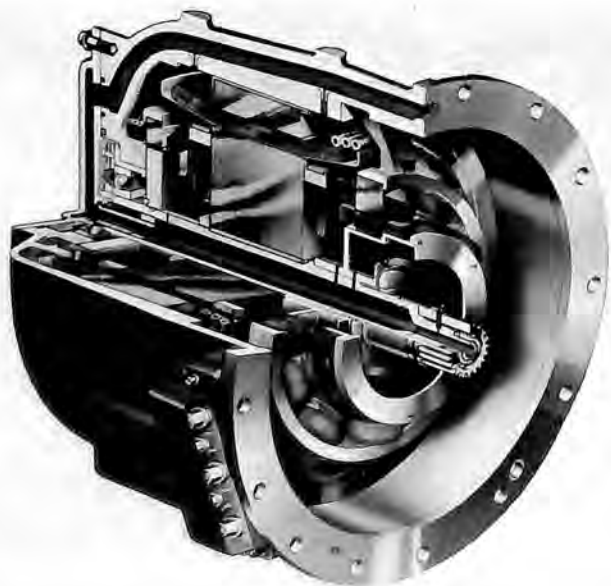
The heart of the IDG Power Generating System is the new generator (photo). It is an AC, 400 Hz, brushless, rotating-rectifier machine which is designed to work with and to become an integral part of the constant-speed drive, used on most large transport and military aircraft to provide constant input speed to an AC generator. The generator has only one bearing. The drive end of the rotor is supported on the constant-speed drive. The generator operates at 12,000 revolutions per minute and uses oil supplied by the constant-speed drive for both internal spray cooling and lubrication. Because of common use of oil, no rotating seals are required, either internally or between the constant-speed drive and the generator. New materials, such as cobalt alloy steels, have been used. The result is that the generator delivers 3 times more power output per pound of weight than conventional systems in service on today's aircraft. A control system protects the generator and aircraft bus from electrical malfunctions. Included is an automatic Failure Announcement Self-Test (FAST) system. Upon operator command, it interrogates passive circuits that would not normally operate until a fault occurred. This is to insure that passive circuits are operable should a fault occur. When a fault or malfunction does occur, FAST makes a logical determination by electronic means, indicates the location on a memory-type indicator, and shuts down that part of the system to avoid further damage. First application is the Lockheed L-1011, each of which has 4 generators and 4 control units, 1 bus protection panel unit, 14 transformers, and 7 3-phase circuit breakers.

DC STATIC CONTROL PANEL

Prime Contractor: Lear Siegler, Inc., Power Equipment Division

Remarks

This DC Static Control Panel makes unusual use of integrated circuits and incorporates all features possible for a 28-volt DC system into one extremely compact panel. The unit includes a solid-state voltage regulator which provides fast response (1 millisecond) and high reliability (30,000 hours mean time between failures). The unit also offers over-voltage protection, overexcitation protection, ground fault protection, reverse current protection, generator polarity reversal protection, equalizer relay, and accurate load division. The control panel has many advantages over its electromechanical predecessor. The unit is 9 pounds lighter and substantially smaller, regulates over a wider current load range, allows closer regulation, and has a much faster response time. Through this new design, LSI/PED gives greater reliability to aircraft using DC electric power systems.



R-222

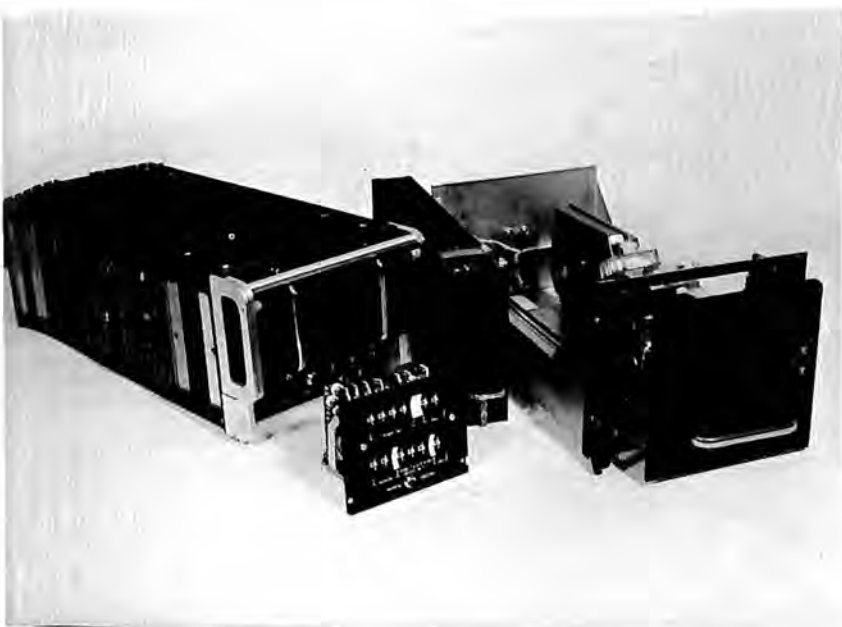


AIRBORNE DATA ACQUISITION SYSTEM

Prime Contractor: Lockheed Aircraft Service Company

Remarks

The aerospace industry's first automatic Airborne Data Acquisition System (ADAS) was developed and manufactured by Lockheed Aircraft Service Company. First units were delivered to Trans World Airlines for its fleet of DC-9 jet transports. The DC-9 installation, monitoring 50 separate parameters of engine information, marked the first fleetwide application of automatic airborne data collection to provide a daily "health report" on aircraft engines and systems. ADAS is designed to reduce DC-9 cockpit paper work by automatically recording data reflecting the state of performance of all monitored components. Recorded on punched paper tape, data are transmitted by teletype to the airline's overhaul base at Kansas City, Missouri, where rapid computer analysis and print-out permit quick and accurate diagnosis of maintenance requirements.

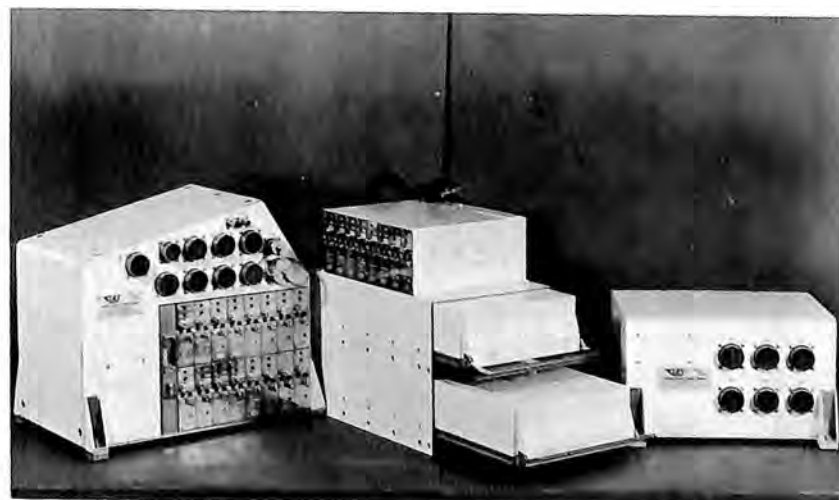


MISSION RECORDER SYSTEM

Prime Contractor: Lockheed Aircraft Service Company

Remarks

The Mission Recorder System was developed by Lockheed Aircraft Service Company for the SR-71 program; it is used primarily for mission reconstruction, and secondarily for maintenance monitoring of aircraft subsystems. The Mission Recorder System allows the recording of all data significant to an operational sequence and provides a complete record of operational status. Thus, the record contains the necessary information for mission reconstruction, operational status appraisal, malfunction analysis, and trend analysis. The recorder provides a permanent record which can be used for compilation of historical data. The recorders handle more than 1,000 input signals in rapid sequence, repeatedly, with extremely close tolerances. Examples of these inputs are AC voltages, DC voltages, frequency, acceleration, pressure, temperature, vibration, rotation, synchro position, linear displacement, and any preconditioned parameter.



R-223

MULTIFUNCTION HELICOPTER ROTOR-BLADE RADAR SYSTEM

Prime Contractor: Lockheed Electronics Company,
Military Systems Division

Remarks

Lockheed Electronics Company has designed, developed, and flight tested the Multifunction Helicopter Rotor-Blade Radar System. Unique features are the rotor-blade antenna, providing 360-degree radar visibility for ground mapping, and an orthogonally placed vertical antenna, giving the third spatial dimension—elevation. The combined use of the rotor-blade and vertical antennas is called the crossbeam system. This approach extends the rotor-blade radar beyond the mapping mode to a true multifunctional radar. The crossbeam system, proved in flight tests, adds terminal navigation/landing, terrain clearance/avoidance, weapons/munitions delivery, and air-to-ground signaling capabilities to the helicopter's versatility. Major advantages of the rotor-blade antenna are large antenna aperture for narrow azimuth beam width and high mapping resolution, unimpeded radar vision (360 degrees, map mode), increased azimuth data rate in forward sector scan (multiblade use), inherent azimuth scanning at rotor-blade speed, undisturbed aircraft aerodynamics and performance, and savings in vital aircraft space and weight. The Multifunction Helicopter Rotor-Blade Radar is a highly compatible system because its modular design and an "around-the-mast" RF rotary joint, in addition to the in-line rotary joint, make the radar adaptable to both hollow and solid drive shaft helicopters. In photo, flight test of the system aboard Enstrom F-28 test-bed.

RADAR SET AN/VPS-2

Prime Contractor: Lockheed Electronics Company,
Military Systems Division

Remarks

Radar set AN/VPS-2, designed and produced by Lockheed Electronics Company, is an integral part of the Army's forward area Vulcan Air Defense System. The radar automatically provides accurate range and range rate inputs to the fire-control system. Since the radar set operates in a high clutter environment, it has been designed to acquire and track a moving target which is buried below a signal return from ground clutter 10,000 times as large as the target. The Doppler principle is used to discriminate between stationary targets and moving targets. The equipment is a coherent Doppler, moving target indicator, X-band radar. When there are no targets in the radar line of sight, the radar automatically searches in range and a target within its range will be acquired automatically. After lock-on, the radar continuously transmits the range and range rate values to the gun sight as analog voltages. To prevent the radar from losing targets that may move into a fade area, an automatic coast feature is provided. This feature enables the radar to continue to track a faded target for a short time so that it can be reacquired when it comes out of the fade, without interrupting the fire-control solution. Modular design is used to facilitate maintenance and to enhance accessibility of units for replacement. Equipment is housed in small units so that it will fit within the limited vehicle space available. Radar circuitry is completely solid state, except for the klystron RF power amplifier. Microcircuit units are used in all digital elements of the equipment. Provisions are included for rapid bore-sighting of the antenna and for checking the operation of the equipment in the field. A neon lamp monitors the RF energy transmitted and a power meter can be used to check transmitter tuning.



R-224

VISUAL APPROACH PATH INDICATOR

Prime Contractor: Lockheed Industrial Products

Remarks

Lockheed Industrial Products in Atlanta is the manufacturing facility for Lockheed-Georgia Company in certain ground-support equipment for aircraft and in cargo loading systems applicable to rail, air, and sea transportation. LIP has introduced the Mark II Visual Approach Path Indicator, an optical device which enables private pilots to make precision approaches and landings. Employing a tricolored beam of amber, green, and red, the pilot can tell his relative angle of approach to the airstrip by straight-line sight. Amber means he is too high, red too low; the green light is the safety zone for a smooth and safe landing.

Specifications

Weight 35 pounds; unit size 21 by 21 inches, 7.5 inches high; 3 power sources through a transformer, 110, 220, and 6 volts. Light is a 35-watt high-intensity reflector bulb which consumes 1/400 kilowatt per hour. Cast aluminum dome protects against ground equipment.

Performance

Visibility 12 miles at night.



ASTRONAUT MANEUVERING UNIT

Prime Contractor: LTV Aerospace Corporation, a subsidiary of Ling-Temco-Vought, Inc.

Remarks

The Astronaut Maneuvering Unit (AMU) is a backpack device designed to permit an astronaut to leave his orbiting capsule and perform useful tasks in space, looking toward the day when man will assemble and service spacecraft in orbit, transfer from vehicle to vehicle, and move equipment. The AMU equips the pressure-suited astronaut with a complete propulsion system for maneuvering, an automatic stabilization system, and 2-way communications plus oxygen, pressure, and temperature systems. The 160-pound pack has sufficient oxygen for nearly 2 hours of operation outside the parent spacecraft. The astronaut maneuvers and travels by operating controls located on 2 arms extending forward of the pack. The pack has 12 hydrogen peroxide reaction jets, 4 firing forward, 4 rearward, 2 up, and 2 down.



R-225

MANEUVERING WORK PLATFORM AND SPACE TAXI

Prime Contractor: LTV Aerospace Corporation, a subsidiary of Ling-Temco-Vought, Inc.

Remarks

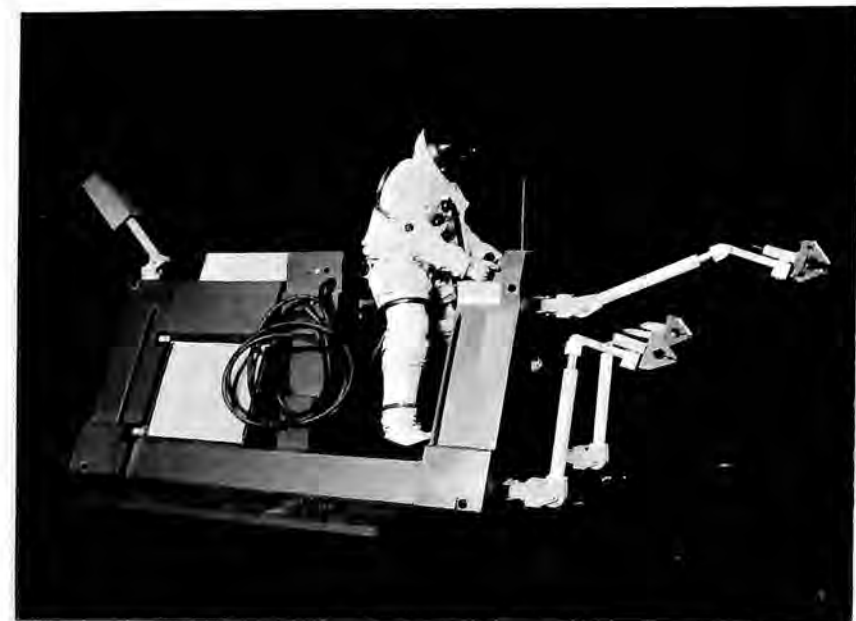
Two advanced extravehicular units, which could operate from a spacecraft to perform construction, maintenance, and servicing tasks at orbital work-sites, have been designed by LTV Aerospace Corporation's Missiles and Space Division. The company performed conceptual design work and constructed full-scale mock-ups under contract to NASA's Marshall Space Flight Center. The Maneuvering Work Platform (shown) is an open "space-going tool shop" with which a space-suited astronaut could maneuver, travel to a structure, and anchor to the worksite by means of extendible docking and anchoring grapples. The Space Taxi is completely enclosed, permitting shirt-sleeve environment, and has remotely controlled manipulators in addition to anchoring grapples. Each vehicle has its own propulsion system, automatic stabilization system, power supply, life-support system, communications, displays, and other equipment needed to operate independently of the parent spacecraft. The basic work platform is designed to carry some 215 pounds of hand tools, maintenance equipment, diagnostic equipment, and spares on board, plus an external supply of expendables weighing up to 200 pounds. However, by using modules such as a tanker section or a "truck bed," it could accommodate far greater loads. The Space Taxi could carry nearly 400 pounds of such equipment on board, plus some 800 pounds of expendables mounted externally. Each would be propelled and maneuvered by 25 hydrazine-powered jets. The work platform can be extended to accept a variety of modules.

AN/TRN-22 TACTICAL AIR NAVIGATION TRANSPONDER BEACON SYSTEM

Prime Contractor: LTV Electrosystems, Inc., a subsidiary of Ling-Temco-Vought, Inc.

Remarks

The AN/TRN-22 portable tactical air navigation transponder beacon system is an LTV Electrosystems development to miniaturize TACAN systems for greater mobility and easier handling and operation. Developed and produced at the Memcor Division's Montek Operation in Salt Lake City, the unit was tested successfully by the British Royal Air Force with the Hawker Siddeley Harrier V/STOL aircraft and later was used with the same aircraft which won the 1969 Daily Mail Transatlantic Air Race. The TRN-22 is light and compact enough to be carried by one man and can be set up in any location in minutes. It is self-contained and has an operating range of approximately 100 miles. The unit, and the slightly larger AN/TRN-26, have both military and civilian applications. Both systems enable precise air navigation to an area where they are set up; they can be used to guide aircraft to tactical air drop zones or to provide pinpoint navigation to evacuation or civil disaster rescue areas.



R-226



AIRBORNE BATTLEFIELD COMMAND AND CONTROL CENTER (ABCCC)

Prime Contractor: LTV Electrosystems, Inc., a subsidiary of Ling-Temco-Vought, Inc.

Remarks

The Airborne Battlefield Command and Control Center (ABCCC), developed and produced for the Air Force by LTV Electrosystems at its Greenville (Texas) Division, was prototype tested in Vietnam and later produced in fleet quantities. ABCCC enables battlefield commanders to direct land, sea, and air forces in a combat area while airborne in a C-130 aircraft or on the ground in a strategic area. Housed in a van which exactly fills the cargo compartment of a C-130, ABCCC uses aircraft power and antennas installed in aircraft structure while airborne. In 2 hours, ABCCC can be removed from the aircraft and can operate from a standard power cart, using its own antennas. The van is completely self-contained and is mounted on retractable wheels. It is equipped with a visual situation display and has complete communications links in HF, UHF, and VHF, with 14 operating stations (photo), each provided with a hinged writing surface and a pedestal console equipped for fingertip selection of any of 4 transceivers in the 20-transceiver bank.

RADA (RANDOM ACCESS DISCRETE ADDRESS)

Prime Contractor: Martin Marietta Corporation, Orlando Division

Remarks

RADA is designed to replace most of the switched telephone systems and selected administrative, logistical, and staff radios in division and brigade echelons. The system will provide dial telephone capabilities with the mobility of radio for battlefield communications. RADA will be able to handle voice, teletype, facsimile, and data transmission without the use of heavy, fixed switching centers or the costly and time-consuming task of laying wire. Among RADA's key features are automatic search and routing, priority service for selected subscribers, conference calls, area warning, and full system security. RADA will use a subscriber unit for direct calls and a retransmission unit for calls beyond the direct range of the calling party. Simultaneous transmissions will occur within a common frequency band without mutual interference. Additional RADA subscriber units and a retransmission unit are being built by Martin Marietta, and Army military potential tests were scheduled for 1970.



R-227



BIRDIE (BATTERY INTEGRATION AND RADAR DISPLAY EQUIPMENT)

Prime Contractor: Martin Marietta Corporation, Orlando Division

Remarks

BIRDIE is an electronic, semiautomatic air defense coordination and fire distribution system which makes optimum use of electronics, with human supervision imposed at critical points. BIRDIE provides effective air defense by automatic acceptance, generation, processing, and distribution of pertinent target data for guided missiles. It can also monitor and/or direct fire unit activity and can even operate autonomously if higher command inputs are interrupted. One of its features is that all functions of surveillance, entry, tracking, monitoring, and friendly protection are combined into a single situation display console. BIRDIE is transistorized and transportable. The system can be tailored to meet the size of the defense battery requirements.

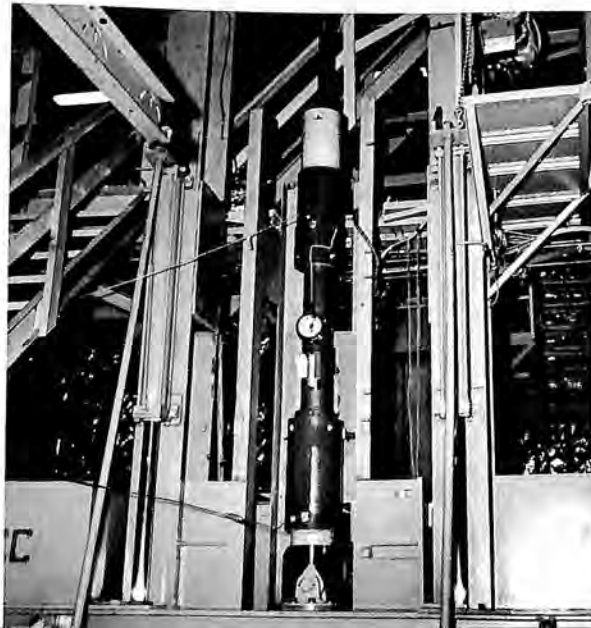


LIQUID SPRING SHOCK/BLAST ISOLATORS

Prime Contractor: Menasco Manufacturing Company

Remarks

Menasco is producing a dual rate, high-pressure liquid spring assembly, one in an interacting system of 4. These systems are in service for all of the Air Force's Wing VI Minuteman missiles to isolate against the effects of attacking near-miss weapons explosions. The assembly's unique design features 2 rigidly attached liquid springs in series having different spring rates. In operation, the initial displacement (compression or extension) is mitigated by the low spring rate (soft) unit until its stroke is expended, after which the high spring rate unit (hard) is utilized. Initial displacements are therefore absorbed by a "soft" system which becomes progressively more resistant to the driving force. Thus, both high-frequency and low-frequency shocks are attenuated. Side or column bending loads have been eliminated by utilization of chain and pin linkages at the attach points. The product has undergone extensive testing to prove its many-cycle capability and service reliability. Little or no maintenance has been required on the field installation. The assembly envelope measures 17.25 inches in diameter and 228.3 inches in length.



R-228

L-1011 LANDING GEAR SYSTEM

Prime Contractor: Menasco Manufacturing Company

Remarks

The L-1011 TriStar landing gear system consists of 2 retractable main landing gears with 4-wheel bogies and one retractable dual-wheel nose gear. The nose gear is supplied with dual push-pull hydraulic steering actuators and a steering control valve system. Both gears use a folding drag or side brace and locking jury strut linkage system. The main gear bogie beam is positioned by a special actuator integrated with the airplane hydraulic system. The nose gear provides the capability of both fore and aft towing with the standard tow bar. Both gears have mechanical visual downlock indicator systems in addition to the normal electrical systems. Other items assembled to the landing gear by Menasco include position-sensing switches, wheels, tires, brakes, antiskid, taxi lights, and associated hydraulic plumbing and electrical bridles. The main gear measures, from trunnion to ground, 140 inches; overall bogie measurements are 120 by 72 inches. Nose gear (trunnion to ground) is 98 inches. Each main gear weighs 7,050 pounds; the nose gear, 1,550 pounds.

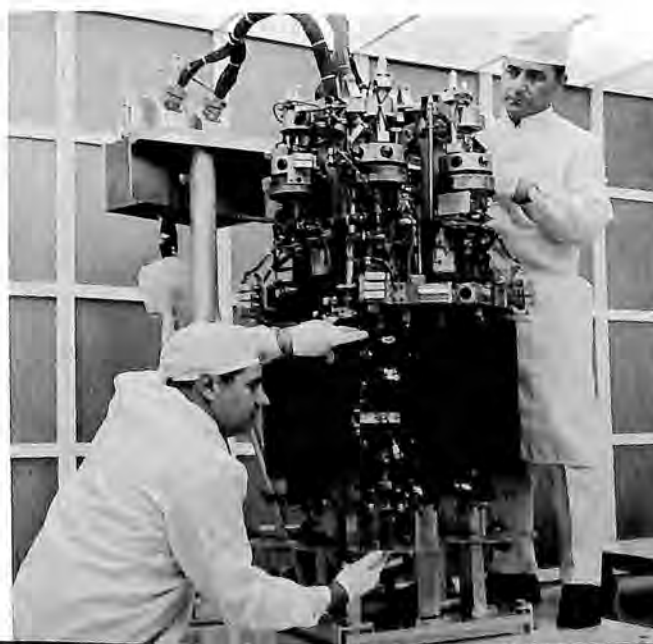


S8DR (SNAP 8) DEVELOPMENT NUCLEAR REACTOR

Prime Contractor: Atomics International, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The S8DR compact nuclear reactor was built for the Atomic Energy Commission as a potential source of reliable, long-life electrical power for earth satellite communications and observation systems, manned space vehicles, orbiting space stations, manned bases on planetary bodies, and such terrestrial uses as hardened missile sites and under-sea bases. The program is being conducted in conjunction with NASA's Marshall Space Flight Center. Representing the third generation of systems developed for the SNAP (Systems for Nuclear Auxiliary Power) program, SNAP 8DR, a zirconium-hydride reactor, has attained design power levels in tests at Atomics International's nuclear field laboratory, Canoga Park, California. A SNAP 8 type reactor could be coupled with thermoelectric conversion to provide 25 to 50 electrical kilowatts of power for a typical manned space station. The reactor is also capable of being operated in conjunction with Rankine or Brayton power conversion systems. An early experimental SNAP reactor, the 3,000-watt SNAP-2, was operated in 1959-60; a SNAP 2 development reactor was operated in 1962-63; and, in 1965, SNAP 10A became the first and only nuclear reactor to operate in earth orbit. SNAP 8's reactor core is approximately 2 feet high and 9.5 inches in diameter. Overall weight of reactor core vessel and reflector control assembly is 600 pounds. The system is designed to produce 600 thermal kilowatts and to operate for 10,000 hours in a space vacuum.



MINUTEMAN II AND III GUIDANCE AND CONTROL SYSTEM

Prime Contractor: Autonetics Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

Microelectronics is the key to major technical improvements incorporated into the Air Force's Minuteman II and III ICBMs. New equipment being furnished by the Autonetics Division, associate contractor for guidance, flight control, and ground check-out equipment, includes an inertial guidance platform featuring use of pendulous integrating gyro accelerometers and a new gyrocompass azimuth assembly that provides backup to the primary optical reference; microelectronic airborne digital computer with expanded memory capacity, greater reliability, and reduced size and weight; and liquid injection for more efficient Stage II rocket motor flight control. Most of the flight control electronics have been incorporated into the "upstage" portion of the system, housed in the lightweight magnesium/cork guidance body section. The "downstage" portion includes an angular accelerometer unit similar to that in Minuteman I, Stage I and III nozzle control units, 2 Stage II electrohydraulic control units, and all-electrical cabling. Key element in the missile's N17 guidance system is the microelectronic computer that accepts information from sensing instruments mounted on the inertial platform and compares it with previously stored information. When course and speed deviations are noted, the computer signals the flight control equipment, which then directs rocket engine thrust toward the proper trajectory. In preflight operational deployment, the computer performs regular checks and reports on missile flight readiness.

POLARIS-POSEIDON SHIP'S INERTIAL NAVIGATION SYSTEMS (SINS)

Prime Contractor: Autonetics Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

Ship's Inertial Navigation Systems (SINS) enable Navy Polaris and Poseidon submarines to navigate submerged for long periods of time and to fix precisely their missile-launching positions. This self-contained system consists basically of a digital computer, velocity meters, and an inertial platform stabilized by gyroscopes. Automatically and accurately, SINS sense a ship's accelerations, measure them, and provide results in the form of continuously available position information, heading, and velocity. Autonetics' first production-model SINS were installed in 1959 aboard the *George Washington*, the nation's first Polaris submarine. Under subsequent contracts, Autonetics became SINS supplier for the balance of the Navy's 41-ship Fleet Ballistic Missile (FBM) force and for Polaris-equipped submarines of the United Kingdom's Royal Navy. Autonetics is now modifying and updating SINS aboard 31 of the FBM submarines for the advanced Poseidon missile. This model includes an additional gyro that monitors and corrects the drift rates of other gyros to increase overall system accuracy. Other versions of the Autonetics' SINS are operational aboard U.S. Navy attack submarines, 3 attack carriers (USS *Enterprise*, USS *Independence*, USS *Ranger*), and 2 range tracking ships (USS *Twin Falls Victory* in the Eastern Test Range, USNS *Range Tracker* in the Western Test Range).



R-230



NORVIPS VOICE WARNING AND MISSION RECORDING SYSTEMS

Prime Contractor: Northrop Corporation

Remarks

Norvips, as a voice warning system, transmits, on a priority basis, vital malfunction information to the crew of an aircraft via the human voice over normal intercom channels. It monitors and reports out-of-tolerance conditions and events quickly and comprehensibly. It commands attention and alerts instantly; it secures immediate response in a repeated 15-second message. As a mission recording system, Norvips provides a transcript of all reported malfunctions, crew conversation, and other significant events and compresses real-time data into short-time replay. It expedites mission performance review and debriefing, and there are no data decoding and reduction delays.

TEST EVALUATION AND MONITORING SYSTEM

Prime Contractor: Northrop Corporation

Remarks

The Navy's new *Knox*-class destroyer escorts have the fleet's fastest troubleshooter—an automatic check-out system that continually monitors sonar gear, fire-control radar, and search radar, all crucial systems for combat. The Test Evaluation and Monitoring System (TEAMS), developed and produced by Northrop Corporation, checks out the 4 sonar and radar sets aboard the ASW ships in just 1.5 minutes. Northrop has a contract to supply 26 TEAMS for the 26 destroyer escorts scheduled to join the fleet in the next 3 years. TEAMS is capable of monitoring up to 10 major systems on the 4,100-ton ships, but is used for the AN/SPS-10 sonar, the AN/SPC-53A fire-control radar, and the AN/SPS-10 and AN/SPS-40 search radars. TEAMS automatically prints out test data whenever it finds a fault in the set being tested. It is programmed to spot marginal performance so that preventive repairs can be made to keep the equipment on the air, ready to respond at all times.



R-231



AIRBORNE DIGITAL COMPUTERS

Prime Contractor: Northrop Corporation

Remarks

With orders for more than 300 special-purpose computers, Northrop is one of the largest producers of such equipment in the United States. Northrop's diversified family of low-cost computers can be tailored to meet specific demands. Accomplishments of Northrop in the specialized computer field include (1) a contract for airborne computers for the C-5 inertial-Doppler navigation system, (2) a contract for the computers for the C-5 Malfunction Analysis and Recording (MADAR) system, (3) the completion of USAF acceptance tests on the NDC-1050A and the integration of that computer into an Air Force navigation system for flight tests, and (4) introduction of the NDC-1051, 1060, and NDC-1070 series of general-purpose airborne digital computers for aerospace uses. All are solid-state microelectronic devices for which an extensive library of checked-out routines, subroutines, tests, and other software packages is available.

C-5 INERTIAL NAVIGATION SYSTEM

Prime Contractor: Northrop Corporation

Remarks

The Air Force C-5, the world's largest aircraft, is the first cargo plane to use both inertial and Doppler navigation systems. Northrop Corporation is producing the inertial-Doppler system under a contract awarded by Lockheed-Georgia, a division of Lockheed Aircraft Corporation. Accuracy of the system is better than 1 nautical mile per hour. Without use of preflight ground equipment, the system needs only 25 minutes to warm up and align itself in temperatures ranging from 65 degrees Fahrenheit to 160 degrees Fahrenheit. The system includes the Northrop Floated Lightweight Inertial Platform (FLIP), primary and auxiliary digital computers, navigational display and control panels, and Doppler radar supplied by GPL. Combined memory capacity of the 2 Northrop computers in the system is 20,000 words. Gyroscopes in the FLIP are also produced by Northrop. Small enough to fit into an average coffee cup, the gyros use ceramic gas bearings which increase the accuracy and life of the gyroscopes.



R-232

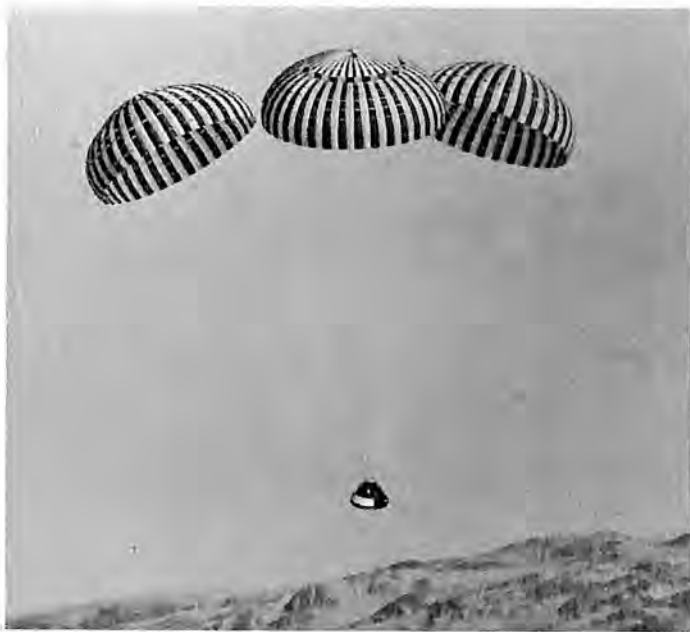


APOLLO EARTH LANDING SYSTEM

Prime Contractor: Northrop Corporation

Remarks

Parachutes used in the Apollo earth landing system are 2 16.5-foot-diameter drogue parachutes; 3 7.2-foot-diameter ringslot pilot chutes; and 3 ringsail-type main parachutes, each with a canopy diameter of 83.5 feet. System operation begins at an altitude of 25,000 feet, where a barometric pressure switch initiates a pyrotechnic device which jettisons the forward heat shield, exposing the parachute compartment. Two seconds later, the drogue parachutes are mortar-deployed for stabilization and deceleration. At about 10,000 feet, the 3 pilot chutes are deployed, also by mortar; each subsequently extracts its respective main parachute. Landing speed is approximately 31 feet per second with 3 parachutes functioning; 38 feet per second, with 2.



XM129 GRENADE LAUNCHER

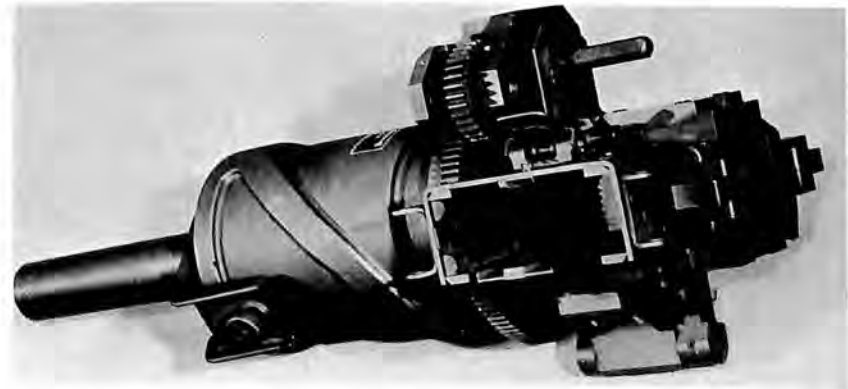
Prime Contractor: Aeronutronic Division, Philco-Ford Corporation

Remarks

The XM129 is a lightweight, externally powered grenade launcher which fires 40-millimeter, high-velocity M384/M385 ammunition. A gear train rotates a drum cam which is mounted concentric to the bore. The cam reciprocates the barrel one full cycle per revolution of the drum cam. The functions of feeding and firing are also governed by cams. The XM129 can be powered by a motor or hand crank at rates up to 440 shots per minute. It can be assembled to feed from either side; and, because the center of gravity coincides almost exactly with the centerline of the bore, mounting problems are greatly reduced. The XM129 is the area target weapon for U.S. Army helicopters. In addition to helicopter applications, the XM129 is a candidate for use on riverboats and ground vehicles. The XM-129 is in quantity production for Army Weapons Command.

Specifications

Weight 43 pounds; length 23.5 inches; width 8.9 inches; height 9.2 inches; rate of fire up to 440 shots per minute; range 2,200 meters; muzzle velocity 790 feet per second; method of feed, belt.



XM140 AUTOMATIC GUN

Prime Contractor: Aeronutronic Division, Philco-Ford Corporation

Remarks

The XM140 is an electrically powered, single-barreled automatic gun which fires the XM552 HE-DP 30-millimeter dual-purpose ammunition. It is a lightweight, compact combination area and point target, aircraft-type weapon, with recoil force characteristics compatible with helicopter and light aircraft structural limits. Half of the entire gun mass is dynamically soft-mounted within the gun cradle so that peak recoil and counterrecoil forces are minimized. An electric motor drives the reciprocating barrel for chambering the ammunition and also drives the feeder. Nominal fire rate is 425 shots a minute. The weapon can be assembled to feed from either side. The gun has a demonstrated 1 mil circular error probable. It is equipped with blast and flash suppressor; blast pressure is less than 5 pounds per square inch at 2 feet. The XM140 is in production by Aeronutronic for Army Weapons Command.

Specifications

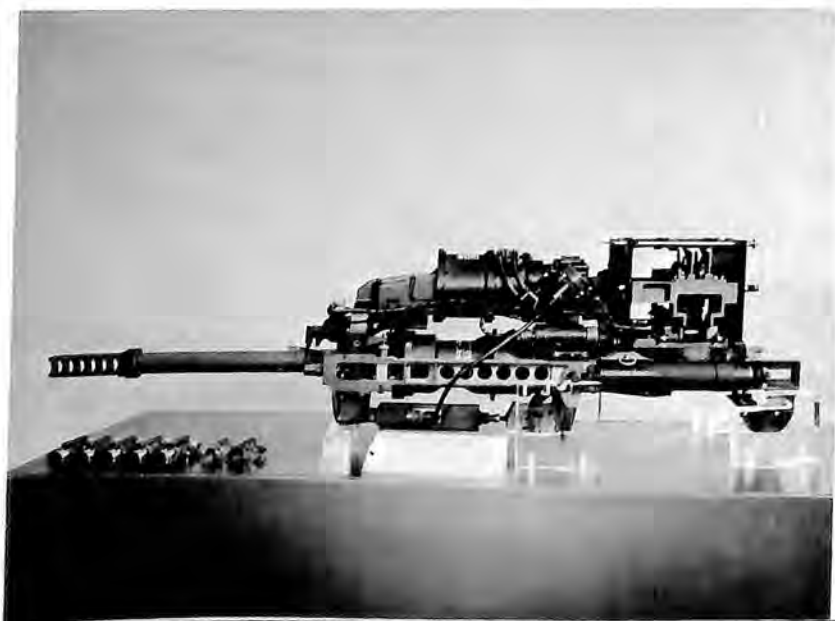
Weight 140 pounds; length 59.3 inches (barrel forward), 51.8 inches (barrel rearward); width 12.2 inches; height 14.4 inches; rate of fire 425 shots per minute; range 3,000 meters; muzzle velocity 2,200 feet per second; method of feed, disintegrating link belt; peak recoil force 1,600 pounds.

SATURN GROUND COMPUTER SYSTEM

Prime Contractor: RCA, Defense Electronic Products, Electromagnetic and Aviation Systems Division

Remarks

The Saturn Ground Computer System is an on-line, real-time computer system utilized to perform automatic check-out and launch control functions for the Saturn IB and Saturn V launch vehicles. The input/output capabilities are tailored to NASA needs on the Apollo program. The RCA 110A SGCS is well suited to meet NASA requirements for increased automatic control, flexibility, check-out capacity, accuracy, speed, and reliability. This computer system is the first process control machine to offer a general-purpose organization featuring core memory and an automatic priority interrupt system for efficient multiprogramming. The unit consists of 19 to 20 cabinets including the following systems or subsystems: data link, discrete, interface to digital data acquisition system, and analog system. The RCA system is used for check-outs in static captive firings, unit tests, and actual launch procedures. Twenty-four systems will be placed in use for testing of individual instrumentation units or booster units and the actual launch of the Saturn IB or Saturn V. Systems are established in the launcher control center or the launcher umbilical transporter. The input data come in analog form and go through scaling, multiplexing, and conversion to digital form when the computer operates upon them. Output data are converted from digital back to analog format with amplification and priority assigned.



R-234



DRUM MEMORY SYSTEMS

Prime Contractor: RCA, Defense Electronic Products, Electromagnetic and Aviation Systems Division

Remarks

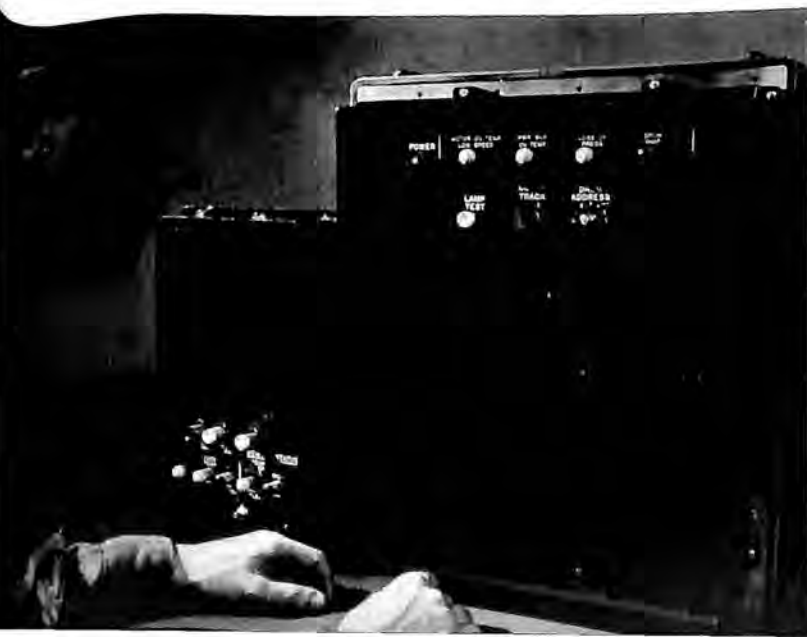
RCA drum memory systems are unique in the area of high-capacity random access storage because of their light weight, rugged construction, and small physical size. The drum memory systems, which have a data capacity up to 35,000,000 bits, are designed to meet both military and commercial requirements. The division is under contract to Litton Industries to supply drum memory systems for the TACFIRE program. The weight of a 35,000,000-bit-capacity system is 65 pounds; the 7,000,000-bit system weighs 40 pounds.

REAL-TIME TELEMETRY DATA SYSTEM

Prime Contractor: RCA, Defense Electronic Products, Missile & Surface Radar Division

Remarks

The Real-Time Telemetry Data System is an electronic system capable of unprecedented speed, accuracy, and simplicity in processing and distributing scientific information transmitted to earth from missiles and space vehicles. The central station of the RCA-built system is at Telemetry Station 4 of the Air Force Eastern Test Range, with other stations on 4 downrange island installations and still others installed aboard tracking ships. The system allows mission directors to program in advance of a flight the data desired from a spacecraft or missile. The information is then transmitted from the downrange stations to the central station in real time in uniform digital form that can be stored, retransmitted, and modified by computer. This eliminates the need to station at these remote areas medical, engineering, and other specialists to monitor and interpret incoming data from space vehicles. It also speeds and simplifies postflight analysis of the performance of missiles and space vehicles.



**AN/FPQ-6 PRECISION
INSTRUMENTATION RADAR**

Prime Contractor: RCA, Defense Electronic Products, Missile & Surface Radar Division

Remarks

The AN/FPQ-6 Instrumentation Radar and its transportable version, the AN/TPQ-18, are the newest generation of precision trackers for observation of the flight characteristics of missiles and space vehicles. They can skin-track a target of 1 square meter in cross section to a range of about 600 nautical miles and are equipped for transponder tracking to 32,000 miles. The radars have 29-foot Casagrain antennas with 5-horn feed, 3-megawatt transmitters, and low-noise (8 decibels) receivers. They have angle tracking precision of .05 mil and systematic errors of plus/minus 2 yards in range. The installation pictured, developed for the Air Force Western Test Range and stationed at Point Pillar, California, uses integrated circuits for all circuitry in its digital range machine, computer, and video integrator and receiver to reduce system space, power, and air-AN/FPS-16 radar, part of the national space tracking network, standardized for use by the military services and NASA. The AN/FPS-16 and its air-transportable counterpart, AN/MPS-25, are C-band passive or active targets with velocities up to 10,000 yards per second. More than 60 of these stations are in use.

HAND-HELD TACTICAL RADAR

Prime Contractor: RCA, Defense Electronic Products, Missile & Surface Radar Division

Remarks

Several years ago RCA decided to leapfrog existing lightweight tactical radar technology by developing the first all-solid-state hand-held tactical radars. The first model (photo) weighed 2.2 pounds exclusive of battery and headphones; it was designed for use as a weapons sight, especially on the M-79 grenade launcher. Three new models have been developed for use in surveillance, perimeter defense, airfield security, and ambush operations. These instruments weigh, with self-contained battery and scanner, about 10 pounds; they can detect man-sized targets at ranges up to 1,500 meters. They are being produced for all of the military services. Additional development, now taking place, will adapt the radar's circuitry and packaging for use in radar altimeters, collision avoidance instruments, small boat navigation, and medical electronics.



R-236

SKAMP

Prime Contractor: RCA Defense Electronic Products, Astro-Electronics Division

Remarks

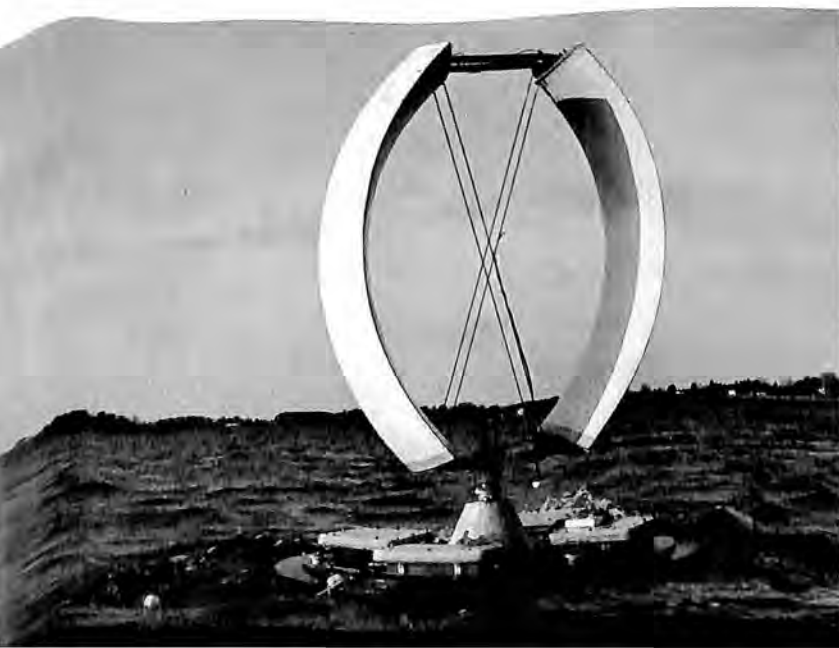
The Station Keeping and Mobile Platform (SKAMP) is a unique, unmanned sailing craft that can navigate itself to virtually any point on the world's seas, then remain on station automatically without a mooring. The buoy-like vessel employs computer-based electronic navigation and a combination of movable airfoils and rudders. It can sail unmanned to a designated location and remain there unattended for up to a year until commanded by radio to return or to move to another station. Receiving information from a navigation system such as the Navy Navigation Satellites, SKAMP's electronics and servo system manipulate the airfoils and rudders to guide the vessel on course to its station. Once there, SKAMP will sail a tight back-and-forth course to remain within .2 nautical mile of its assigned true position. The vessel's "sails" are rigid, foam-filled curved plastic structures that exhibit the same sailing characteristics as cloth. SKAMP has a disc-shaped hull consisting of a deck plate and bottom plate with elastomer foam sandwiched between them. Although wind-driven, it is designed to sail in hurricane-force winds.

LASER TRACKING AND RANGING SYSTEM

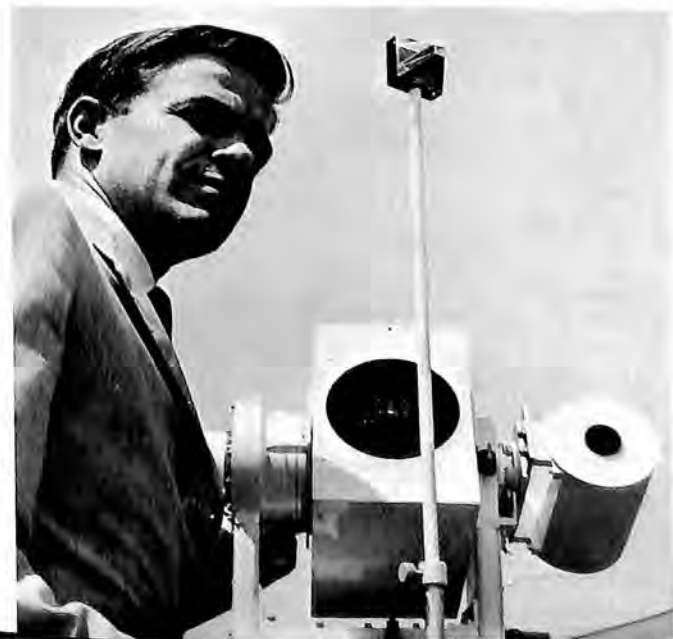
Prime Contractor: RCA, Defense Electronic Products, Astro-Electronics Division

Remarks

The laser tracker shown is a prototype of a new system that could be used on the moon to track exploring astronauts and to help survey the lunar surface. The prototype was built to prove the feasibility of using a laser to automatically follow and determine the position of an astronaut or roving vehicle on the moon. A Gallium Arsenide (GaAs) injection laser produces light pulses, invisible to the human eye, which are returned by a specially designed reflector consisting of a cluster of corner cubes. The reflector, mounted on a staff carried by the exploring astronaut or roving vehicle, will transmit a pulse back to the tracker regardless of which way the staff is turned. The tracker can compute the range or distance to the exploring astronaut by measuring the time difference between transmitted and reflected pulses. The laser automatically locks on the reflector. Range of the prototype is half a mile, but the system is capable of a 5-mile range with accuracy of less than 3 feet.



R-237



**AN/TRC-97 TROPOSPHERIC SCATTER
RADIO RELAY EQUIPMENT**

Prime Contractor: RCA, Defense Electronic Products, Defense Communications Systems Division

Remarks

The AN/TRC-97 is a solid-state radio relay terminal providing tunable microwave, diffraction, or tropospheric scatter communications in the military band of 4,400 to 5,000 megacycles. With power equipment and antenna in a standard trailer, the entire AN/TRC-97, designed for quick reaction tactical use, is readily transportable by ¾-ton truck or suitable aircraft; it can be set up and in operation within an hour after arrival at site. The antenna system consists of 2 8-foot parabolic antennas which can be set up and aligned in less than 40 minutes. More than 100 AN/TRC-97s, built for the Marine Corps, are in use in Vietnam. Additional units are being produced for the Air Force 407L system.

**SHF TACTICAL COMMUNICATIONS
SATELLITE TERMINALS**

Prime Contractor: RCA, Defense Electronic Products, Defense Communications Systems Division

Remarks

The SHF TACCOMSAT Terminals will provide extremely reliable tactical communications and will be highly mobile for battlefield and airborne applications. Present tactical communications are by HF, VHF, and UHF radio plus microwave radio relay and troposcatter systems—techniques which suffer from low propagation reliability, limited range, and severe size and weight penalties. In addition to avoiding these constraints, the SHF TACCOMSAT Terminals will offer significant reliability improvement. Five configurations are to be supplied: airborne, manpack, teampack, jeep-mounted, and 1¼-ton truck shelter terminals. Multi-fold size and weight reduction and high performance will be achieved through state-of-the-art techniques such as differential PSK modulation, parametric amplifiers, and ultrastable frequency control components. Except for the manpack, which is a receive-only unit, each system contains a low-noise uncooled receiver, exciter, power amplifier, beacon receiver, and associated terminal equipment such as teletype, vocoders, and digital modems. Doppler correction is integral to the airborne system. The tactical stations will be tested with an experimental earth-synchronous satellite by all 3 military services.



R-238

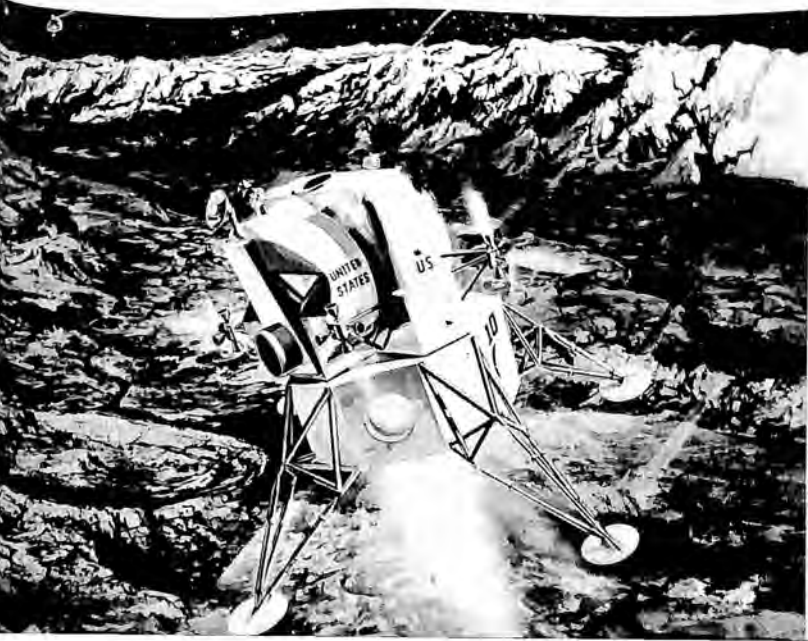


LUNAR MODULE SYSTEMS

Prime Contractor: RCA, Defense Electronic Products, Aerospace Systems Division and Defense Communications Systems Division

Remarks

RCA has multiple systems responsibilities in connection with NASA's Lunar Module, shown descending to the moon after separation from the Apollo spacecraft. RCA provides the DECA (Descent Engine Control Assembly) which regulates the engine thrust over a wide range from a maximum of 10,000 pounds, and the direction of the thrust, determining the rate at which the LM slows. Determination of which attitude control thrusters should be fired and for how long is the job of another RCA system, the ATCA (Attitude and Translation Control Assembly). ATCA also operates in the ascent phase. RCA's landing radar for the LM is designed to measure continually the exact altitude and velocity relative to the lunar surface, an invaluable sensory aid to the descending astronauts. RCA equipment provides the communications link between the LM, earth monitoring stations, and the third astronaut in the Apollo; the company also supplies the EVA backpack radios and a special lunar antenna for relaying television photos to earth. A major RCA assignment is the all-important rendezvous radar, which enables the LM crew to rendezvous and dock with the Command Module for the trip home.



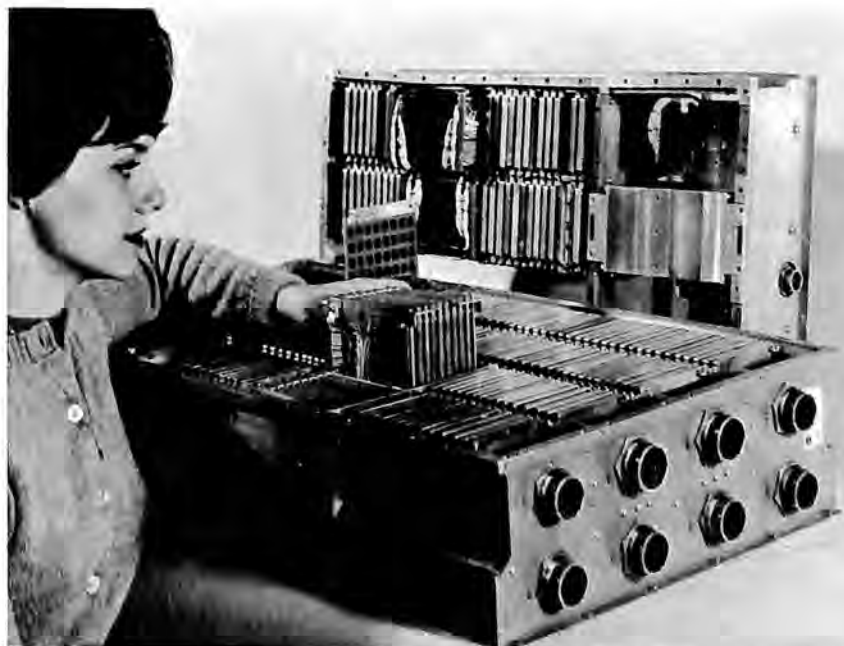
R-239

VARIABLE INSTRUCTION COMPUTER (VIC)

Prime Contractor: RCA, Defense Electronic Products, Aerospace Systems Division

Remarks

The Variable Instruction Computer (VIC) is a joint RCA/USAF development which makes available to the aerospace computer user a high degree of flexibility, modularity, and reliability. For example, this digital computer can, in effect, alter its internal logic to fulfill a wide variety of aerospace applications such as command and control, automatic test systems, and avionics and weapons control. A specific application provides compatibility with a ground-based 7090 command and control computer via the JOVIAL J2 compiler. Making extensive use of integrated circuits and modular construction, this general-purpose 36-bit parallel word machine has redundant 400 Hz power supplies and completely independent 4,096-word main memory modules for reliable operation. The expanded configuration of this system is 4.4 cubic feet; it weighs 175 pounds and has a 32,768-word capacity. VIC's 3-microsecond main memory and .6-microsecond high-speed memories enable it to interface with a wide range of high-speed data processing and communication equipment for future airborne command posts. The system's unique variable instruction technique provides a powerful tool for compatibility and commonality with ground-based C² computers.



**AIR TRAFFIC CONTROL
CENTRAL AN/TSW-7**

Prime Contractor: RCA, Defense Electronic Products, Aerospace Systems Division

Remarks

The AN/TSW-7 Mobile Control Tower is a lightweight, air-transportable, self-contained unit that provides the communication and navigation aid facilities necessary for controlling aircraft on or within the terminal area of an airfield. Basically a second-generation system to the RCA-developed AN/TSW-6, the AN/TSW-7 configuration takes advantage of the latest advances in the development of new techniques and hardware design, such as highly reliable solid-state UHF and VHF radios, DF digital displays, solid-state power supplies, a new antenna coupling scheme, and a unique UHF/VHF antenna design. Adaptable as well as versatile, the AN/TSW-7 allows operation in arctic or tropical areas against the full range of hostile environments, including temperatures from minus 40 to plus 125 degrees Fahrenheit. Within these environmental extremes, the system has the flexibility of autonomous operation, or it can be efficiently interfaced with all ATC systems, including civil and military, foreign and domestic installations.

DC-10 PROPULSION PACKAGE

Prime Contractor: Rohr Corporation

Remarks

Rohr Corporation performs the power plant build-up on the McDonnell Douglas DC-10 jetliner. The DC-10 Series 10 aircraft is powered by 3 General Electric CF6-6 advanced high bypass ratio turbofan engines with 43,500 pounds of static thrust. The DC-10 Series 30 aircraft is powered by CF6-50A, B, or C engines rated from 49,000 to 51,000 pounds static thrust. Acoustic treatment is provided in the inlet and the fan air exhaust ducts. The system is unique because of 2 different treatments used. The inlet uses a single-degree-of-freedom method, while the fan ducts use a 2-degree-of-freedom system. The maintainability features of the power plant are exceptional. Improved maintainability is made possible by placing the gearbox outside the fan case. By opening the forward cowl panels, all major engine components and systems, except the pneumatic system, are completely accessible. Also, any component can be removed by itself without necessitating removal of another piece of equipment. The mounting of the fan thrust reverser is another major technical breakthrough. The reverser is designed in 2 halves and is hinged from the aircraft pylon and latch at its bottom centerline. Each half is provided with actuators to raise the reverser without special ground-handling equipment. With the reverser open, the compressor section of the engine and the pneumatic system are available for inspection or servicing. The forward cowls for the center (tail) engine are power-actuated open and closed. Provision for power actuation on wing position cowls is built in. Space provisions are allotted for AIDS (Airborne Integrated Data System) and BITE (Built-In Test Equipment) for those operators who choose to use these systems.



R-240



DIRECTIONAL CONTROLLED ROCKET ASSISTED PROJECTILE (DICORAP)

Prime Contractor: Kearfott Division, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

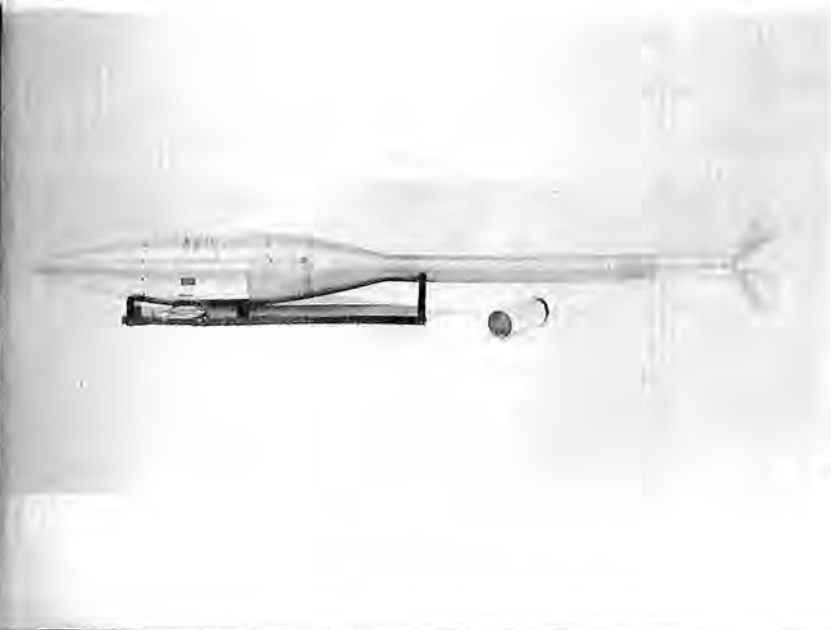
The DICORAP system consists of 4 major subsystems: guidance sensor, thrust vector control system, rocket engine, and fin mechanism and canister assembly. The guidance sensor consists of a hermetically sealed fluidic gyroscope which, when spun up and suspended, provides pick-off signals using only integrally stored cold gas. This gyro uses a new, simple, unique method to provide linear output displacement information in a Pulse-Duration Modulation (PDM) form. When used with a Liquid Injection Thrust Vector (LITVC) system, it converts pneumatic signals to suitable electrical signals by means of a simple fluidic-electric transducer. Activated by an electrical signal, the gyro consistently demonstrates its ability to withstand and operate through a 1,000 g shock load. Engineering techniques employed in the thrust vector control system design make it the shortest and lightest operational system possible. The rocket engine used with DICORAP is a prepackaged liquid propulsion system containing hypergolic fuels; it is a hermetically sealed system started by igniting a solid propellant gas-pressurizing grain. The hot gas operated piston and cam mechanism serving to deploy folded fins is located at the projectile's aft end. Projectile ejection and fin deployment sequence is as follows: when the howitzer charge squib receives an electrical signal, it initiates a booster charge igniter, which in turn ignites the howitzer charge. The resulting pressure starts the projectile moving.

DOPPLER RADARS AN/APN-190(V), GPD-102, AN/APN-153(V)

Prime Contractor: Kearfott Division, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

The AN/APN-190(V) system consists of an antenna, receiver-transmitter, control indicator, and receiver-transmitter mount. Total weight is less than 68 pounds. The system provides digital and analog output signals of ground speed (100 to 999 knots) and drift angle (0 to plus or minus 30 degrees). Accuracy of the digital output of ground speed is such that the probable error is less than .075 percent and .055 knot and the analog signal is within .1 percent and .1 knot. This subsystem interfaces with the IBM Navigation Weapon Delivery Computer for the A-7D/E aircraft. GPD-102 is a compact, all-solid-state system which uses an FM-CW radar operating at Ke band to measure ground speed and drift angle. Because of the beam lobing technique, operation is equally precise over land and water during all weather conditions. The system weighs 36 pounds and occupies 1 cubic foot. It is used on the Air Force C-5. AN/APN-153(V) (photo) is a 49-pound, 1.2-cubic-foot velocity sensor giving accurate ground speed and drift angle. It is a transistorized, Janus-mixing, self-coherent Ke band Doppler navigation radar consisting of a receiver-transmitter, control indicator, and antenna assembly. The AN/APN-153(V) beams signals to the ground, receives echoes, and measures the frequency shift produced by the relative motion between aircraft and earth. The system employs self-test. It is used on 10 Air Force and Navy aircraft and on certain executive transports and foreign military aircraft.



R-241



GYRO REFERENCE ASSEMBLY

Prime Contractor: Kearfott Division, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

The Gyro Reference Assembly is a single-unit device designed to provide signals for 3-axis stabilization and control of an orbiting satellite. It consists basically of 3 single-degree-of-freedom, floated rate-integrating gyroscopes and their associated electronics. Physically, the unit is divided into 2 blocks: a gyro block and an electronics block. Within the gyro block are the 3 floated rate-integrating gyroscopes and temperature-control circuitry. Within the electronics block are various plug-in electronic boards, a power conditioner, and a main interconnect board and flex tape assembly.

TACTICAL LANDING APPROACH AID (TALAR)

Prime Contractor: Kearfott Division, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

TALAR® accurately guides any type aircraft or helicopter on an instrument approach path by providing precise glide slope and localizer information. The TALAR system contains a ground transmitter which radiates a microwave beam at 15.5 GHz and an airborne receiver which interprets the data and provides steering signals to standard instruments such as cross-pointers, flight directors, and autopilots. The transmitter (photo) weighs only 57 pounds; the airborne receiver (2 separate boxes) weighs 8 pounds. The system is capable of 10-mile range in rainfall of 10 millimeters per hour.

GPK-20 COMPUTER

Prime Contractor: Kearfott Division, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

The GPK-20 computer is a general-purpose digital machine for navigation and guidance functions and weapons delivery in antisubmarine warfare aircraft. A modular random-access solid-state core memory, arithmetic and control sections, analog to digital signal conversion, and a power supply are all contained in a single unit which incorporates self-protection features guarding against inadvertent memory loss. The memory, operating at a 4-microsecond cycle time and a 1-microsecond access time, can be expanded without redesigning non-destructive readout (wired program) or writable configuration combinations. Solid-state components, including microelectronic integrated circuits, are used exclusively in the conversion segment which can condition the analog interface entirely within the computer. This element converts both input and output data, with no degradation of system information, to accuracies up to 11 bits. The power supply, designed to meet MIL-STD-704, Category B, includes controls protecting the computer from input and regulated output conditions that are unacceptable for orderly computer shutdown and data preservation.



R-242



AUTOMATED MICROFILM APERTURE CARD UPDATING SYSTEM

Prime Contractor: Link Division, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

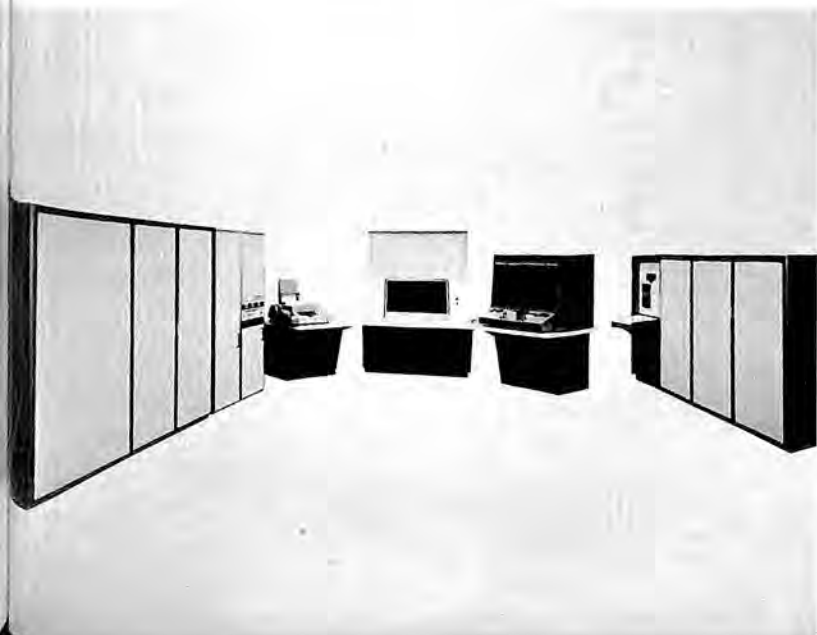
Link developed the Automated Microfilm Aperture Card Updating System (AMACUS) under contract with the Army Weapons Command, Rock Island, Illinois. The system allows an operator to add to and to correct technical drawings and data sheets that are stored on microfilm aperture cards. Revisions are performed electronically without the usual series of intermediate steps that include creating a print from the film, manually updating the print, and then photographing it when the changes are completed. The filmed data on the aperture card are scanned with a high-precision CRT flying spot scanner and digitized for storage on a 30-megabit magnetic drum. The entire drawing or selected portions of it are presented on a display to the operator, who enters the revisions by means of a light pen control keyboard and teletypewriter. The revisions directly modify the digitally stored information on the drum, and the new data are presented immediately on the display for verification, enabling the operator to view the results of his work. When all the changes are completed, the precision CRT system creates a new film recording. The new aperture card is processed automatically and is available for use immediately.

APD-5000 MICROFILM PLOTTER

Prime Contractor: Link Division, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

The new APD-5000 microfilm plotter introduces a marked improvement in both resolution and cost to the plotter industry. The Link plotter has a number of significant advancements in resolution, speed, system design, service, and software. One of the most important advancements offered by the Link plotter is its high resolution. Each film frame is divided into 4,096 by 4,096 raster elements. This means that the user is provided with the necessary resolution to produce intricate and detailed drawings on 35-millimeter film that can be enlarged to D size without losing any detail. In ordinary use, the film aperture produced on this system is divided into 4,096 horizontal and 2,731 vertical raster elements. This has been done to provide maximum use of the film area and to achieve frame butting when needed. The square raster of 4,096 by 4,096 is also available. The Link plotter has the ability to draw 4 different line widths. Each line width is programmable, can be made up of any number of raster elements, and can have a varied intensity level if desired. The variable line width feature eliminates the necessity of retracing to produce wider lines. It will plot at the speed of 100,000 points/second when operating on-line. The Link plotter will operate at the same high speed when connected to an optional off-line special magnetic tape unit. Included in the purchase price of the APD-5000 is a complete software package. This third-generation software package is of superior design, providing a more effective utilization of computer time costs.



R-243



**VARIABLE ANAMORPHIC MOTION
PICTURE (VAMP) VISUAL SYSTEM**

Prime Contractor: Link Division, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

Link has made a major contribution to the simulation of visual approaches and landings with the development of the VAMP visual system. The VAMP provides a means for improving pilot skills in landing aircraft under Normal, Category II, and Category III restricted visibility conditions. The visual system provides a display covering the forward cockpit windcreens of an aircraft simulator such as the Boeing 707 and 727 and the McDonnell Douglas DC-8 and DC-9. A wide variety of approach and landing situations for any visibility condition can be provided. Pilots and copilots can be exposed to combinations of approach and visibility conditions, day or night, at any area of the world, without leaving the simulator cockpit. The new approach used in the VAMP visual system employs 70-millimeter Todd-AO color motion picture films taken during actual aircraft takeoffs, approaches, and landings. The VAMP optically modifies the perspective of the original scene in synchronism with the pilot's control movements to provide an image as seen from the position and attitude of the simulated aircraft. The VAMP system is built as a complete entity which can be fully integrated with the simulator without expansion of the basic computer.

FLIGHT SUIT PRESSURE REGULATOR

Prime Contractor: Vāp-Air Division, Vapor Corporation, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

Vāp-Air has developed a pressure regulator controlling low-pressure bleed air to pilots' and copilots' flight suits for the F-111 tactical fighter. The poppet-type regulator provides a dual function, operating at 3 psig to a given altitude and then shifting to another regime, operating at an absolute pressure of 6.5 pounds per square inch. The regulator, cast in aluminum alloy for light weight, achieves a high degree of sensitivity by utilizing the maximum-size diaphragm within the packaging limitations. Outlet pressures are maintained to .1 pound per square inch over a flow range of 2 to 28 cfm and at inlet pressures varying from 5 to 80 psig.



R-244



ANTI-ICE AND RAIN REMOVAL VALVE

Prime Contractor: Vap-Air Division, Vapor Corporation, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

Vap-Air has developed a new 2-inch valve used for windshield anti-ice application and rain removal. The valve, fabricated of hydroformed stainless steel, controls the flow of air at 155 psig and at temperatures to 1,120 degrees Fahrenheit. Furnace-brazed, precision-cast internal parts, permitting smooth contour shape and efficient aerodynamic web design, promote efficient flow and low pressure drop. The valve, used in a windshield anti-ice application on the F-111 tactical fighter, can be furnished with threaded or flanged connections. It is 5 inches long and 3.75 inches wide and weighs 2.54 pounds.



T62T AUXILIARY GAS TURBINE

Prime Contractor: Solar Division of International Harvester Company

Remarks

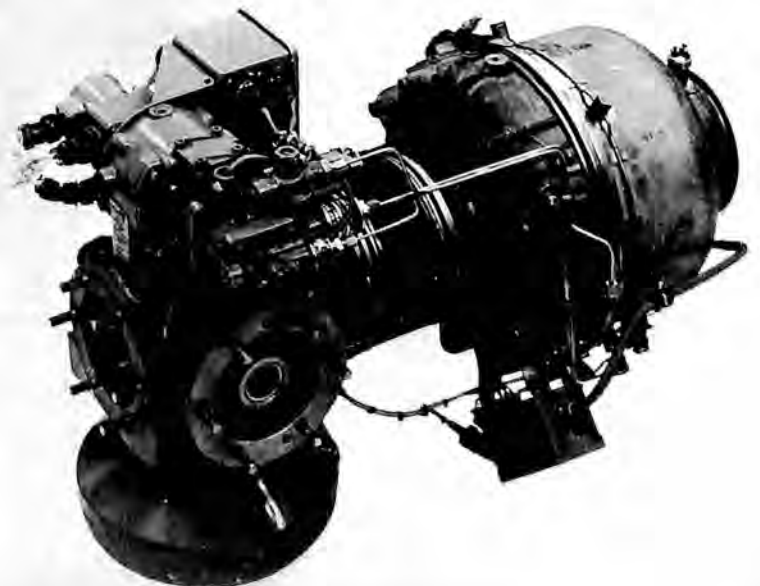
The T62T Titan is an extremely rugged, compact gas turbine engine which has been service-proven in both military and commercial applications. It is being used as the Auxiliary Power Unit (APU) in every major U.S. military cargo helicopter program. In these applications, the APU provides power necessary to start main engines and to operate all hydraulic and electrical systems, allowing aircraft operation completely independent of ground-support equipment. Titan commercial applications include installations in F-27 and FH-227 aircraft of several airlines and in Falcon, JetStar, Sabreliner, DH-125, and Jet Commander business jet aircraft. Functions in these installations include driving the aircraft air-conditioning system and providing both AC and DC electric power for main engine starting and emergency service. The unit is certified for in-flight service.

Specifications

Length 26 inches; diameter 12.5 inches; weight 70 pounds; radial flow; electric or hydraulic starting.

Performance

Rating 80 to 150 horsepower; up to 37 pounds per minute pneumatic bleed flow at 3:1 pressure ratio.



TERRIER FIRE-CONTROL SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Gyroscope Division

Remarks

Mark 76 fire-control systems for the Terrier surface-to-air missile, used in fleet air defense role, are being modernized on DLG-class ships. The program is designed for rapid equipment turnaround to keep ship out-of-commission time to a minimum. Sperry constructed full-scale working replicas of the ship's 7 fire-control compartments within its Great Neck, New York, plant. Engineers, working with actual equipment and ship interior designs, were able to precisely plan electrical cable runs and connector locations, to check equipment installation areas, and to correct problems found before actual installation of equipment aboard ship, where delays can be costly. Currently, 20 ships are programmed; 3 of them have been completed and 7 are in the process of being "turned around." Each Mark 76 system consists of 2 Sperry AN/SPG-55B tracking radars, 2 Mk 119 fire-control computers, and control and ancillary equipment. The new systems will be capable of handling the new Standard missile as well as the Terrier missile.

LORAN-D RADIO NAVIGATION SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Gyroscope Division

Remarks

The Loran-D portable radio navigation system consists of navigation receivers for both ground and air vehicles plus transportable ground stations which broadcast position signals. It enables forces to operate from the same, exact position information, particularly important in a limited-warfare operation in which battle lines are fluid and pinpoint navigation is essential. Loran-D is an outgrowth of Loran-C, which enables a navigator to determine his position by timing the arrival of simultaneously broadcast signals from different transmitting stations. Loran-D transmitters are air transportable and can be set up quickly. Loran-D is on order for the Air Force. In photo, air-transportable transmitter hut.



R-246



FLIGHT INSTRUMENT SYSTEMS

Prime Contractor: Sperry Rand Corporation, Sperry Flight Systems Division

Remarks

Flight instrument indicator systems for the latest generation of jet transport aircraft have been developed by Sperry Flight Systems Division. Two such systems are an attitude director indicator (HZ-6F) and a horizontal situation indicator (RD-350), each incorporating the latest available techniques in indicator construction and display methods. The attitude director indicator displays aircraft attitude and flight path information as well as flight director commands. Among its features are use of DC torquer motors instead of AC servos to drive the attitude sphere. This method eliminates the gear train used in other, similar indicators to move the attitude sphere, increasing instrument reliability and decreasing the production of heat within the indicator case. The companion horizontal situation indicator displays compass heading, radio facility bearing and distance information, and instrument landing system information. A new feature of this indicator is presentation of distance measuring equipment readouts through use of gas plasma segmented digital displays instead of counter drum displays as formerly used. Each indicator has all associated amplifiers built into the indicator case rather than located remotely in the aircraft electronics rack, simplifying installation and maintenance and decreasing weight.

AUTOMATIC LANDING AUTOPILOT SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Flight Systems Division

Remarks

A 3-axis autopilot system, certified for making automatic landings at approved airports and in regular passenger service aboard certain Boeing 727 jetliners, is produced by Sperry Flight Systems Division. The system is a basic 727 autopilot plus additional components to provide full dual pitch channels, an independent roll monitor, a flare coupler, and 2 normal accelerometers. Provision is made for automatic disengagement of the autopilot in case of a disagreement between the dual pitch channels or between the roll channel and the roll monitor. In case of a failure of one pitch channel, the pilot may select the valid channel to make an automatic approach, then resume manual control for touchdown. In addition to automatic monitoring of pitch and roll channel performance, the system provides cross-check monitoring of the 2 localizer receivers, 2 compass systems, and 2 vertical gyros, as well as monitoring of several stages of signal processing and amplifier circuits. An autothrottle is an optional part of the system.



R-247



INTEGRATED AUTOPILOT/FLIGHT DIRECTOR SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Flight Systems Division

Remarks

Integration of autopilot and flight director computer channels is a key feature of the system being produced by Sperry Flight Systems Division for the Boeing 747. The illustrated pilots' controller serves both the autopilot and the flight director systems. Other components include pitch and roll computers, automatic stabilizer trim unit, and monitor and logic unit, plus a small additional pilots' controller used for making autopilot pitch and roll adjustments. The system uses triplex pitch and roll computer channels with provision in the design for growth to full triplex fail-operational configuration. Integration of autopilot and flight director computers simplifies pilot procedures, reduces amount of electronic equipment needed, and allows closer tracking of the autopilot by the flight director. The system makes extensive use of high-density embedded modules for saving space and weight, and of DC computation techniques which make possible wide use of standardized microcircuits. The DC computation also allows close electrical tolerances to be held without external adjustment. Sophisticated built-in test equipment, with "go/no go" indicators, is an integral part of the system.

FLY-BY-WIRE STUDY SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Flight Systems Division

Remarks

A breadboard fly-by-wire system for studying concepts and defining problems involved in practical hardware situations has been designed and built by Sperry Flight Systems Division for the Flight Dynamics Laboratory at Wright-Patterson Air Force Base. It provides complete simulation of a full fly-by-wire system in which pilot's control movements are transmitted to actuators by electrical wires instead of mechanical linkages, with feedback employed to assure that vehicle motion is the controlled parameter. Four electronics channels are used for each of the 3 control axes. The 4 channels assure the system's operation without degradation after 2 failures in any axis. These 4 channels consist of 3 active channels and an electronic model. Mid-value logic is used to determine the value of the output signal which is transmitted to the actuators. All 4 channels are monitored to detect failures and to annunciate them to the pilot. The actuator, a triplex force-summed configuration, is also monitored electronically and will continue to operate after 2 failures. The system includes a complete self-test feature which checks for any latent failure in the logic and monitoring circuitry.



UHF RANGING BEACON SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Flight Systems Division

Remarks

The Sperry Remote Area Terminal System is a combination communication, ranging, and letdown system operating in the military UHF communications band. It consists of a ground unit, which includes a beacon transponder and a voice transceiver, and of a set of airborne units, which includes an interrogator, a pilot's controller, and a cockpit indicator. These airborne units provide a pilot with information on range and bearing to the ground beacon. This information, plus manual setting of ground barometric pressure into the airborne unit, makes possible descent of the aircraft toward the beacon from any direction and along a pilot-selected glide path angle. The airborne equipment can be linked to standard cockpit instrument landing system indicators. The unit is designed for use in rotary- or fixed-wing aircraft for such missions as logistic support, tactical approach and letdown, medical evacuation, and station keeping.

UNIVAC CP-890 COMPUTER

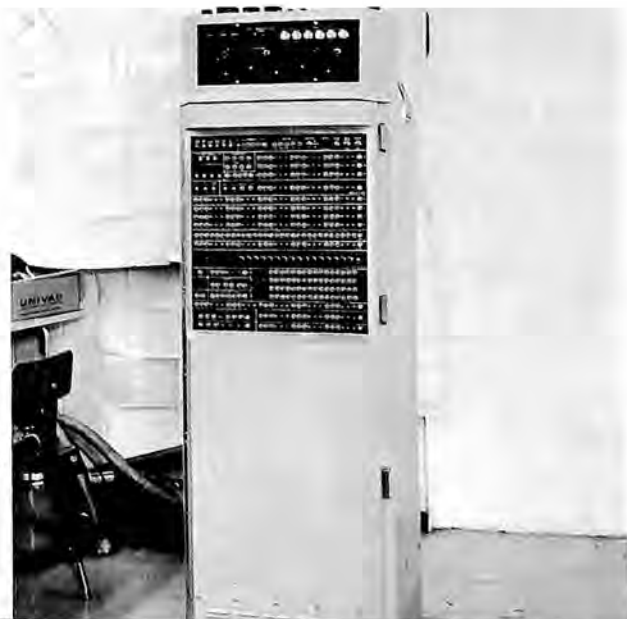
Prime Contractor: Sperry Rand Corporation, Univac Division

Remarks

The UNIVAC CP-890 computer, utilizing micro-electronic circuitry and wire-wrapped connections, is equipped with a 1.8-microsecond memory of 32K 30-bit words and 12 I/O channels expandable to 16. The cabinet measures 65 inches high, 22 inches wide, and 18 inches deep with chamfered corners designed to permit passage through a 25-inch submarine hatch without dismantling. A display panel includes approximately 400 indicator light switches, a keyboard, and a keyset. UNIVAC CP-890s, to be used in the Navy's Polaris/Poseidon submarine navigation system, are expected to double the accuracy of the new missile-firing submarine's navigation system. Improvement in overall system performance will be achieved largely through refined data processing and calibration techniques made possible by the replacement of 3 existing computers with one CP-890.



R-249



UNIVAC CP-642B MILITARY COMPUTER

Prime Contractor: Sperry Rand Corporation, Univac Division

Remarks

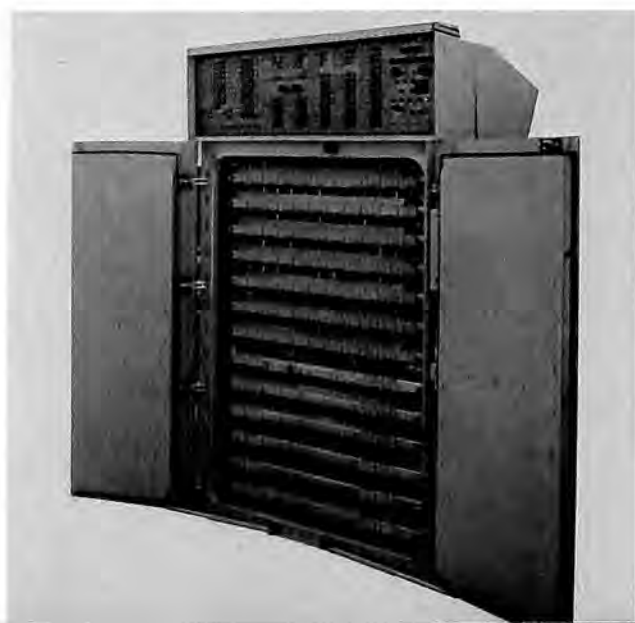
The UNIVAC CP-642B military computer was developed as the next-generation NTDS (Naval Tactical Data System) computer, incorporating thin-film memory and UNIFLUXOR NDRO memory. Utilizing advances in computer technology, the CP-642B was designed to be compatible with the CP-642A, but with internal processing speeds twice as fast, and 16 I/O channels with transfer speeds 4 times as fast. The thin-film memory is used as 64 words of control and index register storage at 667-nano-second cycle time, operating independently of the main memory. CP-642B computers, mounted in ruggedized, transportable shelters, are principal elements in the MTDS (Marine Tactical Data System), a land version of the NTDS.

UNIVAC CP-901 AVIONICS COMPUTER

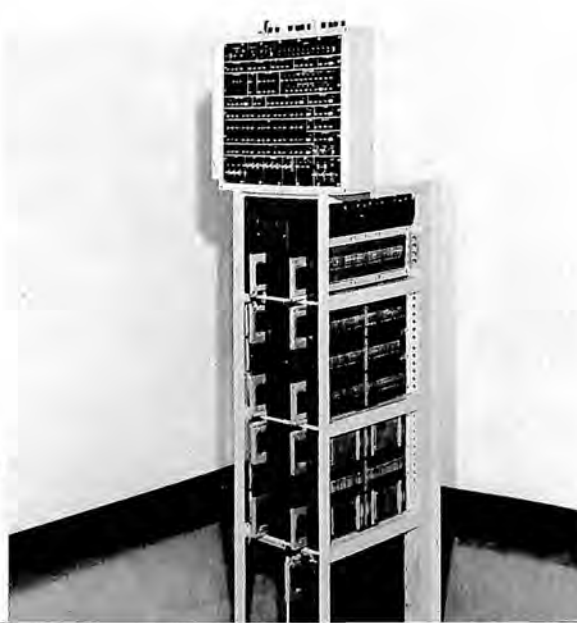
Prime Contractor: Sperry Rand Corporation, Univac Division

Remarks

The UNIVAC CP-901 computer, an integrated-circuit version of the UNIVAC 1230, is designed for special application requiring a 32K memory, 30-bit parallel I/O on each of 16 channels, occupying only 3 cubic feet of space. This computer was designed to MIL-E-5400 in a basic aerospace configuration adapted to general, limited-space utilization. The UNIVAC CP-901 is in production for the A-NEW antisubmarine warfare program for the Navy. The concept includes a computer-centered airborne command and control system which accepts and evaluates sensor data, displays the information for the commander, and recommends a course of action. If further information or alternative plans of action are desired, the commander can request them from the computer. Ship and aircraft are linked by a computer data link so that all information for concerted ASW action is available to all elements of the force.



R-250



INTEGRATED DRIVE GENERATOR

Prime Contractor: Sundstrand Aviation, a division of Sundstrand Corporation

Remarks

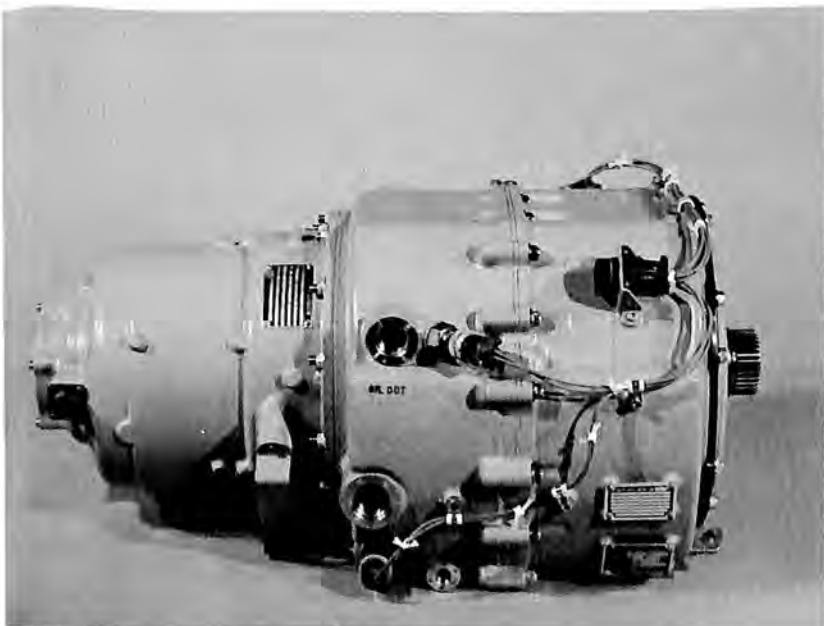
The Integrated Drive Generator (IDG) combines an axial gear differential constant-speed drive with an advanced-design oil-spray-cooled generator. The system provides constant frequency AC power to aircraft systems by converting varying engine shaft speeds to constant output speed. The major difference between the IDG and earlier constant-speed drive and generator systems is a unique interface design which permits the IDG drive to circulate oil through the generator section. This feature eliminates the need for certain rotating oil seals, provides positive lubrication of the generator bearings, and introduces the use of a highly efficient oil-mist cooling system, resulting in a lighter, more compact package. The drive portion consists of a mechanical axial gear differential and a hydraulic log containing slipper piston hydraulic units. The majority of the input power is transmitted directly to the generator through the differential with speed trim provided by the governor-controlled hydraulic log.

ACCESSORY DRIVE SYSTEMS

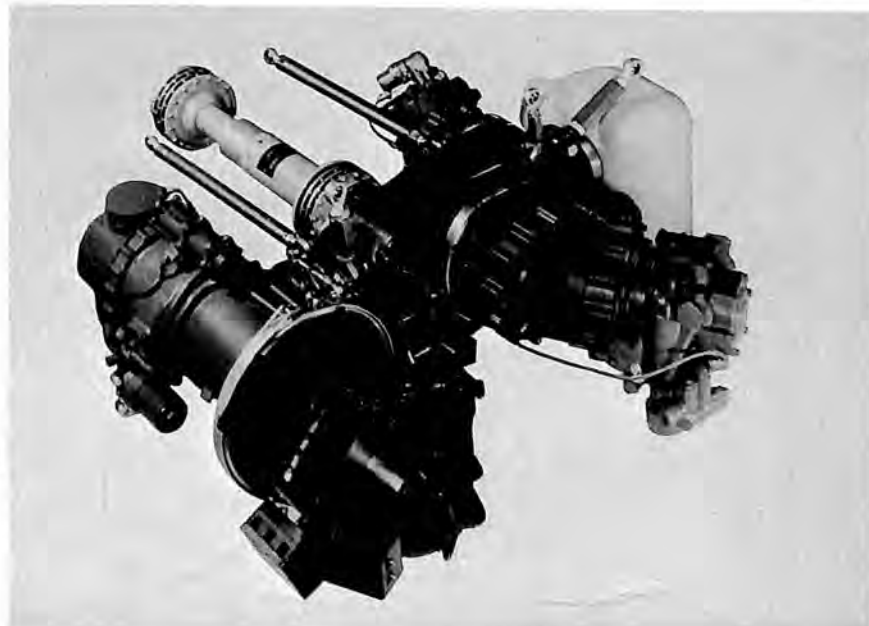
Prime Contractor: Sundstrand Aviation, a division of Sundstrand Corporation

Remarks

Accessory drive systems provide the complete secondary power required in modern aircraft. They consist of shaft-driven gearboxes mounting accessories such as constant-speed drives, generators, hydraulic pumps, fuel pumps, starters, coolers, fans, and decoupler/recoupler provisions. With these added provisions, ground power can be provided through pneumatic motoring. Single-piece cast housings provide maximum reliability, long life, and light weight. In addition to magnesium housings, accessory drive systems utilizing fabricated steel or titanium have been developed and produced for special applications. A typical accessory drive system is shown in photo. As systems manager, Sundstrand has responsibility for design, procurement, testing, and performance of the system from concept through qualification testing.



R-251



EMERGENCY POWER UNIT

Prime Contractor: Sundstrand Aviation, a division of Sundstrand Corporation

Remarks

Sundstrand Emergency Power Units (EPU) are used to provide hydraulic and/or electrical power under all engine-out conditions. The EPU consists of one or 2 hydraulic and/or electrical units which are driven by a conservatively rated axial-flow impulse turbine through a jackshaft-type gearbox. Warm gas to drive the turbine is obtained by decomposing a liquid monofuel in a thermal bed decomposition chamber. Turbine speed is regulated with on-off control valves. The system fuel is contained in a hermetically sealed fuel tank for long-term storage capability. Fuel pressurization is accomplished by using a centrifugal fuel pump and by bootstrapping the fuel tank with low-pressure warm gas bled from the turbine nozzle. System operation is initiated with hermetically sealed, electrically actuated start initiators.

ACTUATION SYSTEMS

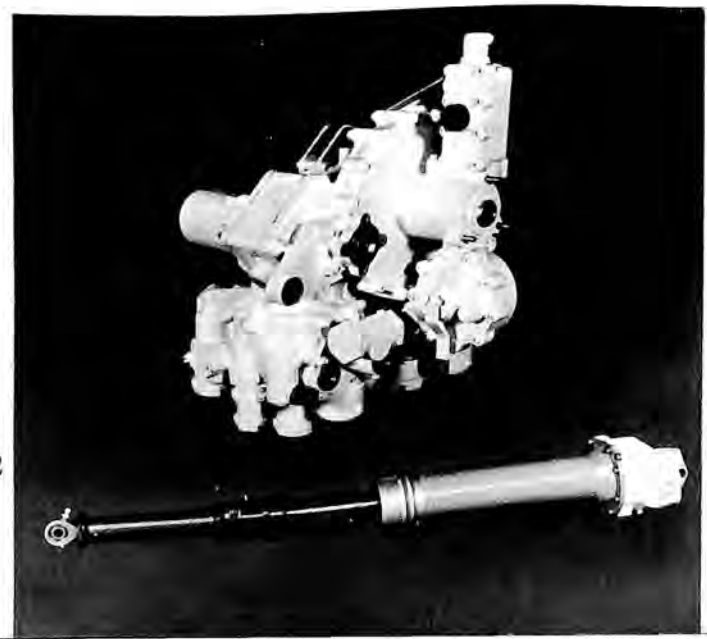
Prime Contractor: Sundstrand Aviation, a division of Sundstrand Corporation

Remarks

Sundstrand Aviation designs, develops, and manufactures aircraft secondary flight control and utility actuation systems. These systems meet the specialized requirements of flight controls, such as wing sweep, leading and trailing edge flaps and slats, and pitch-trim devices, as well as a wide variety of other applications such as landing gear and hatches. Pictured is the Power Drive Unit (PDU) and ball screw actuator from a typical Sundstrand high-lift system developed for commercial application. The system positions the leading edge surfaces of the wings. All surfaces operate simultaneously and are driven by a single torque tube system powered by the PDU. Shafting from the PDU is connected to angle gearboxes and then through the surface actuators to an asymmetry detector and brake located in each wing tip. In order to optimize the size and weight of drive-train components, torque limiters (located outboard of the PDU and in the actuators) are utilized to protect the system from excessive torque.



R-252



AN/APN-182 DOPPLER NAVIGATION RADAR SET

Prime Contractor: Teledyne Ryan Aeronautical,
Electronic and Space Systems

Remarks

Production of the AN/APN-182 accurate hovering control radar is for the Sikorsky SH-3D, mainstay of the Navy's ASW helicopter fleet. The AN/APN-182 replaces the Ryan AN/APN-130 Doppler, which was installed in some 500 SH-3A helicopters. Major improvements are lighter weight, greater accuracy, increased mean time between failures, and elimination of a liquid cooler system. The SH-3D entered active service in 1969. The radar senses velocity in all directions and is the primary sensor for control of the automatic transition and hover maneuver performed in ASW and sea rescue missions.

Specifications

Alternate antenna types available for new applications (for immediate compatibility with the older APN-130, the same antennas were used); total system weight, depending upon antenna used, 46 to 67 pounds; control indicator weight .75 pound; other indicators offered as optional equipment.

Performance

Capable of flight at altitudes from zero to 20,000 feet, with a hover mode altitude of zero to 2,500 feet; accuracy .5 percent plus or minus .5 knot; horizontal velocity minus 40 to plus 350; vertical velocity plus or minus 6,000 feet per minute; 600 hours mean time between failures.

AN/APN-193 DOPPLER VELOCITY SENSOR

Prime Contractor: Teledyne Ryan Aeronautical,
Electronic and Space Systems

Remarks

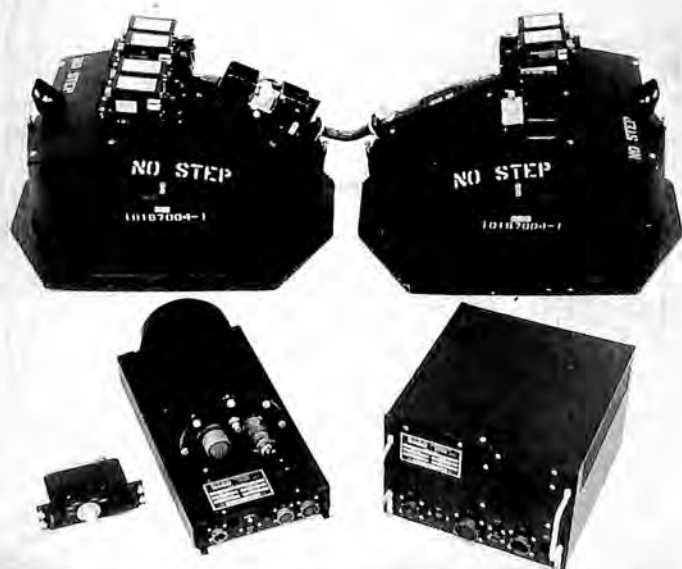
Most advanced of Ryan's line of Doppler radar navigation sensors, the AN/APN-193 features a solid-state transmitter; a low-profile, flush-mount antenna; single-unit construction (electronics mounted atop the antenna structure); and a highly sensitive, cross-correlation frequency tracker. Designed for all-weather operation, the system performs over land or sea. It transmits and receives microwave energy in 4 narrow beams to determine velocity by Doppler shift principles.

Specifications

Complete system weight 44 pounds; transmits at 1 watt, operates at 13.3 GHz; size 26 by 30 by 7.5 inches.

Performance

Demonstrated accuracy in flight tests of .1 percent of the ground track flown; capable of operation at altitudes in excess of 70,000 feet, at pitch angles as great as 30 degrees and roll angles as great as 45 degrees, without losing lock on the surface overflown.



6425 25-MILLIMETER WEAPON SYSTEM

Prime Contractor: Jet & Ordnance Division, Equipment Group of TRW Inc.

Remarks

The TRW 6425 25-millimeter weapon system has been under design and development by TRW since 1964 in anticipation of the Army's forthcoming Vehicle Rapid Fire Weapon System-Successor "Bushmaster" program for weapon applications to several military combat vehicles of the seventies and eighties. The system consists of a recoil-operated, dual-feed, automatic weapon, a family of 25-millimeter ammunition, and associated ancillary devices for direct and remote operation of the weapon. The weapon design provides for selective rates of fire of 100 and 200 shots per minute and full automatic fire of 570 shots per minute; the rates are selectable by the gunner to enable him to effectively engage various combat targets. The weapon can be "field stripped" in seconds without tools. The ammunition family consists of 10 types of rounds including armor-penetrating discarding sabot, high-explosive incendiary, armor-piercing high-explosive incendiary, and their companion tracer and practice versions. The high muzzle velocities of the ammunition, combined with advanced external and terminal ballistics of the warheads, provide highly superior target destruct capabilities at long tactical combat ranges greater than the threat posed by potential enemy armies. The system is being tested and evaluated by the U.S. Army, the Royal Army of the Netherlands, France, and Great Britain, with evaluation and potential adoption by other NATO countries planned. The highly adaptable system is designed to meet a specific combat role. Potential applications, however, include helicopters, counterinsurgency aircraft, patrol boats, antiaircraft (multiple weapon) units, and ground mounts.

TORQUE LOCKS

Prime Contractor: Mechanical Products Division, Equipment Group of TRW Inc.

Remarks

Modern aircraft utilize hydraulic or pneumatic motors to drive flaps, thrust reversers, landing gear doors, and other power-operated accessories. Because of the need for minimum weight, it is necessary to use multibranch systems. A jam in any single branch will result in transfer of the motor full-stall torque to the jammed branch. The result is a driving torque many times greater than the normal torque. To protect the driven mechanism from excessive torque inputs, torque-sensitive brakes are used to stop the motion of the power supply while limiting the torque when a jam occurs in the driven mechanism. The torque-limiting devices in use are limited to low-speed operation (usually less than 300 revolutions per minute) because of their inability to avoid damage from high-inertia torques when stopping a rapidly turning shaft. However, system studies have shown a large weight advantage for operation at high shaft speeds. As an outgrowth of the need for a high-speed torque-limiting device, TRW has developed and qualified a torque lock which is not speed limited. Basic functions of the torque lock mechanism are to limit the torque transmitted through the torque lock so as to protect the downstream system elements from being subjected to full system stall torque levels, to decelerate the upstream elements at a controlled rate to prevent excessive inertia torques, to allow the transmission of normal operating torques with minimum energy losses, and to maintain synchronization of the branches of the system during all phases of operation.



R-254

BOEING 747 ENVIRONMENTAL CONTROL SYSTEM

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

The Boeing 747 environmental control system supplies the cooling, heating, ventilation, and pressurization requirements of the 380-passenger superjet. Its 72-ton cooling capacity can condition 8,000 cubic feet of air per minute, completely changing the air inside the passenger compartment every 3.5 minutes. The system's 3 air-conditioning packages process air bled from the 747's engines during flight or supplied on the ground by an auxiliary power unit. Two packs can handle cooling requirements if one becomes inoperative. The cooling task is performed by each pack's "simple bootstrap" air-cycle machine developed by Hamilton Standard. The 3-wheel design places the air circulation fan on the same shaft as the compressor wheel and cooling turbine instead of on a separate mounting as in other types of refrigeration units. Power produced by the turbine drives the fan, eliminating the need for a separate power source. This simpler arrangement increases cooling efficiency and reduces the unit's weight, electrical power requirements, and maintenance costs. At 30,000 feet, where the air is cooler, the 747 system's heat exchangers, one per air-conditioning package, take over the cooling function. Before entering the passenger compartment, processed air is mixed with warm engine bleed air. A 4-zone temperature control subsystem automatically maintains cabin temperatures between 70 and 80 degrees Fahrenheit. Each control zone is designed to operate independently of the others. The automatic cabin pressurization control maintains pressure at an equivalent 8,000-foot altitude. The 747 heat exchanger combines the primary and secondary heat exchangers in one unit.



U.S. NAVY PLAINVIEW HYDROFOIL AUTOPILOT

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

The autopilot, an integral part of the U.S. Navy *Plainview* ship's hydrofoil system, controls and stabilizes the experimental craft during all foilborne conditions in calm and rough seas. It senses pitch, roll, and yaw motions and feeds the electronic information to a computer. Hydraulic actuators adjust the foils to maintain the *Plainview's* attitude and height above the water. Automatic control sensitivity allows the foilborne 212-foot ship to cut through waves in low and moderate seas or to ride wave contours in heavy seas. Its design based on helicopter automatic stabilization systems, the autopilot also controls the 300-ton craft when it makes coordinated turns on its hydrofoils. Three sonic height sensors, 2 forward and one aft, maintain the hull several feet above the waves. Electromagnetic sensors measure both hullborne and foilborne speeds. Major system components include computer; pitch, roll, and acceleration sensor package; height sensors and transducers; attitude and foil-angle indicators; self-test and control panels; alarm lights; and static inverter power supply.



R-255

LUNAR MODULE ABORT SENSOR ASSEMBLY

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

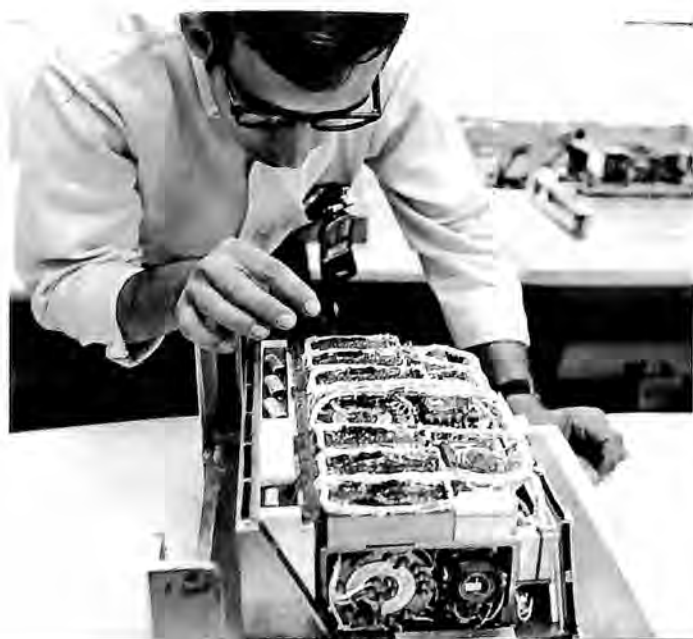
The abort sensor assembly is the strapdown inertial measuring of the abort or backup guidance system for the Apollo Lunar Module (LM). The unit constantly monitors and compares navigational values with the primary guidance and navigation system during the LM's orbit of the moon, lunar touchdown maneuvers, and the return flight and docking with the moon-orbiting Command Module. The preprogrammed, semiautomatic abort sensor assembly is designed to take over all the functions of the primary guidance system in the event of a malfunction. It measures the LM's attitude and velocity, senses changes in the spacecraft's attitude and acceleration, and sends the information to a computer for processing into navigational information. Three accelerometers measure the LM's rate and gain of velocity in 3 axes—roll, pitch, and yaw. Three gyroscopes measure spacecraft attitude or position to within .001 degree. Changes in velocity are indicated in increments of .01 foot per second. The abort sensor assembly's electronics are microminiaturized for minimum weight and maximum reliability. In qualification tests, it has demonstrated a mean-time-between-failure rate of 5,700 hours. Located in the LM craft's equipment bay above the astronauts' heads, the 20.7-pound unit measures 11.5 by 9 by 5 inches. Hamilton Standard developed the LM abort sensor assembly for the Systems Group of TRW Inc.

F-111 AIR INLET CONTROL

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

The air inlet control for the Air Force/General Dynamics F-111 fighter-bomber matches the variable-geometry inlet to engine operation to assure proper airflow to the twin engines during all supersonic and subsonic flight conditions. The hydromechanical system automatically adjusts the inlet spikes, which slow down and compress the airflow, and maintains the normal shock in the proper position in the ducts by expanding or contracting the spike's cone section. Pneumatic signals from probes and taps on the air inlet are transmitted to 3 pressure ratio sensors, on the main control, which respond to minute pressures. The signals are translated into hydraulic pressure for activating the spike and cone servo actuators. The system is designed to respond to pressures as small as one-thousandth of a pound per square inch, yet to accurately position the spike within 1.5 percent of total travel against multi-ton loads. Its main components include main control, spike actuator, cone angle actuator, and feedback transmission. In event of hydraulic failure, the pilot activates an emergency shuttle valve to supply pneumatic pressure which fully extends the spike and contracts the cone for flight safety.



R-256



PORTABLE LIFE-SUPPORT SYSTEM FOR APOLLO SPACE SUIT

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

The Portable Life-Support System (PLSS) is worn by space-suited astronauts when they explore the lunar surface. Weighing 84 pounds, it supplies oxygen and pressurization and controls the temperature, relative humidity, carbon dioxide, and other contaminants of the ventilating gases in the suit. The PLSS also recirculates and recools the water that flows through the tubing of the liquid-cooling garment worn under the Apollo space suit. This water removes the astronaut's body heat. The life-support pack permits 4-hour extravehicular expeditions. Its expendables are recharged in the Lunar Module (LM) for the pack's reuse. A 2-way radio and telemetry unit provides voice communication and the transmission of astronaut physiological and space suit data to the LM for relay to earth. An oxygen purge system on top of the PLSS holds a 30-minute supply of oxygen for emergency and backup use. Connected separately to the suit, it also can be used independently as a life-support chest pack during extravehicular transfer of astronauts between the Lunar Module and the Command Module. Hamilton Standard developed the PLSS for NASA's Manned Spacecraft Center.



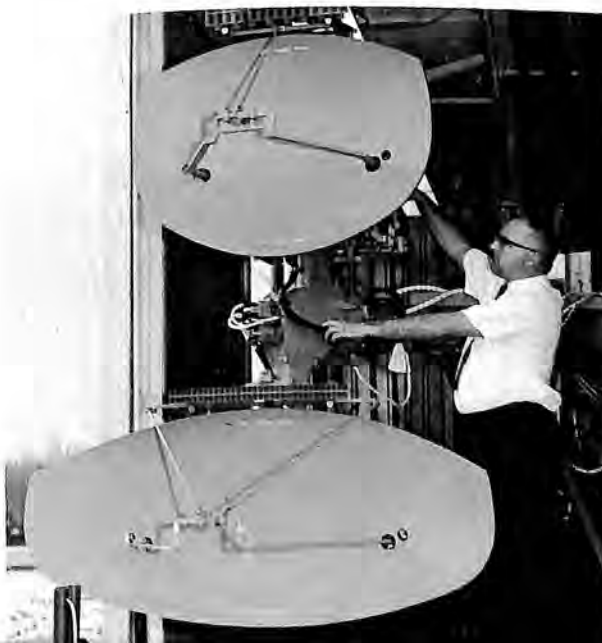
C-5 MULTIMODE RADAR SYSTEM

Prime Contractor: Norden Division of United Aircraft Corporation

Remarks

The C-5 multimode radar, developed by Norden for Lockheed-Georgia Company, applies the latest multipurpose radar concepts for meeting tactical and strategic aircraft requirements under all weather conditions. Ground mapping, precision fix taking, beacon, weather mapping, terrain following, and radar approach to landing are included in the modes of operation. The system features 2 essentially independent radars, X-band and Ku-band, and 3 indicators, 2 for the pilots and one for the navigator. Each radar has identical mode capabilities, utilizing different frequencies to emphasize certain features. Ku-band provides higher resolution; X-band offers decreased sensitivity to weather. The X- and Ku-band radars can be independently controlled at any of the 3 operator stations, and either radar can be viewed on any indicator. Each antenna/receiver contains a reflector and a passive interferometer array rigidly attached to the scan column and maintained in boresight coincidence with the reflector. The reflectors are used for both transmitting and receiving; the interferometers are used only for receiving. The interferometers are utilized for the processing of radar returns to generate elevation profile data for terrain following, contour map, and radar approach. The antenna/receivers are mounted on a common roll unit. The C-5 is sponsored by the Aeronautical Systems Division, Air Force Systems Command.

R-257



ELECTRONIC ATTITUDE DIRECTOR INDICATOR SYSTEM

Prime Contractor: Norden Division of United Aircraft Corporation

Remarks

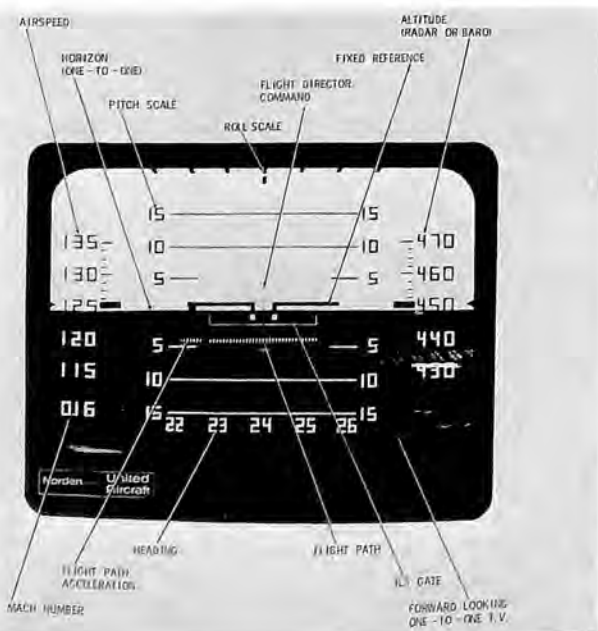
The Electronic Attitude Director Indicator (EADI) system is designed to make available for commercial aircraft the capabilities of the all-electronic integrated display systems produced for military aircraft. The Norden EADI provides a simultaneous display of critical flight information through the use of electronically generated symbology: heading, airspeed, Mach number, attitude, altitude, command, and rate information. The EADI is also capable of displaying on the screen forward-looking low-light-level television or high-resolution air-to-ground radar data. The EADI system reduces instrument clutter and eases the pilot's work load. It enhances safety during adverse weather conditions by integrating flight data required for approach and landing. Built-In Test Equipment (BITE) monitors various signal chains, and, in the event of a failure, warns the pilot on the display quickly and accurately. BITE and test patterns assist line mechanics and bench technicians in rapidly identifying and repairing any failed components.

SELF-SKINNING FOAM

Prime Contractor: UOP Aerotherm Division and UOP Bostrom Division, Universal Oil Products Company

Remarks

A joint effort by the Aerotherm and Bostrom divisions resulted in the production of a high-quality self-skinning urethane foam. The new urethane has extremely good abrasion and puncture resistance characteristics, meets Federal Aviation Administration flame retardancy requirements, and can be provided in no-fade colors and various densities to meet specific comfort criteria. Production of commercial airline passenger seat armcaps was the first new product application. The new armcap is a disposable unit that can be easily and quickly replaced aboard the aircraft by airline personnel without interference with on-time departures. It eliminates the task of frequently removing upholstered or conventional vinyl armcaps and having them cleaned, recovered, and replaced at high labor and material costs. Field tests are being conducted on small land vehicle seats with potential applications to tractors and other small all-weather vehicles in which the seat is exposed to weather conditions. Extensive research and development is being directed to broader applications of new self-skinning foams.



R-258



AIRCRAFT CARGO PALLET

Prime Contractor: UOP Aerotherm Division, Universal Oil Products Company

Remarks

An entirely new concept in cargo pallets has been introduced by the UOP Aerotherm Division. The pallet is all extruded aluminum construction and meets 3 g and 9 g specifications as one unit. It is designed as an 88- by 125-inch pallet; the addition of one piece of floor track permits its use as an 88- by 108-inch size when an aisle is required in the aircraft. The standard pallet fits all Boeing 707, 720, 727, and 737 aircraft and all McDonnell Douglas DC-8-60 series aircraft. Other sizes to fit the B-747, the DC-10, and the L-1011 are under test for certification. Outstanding advantages of the all-aluminum pallet include lighter weight, longer life, delamination proof, and easy repair with ordinary on-line maintenance equipment.



FLEXIBLE DUCTING

Prime Contractor: Calumet & Hecla Corporation, division of Universal Oil Products Company

Remarks

At high speeds, high altitudes, high pressures, and extreme temperatures, flexible ducting becomes important. It must be able to expand and contract, take motion in any direction, and carry high pressures. It must also be light in weight and available in unusual shapes and sizes. Special Flexonics ducting components made a first appearance on early World War II aircraft. Since then, the ducting demands of supersonic aircraft and advanced aerospace vehicles have been and are being met by Flexonics. Typical applications for flexible ducting include cabin air conditioning, engine exhaust, anti-icing, rain removal, and boundary layer control. Metal hose applications include hydraulic brakes, fuel lines, oil lines, oxygen breathing, vibration absorbing connections, and exhaust connections.



HIGH-PRESSURE SAFETY RELIEF VALVE

Prime Contractor: UOP Instruments Division, Universal Oil Products Company

Remarks

A high-pressure safety relief valve with a temperature operating range of minus 65 to plus 275 degrees Fahrenheit has been introduced by the UOP Instruments Division. The compact, lightweight, rugged unit, known as the V-736 series, is engineered to handle critical high-pressure applications with maximum reliability. The instrument's spring and poppet combination prevents leakage at low pressure; a special entrance-port filter assures cleanliness of the valve seats and poppets, extremely important under high-pressure operation. V-736 units can be adjusted quickly and easily so that they operate with zero leakage in both pneumatic and hydraulic systems. Extremely close differentials, as low as 4 percent of cracking pressure, are readily obtained. The V-736 is being used in the pneumatic system of the F-111 and other high-performance aircraft.

Specifications

Weight .15 pound; maximum diameter .62 inch; maximum length 1.7 inches; operating media, air and nitrogen; pressure ratings: working nominal 3,000 pounds per square inch, working maximum 4,050 pounds per square inch, cracking minimum 4,800 pounds per square inch (V-736-1), 4,500 pounds per square inch (V-736-2), reset minimum 4,500 pounds per square inch (V-736-1), 4,300 pounds per square inch (V-736-2).

LIQUID LEVEL INDICATOR AND TRANSMITTER

Prime Contractor: UOP Instruments Division, Universal Oil Products Company

Remarks

A unique, high-performance system for pinpointing aircraft liquid levels has been designed by the UOP Instruments Division. Basic operational principles of standard float switches have been adapted to electronic measurement for maximum accuracy to provide high performance under the most severe environmental conditions. An electronic transmitter, the heart of the system, senses the liquid level and converts its readings into incremental resistance changes. A magnetic float operates a series of reed switches in sequence as the float rises or descends with the level of the fluid. The switches shunt a resistor network that produces a linear current change regardless of the configuration of the vessel holding the liquid. The F-306 series is protected from stray field effects by magnetic shielding while its low current operation minimizes any possibility of errors due to lead resistance. This precision performance instrument resists shock and vibrations encountered in jet aircraft. An internally lighted dial and pointer assure easy readability for both pilot and copilot in daylight as well as at night. Electrical rating is 28 VDC-lamp; accuracy indicator plus or minus 1 percent full scale, transmitter 3 percent; operating temperature minus 65 to plus 350 degrees Fahrenheit. The transmitter section can be supplied in lengths to fit specific applications. The F-306 series can be supplied to read actual liquid level, or it can be electrically contoured to show actual fluid contents in a nonsymmetrical-type fluid container. Dial movement configurations of 90 and 180 degrees can be supplied.



R-260



AIRLINE BEVERAGE SERVICE CARTS

Prime Contractor: REF Dynamics Division, Universal Oil Products Company

Remarks

A new series of airline beverage service carts has been developed by the REF Dynamics Division for use on the McDonnell Douglas DC-8 and DC-10, the Boeing 707, 720, 727, 737, and 747, and the Lockheed L-1011. Identified as Skycarts, the new series highlights 2 specific models. The Skycart on the left in photo features a beverage dispensing system utilizing either an electromechanical or completely mechanical beverage dispensing head that can dispense 5 to 7 different types of beverages—ginger ale, cola, club soda, etc.—at the press of a button. Beverages are stowed in a module of bulk beverage containers housed in the lower section of the cart. The model at the right uses the levelator system for stowage of canned beverages. As the top can is removed, the next can is elevated into an accessible position. Beverage glasses are stowed in a tube equipped with a leveling device for easy accessibility. Both carts have provisions for liquor miniature storage, waste chute and container, and stowage compartments for ice cubes, napkins, stirrers, and condiments. Alternate designs provide for storage of liquor miniatures in tubes with levelator devices. Inserts and decorative side panels are removable for cleaning; they meet the latest fire retardancy regulations. All carts are easy to maneuver and will save stewardesses considerable time and effort in serving passengers. Other Skycart designs include food, tray, and refrigerated carts.



R-261

DC-10 UPPER DECK SERVICE CENTER

Prime Contractor: REF Dynamics Division, Universal Oil Products Company

Remarks

McDonnell Douglas DC-10 jets will be equipped with upper deck forward service centers provided by the REF Dynamics Division. Units are all-bonded structures and include drinking fountain, built-in intercom system, hot plates, waste cart stowage, ice stowage, cup dispensers, sink, and areas to accommodate personnel and tray cart elevators. Galley units have been designed to accommodate the identical refrigerator-freezers and coffee brewers presently furnished American Airlines and United Air Lines. REF is also providing the aft coffee bar and stowage compartment for the DC-10. Refrigerator-freezers and coffee brewers are being built for the lower-lobe food preparation complexes on the 747. Complete inflight food service systems have been designed for the Northwest Orient Airlines DC-10s, the Japan Air Lines 747s, and Aer Lingus-Irish 747s. All units meet the latest Federal Aviation Administration regulations for flame retardancy and have been designed to meet public health sanitation requirements. All units reflect the latest in materials applications and provide easy but low maintenance characteristics.



GEOLOGICAL MAPPING RADAR

Prime Contractor: Westinghouse Electric Corporation, Aerospace Division

Remarks

Westinghouse has adapted an airborne radar mapping system developed for military reconnaissance for use as a geological reconnaissance system to help scientists in oil and mineral exploration. The Westinghouse-built radar is installed on a company-operated DC-6B. A side-looking radar, it produces photo-like imagery of the ground. Such imagery has been produced for the Army Topographic Laboratory and the Department of Defense, for government-funded university scientific work, and for geologists involved in oil and mineral exploration. The DC-6B airplane is a self-contained mapping unit in that every step of the process can be performed in it. The radar system receives the reflected signals, amplifies them, and displays them on a cathode ray tube. A 50-foot-long, 9-inch-wide strip of photographic film passes across the face of the cathode ray tube, recording line by line the image of the ground displayed. The film speed is synchronized to the ground speed of the airplane. The film can be processed in the airplane's darkroom and viewed on a built-in light table. The antenna subsystem is mounted below the airplane (photo). It is in a pod about 15 feet long and 24 inches in diameter. The subsystem is gyro stabilized so that movements of the airplane do not affect the accuracy of the imagery. Radar geological reconnaissance is a new and additional tool of considerable importance. In some areas previously mapped by other methods, lineaments (a class of geological features) were seen for the first time on radar imagery. Such lineaments are one of the indicators of the nature of the subsurface structure. This knowledge helps geoscientists to draw conclusions about the potential presence of minerals or hydrocarbons.



RADIOISOTOPE THERMOELECTRIC GENERATOR

Prime Contractor: Westinghouse Electric Corporation, Astronuclear Laboratory

Remarks

Westinghouse Astronuclear Laboratory has developed, for Jet Propulsion Laboratory, a thermoelectric power generation system which is the highest-power radioisotope-fueled device built for the space program. Output of the unit is about 120 watts, 3.5 volts at 34 amperes. Efficiency is nearly 6 percent. The generator consists of a heat source, heat pipe, thermoelectric module, and planar radiator. For testing purposes, the unit is operated with electrical heaters instead of a radioisotope as the heat source. Thermal energy produced by the heat source is transferred to the interior of a tubular thermoelectric generator by the heat pipe (photo). The interior of the generator is the hot side of the thermoelectric couples; the radiator is the cold side. The generation system is the first practical application of the heat pipe which up to now has been largely a laboratory curiosity. The heat pipe is highly efficient; it transfers almost 100 percent of the heat from its evaporator section at one end to the condenser section at the other end. Design of the tubular thermoelectric module is a result of 8 years of development and testing at the Westinghouse laboratory. Total testing time on developmental modules exceeds 180,000 hours. The modules can operate in air, in inert gas, or even submerged in liquids.



R-262

AN/TPS-43 TACTICAL RADAR

Prime Contractor: Westinghouse Electric Corporation, Westinghouse Defense and Space Center, Surface Division

Remarks

AN/TPS-43, developed and produced by Westinghouse for the Air Force Systems Command's Electronics Systems Division, is a new tactical radar which is part of the USAF's 407L tactical air control system. For ease of transportation, the radar system is in 2 units, each weighing 3,500 pounds. The units can be transported in a variety of ways, including helicopter transfer. The reliability and mobility of the system were demonstrated for Air Force experts. In a reliability test, a system was operated continuously for 1,000 hours over a period of 7 weeks. One hour each day was allotted for preventative maintenance, but in several instances the system was operated for a full 24 hours. Mobility of the system was demonstrated in tests at the Westinghouse division's plant and in a high-altitude test in Arizona. The AN/TPS-43 is a 3-dimensional system; it computes and displays the altitude of a target aircraft in addition to the usual bearing and range information. It is capable of detecting aircraft to a range of 120 nautical miles. High reliability in the new system is achieved through extensive use of solid-state components. Only 12 electronic tubes are used in the system along with about 3,000 integrated circuits and 1,200 transistors.

HELIUM SPEECH UNSCRAMBLER

Prime Contractor: Westinghouse Electric Corporation, Underseas Division

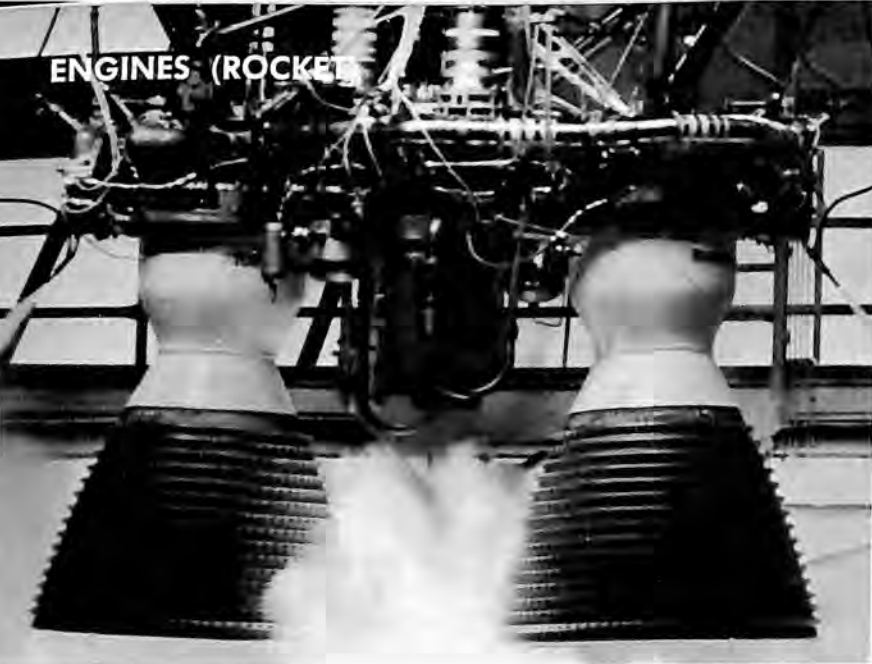
Remarks

The "Donald Duck" speech of deep water divers is made understandable by a new helium speech unscrambler. It was developed for the Navy's Office of Naval Research by the Westinghouse Underseas Division. At depths beyond about 150 feet, helium is substituted for nitrogen in normal air. This is done to prevent the narcotic effect of nitrogen on divers under pressure. Helium is much lighter than nitrogen and causes the resonant characteristics of the vocal system to change. The result is high-pitched speech and the deeper a diver goes, the more pronounced the effect becomes. By the time the diver reaches 600 feet, his speech intelligibility is only 10 to 20 percent of what it is at the surface. The helium speech unscrambler reduces this communication problem by shifting the Donald Duck sounds into a range of more normal voice sounds. Since speech sounds are formulated in different ways, the effect of helium on them differs. For example, vowels are produced primarily by the vocal cords and are greatly affected by helium, whereas consonants are produced mainly in the mouth and are only slightly affected by helium. The different sounds are separated, digitally processed, and recombined to form normal speech sound. The processing takes place instantaneously so that no loss in time occurs. Solid-state components used throughout the unscrambler give it high reliability, ruggedness, and immediate response. More extensive use of integrated circuits will lead to extremely small versions that can be attached to a diver's equipment without adding a significant amount of weight and bulk.



R-263





TITAN II AND III FIRST-STAGE ENGINE

Prime Contractor: Aerojet-General Corporation

Remarks

The Titan II first-stage engine system—manufactured by Aerojet-General Corporation's Liquid Rocket Division, Sacramento, California—is the liquid rocket engine system which successfully boosted 20 astronauts into space from Cape Kennedy on the Gemini launch vehicle. It is also the first-stage booster engine for the Titan II ICBM. The Titan III first-stage engine, a modified version of the Titan II, is the first-stage, liquid-propellant booster engine for the Air Force's Titan III space program. In the Titan III version, the engine is capable of ground ignition, like the Titan II, but in addition it is capable of altitude ignition when used in conjunction with solid-propellant, zero-stage boosters. This twin-barrel engine is pump fed and regeneratively cooled, as is the Aerojet second-stage engine. A feature of Aerojet's propulsion system for Titan II and III launch vehicles is storable propellants. The fuel is a blend of hydrazine and unsymmetrical dimethyl hydrazine (UDMH) with nitrogen tetroxide (N_2O_4) as oxidizer. These hypergolic propellants require no ignition system since they ignite on contact. They are the key to the quick reaction time of the Titan launch vehicle and the simplicity of its engine system.

Performance

Thrust 430,000 pounds at sea-level ignition, 470,000 pounds at altitude ignition.



TITAN II AND III SECOND-STAGE ENGINE

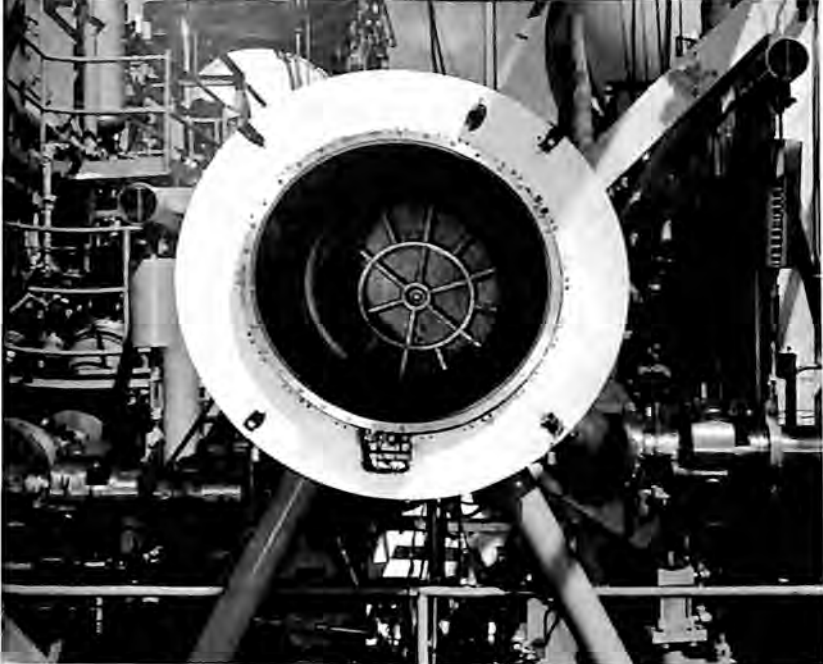
Prime Contractor: Aerojet-General Corporation

Remarks

The second-stage Titan II and III liquid rocket engine, working with its first-stage mate, successfully placed 20 Gemini astronauts directly into orbit, and it is a vital stage in the space operations of the Titan III launch vehicle. Like the first-stage engine, the Aerojet single-barrel, second-stage propulsion system burns hypergolic propellants UDMH and nitrogen tetroxide which are pump fed. Operating at high altitudes, this engine has added to its thrust chamber an ablative skirt which increases the expansion ratio from 13:1 to 49.2:1.

Performance

Thrust 100,000 pounds at altitude.

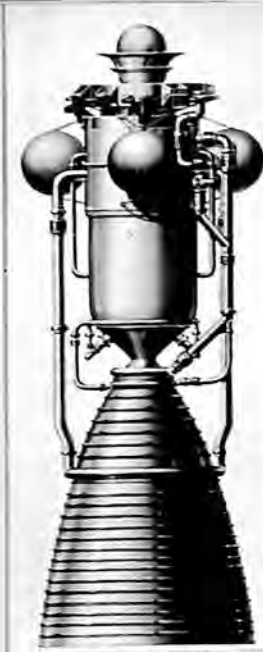


ADVANCED HIGH-THRUST HYDROGEN ROCKET PROGRAM

Prime Contractor: Aerojet-General Corporation

Remarks

A NASA program to advance the state of the art in high-thrust hydrogen/oxygen engine systems is being conducted at Aerojet's Sacramento facility under the direction of NASA's Lewis Research Center. A fluorine ignition system has been developed, along with pumps and a thrust chamber, for engine systems of 1,500,000 pounds thrust and above. Test firings are continuing with systems producing the vacuum equivalent of 1,500,000 pounds. Photo shows "breakthrough" injector. This "first-cut" injector has demonstrated excellent performance, mechanical integrity, and good stability.



ENGINES (ROCKET)

NERVA (NUCLEAR ENGINE FOR ROCKET VEHICLE APPLICATION)

Prime Contractor: Aerojet-General Corporation
Principal Subcontractor: Westinghouse Electric Corporation, Astronuclear Laboratory
Program Direction: Atomic Energy Commission and National Aeronautics and Space Administration

Remarks

NERVA is America's first nuclear rocket-propulsion system. It is under development by Aerojet-General Corporation, with Westinghouse Electric Corporation, as principal subcontractor, providing the nuclear reactor. The NERVA engine development is based on the solid core, heat exchanger reactor concept. Liquid hydrogen (minus 423 degrees Fahrenheit) is provided from tankage to a turbopump which delivers high-pressure hydrogen to the NERVA engine nozzle as a regenerative coolant; it then flows through the reactor where it is heated to thousands of degrees by fission energy and exhausted supersonically out the nozzle, providing thrust. A successful test of a breadboard version of NERVA was conducted at Jackass Flats, Nevada, on February 3, 1966; this was the world's first known test of a nuclear rocket engine. A series of "cold flow" tests of an experimental nuclear rocket engine—the first down-firing engine—was completed successfully at the Nevada test site in April 1968. A series of highly successful "hot" tests was run in 1969, including a test at full power. Nuclear stages employing NERVA offer dramatic advantages over chemical stages now in use since they are capable of much higher specific impulses, promising far greater payloads to the moon, Mars, and Venus, and for deep space probes.



MINUTEMAN II SECOND-STAGE ENGINE

Prime Contractor: Aerojet-General Corporation

Remarks

The second-stage, solid-propellant rocket motor for the Air Force Minuteman II ICBM is 50 percent more powerful than its predecessor, increasing the missile range from Minuteman I's 6,300 to 7,000 miles. The advanced motor is equipped with a large single nozzle instead of the 4 smaller nozzles that move in pairs on the 2 other stages to guide the vehicle during flight. The motor uses an advanced thrust vector control system that injects cold liquid freon into the fast-moving hot gas stream in the nozzle exit area to create a shock which turns the missile to the desired heading.



APOLLO SERVICE PROPULSION SYSTEM

Prime Contractor: Aerojet-General Corporation

Remarks

The Apollo Service Propulsion System engine is America's largest and most powerful spacecraft rocket engine. Producing over 20,000 pounds of thrust in space, it can be fired either automatically or manually by the Apollo astronauts. It is a pressure-fed liquid rocket engine capable of being restarted in space at least 50 times; it uses a bipropellant feed system which makes possible a step-thrust capability from 70 percent to full thrust. Using hypergolic storable propellants aerazine 50 and nitrogen tetroxide, the SPS engine is a simple propulsion unit with ablative thrust chamber and large titanium/columbium extension skirt with an expansion ratio of 62.5:1. This expansion ratio is larger than that of any other U.S. rocket engine. The engine has a design life of 750 seconds. The Aerojet SPS engine (1) provides midcourse corrections to and from the moon, (2) puts the Apollo spacecraft into proper lunar orbit through retro action, (3) maintains correct lunar orbit as the Lunar Module descends to the moon's surface, (4) goes down to within 12 miles of the lunar surface (if necessary) to rescue the LM, and (5) provides power to break out of lunar orbit and return to earth. The engine is capable of any other large maneuvers required by the Apollo Command/Service Modules. At the end of the Apollo 12 mission, the SPS engine had performed successfully 45 times out of 45 firings on both manned and unmanned Apollo missions.



PHOEBUS-2 NUCLEAR ROCKET NOZZLE

Prime Contractor: Aerojet-General Corporation

Remarks

America's nuclear rocket program moved closer to its ultimate goal with the completion of successful qualification tests of the Phoebus-2 nozzle, the world's largest nuclear rocket nozzle, at Aerojet-General Corporation's Sacramento, California, facility. The chemical simulation testing demonstrated development of a 250,000-pound-thrust oxygen/hydrogen thrust chamber assembly with performance approaching 100 percent of theoretical. Electrical discharge machining of the Hastelloy X nozzle represented major advances in state-of-the-art technology. Aerojet developed the system for the joint AEC/NASA Space Nuclear Propulsion Office.

MINUTEMAN III STAGE III MOTOR

Prime Contractor: Aerojet-General Corporation

Remarks

Increased performance of the Minuteman III ICBM over its predecessors is the major factor of this new third-stage, solid rocket motor produced for the Air Force by Aerojet's Solid Rocket Division. This newest member of the Air Force's deterrent force underwent a very successful initial flight on August 16, 1968, from Cape Kennedy, Florida. The motor has the same diameter as the second stage of the missile. Previous third-stage motors had a smaller diameter.



DELTA SECOND-STAGE ENGINE

Prime Contractor: Aerojet-General Corporation

Remarks

The Delta second stage is one of America's "old reliable" rockets because of its near-flawless performance in helping to orbit many satellites (Intelsat, Explorer, Telstar, IMP, Early Bird, Tiros) in more than 100 flights. The Delta engine uses storable hypergolic propellants and is regeneratively cooled. The liquid propellant system uses inhibited red fuming nitric acid as oxidizer and unsymmetrical dimethyl hydrazine for the fuel. The engine can provide 7,890 pounds of thrust for durations up to 400 seconds.

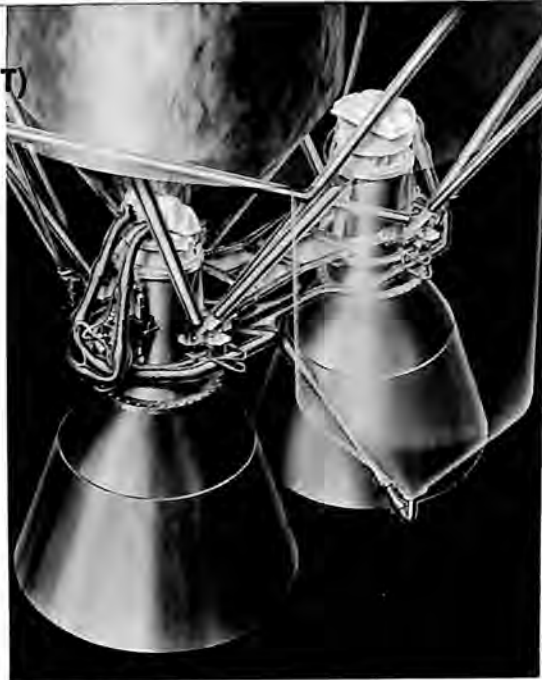
SVM-2 APOGEE SPACECRAFT ROCKET

Prime Contractor: Aerojet-General Corporation

Remarks

Aerojet-General's Solid Rocket Division produced the SVM-2 apogee motor for the Systems Group of TRW Inc., contractor to the Communications Satellite Corporation for the Intelsat 3 satellite. The motor is 22.25 inches in diameter and 35.1 inches long; weighs 350 pounds, loaded; and produces 3,140 pounds of thrust, average, over its 27.6-second firing duration. The motor fires in space to place the satellite in synchronous earth orbit.

ENGINES (ROCKET)



TITAN III TRANSTAGE ENGINES

Prime Contractor: Aerojet-General Corporation

Remarks

The USAF Titan III Transtage propulsion system consists of 2 identical engines that have ablative combustion chambers and radiation-cooled expansion nozzles. The propulsion system has restart capability and uses pressure-fed hypergolic propellants aerazine 50 and nitrogen tetroxide. Its record-setting 4 restarts on the same space flight in which it placed payloads in 4 different orbits have caused it to be labeled a space "switch" engine.

Performance

Thrust 8,000 pounds each engine, total 16,000 pounds.

ALGOL

Prime Contractor: Aerojet-General Corporation

Remarks

Algol is used as the first stage of the NASA Scout launch vehicle. Originally designed and developed by Aerojet-General Corporation's Solid Rocket Division as a static test motor, it is the forerunner of such solid rockets as Polaris and Minuteman. Algol is approximately 30 feet long and 40 inches in diameter and contains nearly 10 tons of propellant. It produces over 100,000 pounds of thrust. Algol serves also as the first stage of the Air Force Blue Scout, and it was used in clusters during the NASA Little Joe program.



VARIABLE-THRUST LIQUID ENGINE

Prime Contractor: Aerojet-General Corporation

Remarks

A versatile, high-performance, wide-range throttling rocket engine weighing less than 90 pounds, this propulsion unit is capable of the most rapid transient responses of all engines of this elevated thrust class. It has excellent durability and compatibility characteristics which have been demonstrated in more than 200 tests. The concept for throttling—a technique of momentum exchange in propellant flow—is applicable to most bipropellant systems and a wide range of chamber pressures. The engine is suitable for a number of space missions in which rapid provision of desired thrust levels is necessary for midcourse correction, rendezvous maneuvers, orbit insertion, and landing deceleration. It is built for the Naval Air Systems Command.

ALCOR

Prime Contractor: Aerojet-General Corporation

Remarks

Alcor is used as the third stage of the Air Force Athena launch vehicle. Previous models of the solid rocket motor, produced by Aerojet's Solid Rocket Division, have served as upper stages of the Blue Scout Junior, RAM, Astrobee 200, and Astrobee 1500. Improved propellant, titanium case, and nozzle design uprate the current Alcor, enabling it to produce 10,000 pounds of thrust.



MODEL 8258 ROCKET ENGINE

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

This high-reliability engine is designed for manned space flight. It is capable of multiple restarts and a total burn time of approximately 10 minutes. The basic engine completed qualification in 1968. First sent into space in January 1968, the engine was fired and restarted successfully while in orbit.

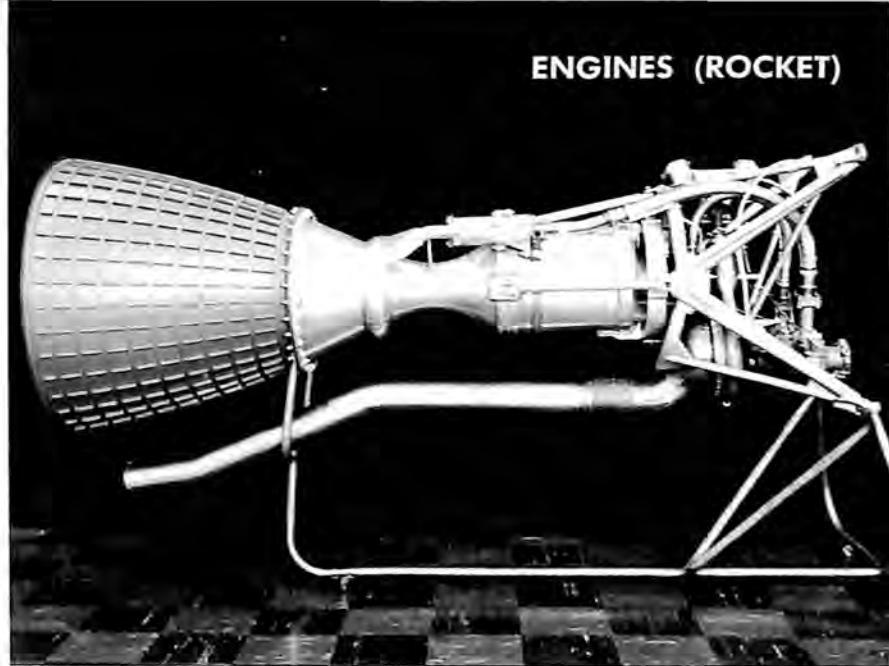
Specifications

Propellants nitrogen tetroxide, 50/50 blend of hydrazine and UDMH; ablative thrust chamber and nozzle; hypergolic ignition; pressure-fed engine with series-parallel redundant valving with a valve-out capability.

Performance

Average thrust 3,500 pounds.

ENGINES (ROCKET)



AGENA ENGINE (MODEL 8096)

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

The Agena engine is a liquid bipropellant system used in a number of Air Force and NASA programs including Lunar Orbiter, Ranger, Mariner, Nimbus, Echo, OGO, and OAO. A multiple-restart version of the engine was used to propel the Agena target vehicle for Project Gemini rendezvous missions. In production at Bell Aerospace since 1958, the Agena engine has orbited more than 80 percent of the Air Force and NASA satellites launched and has placed approximately 60 percent of the free world's functional unmanned payloads in space. Fired in space hundreds of times, the Agena engine has a reliability record exceeding 99 percent.

Specifications

Length 7 feet; width 3 feet; weight 300 pounds; propellants UDMH and inhibited red fuming nitric acid.

Performance

Thrust 16,000 pounds average; specific impulse approximately 300 seconds; chamber pressure approximately 500 pounds per square inch.

ENGINES (ROCKET)



LUNAR FLYING VEHICLE ENGINE

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

Bell Aerospace has developed a spacecraft maneuvering engine that is capable of impulse modulation by both throttling and pulsing to provide any thrust-time schedule on demand with fast response. The engine is radiation-cooled. A close-coupled, fast-reacting, torque-motor-driven bipropellant valve is used in conjunction with a throttling valve.

Specifications

Propellants nitrogen tetroxide and a blend of hydrazine and unsymmetrical dimethyl hydrazine; design life 1 hour; overall length with valves 17.9 inches; engine weight with valves 8.5 pounds.

Performance

Thrust 100 pounds throttleable to 12 pounds; specific impulse 290 seconds throttling to 254 seconds; minimum impulse bit 1 pound per second.



ATTITUDE CONTROL ENGINES

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

Bell Aerospace has developed 3 types of attitude control engines for spacecraft/launch vehicle/missile applications. (1) In photo is a small bipropellant engine designed for attitude control of missiles and satellites. The engine, producing 5 pounds thrust, is fabricated of columbium. A fast-response, torque-motor-operated bipropellant valve is used with the engine. (2) Bell has developed radiation-cooled and buried engines of 25 pounds thrust for attitude control applications on missiles and satellites. The engines are all-welded of columbium and utilize a thermally decoupled, fast-acting, torque-motor-operated bipropellant valve. (3) Bell has completed development and accomplished several successful flights of the Centaur reaction control and ullage rocket system. Single engines of this program have operated for a total of more than 5,600 cycles. The engines produce 1.5 and 3 pounds thrust, use hydrogen peroxide as propellant, and have a design life of 2 hours minimum.

Specifications (5-pound-thrust engine)

Propellants nitrogen tetroxide and a blend of hydrazine and monomethyl hydrazine; design life 1 hour minimum; overall length with valve 8 inches; engine assembly weight with valve 1.3 pounds; nominal specific impulse 275 seconds.

Specifications (25-pound-thrust engine)

Propellants nitrogen tetroxide and monomethyl hydrazine; design life 1 hour, 50,000 starts; overall length with valve 10 inches; engine weight with valve 3 pounds; nominal specific impulse 290 seconds.



AUXILIARY ROCKET ENGINES

Prime Contractor: Bell Aerospace Company Division of Textron Inc.

Remarks

Bell has developed a versatile 300-pound-thrust bipropellant engine (photo) for use in spacecraft, satellite, and missile propulsion systems. The company has also designed, fabricated, and tested several auxiliary rocket engine assemblies of 100 pounds thrust that have direct application to a number of vehicles, including space stations, shuttles, and missiles.

Specifications (300-pound-thrust system)

Propellants nitrogen tetroxide and monomethyl hydrazine; design life 1 hour; overall length with valve 19.5 inches; overall weight with valve 12.6 pounds.

Performance (300-pound-thrust system)

Thrust 300 pounds; specific impulse 298 seconds; impulse bit at 75 milliseconds 18.3 pounds/second.

Specifications (100-pound-thrust system)

Propellants nitrogen tetroxide and monomethyl hydrazine or blend of hydrazine and unsymmetrical dimethyl hydrazine; design life 2 hours minimum; overall length with valve 14.9 inches; assembly weight with valve 5 pounds.

Performance (100-pound-thrust system)

Thrust 100 pounds; nominal specific impulse 295 seconds.

HERCULES SOLID ROCKET SERIES

Prime Contractor: Hercules Incorporated

Remarks

Hercules Incorporated builds solid-propellant rocket motors for the following missile systems: Honest John, Little John, Minuteman, Polaris A2, Polaris A3, Nike Ajax (booster), Poseidon, Sprint, Hibex, Nike Hercules (booster), Talos (booster), Terrier I, Terrier II, Bullpup, and Sparrow. In addition, the company manufactures these motors:

X248 ALTAIR (photo)

Incorporated into Thor, Delta, Scout, Argo, and other programs, the Altair was the first rocket to feature a glass fiber filament-wound case structure.

Specifications

Length 58 inches; diameter 18 inches; weight 500 pounds.

Performance

Thrust 3,100 pounds; time 38 seconds.

ANTARES

A scale-up of the X248 Altair built specifically for Scout, Antares is also used in several other space vehicles. It has a mass fraction of .93.

Specifications

Length 113 inches; diameter 30 inches; weight 2,285 pounds.

Performance

Thrust 14,000 pounds; time 36 seconds.



HERCULES SOLID ROCKET SERIES (Continued)

Prime Contractor: Hercules Incorporated

RANGER RETRO (photo)

Originally designed for the Ranger lunar impactor, this motor is now used to place the twin Vela nuclear detection satellites in orbit. The motor is 31 inches long, 18 inches in diameter, and weighs 200 pounds.

DEACON

Specifications

Length 9.7 feet; diameter 6.25 inches; weight 200 pounds.

Performance

Thrust 6,400 pounds; time 3.2 seconds.

X258 ADVANCED ALTAIR

Specifications

Length 58 inches; diameter 18 inches; weight 500 pounds.

Performance

Thrust 5,000 pounds; time 24 seconds.

X259 ADVANCED ANTARES

Specifications

Length 113 inches; diameter 30 inches; weight 2,785 pounds.

Performance

Thrust 23,500 pounds; time 33 seconds.



HYDAC, JAVELIN II, JAVELIN III, SIROCCO

Prime Contractor: Lockheed Propulsion Company

Remarks

The Hydac and Javelin III solid-propellant rocket motors are in operation as single-stage motors and in various second-, third-, and fourth-stage configurations of the Terrier, Honest John, and Nike systems. The Sirocco unit is used primarily as a single-stage vehicle; the Javelin II is a successful sled and sounding rocket. Photo shows single-stage Hydac vehicle at top of stand, a Javelin III in the lower front, and a Javelin II sled rocket motor in the lower rear of the stand.

Specifications

Hydac: length 146 inches; diameter 9 inches; weight 557 pounds. Javelin II: length 101 inches; diameter 8.7 inches; weight 341 pounds. Javelin III: length 103 inches; diameter 9 inches; weight 363 pounds. Sirocco: length 112 inches; diameter 5.5 inches; weight 144 pounds.

Performance

Hydac: 10,200 pounds thrust for 9.4 seconds duration. Javelin II: 31,560 pounds for 1.76 seconds. Javelin III: 10,710 pounds for 4.8 seconds. Sirocco: 3,340 pounds for 5.5 seconds.



APOLLO LAUNCH ESCAPE MOTOR

Prime Contractor: Lockheed Propulsion Company

Remarks

The Apollo Launch Escape Motor subsystem consists of 2 solid-propellant rocket motors designed to pull the Apollo Command Module away from the Saturn booster in the event of malfunction during launch. A solid-fuel motor (1) supplies the main impulse. The escaping spacecraft is put into an arching trajectory by a smaller, pitch control motor (2) mounted in the forward section of the assembly. Photo shows Launch Escape Motor being integrated into the Launch Escape System (LES) at Cape Kennedy.

Specifications

Length 15 feet (1), 2 feet (2); diameter 26 inches (1), 9 inches (2); weight 4,700 pounds (1), 50 pounds (2).

Performance

Thrust 145,000 pounds (1), 2,400 pounds (2).

LOCKHEED 156-INCH SOLID MOTOR

Prime Contractor: Lockheed Propulsion Company

Remarks

Under an Air Force feasibility demonstration program, Lockheed's 156-inch-diameter solid rocket motors have developed thrusts up to 3,000,000 pounds for durations up to approximately 120 seconds. Segmented and monolithic maraged steel cases have been employed in the tests, which have also demonstrated liquid injection, jet tab, and hot gas valve thrust vector control systems.

VIP ROCKET MOTORS

Prime Contractor: Lockheed Propulsion Company

Remarks

Lockheed has production contracts for over 20 versions of its small VIP (Velocity Increment Producing) rockets being produced for several missile programs including the Air Force Minuteman. Actually 2 rocket motors within a single case, the VIP units are capable of imparting both spin and axial thrust in varying amounts that can be tailored with exact precision.

ENGINES (ROCKET)



SRAM PULSE MOTOR

Prime Contractor: Lockheed Propulsion Company

Remarks

Lockheed is developing the solid rocket pulse motor for the Air Force's new SRAM (Short-Range Attack Missile), or AGM-69A missile, slated to be carried aboard FB-111 and B-52 aircraft. Lockheed Propulsion has test fired solid rocket motors containing nearly 350 pulses during the 5 years it has been engaged in pulse motor work.

GUN-LAUNCHED ROCKETS

Prime Contractor: Lockheed Propulsion Company

Remarks

Lockheed Propulsion Company is conducting a series of research, development, and demonstration programs, some sponsored by the military services, of launching high mass fraction rocket vehicles from guns using normal powder charges to blast the vehicles from their muzzles. The work is based on 2 recently received Lockheed patents which cover the firm's liquid suspension method of launching. The new technique offers velocity double that of a standard shell and significant increases in range. One-stage-to-orbit vehicles and low-cost sounding rockets are also under study using this technique.

RSVP ROCKET MOTORS

Prime Contractor: Lockheed Propulsion Company

Remarks

Lockheed is conducting a series of development programs with controllable rocket motors, among which the RSVP (Restartable, Solid, Variable Pulse) rockets are prominent. Designed for use in upper-stage applications, RSVP systems have an inherent capability of unlimited starting and stopping and variation of thrust over a wide range. Hundreds of RSVP motors have been fired by the firm; the longest test was 7.5 minutes. RSVP rockets, which come in solid-solid and liquid-solid versions, are based on the mass augmentation principle developed at Lockheed. Photo shows a liquid-solid engine of heavy weight design undergoing 19:1 throttling test, with full thrust depicted at top, intermediate thrust in the center, and low thrust at bottom.

AIR-AUGMENTED HYBRID ROCKET

Prime Contractor: Lockheed Propulsion Company

Remarks

Under development at Lockheed for the Air Force is an advanced air-augmented rocket engine designed to combine air scooped up during flight with fuel-rich exhaust products of a hybrid rocket gas generator. Secondary combustion, taking place in an afterburner, results in an increase in specific impulse.

**R-4D**

Prime Contractor: The Marquardt Company

Remarks

The Model R-4D is a liquid hypergolic bipropellant rocket engine being used for space applications, including attitude control, propellant ullage control, and small velocity corrections on the NASA Apollo Service Module and Lunar Module (16 engines on each module, mounted in clusters of 4 engines). This engine served also as the velocity control rocket for NASA's Lunar Orbiter spacecraft, and it is used on 2 other classified vehicles. The Model R-4D provides high pulsing and steady-state performance in combination with reliable, long-life operation. Fully qualified and in production, the engine has successfully demonstrated flight reliability on Apollo/Saturn flights as well as on 5 Lunar Orbiter missions.

Specifications

Length 13.4 inches; diameter 5.6 inches; weight 4.9 pounds; propellants (oxidizer) nitrogen tetroxide and (fuel) 50/50 blend of hydrazine and unsymmetrical dimethyl hydrazine or monomethyl hydrazine; radiation-cooled chamber.

Performance

Thrust 100 pounds nominal vacuum.

R-5B

Prime Contractor: The Marquardt Company

Remarks

The Model R-5B liquid hypergolic bipropellant rocket engine was developed for NASA as an ullage and Delta V rocket, originally for application on the Saturn S-IVB stage.

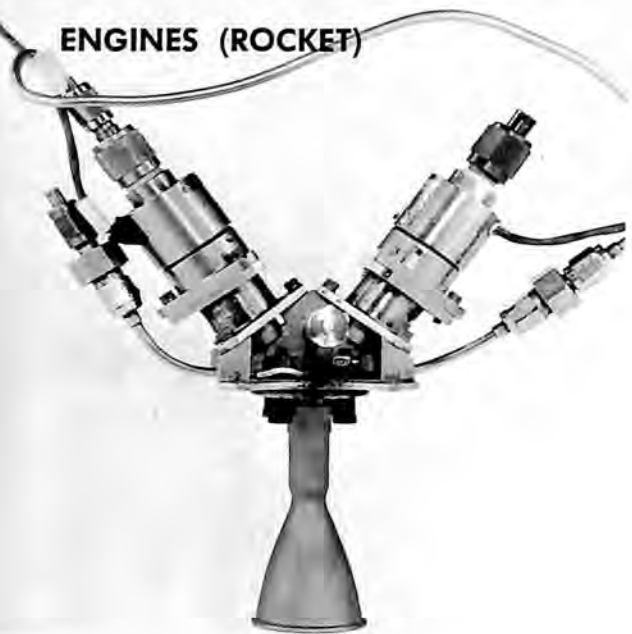
Specifications

Length 38.7 inches; diameter 17 inches maximum; weight 70 pounds; propellant (oxidizer) nitrogen tetroxide and (fuel) 50/50 blend of nitrogen tetroxide and unsymmetrical dimethyl hydrazine; ablative chamber.

Performance

Thrust 1,750 pounds nominal vacuum.

ENGINES (ROCKET)



R-6C

Prime Contractor: The Marquardt Company

Remarks

The Model R-6C is a liquid hypergolic bipropellant rocket engine, originally developed as a velocity control, spin rate control, and station-keeping rocket engine for NASA's advanced Syncom communications satellite. Since completion of advanced Syncom activity, the engine has been further developed to provide excellent pulsing and steady-state performance in combination with long-life, low-weight, high-reliability operational characteristics.

Specifications

Length 5.2 inches; diameter 3.95 inches; weight 1.21 pounds; propellants (oxidizer) nitrogen tetroxide and (fuel) 50/50 blend of hydrazine and unsymmetrical dimethyl hydrazine or monomethyl hydrazine; radiation-cooled chamber.

Performance

Thrust 5 pounds nominal vacuum.



R-1E

Prime Contractor: The Marquardt Company

Remarks

The Model R-1E, a liquid hypergolic bipropellant rocket engine, is an advanced version of the rocket originally designed and developed for the Advent communication satellite orbit adjust propulsion system. It is now used on a classified vehicle. The engine is developed for high pulsing and steady-state performance in combination with reliable, long-life operational characteristics.

Specifications

Length 10.1 inches; diameter 6 inches; weight 3.5 pounds; propellants (oxidizer) nitrogen tetroxide and (fuel) monomethyl hydrazine or blend of hydrazine and unsymmetrical dimethyl hydrazine; radiation-cooled chamber.

Performance

Thrust 22 pounds nominal vacuum.



**DEMAND MODE INTEGRAL
ROCKET RAMJET**

Prime Contractor: The Marquardt Company

Remarks

The Demand Mode Integral Rocket Ramjet (DMIRR) is intended as the propulsion system for advanced volume-limited air-launched tactical missile systems. The system combines liquid-fueled rocket and ramjet engine technology to provide potential mission flexibility. DMIRR is in exploratory development under Navy sponsorship.

ENGINES (ROCKET)



R-13D

Prime Contractor: The Marquardt Company

Remarks

The Model R-13D is a monopropellant hydrazine rocket engine developed as a spin rate control, station-keeping, and plane change engine for spacecraft. The engine has been developed for high-performance reliability and long life in both the steady-state mode and the pulsing mode.

Specifications

Length 5.76 inches; diameter 3.13 inches; weight 1.6 pounds; fuel hydrazine.

Performance

Thrust 5 pounds nominal vacuum.

ENGINES (ROCKET)

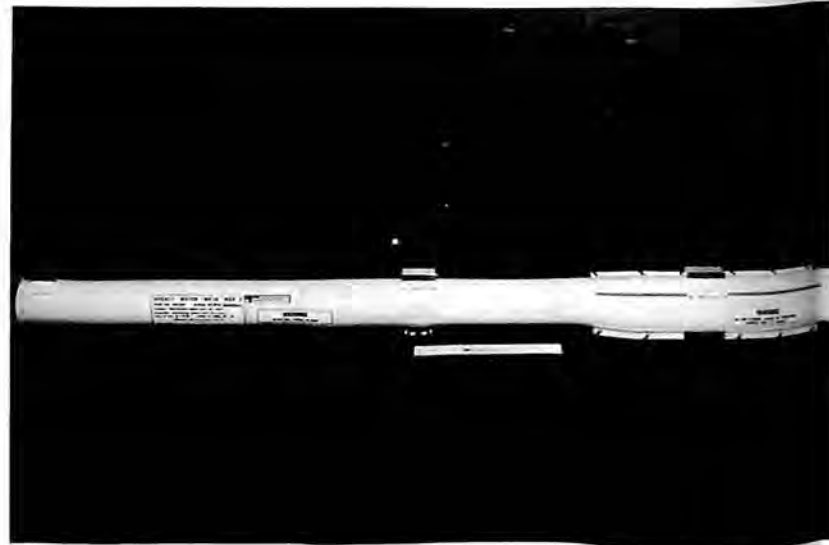


SCP/LASRM INTEGRAL RAMJET ROCKET

Prime Contractor: The Marquardt Company

Remarks

Developed for the Air Force, the Supersonic Chemical Propulsion for Low-Altitude Short-Range Missiles (SCP/LASRM) combines the high acceleration capability of the solid rocket and the high-speed cruise capability of the ramjet in a single propulsion package. This is an advanced development program including both ground and flight testing to demonstrate the feasibility of combining the 2 propulsion modes. The integral ramjet rocket has particular application to that class of airborne missile requiring low-volume, high-payload capability.



SIDEWINDER IC ROCKET MOTOR (AIM-9C/D)

Prime Contractor: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

Greater speed and range, plus improved operational characteristics, have marked the second generation of Sidewinder; its advanced solid propulsion system, the MK36 Mod 5, was qualified by Rocketdyne in late 1963. Sidewinder, a Navy air-to-air missile mounted on the F-8 and the F-4B, was designed to destroy high-performance fighter aircraft and bombers. The rocket motor is 72 inches long and 5 inches in diameter and contains 60 pounds of Flexadyne propellant. Loaded with propellant, the motor was subjected to extensive vibration, shock, and drop tests simulating extremes of operational use, and to temperature extremes ranging from sub-zero to over 300 degrees Fahrenheit. In over 200 firings during development and evaluation, the motor showed 100 percent reliability. Original versions developed by the Naval Ordnance Test Station became operational in 1953; the Mod 2 version is being used by U.S. forces in Vietnam.



SPARROW III 6-B ROCKET MOTOR (AIM-7E)

Prime Contractor: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The MK38 Mod 4 solid propulsion system for Sparrow III, one of the Navy's most advanced air-to-air missiles, has been in production at Rocketdyne since early 1961. Development and qualification of the advanced propulsion system were completed in 22 months; successful flight tests were held 12 months after initial contract award. Specifically designed to propel the electronically controlled Sparrow III 6-b, primary armament on the Navy F-4B and the Air Force F-4C aircraft, the new rocket motor increases the missile's operational temperature range as well as its total power and firing range. To qualify for supersonic missions, the advanced motor completed test firings at temperatures from subzero to over 300 degrees Fahrenheit, survived several days of continuous vibration, and passed drop tests from heights up to 40 feet and special shock tests simulating aircraft carrier catapult and arrested landing conditions. The Sparrow III motor is the first to use Flexadyne, a solid propellant which increases performance and operating temperature range and resists cracking or tearing at extremely low temperatures.



ENGINES (ROCKET)

SHRIKE ROCKET MOTOR (AGM-45A)

Prime Contractor: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The Navy's Shrike air-to-ground missile is powered by a solid-propellant rocket motor, the MK39 Mod 7, similar in design and performance to the propulsion system of Sparrow III 6-b (AIM-7E). Both motors combine a case-bonded propellant charge (grain) with Flexadyne, a solid propellant providing substantial performance increase and wider operating temperature range. An improved boost-sustain motor is in qualification.

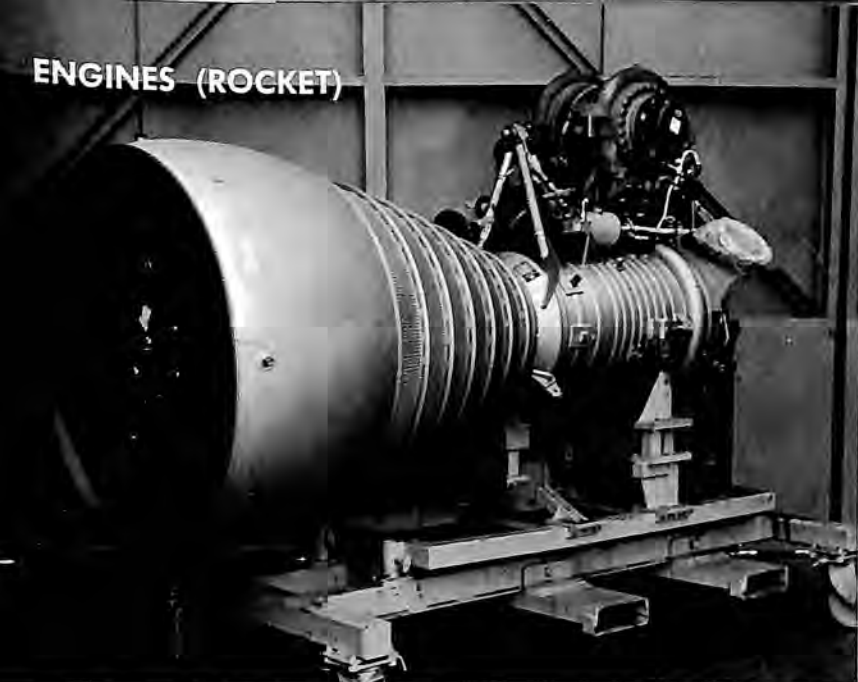
ROCKETDYNE SOLID MOTORS

Prime Contractor: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

Rocketdyne's Solid Rocket Division, McGregor, Texas, produces a number of motors for specialized applications. Among them are the ullage motors for the S-II second stage of the Saturn V launch vehicle. These motors, attached in clusters of 4 around the periphery of the interstage structure between the first and second stages, provide artificial gravity by momentarily accelerating the second stage forward after first-stage burnout. Each motor is 89 inches long and 12.5 inches in diameter; it delivers 22,500 pounds of thrust for approximately 4 seconds. Other Rocketdyne solids include the Roadrunner (MQM-42A) launch booster, zero launch boosters for the F-104G and F-100 aircraft and the MQM-15A target drone, and turbine starters for the H-1 and J-2 liquid rocket engines.

ENGINES (ROCKET)



H-1 ENGINE

Prime Contractor: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

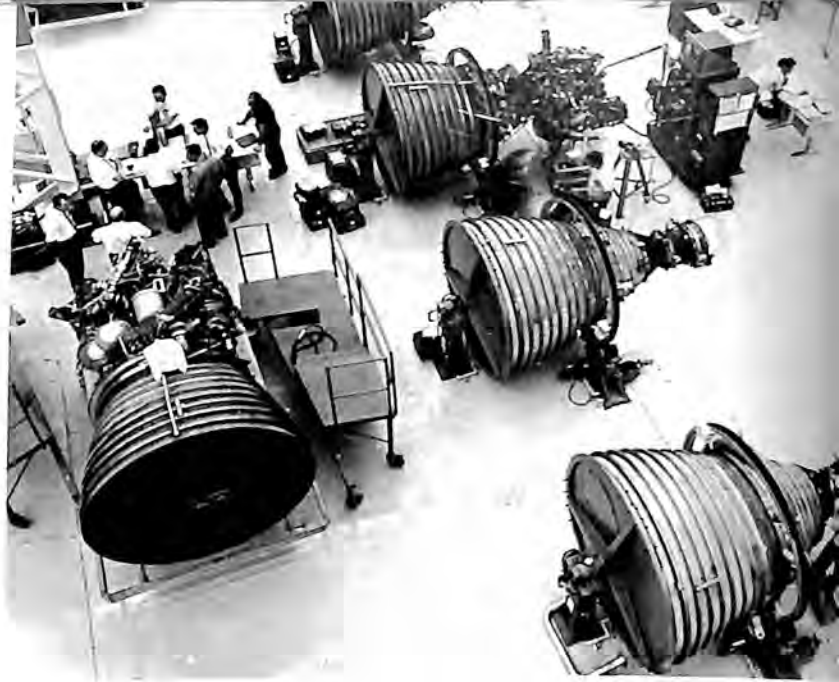
A key engine in the U.S. national space program, the H-1, in a cluster of 8 units, has been uprated to first-stage thrust of 1,640,000 pounds for later flights of the Saturn IB vehicles. Regeneratively cooled, it burns a combination of RP-1 fuel and liquid oxygen oxidizer. Engines are tested singly at Rocketdyne's Santa Susana Field Laboratory in California prior to delivery to NASA's Marshall Space Flight Center and the Chrysler assembly plant at Michoud, Louisiana.

Specifications

Maximum envelope length 102 inches; maximum diameter 66 inches.

Performance

Thrust 205,000 pounds.



J-2 ENGINE

Prime Contractor: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

One of the major engines in NASA's manned space flight program is the J-2, which burns liquid hydrogen fuel with a liquid oxygen oxidizer; it is the largest hydrogen-burning engine to reach qualification and production status (in photo, J-2 production line at Rocketdyne's Canoga Park, California, plant). The regeneratively cooled, 225,000-pound-thrust engine plays an important role in the nation's 2 largest launch vehicles: in Saturn IB, it is used singly, as the propulsion unit for the S-IVB stage, second stage of the vehicle; in Saturn V, it is employed in a 1,125,000-pound-thrust cluster of 5 in the S-II second stage and in the S-IVB third stage, which sends Apollo astronauts into a lunar trajectory. J-2 was developed under the technical direction of NASA's Marshall Space Flight Center.

Specifications

Maximum envelope length 133 inches; maximum envelope diameter 80.5 inches.

Performance

Maximum thrust 230,000 pounds.



F-1 ENGINE

Prime Contractor: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

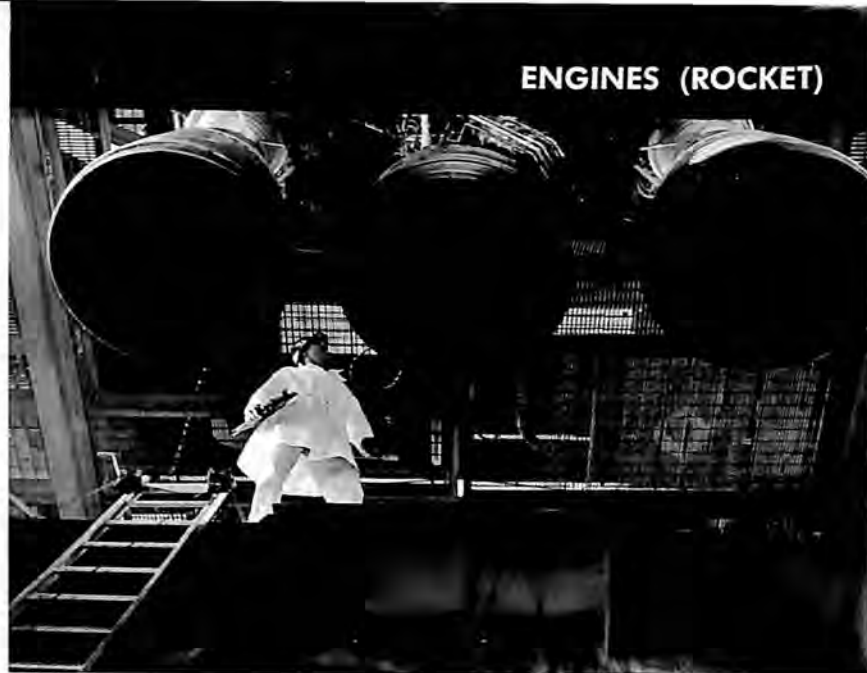
The primary engine in the U.S. manned space flight program, the F-1 is the most powerful liquid-fueled engine in the U.S. inventory. Developed under the technical direction of NASA's Marshall Space Flight Center, it is regeneratively cooled and burns a combination of RP-1 fuel and liquid oxygen oxidizer. A cluster of 5 F-1s, with a total thrust of 7,610,000 pounds, makes up the propulsion system of the S-IC, basic stage of the huge Saturn V launch vehicle.

Specifications

Maximum envelope length 19 feet; maximum envelope diameter 12.4 feet.

Performance

Thrust 1,522,000 pounds.



ENGINES (ROCKET)

ATLAS MA-5 SYSTEM

Prime Contractor: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

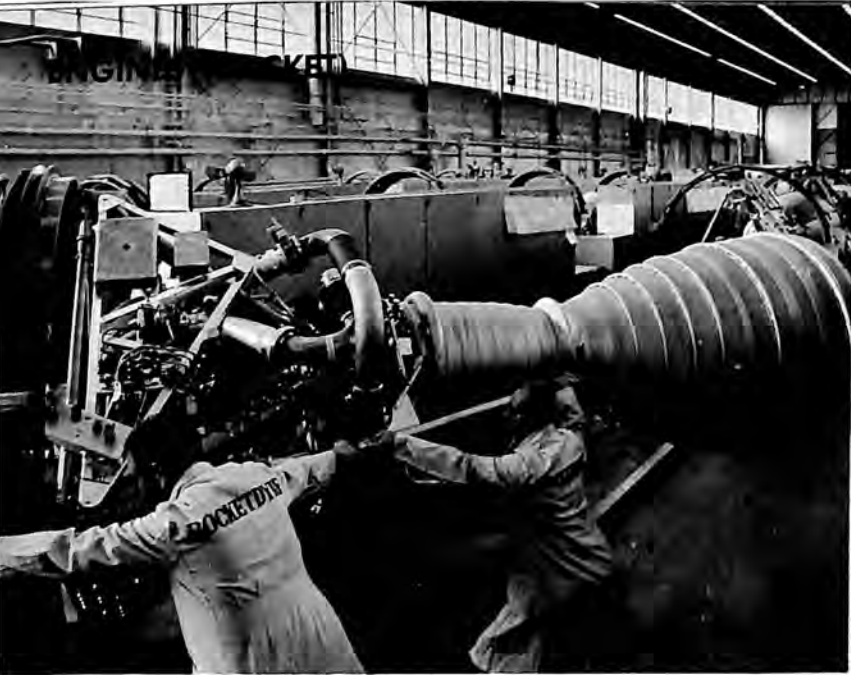
The MA-5 system is the propulsion package for the SLV-3 launch vehicle used for space launches. The primary engine units are composed of a twin-chambered booster on each side and a sustainer in the center; the complete Atlas standard launch vehicle propulsion system includes 2 small vernier, or stabilizing, engines mounted on the missile frame to provide roll control.

Specifications

Length (booster package including 2 engines) 134 inches, sustainer 98 inches; diameter booster package 168 inches; fuel RP-1; oxidizer liquid oxygen.

Performance

Thrust 388,300 pounds total, including boosters 330,000, sustainer 57,000, 2 verniers 669 each; cooling regenerative.



MB-3

Prime Contractor: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

MB-3 engines for the Thor booster are produced for the Air Force by Rocketdyne. A liquid-propellant engine, the MB-3 features 2 small verniers (stabilizing engines) to provide roll control. More space vehicles have been boosted by Thor than by any other propulsion system.

Specifications

Length 141.5 inches; diameter 66.7 inches; fuel RJ-1; oxidizer liquid oxygen.

Performance

Thrust 170,000 pounds main engine, 1,130 pounds each vernier engine.



AR2-3

Prime Contractor: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

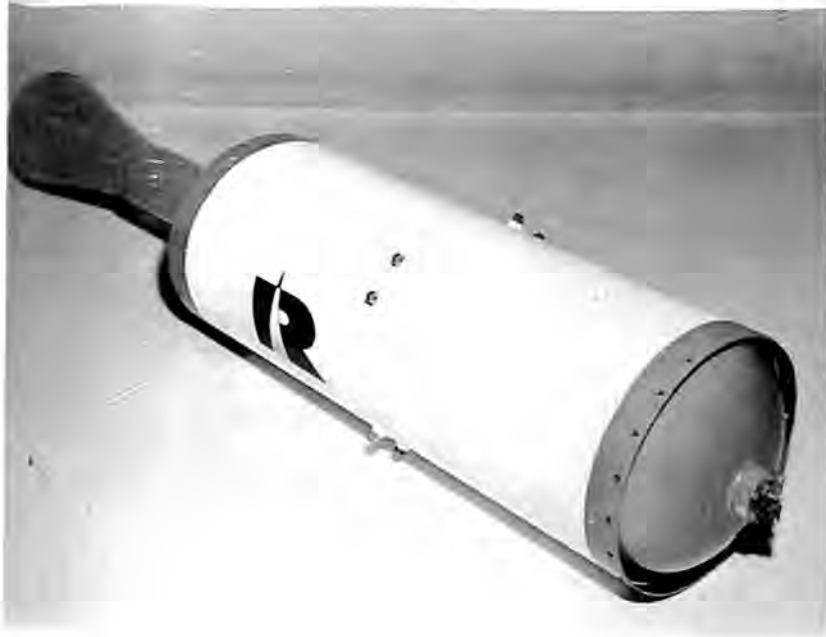
A supplemental propulsion unit for manned aircraft, the AR2-3 provides extra thrust for the Lockheed NF-104A Starfighter to augment its turbojet engines and enable it to attain altitudes up to 130,000 feet for aerospace training missions. The liquid-propellant rocket engines boost thrust by over 6,000 pounds.

Specifications

Length 32 inches; diameter 15 inches; weight 235 pounds; fuel JP-4 or JP-5; oxidizer hydrogen peroxide.

Performance

Thrust throttleable from 50 percent to maximum of 6,600 pounds at 35,000 feet.



PHOENIX ROCKET MOTOR (AIM-54A)

Prime Contractor: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The solid propulsion system for the Navy's Phoenix missile has completed an extensive qualification program at Rocketdyne. All work on the propulsion system is being done at Rocketdyne's Solid Rocket Division, McGregor, Texas. First powered flight test of the Phoenix missile, designated AIM-54A, came in April 1966, just 2 months after completion of the propulsion development program. The Phoenix motor utilizes Flexadyne, a proven solid propellant developed by Rocketdyne to provide tactical missiles with performance increases throughout an extended environmental operating temperature range. Flexadyne propellant is particularly adaptable to the Phoenix missile requirements of high volumetric loading, high total impulse, and long burning time, thus providing the long-range operational capability required by the Navy.



APOLLO ATTITUDE CONTROL THRUSTERS

Prime Contractor: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The Apollo attitude control thrusters are small, liquid-propellant rockets which burn a combination of monomethyl hydrazine fuel and nitrogen tetroxide oxidizer. They are employed for corrections of spacecraft attitude in orbit, in lunar trajectory, and during reentry. The units are employed in multiples. The Apollo system (individual units shown in photo) has 2 sets of 6 engines each, one set redundant, all engines 93 pounds thrust.

P4-1 DRONE ENGINE

Prime Contractor: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The P4-1 storable liquid propellant engine powers Navy AQM-37A and Air Force Q-12 target missiles produced by Beech Aircraft Corporation. It is a small, compact system having both sustainer and booster and producing over 600 pounds of thrust to power the target missile to Mach 2 at 70,000 feet.

Specifications

Length 21 inches; diameter 6.6 inches; fuel hydne (MAF-4); oxidizer inhibited red fuming nitric acid.

Performance

Thrust 106 pounds at 70,000 feet (sustainer), 550 pounds at 25,000 feet (booster).

ENGINES (ROCKET)



RL10 ROCKET ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

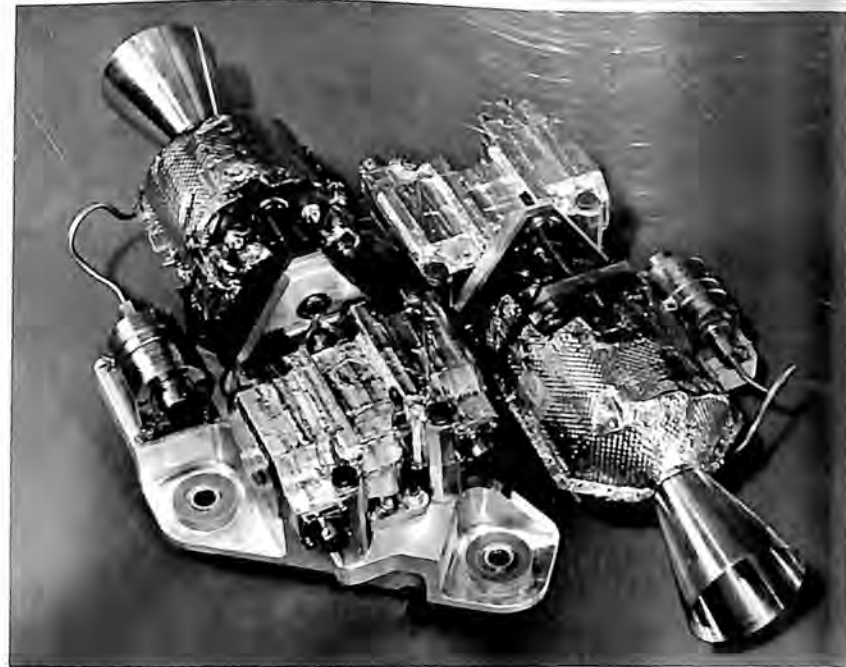
The RL10A-3-1 was the world's first operational liquid-hydrogen rocket engine. It was developed for NASA as power plant for the Centaur and for the McDonnell Douglas S-IV stage of Saturn I. The latter, a developmental stage leading to larger hydrogen-powered space vehicles, was phased out after 6 successful flights. Centaur was designed to carry unmanned scientific payloads to the moon, Mars, and other planets. An advanced model of the RL10, the 10A-3-3, has been flown successfully on the more recent Centaur flights.

Specifications

Length 69 inches; diameter at exhaust nozzle 40 inches; weight (approximate) 292 pounds; expansion ratio 40:1 (RL10A-3-1), 57:1 (10A-3-3); propellants liquid hydrogen and liquid oxygen.

Performance

Thrust 15,000 pounds, throttling capability from 100 to 10 percent of rated thrust; specific impulse 433 seconds (10A-3-1), 444 seconds (10A-3-3).



MRM-3A

Prime Contractor: Rocket Research Corporation

Remarks

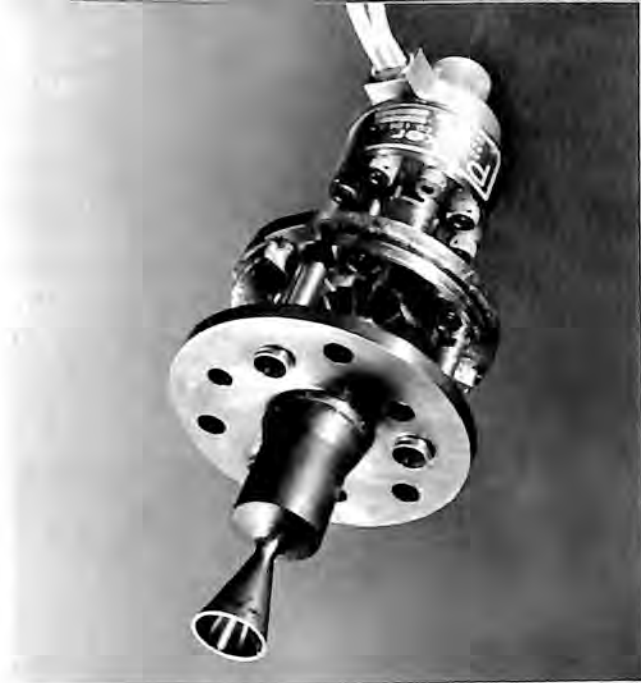
The Model MRM-3A hydrazine monopropellant rocket engine module was developed to provide attitude control, stabilization, vernier velocity corrections, and ullage control for the Air Force's Titan IIIC Transtage launch vehicle. The unit pictured is a roll control module with the engines mounted parallel/opposed; a similar module with the 2 engines mounted parallel/allied is used for pitch and yaw control. Two of the former and 4 of the latter modules are used in each vehicle. The engines are flight qualified to provide high pulsing and steady-state performance, as well as long life in a wide combination of thermal/structural environments and firing duty cycles.

Specifications

Length 12.1 inches; diameter 3.2 inches; weight of engine with Moog dual redundant torque motor valve and thermal isolation mount 5 pounds (roll module weight 15.6 pounds, pitch/yaw module weight 15.3 pounds); propellant hydrazine, catalyst Shell 405.

Performance

Thrust 26.5 pounds at high feed pressure (15 pounds at minimum blowdown feed pressure); specific impulse 223 seconds minimum and 227 rated nominal.



MR-6A

Prime Contractor: Rocket Research Corporation

Remarks

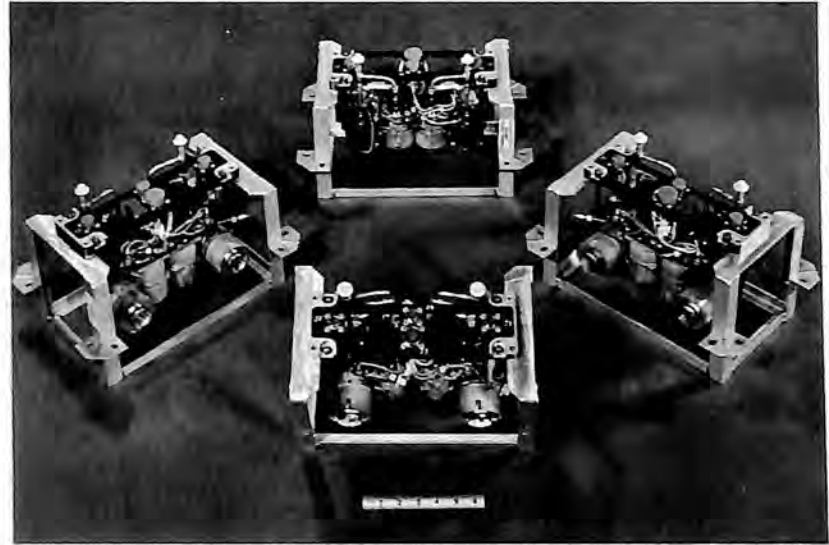
The Model MR-6A hydrazine monopropellant rocket engine was developed to provide attitude control on a classified satellite. Six MR-6A engines are used on each attitude control system. The engines are flight qualified to provide both pulsing and steady-state operation over a variety of mission duty cycles.

Specifications

Length 5.4 inches with Parker series redundant solenoid valve; diameter at mounting flange 2 inches; weight .9 pound mass; propellant hydrazine, catalyst Shell 405.

Performance

Thrust .5 pound force at high feed pressure, .25 at minimum blowdown feed pressure; specific impulse 224 seconds nominal; engine has been cycled over 1,000,000 pulses without failure.



MR-50A

Prime Contractor: Rocket Research Corporation

Remarks

The MR-50A hydrazine monopropellant rocket engine was developed to provide attitude control for a classified Air Force satellite. Four MR-50A engines are mounted on a rocket engine module which includes valves, pressure and temperature instrumentation, thermostatically controlled electrical heaters, necessary mounting, and interface structure. The engines will soon be qualified to provide high pulsing and steady-state performance as well as long life.

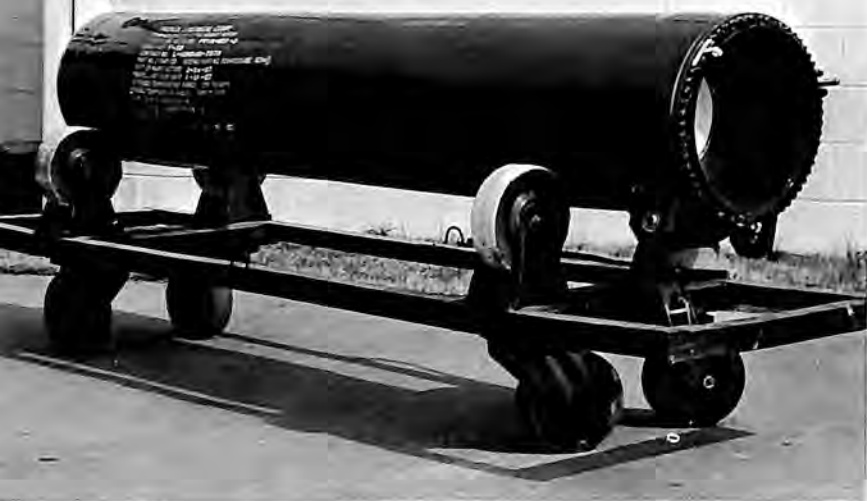
Specifications

Length 5.6 inches; diameter 2.4 inches; weight of engine with Parker solenoid valve, heat shield, support structure, and thermal standoffs 1.1 pounds; propellant hydrazine, catalyst Shell 405.

Performance

Thrust 5.7 pounds at high feed pressure, 3.4 pounds at minimum blowdown feed pressure; specific impulse 230 seconds nominal.

ENGINES (ROCKET)



SATURN SOLID ROCKET MOTORS

Prime Contractor: Thiokol Chemical Corporation

Remarks

Separation of the first, second, and third stages of the Saturn V Apollo launch vehicle is provided by 2 types of Thiokol solid-propellant rockets: the TE-M-424 Saturn Retro (photo) and the TE-M-29-4 Recruit, modified for this retro application. Eight TE-M-424 motors are mounted in pairs around the base of the first stage. Developing a total thrust of about 700,000 pounds, they fire upward 2.5 minutes after lift-off, providing the reverse force that separates the spent first stage from the second stage. The Thiokol TE-M-29-4 second stage retro is a Recruit motor with the nozzle canted 9.5 degrees from the centerline of the motor. On the Saturn vehicle, 4 Recruits are mounted, nozzles up, on the interstage between the second and third stages. After second-stage burnout, they burn for 1.5 seconds, developing a total thrust of about 140,000 pounds to separate the second and third stages of the vehicle. After separation, these motors fall away with the second stage and interstage section. Thiokol's TE-M-380 rocket motor jettisons the Saturn/Apollo escape system 30 seconds after ignition of the second-stage engines; its 33,000 pounds of thrust pull the escape system up and away from the spacecraft.

Specifications

Weight 504, 361.5, 528 pounds for TE-M-424, TE-M-29, TE-M-380, respectively; length 84, 105, 56 inches; diameter 15, 9, 26 inches; pyrogen igniters for all.

Performance

Burn time .633, 1.52, 1.1 seconds for TE-M-424, TE-M-29, TE-M-380; maximum thrust 91,000, 39,400, 33,600 pounds; total impulse 60,600, 59,400, 34,500 pounds/second.



TE-M-364 DELTA THIRD-STAGE MOTOR

Prime Contractor: Thiokol Chemical Corporation

Remarks

The TE-M-364 Delta rocket motor is used as third-stage propulsion on NASA's workhorse Delta launch vehicle. Since Delta first launched a satellite (Echo) in May 1960, NASA has continually improved the launch vehicle by increasing the size and improving the performance of propulsion systems. The third-stage TE-M-364 motor is a spherical, solid-propellant unit equipped with a semisubmerged nozzle to minimize overall length. The unique composite nozzle structure incorporates a glass cloth-phenolic structural member running the length of the nozzle. The nominal expansion ratio is 53.1. The pyrogen (miniature rocket motor) igniter system is equipped with a safe-and-arm device and 2 squibs. The motor case is of D6AC steel with a minimum membrane thickness of .037 inch.

Specifications

Length 37 inches in diameter, 55 inches overall; propellant weight 1,440 pounds; burnout weight 122 pounds.

Performance

Burn time 40 seconds; total impulse 418,000 pounds/second.



AF 156-8 LARGE SOLID BOOSTER MOTOR

Prime Contractor: Thiokol Chemical Corporation

Remarks

The AF 156-8 motor, incorporating the world's largest segmented fiber glass reinforced case, was test fired at the Wasatch Division of Thiokol Chemical Corporation near Brigham City, Utah, on June 25, 1968. Developed under a manufacturing technology program funded by the Air Force Materials Laboratory, Wright-Patterson Air Force Base, the segmented fiber glass case weighed approximately 26,000 pounds. It was designed by Thiokol and fabricated under subcontract by the Aerospace and Defense Products Division of the B. F. Goodrich Company, Akron, Ohio. The nonhydroclaved ablative nozzle was developed in a separate program by the Systems Group of TRW Inc., Cleveland, Ohio. The segmented case was hydroproof tested prior to loading with approximately 500,000 pounds of propellant, then hydrostatically burst following the static firing. The motor developed approximately 1,000,000 pounds of thrust during the 120-second firing, and all test objectives were met.

Specifications

Overall length of assembled case 606.87 inches; outside diameter 156 inches; loaded weight 519,800 pounds; nozzle throat diameter 32.9 inches.

Performance

Operating time 123.8 seconds; total impulse 118,000,000 pounds.

ENGINES (ROCKET)



CASTOR II, CASTOR IV MOTORS

Prime Contractor: Thiokol Chemical Corporation

Remarks

The Castor II (photo), developed by Thiokol Chemical Corporation's Huntsville Division as an improved version of the Castor I, has proved one of the most useful off-the-shelf motors available. In various modifications, the Castor II has provided propulsion for a series of Air Force and NASA scientific and experimental programs including Little Joe, Scout, Athena, Agena, ARPAT, Thrust Augmented Thor, and Thrust Augmented Delta vehicles. It weighs approximately 9,800 pounds and is 233 inches long and 31 inches in diameter. The Castor family includes the Castor I which uses the same size case as the Castor II. More than 500 Castor I motors have flown successfully. Latest in the family of Castor motors is the Castor IV. It weighs 23,269 pounds and is 358 inches long and 40 inches in diameter. It provides an average thrust of 88,900 pounds with a total burning time of approximately 56 seconds. The Castor IV, currently under development, is designed for use as the first stage of the Athena H vehicle.

ENGINES (ROCKET)



LR62-RM-2/4 ROCKET ENGINE

Prime Contractor: Thiokol Chemical Corporation

Remarks

The LR62 packaged, liquid-propellant rocket engines provide power for the Navy and Air Force Bullpup B (AGM-12C) air-to-surface guided missile. The engine, a larger version of Thiokol's LR58 engine which was developed for Bullpup, utilizes factory-loaded propellants of inhibited red fuming nitric acid (IRFNA) and a mixed amine fuel (MAF-1). Arrangement of internal components and operation are the same as in the smaller LR58 engine. The engine is handled like a round of ammunition, requiring only insertion of an igniter to arm it for firing. Being a packaged liquid, LR62 can withstand the severe handling and thermal environments associated with high-speed carrier aircraft operations.

Specifications

Length 61.2 inches; diameter 17.32 inches; weight 536 pounds (loaded).

Performance

Storage life 5 years; reliability 99.84 percent.



M55A1 MINUTEMAN STAGE I MOTOR

Prime Contractor: Thiokol Chemical Corporation

Remarks

The first full-scale Stage I Minuteman motor was successfully static tested in April 1959. Subsequent static tests demonstrated a successful motor design that was subjected to preliminary flight rating tests (PFRT) beginning in October 1960. The first Minuteman flight test followed in February 1961 and was completely successful. Following this initial success, the PFRT configuration motor was optimized into the Wing I motor configuration for qualification and delivery to the first operational wing at Malmstrom Air Force Base, Montana. Wing I motor production was initiated in November 1961. Production of Wing II configuration motors was initiated in December 1962. In early 1966, production of an improved Wing VI motor configuration was started. The Stage I motor has exceeded all performance and reliability requirements for the Minuteman system.

Specifications

Overall length, including 4 nozzles, 294.9 inches; diameter, including insulation, 65.9 inches; case material D6AC steel; nozzle type, gimbaled, hydraulically actuated.

Performance

Thrust level (approximate) 180,000 pounds; operational time 60 seconds.



AIR-2A GENIE MOTOR

Prime Contractor: Thiokol Chemical Corporation

Remarks

The AIR-2A Genie is an air-to-air missile, weighing 800 pounds, which is operational on the F-101B, F-106, and F-4 aircraft. The TU-289 rocket motor, which powers the AIR-2A Genie, is produced by the Wasatch Division of Thiokol Chemical Corporation. The solid-propellant motor weighs 482 pounds loaded. It has been qualified for environments specified by the MIL-R-25532 series. Motor shelf life is in excess of 6 years.

Specifications

Length 67 inches; diameter 15 inches; case material AISI 4130 steel; propellant weight 320 pounds.



SPARM

Prime Contractor: Thiokol Chemical Corporation

Remarks

Air-augmented propulsion can provide a severalfold increase in performance over conventional chemical rockets. This has been amply demonstrated in many subscale and full-scale direct tests, as well as in free flight jet and flight tests. Thiokol, under direction of Eglin Air Force Base, conducted an Air Force program called SPARM (Solid-Propellant Augmented Rocket Motor). Using a modified AQM-37A target drone as the test vehicle, 2 vehicles were launched from an F-4B aircraft at the Naval Missile Test Center, Point Mugu, California, to complete the program. SPARM incorporated a unique feature using the secondary combustion chamber as the chamber for a conventional booster motor. After boost, the head end dome and the booster nozzle were jettisoned, resulting in a minimum-weight 2-stage system. Through contracted and company-funded programs, significant improvements over SPARM performance have been demonstrated; gas generators employing both solid and liquid/slurry propellants generate fuel-rich gases which are mixed with air for subsonic combustion in a secondary combustion chamber. In addition, supersonic combustion has been demonstrated in a realistic hardware configuration with fuel-rich solid propellants. Major improvement of propulsion technology continues in the air-augmented area.

ENGINES (ROCKET)



TX-174, TX-175 PERSHING MOTORS

Prime Contractor: Thiokol Chemical Corporation

Remarks

TX-174 and TX-175 (photo) Pershing first- and second-stage motors were developed by Thiokol Chemical Corporation at its Huntsville Division. The 40-inch-diameter motors are in production at Thiokol's Longhorn Division. The first-stage case length is a little over 78 inches while that of the booster stage is approximately 63 inches. Total weight of the first stage is approximately 5,000 pounds; the second stage weighs slightly over 3,000 pounds.



LUNAR MODULE DESCENT ENGINE

Prime Contractor: Systems Group of TRW Inc.

Remarks

This throttleable space engine, developed by TRW, is used to power the descent phase of Apollo lunar missions. Because of the various propulsion requirements and the high engine reliability imposed by the manned lunar landing mission, the engine has characteristics designed into it that allow it to be readily adapted to many other missions. The LMDE version of this engine operates over a continuously variable thrust range of 10,000 to 1,000 pounds and has a total burning life of 1,000 seconds. LMDE uses storable bipropellants at a mixture ratio of 1.6. The engine has an ablative chamber with a lightweight titanium nozzle extension.

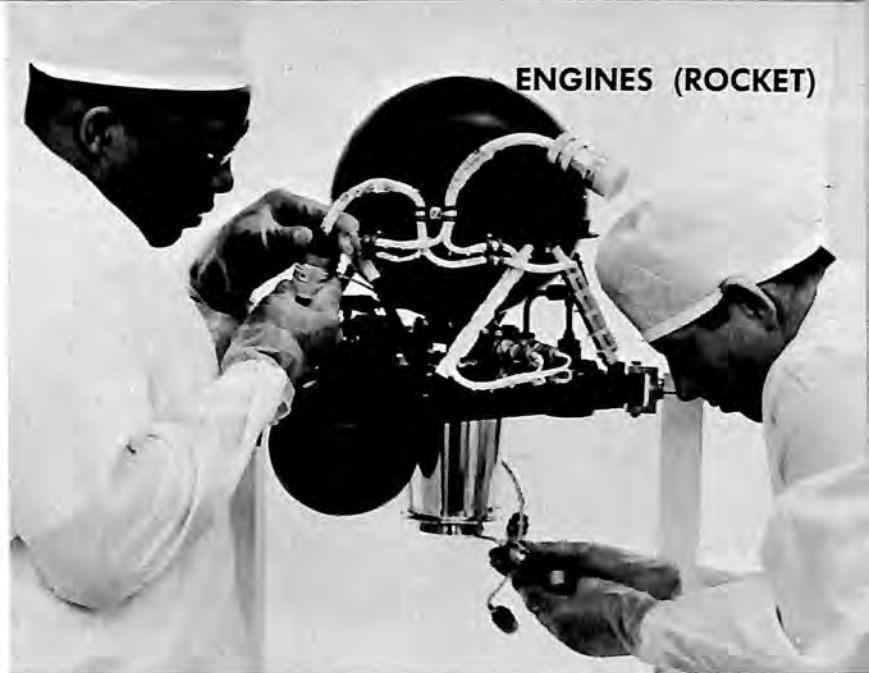


INTELSAT 3 POPS

Prime Contractor: Systems Group of TRW Inc.

Remarks

The Position and Orientation Propulsion System (POPS) for Intelsat 3 was developed by TRW. This is a monopropellant hydrazine propulsion system which uses Shell 405 spontaneous catalyst to decompose the propellant. A series redundant valve on each thruster is designed for 50,000 cycles. The POPS is designed for 5 years in space operation. The system operates over a blowdown range of 4 pounds thrust to 1.2 pounds thrust and has 2 sets of 2 thrusters each (redundant). The system loaded weighs 63 pounds and each thruster valve assembly weighs .53 pound.



ENGINES (ROCKET)

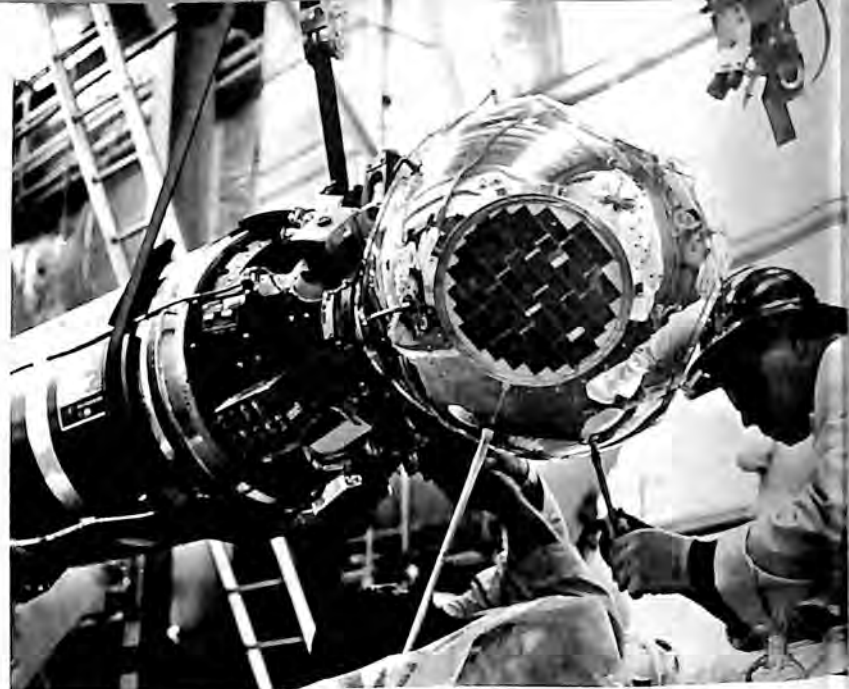
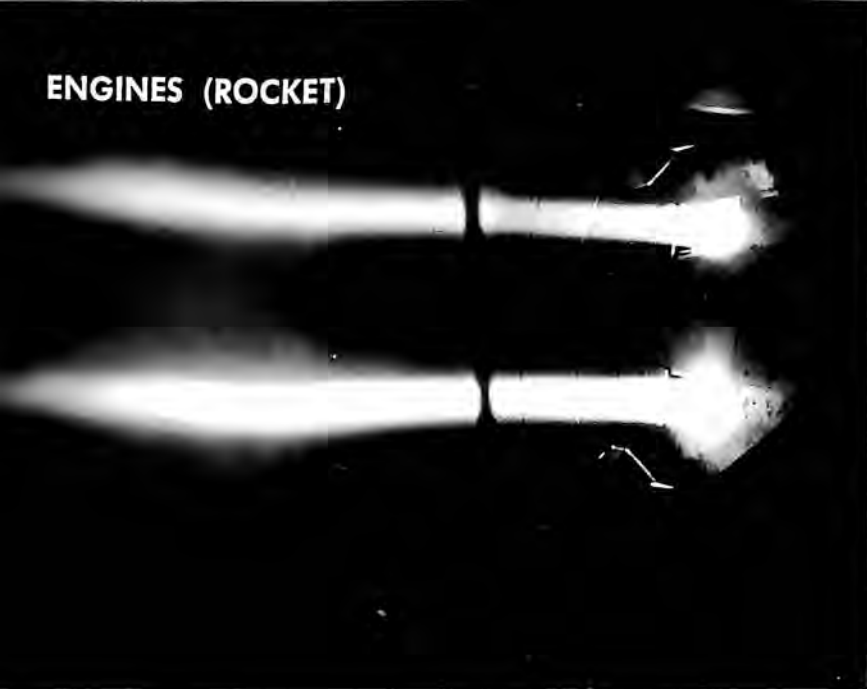
MARINER '69 PROPULSION SYSTEM

Prime Contractor: Systems Group of TRW Inc.

Remarks

This system, built by TRW, was used by Jet Propulsion Laboratory on Mariners 6 and 7. The system uses monopropellant hydrazine which is decomposed by Shell 405 catalyst. The 50-pound-thrust engine includes quadredundant squib valves and jet vanes for thrust vector control.

ENGINES (ROCKET)



TRW ION ENGINE

Prime Contractor: Systems Group of TRW Inc.

Remarks

One major effort of TRW Systems in its extensive research and development in the field of electric propulsion is a working ion engine, a cesium contact thrust device. The engine operates by feeding cesium to a hot tungsten plate where it ionizes; the positive ions leave the hot plate and pass through a charged electric grid. Accelerating the ions, the grid causes them to exit through the nozzle at velocities of about 30 miles per second.

FW-4 UPPER-STAGE ROCKET

Prime Contractor: United Technology Center

Remarks

The FW-4 solid-propellant upper-stage rocket motor is designed for use on boost vehicles with orbital, probe, or reentry missions, as well as for retrorocket propulsion for space vehicles and as a sounding rocket. It is being flown by NASA on the uprated Scout and thrust-augmented Delta launch vehicles and by the Air Force as a top stage on its Atlas and Thor boosters. The FW-4 is believed to have a higher mass fraction—92 percent—than any other operational solid rocket. FW-4S is a 6,000-pound-thrust USAF version used as improved Scout fourth stage.

Specifications

Length 58.43 inches; diameter 19.6 inches; weight 660.5 pounds; propellant PBAN with aluminum additives and ammonium perchlorate oxidizer; nozzle composite structure of aluminum, graphite, and silica; ignition redundant squib pyrogen.

Performance

Thrust 5,400 pounds.



1207 SOLID ROCKET MOTOR

Prime Contractor: United Technology Center

Remarks

The 1207 segmented solid-propellant rocket motor is the most powerful of its kind to be developed. Produced by UTC, the motor is a complete propulsion system requiring only electrical signals for launch and guidance commands during flight. It contains a liquid-injection thrust vector control system, an ignition system, a thrust termination system, and its own staging sequence capability.

Specifications

Length 112 feet; diameter 120 inches; weight 350 tons; propellant PBAN with aluminum additives and ammonium perchlorate oxidizer; nozzle material steel with graphite cloth-phenolic and silica cloth-phenolic cone liner; ignition small solid rockets.

Performance

Thrust 1,400,000 pounds.



1205 SOLID ROCKET MOTOR

Prime Contractor: United Technology Center

Remarks

The 1205 segmented solid-propellant rocket motor is a versatile and economical space booster produced by UTC and flown in pairs as stage zero on the Air Force Titan IIIC space vehicle. The motor contains a thrust termination system, a destruct system, a liquid-injection thrust vector control system, and a forward-end ignition system; it has its own staging sequence capability. It was developed with all of the subsystems and reliability provisions necessary for use as a man-rated stage. These rockets are also used as the booster stage of the Titan IIID vehicle. For this application, however, they are not man-rated and do not employ a thrust termination system.

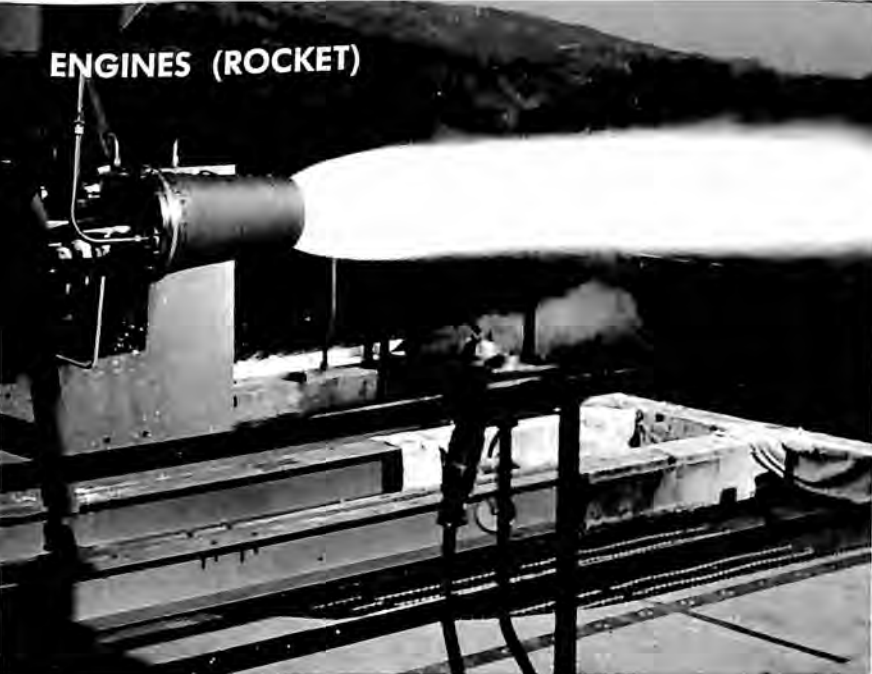
Specifications

Length 86 feet; diameter 120 inches; weight 250 tons; propellant PBAN with aluminum additives and ammonium perchlorate oxidizer; nozzle material steel with graphite cloth-phenolic and silica cloth-phenolic cone liner; ignition small solid rockets.

Performance

Thrust 1,200,000 pounds.

ENGINES (ROCKET)



HIGH-PERFORMANCE, UPPER-STAGE LIQUID ROCKETS

Prime Contractor: United Technology Center

Remarks

UTC has developed a family of high-performance liquid-propellant engines that can remain in space with stop-start capability for several years. The engines utilize a lightweight ablative thrust chamber and a UTC-designed injector. The injector provides an improved propellant spray pattern within the combustion chamber, reducing erosion of the combustion chamber lining and permitting the use of a thinner and simpler silica-phenolic lining. In photo, 5,000-pound-thrust version.

Specifications

Length 52 inches (smallest), 75.5 inches (largest); diameter 26 inches (smallest), 48 inches (largest); weight 72 pounds (smallest), 185 pounds (largest); propellant 50/50 hydrazine and unsymmetrical dimethyl hydrazine and nitrogen tetroxide; nozzle composite structure with fiber glass shell and silica-phenolic liner; ignition hypergolic.

Performance

Thrust 2,000 pounds (smallest), 50,000 pounds (largest).



TITAN IIIC STAGING ROCKET

Prime Contractor: United Technology Center

Remarks

Titan IIIC's staging rockets are timed to fire automatically at booster-stage burnout to separate the 2 120-inch-diameter solid-propellant boosters from the center core. Each of the big boosters has 8 staging rockets, an aft cluster of 4 and a forward cluster of 4, or a total of 16 staging rockets for the booster stage. The staging rockets have operated flawlessly on all Titan IIIC flights to date.

Specifications

Length 56 inches; diameter 6 inches; weight 84.5 pounds; propellant PBAN with aluminum additives and ammonium perchlorate oxidizer; nozzle material composite structure with aluminum housing, asbestos phenolic exit cone, and graphite throat; ignition redundant squib pyrogen.

Performance

Thrust 4,500 pounds.



TITAN II TRANSLATION ROCKET

Prime Contractor: United Technology Center

Remarks

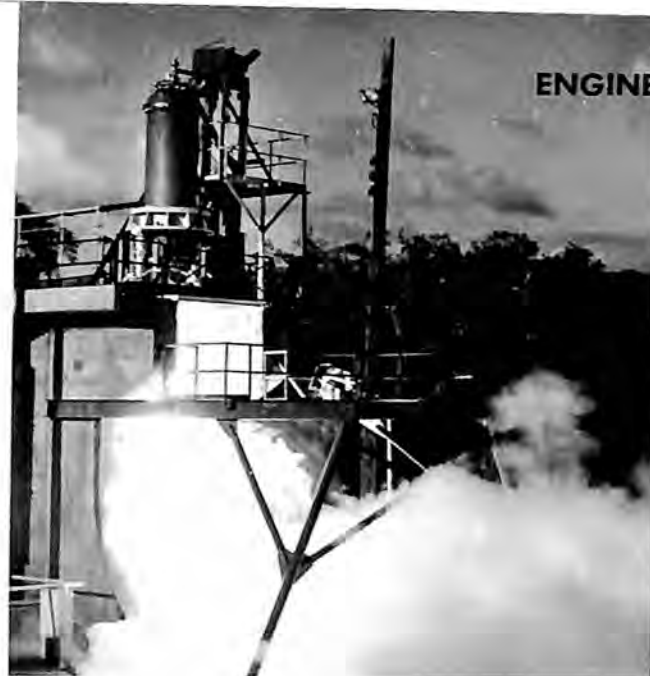
UTC's solid-propellant translation rockets were developed in 1963 for use in separation of the Titan II intercontinental ballistic missile's stages. The company designed, produced, and test fired the first translation rocket in 122 days. In mass production at UTC, the aluminum-encased rocket is also used as a staging rocket on the Air Force Titan IIIC. The only difference between the Titan II and Titan IIIC motors is the nozzle configuration.

Specifications

Length 5 feet; diameter 6 inches; weight 84.5 pounds; propellant PBAN with aluminum additives and ammonium perchlorate oxidizer; nozzle material composite structure with aluminum housing, asbestos phenolic exit cone, and graphite throat; ignition squib pyrogen.

Performance

Thrust 5,000 pounds.



ENGINES (ROCKET)

HIGH-THRUST, HIGH-PERFORMANCE HYBRID ROCKET

Prime Contractor: United Technology Center

Remarks

Developed and tested by UTC, this engine is America's largest, most powerful hybrid rocket. Hybrids utilize a solid fuel and a liquid oxidizer to achieve a combination of advantages unobtainable in either all-solid or all-liquid systems. These include safety, reliability, economical high performance, stop-start capability, and thrust control over a wide range.

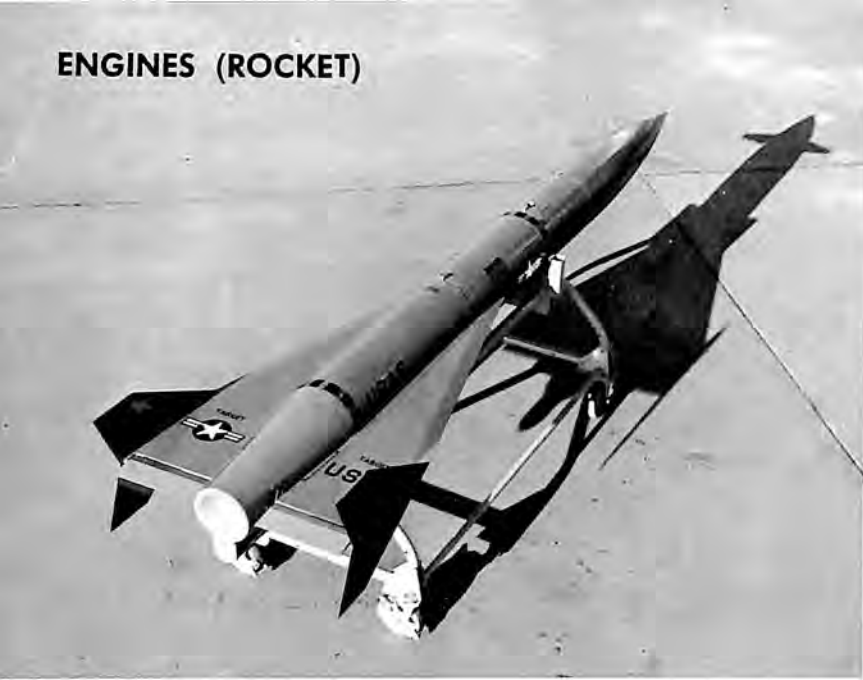
Specifications

Length 184.5 inches; diameter 38 inches; weight 12,375 pounds; propellant polyurethane with aluminum additives and nitrogen tetroxide as oxidizer; nozzle material steel and fiber glass shell with high-density graphite throat; ignition hypergolic bipropellant.

Performance

Thrust 40,600 pounds.

ENGINES (ROCKET)



SANDPIPER PROPULSION SYSTEM

Prime Contractor: United Technology Center

Remarks

The Sandpiper is an Air Force target missile being developed for use in the 1970s to test the effectiveness of advanced air defenses at subsonic and supersonic speeds. Its propulsion system will be the nation's first operational hybrid rocket and will use a solid fuel and liquid oxidizer. It offers, for the first time in any rocket engine, a wide-range flight pattern which can be predetermined by the simple twist of a mechanical dial. This system is known as "dial-a-thrust." Airframe for the vehicle is a modified AQM-37A target missile produced by Beech Aircraft.

Specifications

Sandpiper is 175 inches long and 10 inches in diameter and weighs 450 pounds; propellant Plexiglas fuel grain with additives and combination of nitric oxides as oxidizer; nozzle material composite structure with aluminum housing, asbestos phenolic exit cone, and graphite throat; ignition squib-actuated pyrogen.

Performance

Thrust range from 600 to 60 pounds.



ALGOL III SOLID ROCKET MOTOR

Prime Contractor: United Technology Center

Remarks

The Algol III solid-propellant rocket motor is produced by UTC as the lift-off stage for the updated Scout space launch vehicle. The new motor gives the Scout an increase in its payload capability from 200 to 300 pounds. It burns for 75 seconds and boosts the Scout to an altitude of 30 miles before burnout.

Specifications

Length 30 feet; diameter 45 inches; weight 15 tons; propellant PBAN with aluminum additives and ammonium perchlorate oxidizer; nozzle material steel with graphite cloth-phenolic and silica cloth-phenolic cone liner; ignition small solid rocket.

Performance

Thrust 130,000 pounds.

O-235 SERIES RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

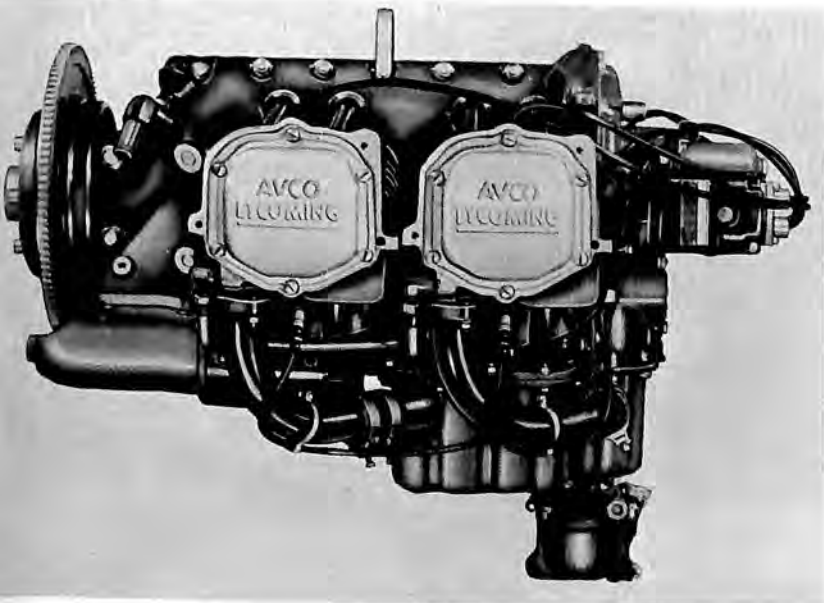
The O-235 series engine has been in the Lycoming line for many years. A popular flat opposed engine, it is being used in the new American Aviation Yankee and Champion and in some export aircraft.

Specifications

Length 30.7 inches; width 32 inches; height 22.4 inches; weight 242 pounds; bore 4.375 inches; stroke 3.875 inches; displacement 235 cubic inches; compression ratio 6.75:1.

Performance

115 horsepower continuous.



IO-320 RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

The IO-320 engine is a high-compression, fuel-injected version of the original famous Lycoming 150-horsepower, flat opposed engine that is so well known in the general aviation industry. The engine is being used by Piper in the Twin Comanche and by Wing Aircraft in the Derringer. The engine is supplied with an automotive type starter and generator/alternator and uses 91/96 octane fuel.

Specifications

Length 33.59 inches; width 32.24 inches; height 19.22 inches; weight 287 pounds; bore 5.125 inches; stroke 3.875 inches; displacement 320 cubic inches; compression ratio 8.5:1.

Performance

160 horsepower continuous.



ENGINES (PISTON)

AIO-360 AEROBATIC ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

Avco Lycoming was the first domestic engine manufacturer to receive a production certificate for an aerobatic engine. This engine is equipped with a continuous fuel flow injection system; a small oil sump on top of the engine is designed in such a manner that the engine will receive proper lubrication when the aircraft is being flown inverted. Avco Lycoming designed this engine because of the many requests received from aerobatic pilots both in the United States and in foreign countries.

Specifications

Length 30.08 inches; width 34.25 inches; height 20.76 inches; weight 331 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 360 cubic inches; compression ratio 8.7:1.

Performance

200 horsepower continuous.

TIO-360 FUEL-INJECTED TURBOCHARGED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

This is the first 4-cylinder, flat opposed engine to come from the manufacturer equipped with turbocharging. Several aircraft flying in the United States are equipped with this model engine. Siai-Marchetti, an Italian manufacturer, has taken delivery of the engine.

Specifications

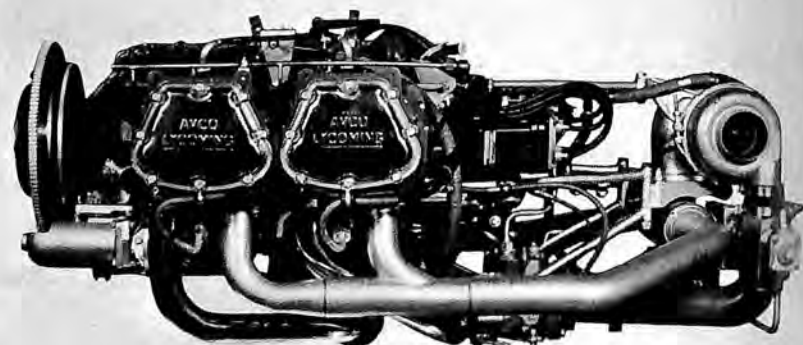
Length 45.41 inches; width 34.25 inches; height 19.92 inches; weight 386 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 360 cubic inches; compression ratio 7.3:1.

Performance

200 horsepower continuous to 15,000 feet.



R-298



TVO-435 HELICOPTER ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

This is the turbocharged version of the basic VO-435 helicopter engine that Avco Lycoming has produced for the Bell Helicopter Company for many years. It is an updated version which incorporates all of the refinements that Avco Lycoming has been designing into its flat opposed engines for fixed-wing aircraft. The engine incorporates the latest in design, heavy cylinders, piston-cooling oil jets, and the AiResearch turbocharger which is used for ground boost as well as altitude performance.

Specifications

Length 39.46 inches; width 34.11 inches; height 34.32 inches; weight 487 pounds; bore 4.875 inches; stroke 3.875 inches; displacement 435 cubic inches; compression ratio 7.3:1.

Performance

Takeoff horsepower 280, continuous horsepower 250.



IGSO-480 FUEL-INJECTED, GEARED, SUPERCHARGED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

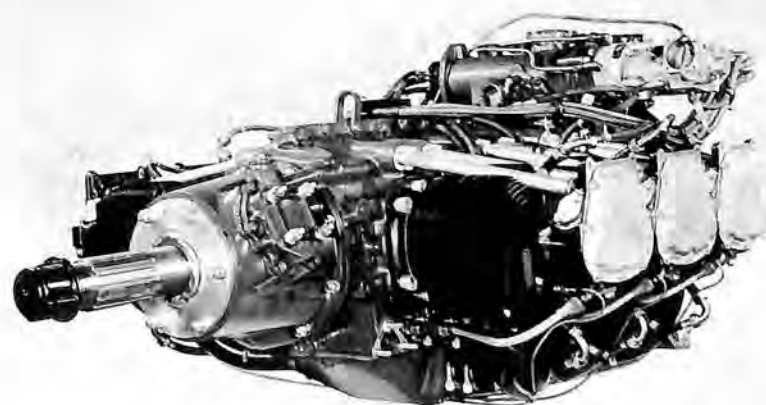
This engine is the latest refined version of the basic geared, supercharged 480 series engine used by Beech, Aero Commander, Helio Courier, and others for many years. The present model is used to power the Beech Queen Air 65 aircraft. Side-mounted accessories provide ease of maintenance. The military has been getting a high number of hours between overhauls on the IGSO-480 engine.

Specifications

Length 47.27 inches; width 33.12 inches; height 31.05 inches; weight 515 pounds; bore 5.125 inches; stroke 3.875 inches; displacement 480 cubic inches; compression ratio 7.3:1.

Performance

Takeoff horsepower 340, continuous horsepower 320.



ENGINES (PISTON)

O-540-B SERIES RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

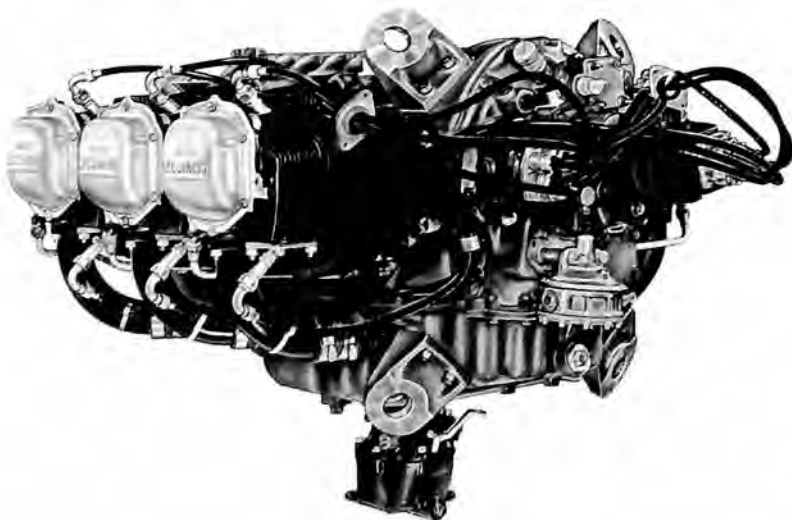
This is a low-compression version of the long-standing Avco Lycoming 6-cylinder 540 series engine. It is being used by Piper Aircraft in its 235 Cherokee and Pawnee agricultural aircraft. The engine uses 80/87 octane fuel and has a reputation in the industry for long maintenance-free life.

Specifications

Length 37.22 inches; width 33.37 inches; height 24.56 inches; weight 395 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 540 cubic inches; compression ratio 7.2:1.

Performance

235 horsepower continuous.



IO-720 SERIES FUEL-INJECTED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

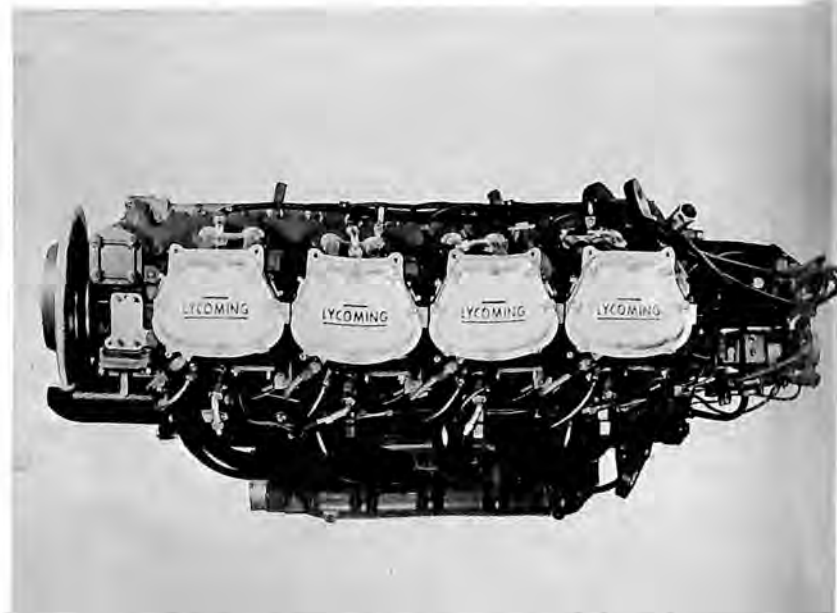
This 400-horsepower, direct-drive engine powers the single-engine Piper Comanche 400. The same basic model engine is used to power the Riley Dove, the Imco Model B1 agricultural sprayer, and the Swearingen conversion of the Beech Queen Air 65. Like many of its sister engines in this family, the IO-720 incorporates piston-cooling oil jets and a continuous-flow fuel-injection system.

Specifications

Length 46.08 inches; width 34.25 inches; height 22.53 inches; weight 610 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 722 cubic inches; compression ratio 8.7:1.

Performance

400 horsepower continuous.



R-300

IO-540-K RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

This fuel-injected, flat opposed, direct-drive piston engine powers the Piper Cherokee 300, a 6-place single-engine utility aircraft. The engine incorporates piston-cooling oil jets, a tuned induction system, and a continuous-flow fuel-injection system; like all Avco Lycoming direct-drive engines, it is supplied with an automotive-type starter and generator or alternator. This engine has a continuous rating of 2,700 revolutions per minute and uses 100/130 octane fuel.

Specifications

Length 39.34 inches; width 34.25 inches; height 19.6 inches; weight 470 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 541.5 cubic inches; compression ratio 8.7:1.

Performance

300 horsepower continuous.

IO-360-A1A RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

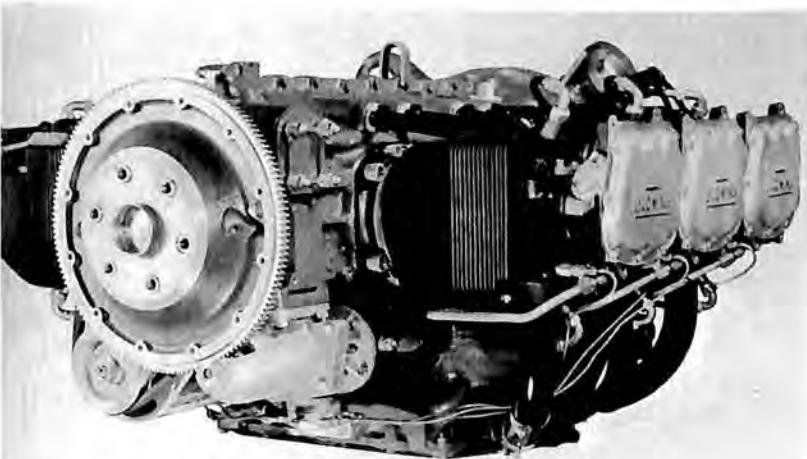
First installed in the Mooney Super 21, this 200-horsepower, 4-cylinder, flat opposed, direct-drive engine also powers the new Mooney Executive model aircraft. Producing 50 horsepower per cylinder, the IO-360-A1A has an excellent horsepower-to-weight ratio while maintaining the simplicity of design associated with the direct-drive-type piston engine. A tuned induction system and a continuous-flow fuel-injection system are incorporated in this series.

Specifications

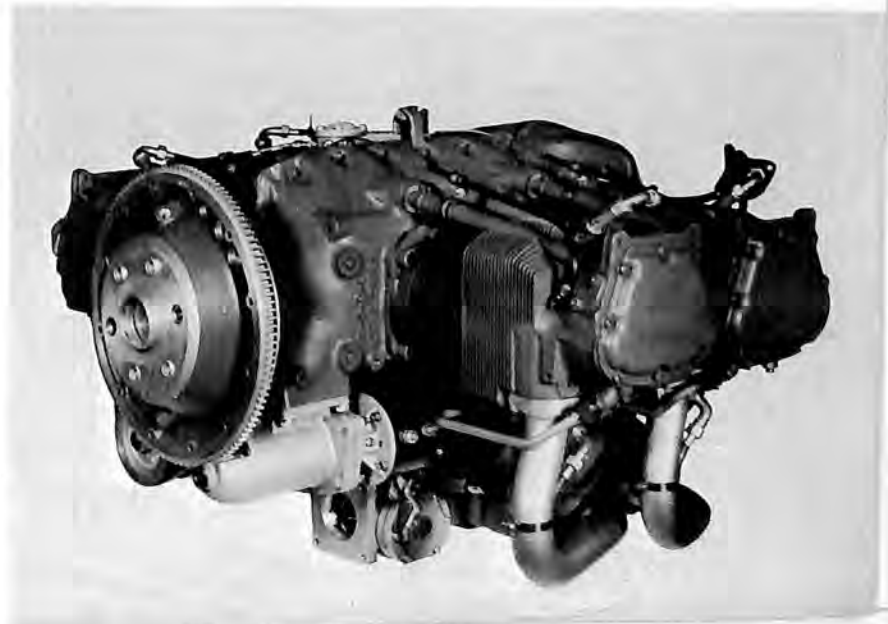
Length 29.81 inches; width 34.25 inches; height 19.35 inches; bore 5.125 inches; stroke 4.375 inches; weight 323 pounds; displacement 361 cubic inches; compression ratio 8.7:1.

Performance

200 horsepower continuous.



R-301



TIO-540-A1A RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

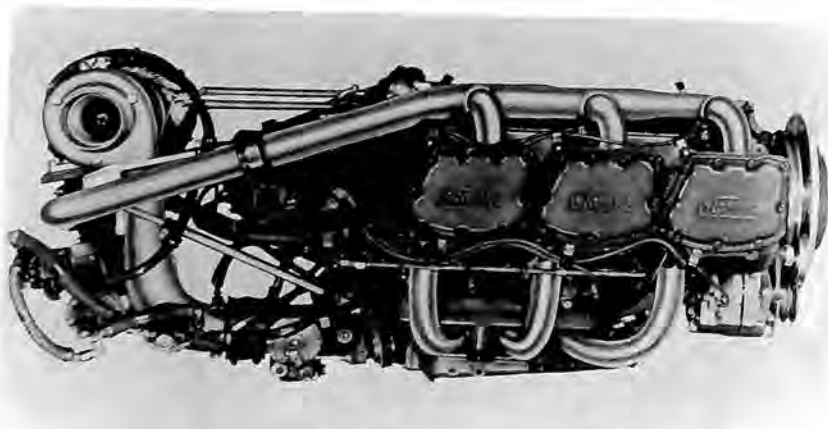
This turbocharged fuel-injected engine powers the new Piper Navajo Twin to weather-topping altitudes beyond the capability of normally aspirated engines. The TIO-540-A1A, like all other Avco Lycoming engines supplied with a turbocharger, incorporates automatic controls. Also, all turbocharged engines built by Avco Lycoming feature shell moulded cylinder heads, .5-inch inconel steel exhaust valves, ni-resist exhaust valve guides, and piston-cooling oil squirts.

Specifications

Length 51.34 inches; width 34.25 inches; height 22.71 inches; weight 535 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 541.5 cubic inches; compression ratio 7.3:1.

Performance

310 horsepower continuous to 15,000 feet and 230 horsepower to 25,000 feet.



TIO-541 TURBOCHARGED PISTON ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

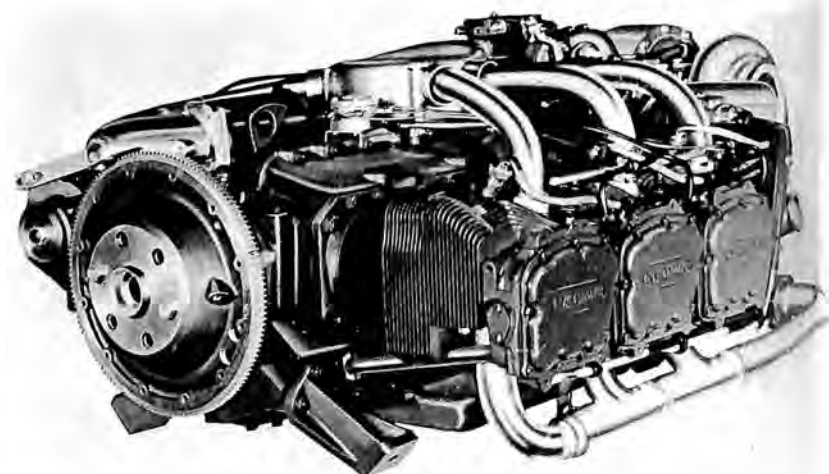
The first in Avco Lycoming's new series of engines is the TIO-541, which powers the Mooney M22. The basic engine is available with a 380-horsepower rating; it powers the Beech Turbo Baron 56TC and the Beech Duke. This new design concept for Avco Lycoming in the piston engine field incorporates all of the engineering improvements learned in 25 years of manufacturing air-cooled aircraft engines. Equipped with side-mounted accessories for ease of maintenance, the TIO-541 also incorporates an integral oil cooler and a turbocharger with provision for cabin pressurization and a drive for a Freon compressor for air conditioning.

Specifications

Length 49.09 inches; width 34.25 inches; height 21.38 inches; weight 579 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 541 cubic inches; compression ratio 7.3:1.

Performance

310 brake horsepower continuous (TIO-541-A1A), 380 brake horsepower continuous (TIO-541-E).



**TIGO-541 SERIES TURBOCHARGED
PISTON ENGINE**

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

The second in the newest family of piston engines to come from Avco Lycoming is the TIGO-541 model. Turbocharged for high-altitude operation, this engine is basically a TIO-541 with an offset reduction gear having a ratio of 2:3. A one-piece crankcase casting provides a housing for the reduction gear and power section, as well as pads for side-mounted accessories. This model engine is equipped with a turbocharger with provision for cabin pressurization, a drive for a Freon compressor for air conditioning, and a torque meter.

Specifications

Length 58.94 inches; width 35.66 inches; height 27.14 inches; weight 663 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 541 cubic inches; compression ratio 7.3:1.

Performance

450 horsepower continuous to 15,000 feet (TIGO-541-D1A), 425 horsepower continuous to 15,000 feet (TIGO-541-E1A).

**IGSO-540 SERIES SUPERCHARGED
RECIPROCATING ENGINE**

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

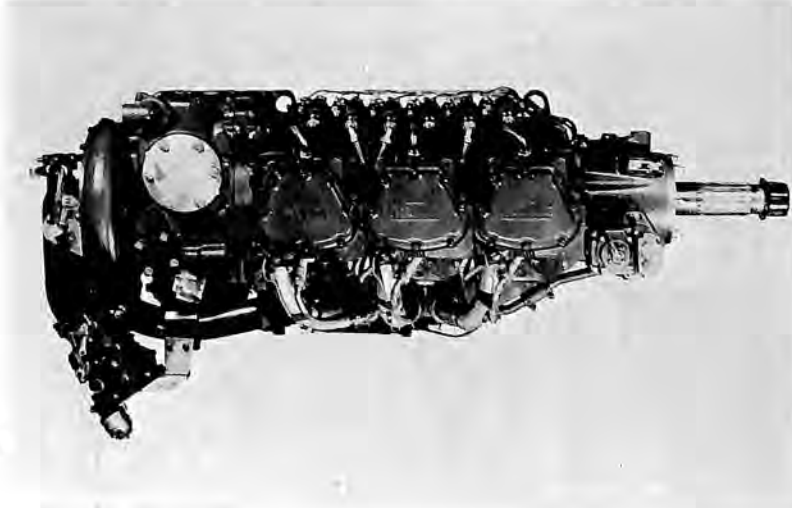
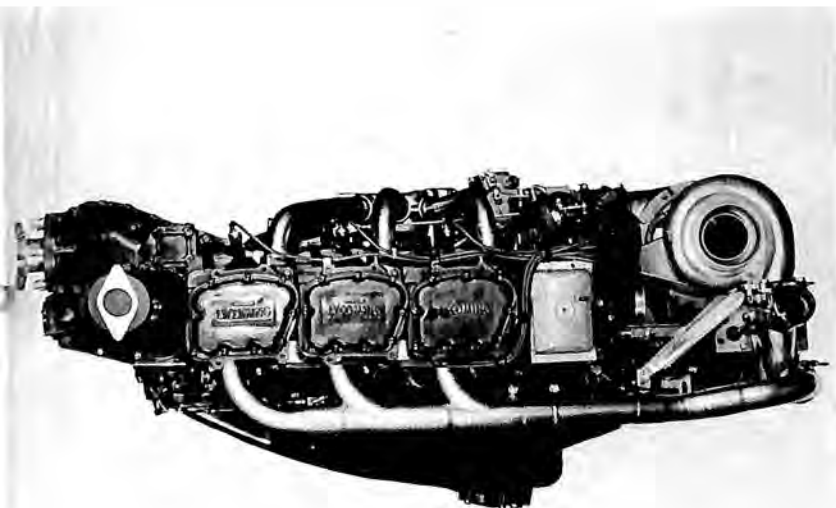
This series of engines powers the 680 series of aircraft manufactured by Aero Commander and the Queen Air 80 model aircraft manufactured by Beech. A mechanically supercharged, fuel-injected engine, this model has accumulated many hours of flight time and compiled an enviable record of safety and low maintenance costs. Side-mounted accessories provide ease of maintenance, and the engine is built with either updraft or downdraft exhaust cylinders. Basically used by Aero and Beech, many smaller companies are using the IGSO-540 as a conversion power plant to increase the performance of other aircraft.

Specifications

Length 48.15 inches; width 34.25 inches; height 28.44 inches; weight 530 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 541.5 cubic inches; compression ratio 7.3:1.

Performance

380 brake horsepower takeoff, 360 brake horsepower continuous.



R-303

ENGINES (PISTON)

MODEL O-200-A

Prime Contractor: Continental Motors Corporation

Remarks

The O-200-A is the power plant for the Cessna Model 150, the Champion Citabria and Lancer, and the Thorpe Sky Scooter (tubular).

Specifications

Dimensions with standard equipment installed: length 28.53 inches, height 23.18 inches, width 31.56 inches; dry weight with accessories 217.87 pounds; cylinders 4; bore 4.06 inches; stroke 3.88 inches; displacement 201 cubic inches; compression ratio 7:1.

Performance

Rated power, sea level, 100 horsepower; takeoff power, sea level, 100 horsepower; recommended cruise rating, sea level, 75 horsepower; revolutions per minute at rated power 2,750; revolutions per minute at takeoff 2,750; cruising revolutions per minute 2,500.

MODELS O-300-A, -B, -C, -D

Prime Contractor: Continental Motors Corporation

Remarks

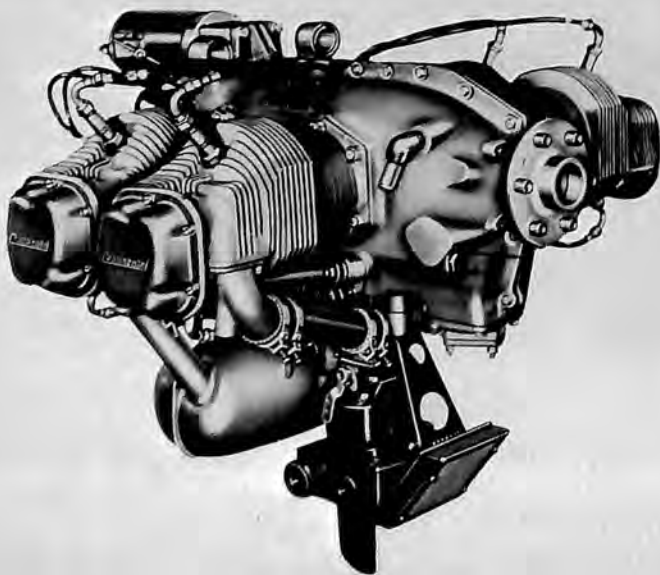
The O-300 engine powers the Cessna 170, 172, and T-41A (military) and the Maule Bee Dee M-4.

Specifications

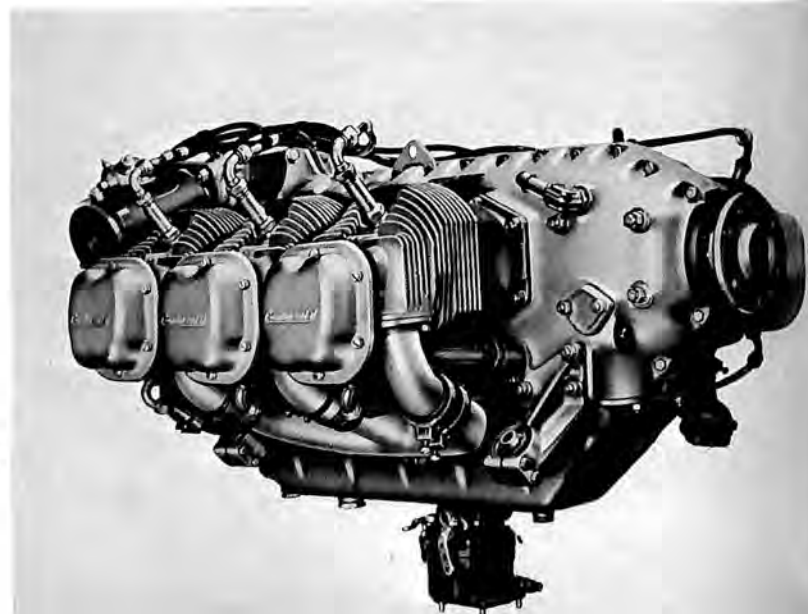
Dimensions with standard equipment installed: length 35.53 inches (-D 36 inches), height 26.91 inches (-D 27 inches), width 31.5 inches; dry weight with carburetor 268 pounds; cylinders 6; bore $4\frac{1}{16}$ inches; stroke $3\frac{7}{8}$ inches; displacement 301 cubic inches; compression ratio 7:1.

Performance

Sea-level rating 145 horsepower; sea-level takeoff power 145 horsepower; cruise 109 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at takeoff power 2,700; cruising revolutions per minute 2,450.



R-304



MODEL IO-346

Prime Contractor: Continental Motors Corporation

Remarks

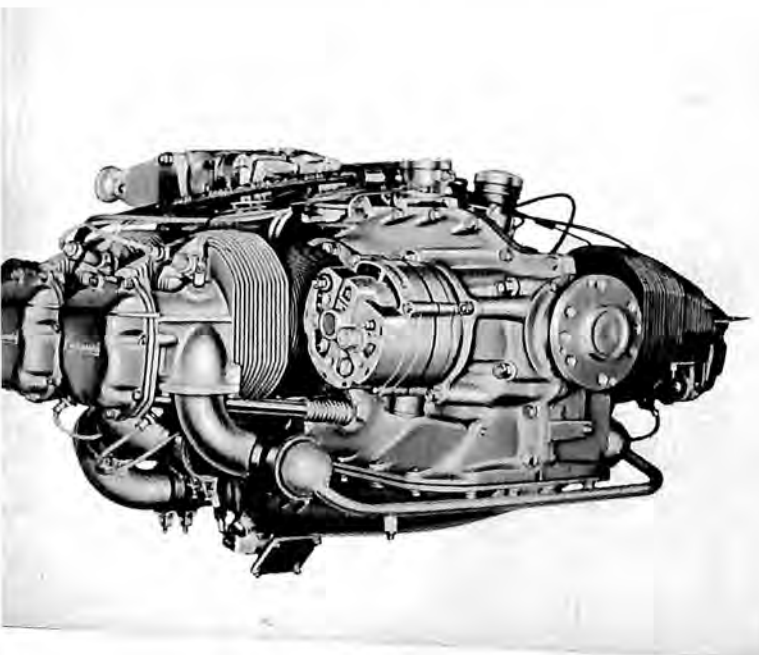
The IO-346 engine is the power plant in the Beechcraft Musketeer.

Specifications

Dimensions with standard equipment installed: length 30 inches, height 22.48 inches, width 33.38 inches; dry weight with accessories 296.5 pounds; cylinders 4; bore 5.25 inches; stroke 4 inches; displacement 346 cubic inches; compression ratio 7.5:1.

Performance

Sea-level rating 165 horsepower; takeoff rating, sea level, 165 horsepower; cruise rating 125 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at takeoff power 2,700; cruising revolutions per minute 2,450.



MODELS IO-360-C, -D

Prime Contractor: Continental Motors Corporation

Remarks

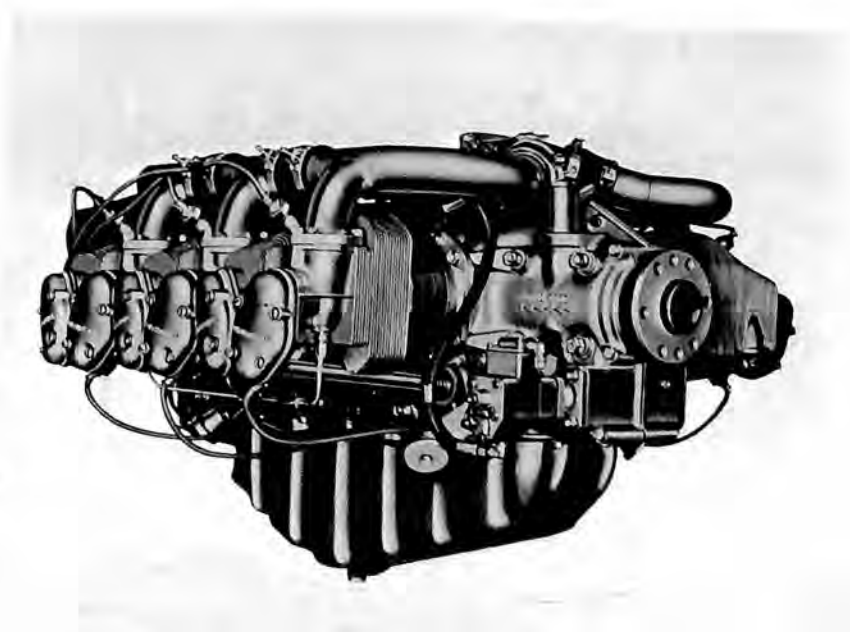
The IO-360 engine is the power plant for the Cessna 337, T-41B, O-2A, and O-2B.

Specifications

Dimensions with standard equipment installed: length 35.34 inches, height 23.74 inches, width 31.4 inches; dry weight with accessories 298.25 pounds; cylinders 6; bore 4.438 inches; stroke 3.875 inches; displacement 360 cubic inches; compression ratio 8.5:1.

Performance

Sea-level rating 210 horsepower; takeoff rating at sea level 210 horsepower; cruise rating 157 horsepower; revolutions per minute at rated power 2,800; revolutions per minute at takeoff power 2,800; cruising revolutions per minute 2,600.



ENGINES (PISTON)

MODELS TSIO-360-A, -B

Prime Contractor: Continental Motors Corporation

Remarks

The TSIO-360-A and -B engines are the power plants in the Cessna T337 Super Skymaster.

Specifications

Dimensions with standard equipment installed: length 35.34 inches (-A), 33.84 inches (-B), height 23.64 inches (-A), 30.74 inches (-B), width 33.11 inches; dry weight with accessories 300.25 pounds (-A), 296.25 pounds (-B); cylinders 6; bore 4.438 inches; stroke 3.875 inches; displacement 360 cubic inches; compression ratio 7.5:1.

Performance

Sea-level rating 210 horsepower; takeoff rating at sea level 210 horsepower; cruise rating 157 horsepower; revolutions per minute at rated power 2,800; revolutions per minute at takeoff power 2,700; cruising revolutions per minute 2,600.

Note: The difference between the -A and -B models is that -A has vacuum pump drive on the rear of the starter adapter.

MODEL O-470-R

Prime Contractor: Continental Motors Corporation

Remarks

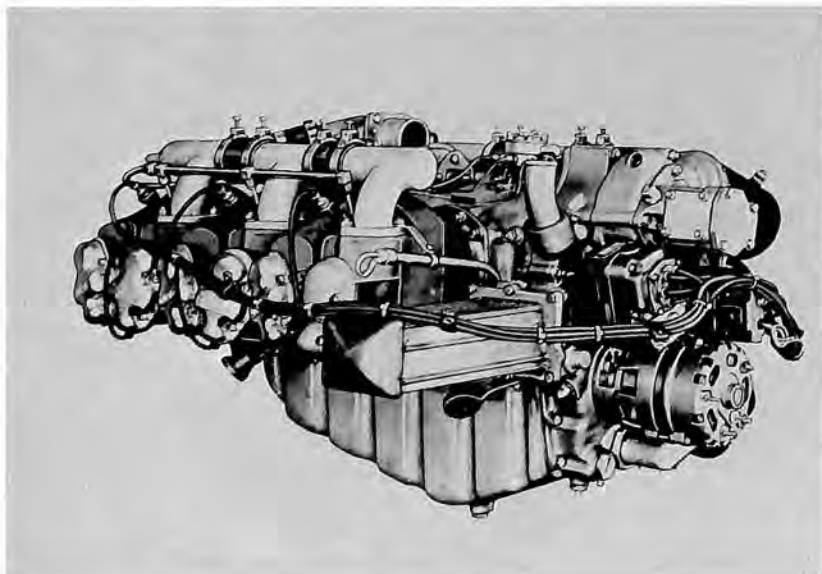
The O-470-R engine powers the Cessna 180, 182, and 188 and the Wren 460.

Specifications

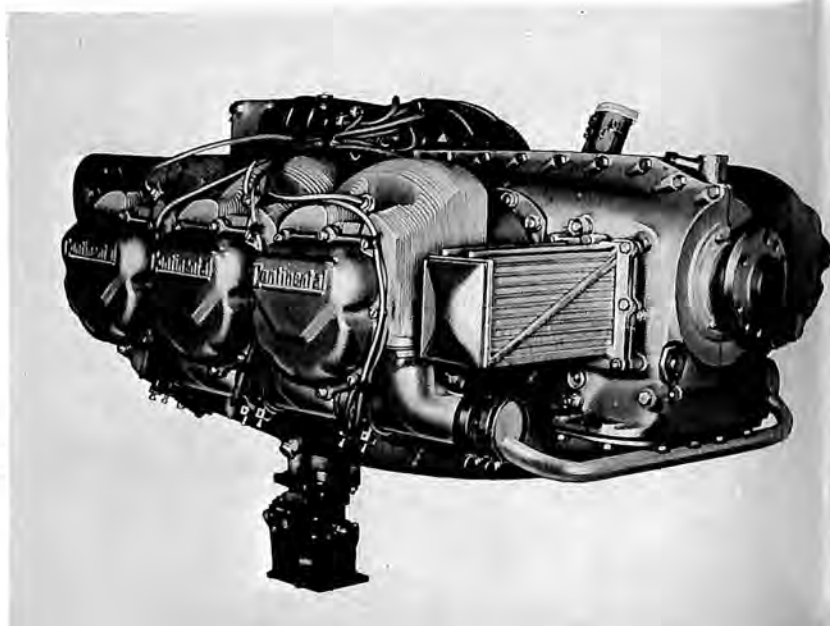
Dimensions with standard equipment installed: length 36.03 inches, height 28.42 inches, width 33.56 inches; dry weight with accessories 438.35 pounds; cylinders 6; bore 5 inches; stroke 4 inches; displacement 471 cubic inches; compression ratio 7:1.

Performance

Sea-level rating 230 horsepower; sea-level takeoff rating 230 horsepower; sea-level cruise rating 172 horsepower; rated power revolutions per minute 2,600; takeoff power revolutions per minute 2,600; cruising revolutions per minute 2,450.



R-306



MODELS IO-470-K, -L

Prime Contractor: Continental Motors Corporation

Remarks

The IO-470-K is the power plant in the Beechcraft Debonair B33; the -L is used in the Beechcraft Baron B55.

Specifications (-K)

Dimensions with standard equipment installed: length 38.14 inches, height 26.81 inches, width 33.39 inches; dry weight with accessories 413 pounds; cylinders 6; bore 5 inches; stroke 4 inches; displacement 471 cubic inches; compression ratio 7:1.

Performance (-K)

Sea-level rating 225 horsepower; takeoff rating, sea level, 225 horsepower; cruise rating 169 horsepower; revolutions per minute at rated power 2,600; revolutions per minute at takeoff power 2,600; cruising revolutions per minute 2,450.

Specifications (-L)

Dimensions with standard equipment installed: length 43.17 inches, height 19.75 inches, width 33.56 inches; dry weight with accessories 469.35 pounds; cylinders 6; bore 5 inches; stroke 4 inches; displacement 471 cubic inches; compression ratio 8.6:1.

Performance (-L)

Sea-level rating 260 horsepower; takeoff rating, sea level, 260 horsepower; cruise rating 195 horsepower; revolutions per minute at rated power 2,625; revolutions per minute at takeoff power 2,625; cruising revolutions per minute 2,450.

MODEL IO-470-V

Prime Contractor: Continental Motors Corporation

Remarks

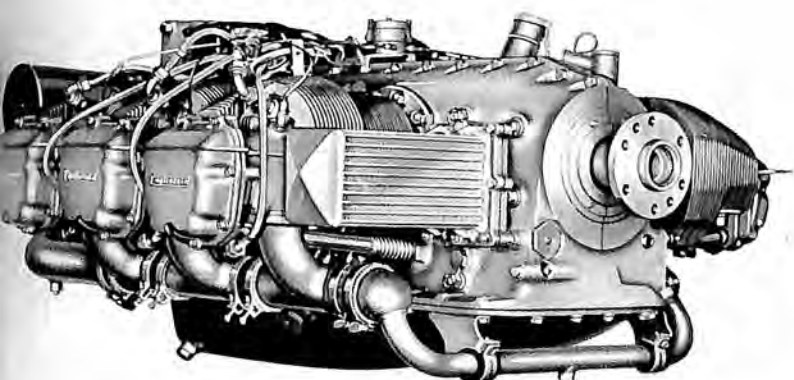
The IO-470-V is the power plant in the Cessna 310K and 310L.

Specifications

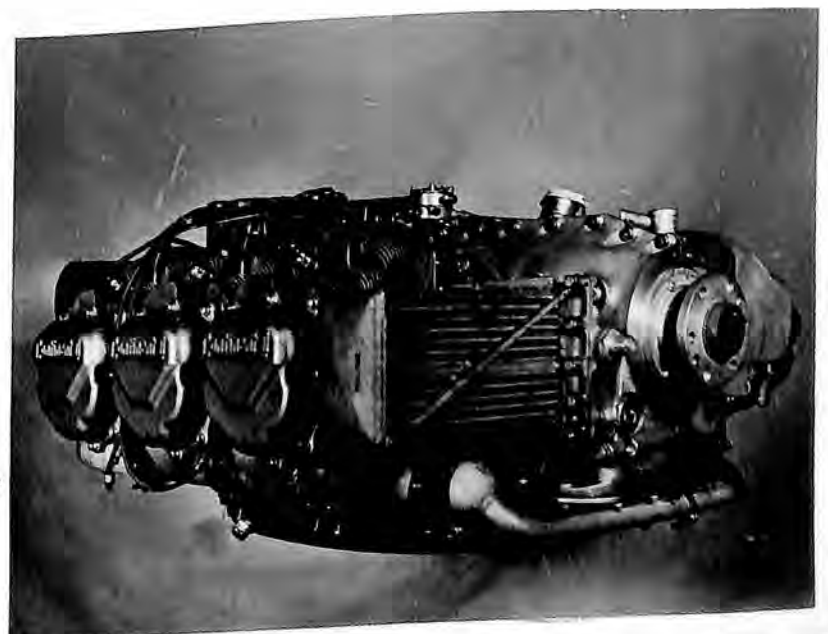
Dimensions with standard equipment installed: length 43.19 inches, height 19.75 inches, width 33.56 inches; dry weight with accessories 423.47 pounds; cylinders 6; bore 5 inches; stroke 4 inches; displacement 471 cubic inches; compression ratio 8.6:1.

Performance

Sea-level rating 260 horsepower; takeoff rating, sea level, 260 horsepower; cruise rating 195 horsepower; revolutions per minute at rated power 2,625; revolutions per minute at takeoff power 2,625; cruising revolutions per minute 2,450.



R-307



ENGINES (PISTON)

MODELS IO-520-A, -D, -E, -F, -J, -K, -L

Prime Contractor: Continental Motors Corporation

Remarks

The IO-520 series engines are employed as follows: IO-520-A in the Cessna 210 and 206, Aero Commander 200D; IO-520-D, Cessna 185 Skywagon and 188 Agwagon, Bellanca Viking; IO-520-E, Aero Commander 500A; IO-520-F, Cessna U206; IO-520-J, Cessna 210; IO-520-K, Bellanca Viking; IO-520L, Cessna 210.

Specifications (-A)

Dimensions with standard equipment installed: length 40.91 inches, height 19.75 inches, width 33.56 inches; dry weight with accessories 471.28 pounds; cylinders 6; bore 5.25 inches; displacement 520 cubic inches; compression ratio 8.5:1.

Performance (-A)

Sea-level rating 285 horsepower; takeoff rating 285 horsepower; cruise rating 215 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at takeoff power 2,700; cruising revolutions per minute 2,500.

Note: Model deviations from -A specifications and performance are: (-D) length 36.86 inches, height 23.79 inches, dry weight 455.56 pounds, takeoff rating 300 horsepower, takeoff revolutions per minute 2,850, cruising revolutions per minute 2,550; (-E) length 47.26 inches, width 35.56 inches, takeoff rating 300 horsepower at 2,850 revolutions per minute, cruise rating 213 horsepower at 2,500 revolutions per minute; (-F) takeoff rating 300 horsepower at 2,850 revolutions per minute, cruise rating 215 horsepower at 2,550 revolutions per minute; (-K) weight 466.43 pounds; (-L) weight 469 pounds.

MODEL IO-520-B

Prime Contractor: Continental Motors Corporation

Remarks

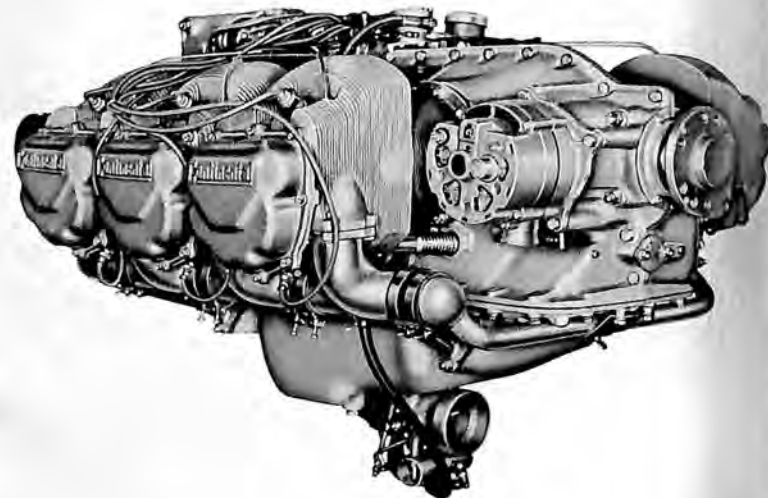
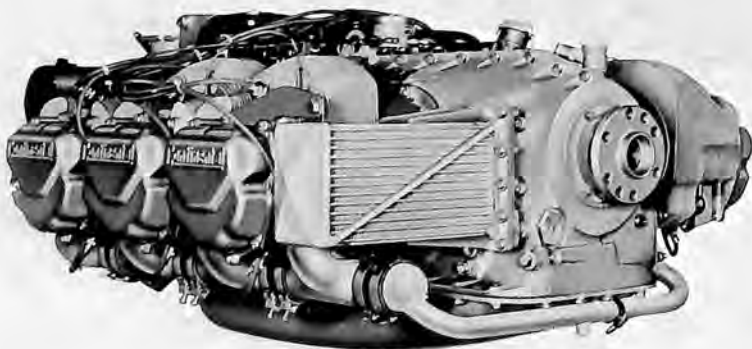
The IO-520-B is the power plant in the Beechcraft Bonanza S35, the Beechcraft Debonair B33A, and the Navion.

Specifications

Dimensions with standard equipment installed: length 38.47 inches, height 26.71 inches, width 33.58 inches; dry weight with accessories 457.65 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 8.5:1.

Performance

Sea-level rating 285 horsepower; takeoff rating, sea level, 285 horsepower; cruise rating 213 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at takeoff power 2,700; cruising revolutions per minute 2,500.



MODEL IO-520-C

Prime Contractor: Continental Motors Corporation

Remarks

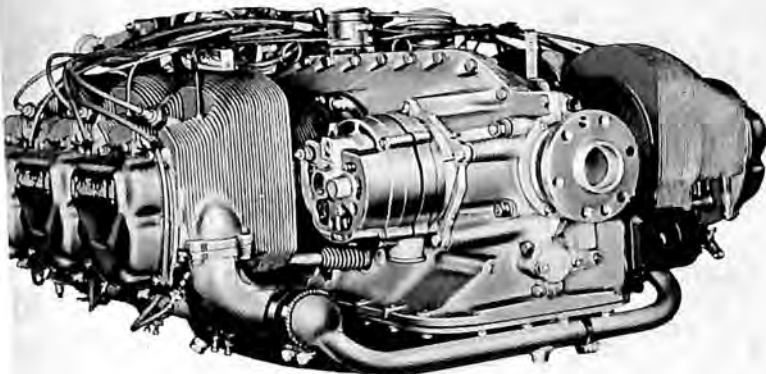
The IO-520-C engine is the power plant in the Beechcraft Baron.

Specifications

Dimensions with standard equipment installed: length 42.81 inches, height 19.78 inches, width 33.56 inches; dry weight with accessories 450.38 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 8.5:1.

Performance

Sea-level rating 285 horsepower; takeoff rating, sea level, 285 horsepower; cruise rating 213 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at takeoff power 2,700; cruising revolutions per minute 2,500.



MODELS TSIO-520-B, -E, -J

Prime Contractor: Continental Motors Corporation

Remarks

The TSIO-520-B is the power plant in the Cessna 320D Skynight.

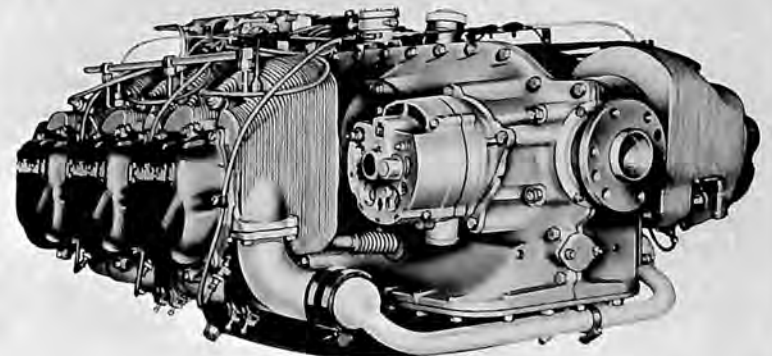
Specifications (-B)

Dimensions with standard equipment installed: length 39.25 inches, height 20.47 inches, width 33.56 inches, length with turbo 57.73 inches; dry weight with accessories 475 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 7.5:1.

Performance (-B)

Sea-level rating 285 horsepower; takeoff rating at sea level 285 horsepower; cruise rating 215 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at takeoff power 2,700; cruising revolutions per minute 2,350.

Note: Model TSIO-520-E, used in the Cessna 401/402, has the same specifications, except for: rated power 300 horsepower at 2,700 revolutions per minute; cruise rating 225 horsepower at 2,450 revolutions per minute. Model TSIO-520-J differs as follows: weight 488 pounds; length 54.36 inches; takeoff 300 horsepower at 2,700 revolutions per minute; cruise 233 horsepower at 2,450 revolutions per minute.



ENGINES (PISTON)

MODELS TSIO-520-C, -G, -H

Prime Contractor: Continental Motors Corporation

Remarks

The TSIO-520-C and -H engines are used in the Cessna T210.

Specifications

Dimensions with standard equipment installed: length 40.91 inches, height 20.04 inches, width 33.56 inches; dry weight with accessories 458.01 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 7.5:1.

Performance

Sea-level rating 285 horsepower; takeoff rating at sea level 285 horsepower; cruise rating 215 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at takeoff 2,700; cruising revolutions per minute 2,500.

MODEL TSIO-520-D

Prime Contractor: Continental Motors Corporation

Remarks

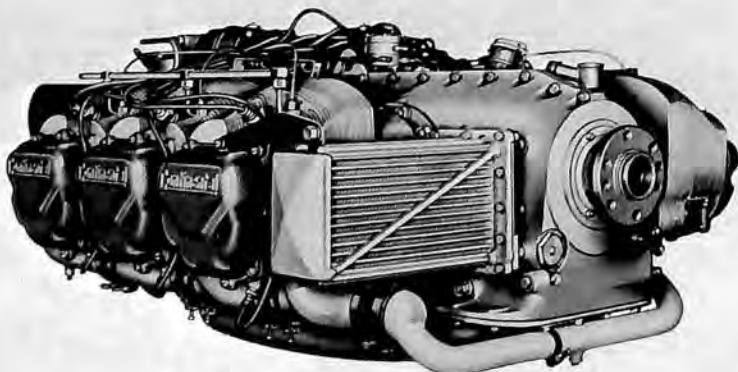
The TSIO-520-D engine is the power plant in the Beechcraft Turbo Bonanza.

Specifications

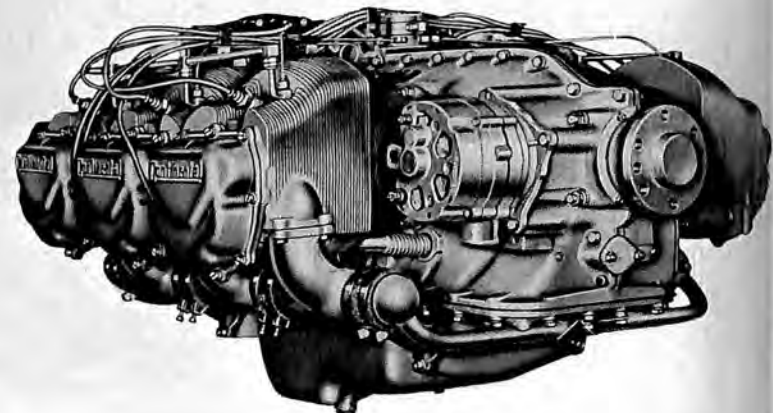
Dimensions with standard equipment installed: length (turbo not included) 42.58 inches, height 29.4 inches, width 33.56 inches; dry weight with accessories 484.5 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 7.5:1.

Performance

Sea-level rating 285 horsepower; takeoff rating, sea level, 285 horsepower; cruise rating 214 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at takeoff power 2,700; cruising revolutions per minute 2,500.



R-310



MODEL GTSIO-520-C

Prime Contractor: Continental Motors Corporation

Remarks

The GTSIO-520-C engine is the power plant in the Cessna 411.

Specifications

Dimensions with standard equipment installed: length 43.06 inches, height 23.25 inches, width 34.04 inches; dry weight with accessories 552.52 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 7.5:1.

Performance

Sea-level rating 340 horsepower; takeoff rating, sea level, 340 horsepower; cruise rating 255 horsepower; revolutions per minute at rated power 3,200; revolutions per minute at takeoff power 3,200; cruising revolutions per minute 2,800.

MODEL GTSIO-520-F

Prime Contractor: Continental Motors Corporation

Specifications

Dimensions with standard equipment installed: length 56.25 inches, width 34.04 inches, height 25.25 inches; dry weight with accessories 590 pounds; other specifications as in -D model below.

Performance

Sea-level rating 425 horsepower; takeoff rating 425 horsepower; cruise rating 318 horsepower; revolutions per minute at rated power and takeoff 3,400; revolutions per minute at cruise 2,900.

MODEL GTSIO-520-D

Prime Contractor: Continental Motors Corporation

Remarks

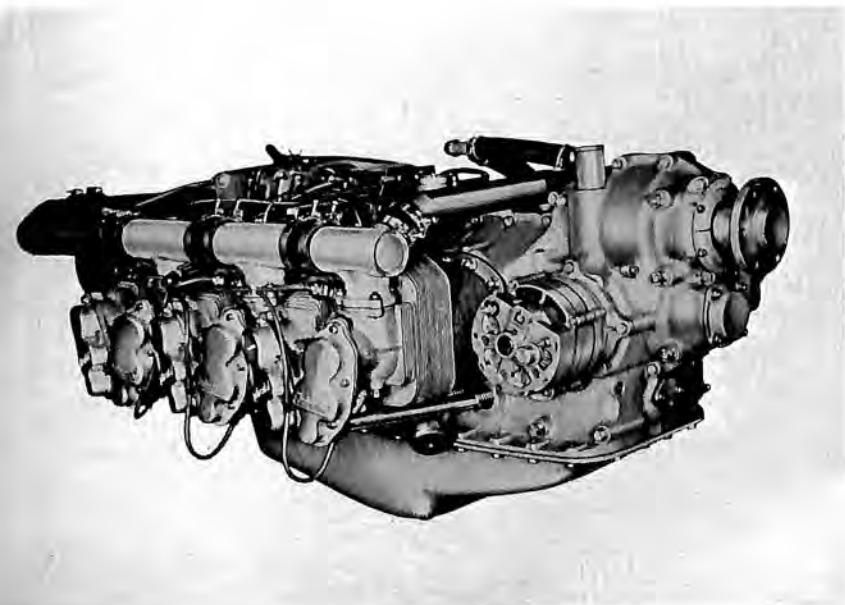
The GTSIO-520-D engine is the power plant in the Cessna 421.

Specifications

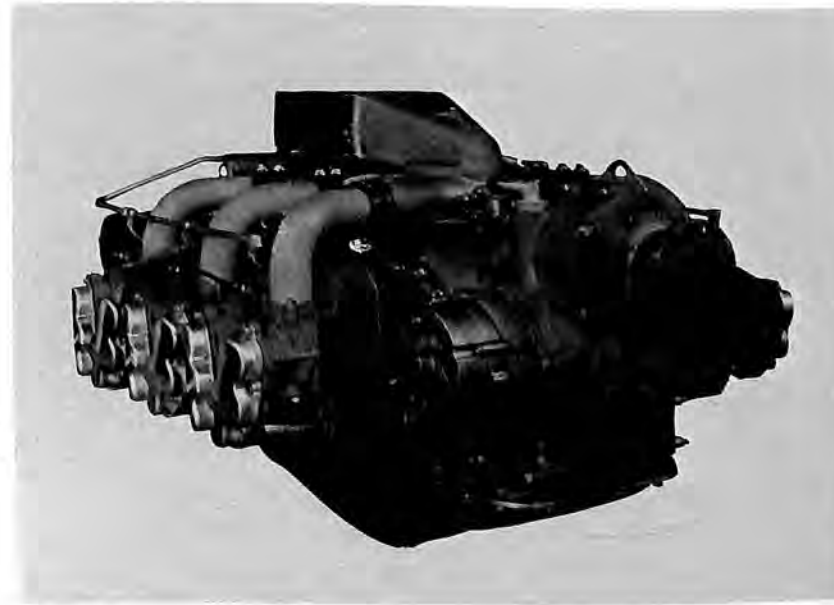
Dimensions with standard equipment installed: length 42.56 inches, height 26.78 inches, width 34.03 inches; dry weight with accessories 578 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 7.5:1.

Performance

Sea-level rating 375 horsepower; takeoff rating, sea level, 375 horsepower; cruise rating 282 horsepower; revolutions per minute at rated power and takeoff 3,400; revolutions per minute at cruise 2,900.



R-311



ENGINES (PISTON)

R1300 ENGINE (C7BA)

Prime Contractor: Curtiss-Wright Corporation

Remarks

Among applications of the R1300 Cyclone 7 series engines are the North American T-28A trainer, the Sikorsky H-19 helicopter, and the Goodyear ZPG and ZS2G airships.

Specifications

Dry weights 1,065 to 1,092 pounds; length 48.12 inches; diameter 50.45 inches; fuel grade 91/96.

Performance

Takeoff power at sea level 800 brake horsepower.

R1820-82A ENGINE (C9)

Prime Contractor: Curtiss-Wright Corporation

Remarks

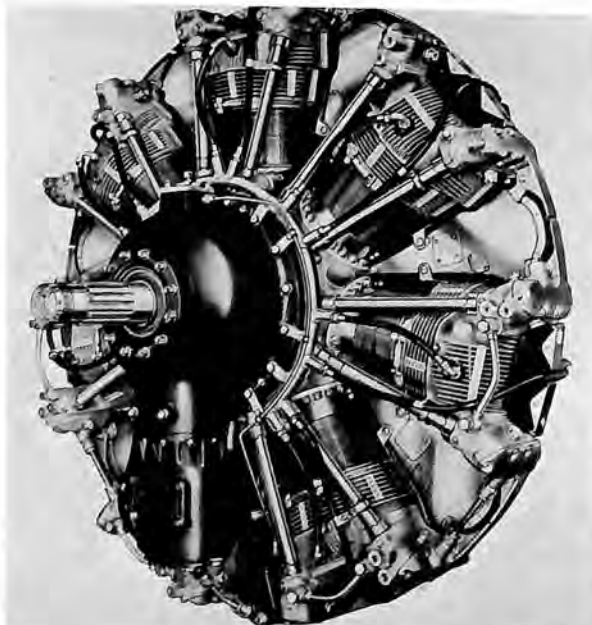
A 9-cylinder, single-row radial reciprocating engine, the C9 is manufactured for the Grumman S-2D, S-2E, and E-1B series aircraft.

Specifications

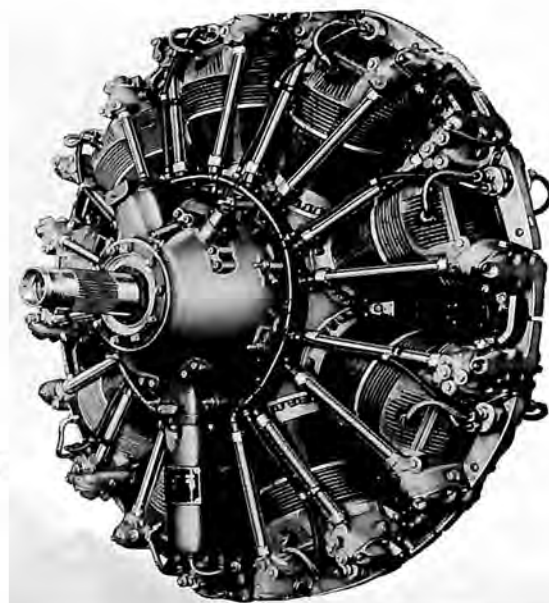
Dry weight 1,479 pounds; length 50.1 inches; diameter 55.74 inches; fuel grade 115/145.

Performance

Takeoff power at sea level 1,525 brake horsepower.



R-312



R3350-26WD ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

An 18-cylinder, double-row radial reciprocating engine, the R3350-26WD is manufactured for the Douglas AD series and the Lockheed P-2 series aircraft.

Specifications

Dry weight 2,925 pounds; length 81.23 inches; diameter 55.62 inches; fuel grade 115/145.

Performance

Takeoff power at sea level 2,700 horsepower.

R3350-32W ENGINE (TC18)

Prime Contractor: Curtiss-Wright Corporation

Remarks

The TC18 is an 18-cylinder, double-row radial turbocompound reciprocating engine used by the military services in P-2 and P-5 series aircraft.

Specifications

Dry weight 3,560 pounds; length 91.8 inches; diameter 56.59 inches; fuel grade 115/145.

Performance

Takeoff power at sea level 3,700 brake horsepower.

YRC-180-2 ROTATING COMBUSTION ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

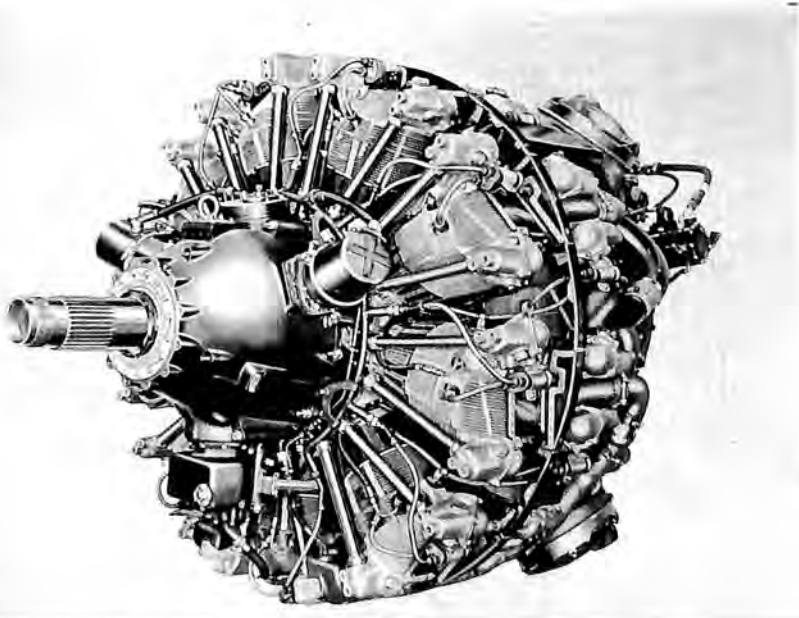
The rotating combustion engine is a new internal combustion engine which operates on the familiar Otto cycle but incorporates a unique and simplified geometry which provides a very high ratio of power to displacement. Designed for Navy aircraft applications, the YRC-180-2 is an advanced version of the RC2-90, the initial rotating combustion aircraft engine developed by Curtiss-Wright. It is an air-cooled, twin-rotor engine incorporating JP fuel injection with coordinated spark ignition. The engine is naturally aspirated and has its own cooling air blower. Torque, air, and fuel consumption characteristics are comparable to conventional reciprocating engines; size, weight, and smoothness of operation approach that of turbine engines.

Specifications

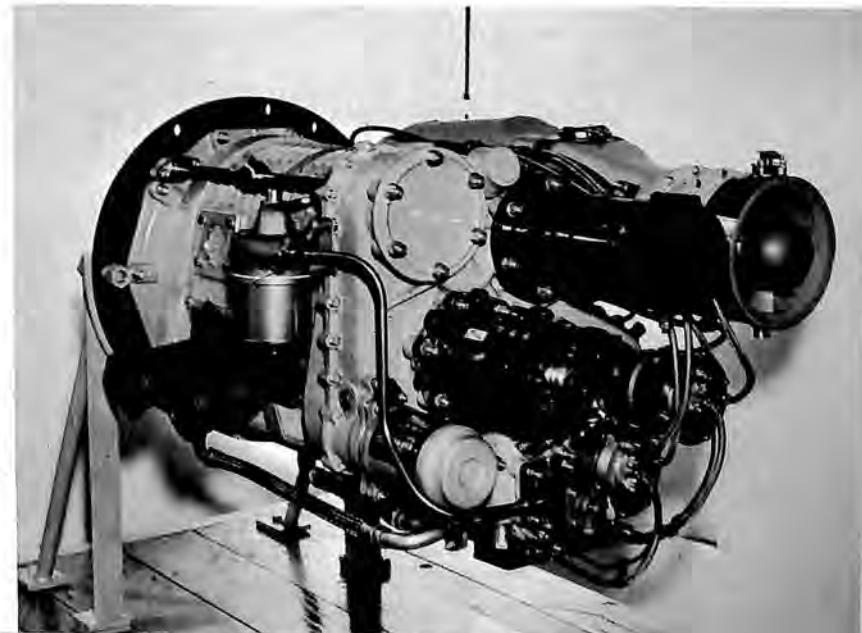
Length 32.4 inches; height 18 inches; width 20.7 inches; weight 278 pounds.

Performance

Takeoff rating 310 brake horsepower at 6,000 revolutions per minute.



R-313



ENGINES (PISTON)

H-63 ENGINES

Prime Contractor: Nelson Aircraft Corporation

Remarks

Nelson Aircraft Corporation produces to order the H-63, a 4-cylinder, 2-cycle air-cooled engine certified by the Federal Aviation Administration as a power plant for single-seat helicopters; it is also available for propeller-driven aircraft. Model H-63-C is the basic helicopter unit for vertical installation. Model H-63-CP (photo) is the same basic engine but without clutch, fan, and shroud; it is intended for installation in a horizontal position with direct drive to the propeller. In development is a new model which will weigh about 75 pounds and will have a propeller speed by reduction gear, a choice from 1,800 to 2,800 revolutions per minute.

Specifications

Weight 76 pounds (H-63-C), 68 pounds (H-63-CP); displacement 63 cubic inches; compression ratio 8:1; fuel grade 80/87.

Performance

H-63-C: takeoff rating 43 horsepower at 4,000 revolutions per minute, continuous same. H-63-CP: takeoff rating 48 horsepower at 4,400 revolutions per minute, continuous 45 horsepower at 4,000 revolutions per minute.



R1830 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

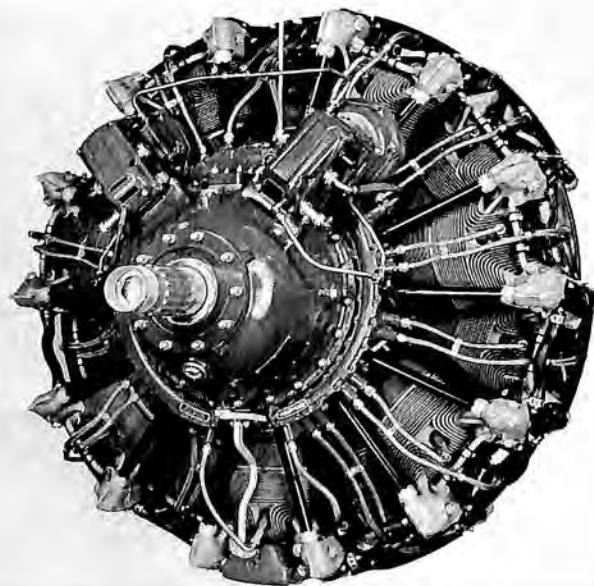
First installed in the famous Pan American Airways Martin China Clipper in the early 1930s, the R1830 Twin Wasp is a 14-cylinder, radial, air-cooled piston engine, now out of production but still in service. A 1,000-horsepower engine was installed in the Douglas DC-3 and the 1,200-horsepower version eventually powered most of the DC-3s. This engine, also the power plant for the Lockheed Lodestar and other aircraft, was manufactured in greater numbers than any other Pratt & Whitney model between 1932 and 1947.

Specifications (Model SIC3-G)

Length 61.16 inches; diameter 48.19 inches; bore 5.5 inches; stroke 5.5 inches; displacement 1,830 cubic inches; compression ratio 6.7:1; dry weight 1,467 pounds.

Performance

Rating 1,200 brake horsepower at 2,700 revolutions per minute.



R-314

R1340 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

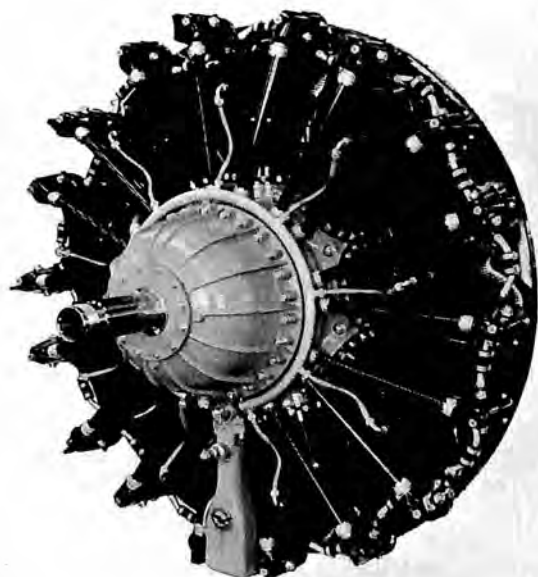
Still in use, the R1340 Wasp was produced in numerous configurations for 35 years—longer than any other Pratt & Whitney engine. It powered many military and commercial airplanes in aviation's pioneering days. Among the planes still flying with R1340 engines are the de Havilland Otter, the Grumman Mallard, and various helicopters.

Specifications (Model SIH1-G)

Length 47.8 inches; diameter 51.81 inches; dry weight 930 pounds.

Performance

Rating 600 brake horsepower at 2,250 revolutions per minute.

**R2000 RECIPROCATING ENGINE**

Prime Contractor: Pratt & Whitney Aircraft

Remarks

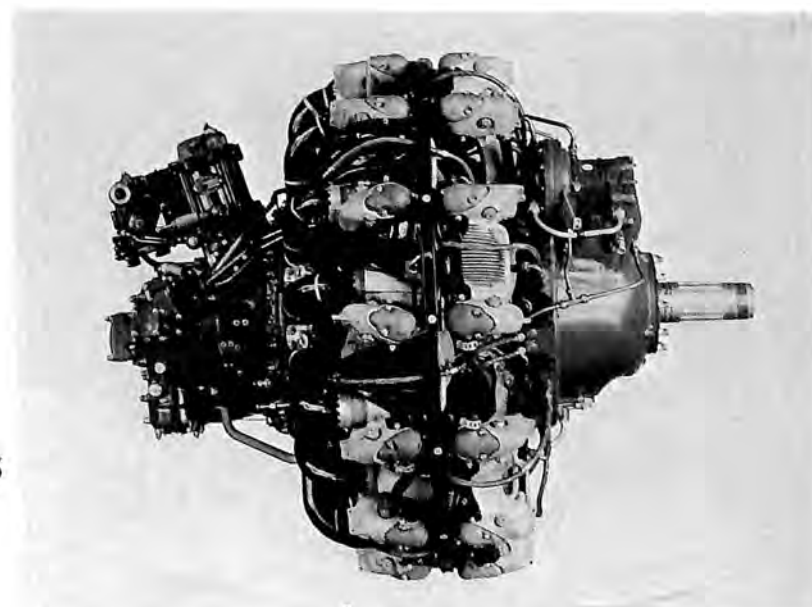
Out of production but still in use, the R2000 Twin Wasp is a 14-cylinder, radial, air-cooled piston engine. It powered the Douglas C-54 Skymaster, workhorse of World War II, the Berlin airlift, and the transpacific airlift supporting the Korean campaign. Presently in Vietnam, it powers the Air Force C-2A or de Havilland DHC-4A Caribou.

Specifications (Model 2SD13-G)

Length 59.66 inches; diameter 49.1 inches; bore 5.75 inches; stroke 5.5 inches; displacement 2,004 cubic inches; compression ratio 6.5:1; dry weight 1,605 pounds.

Performance

Rating 1,450 brake horsepower at 2,700 revolutions per minute.



R-315

R2800 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

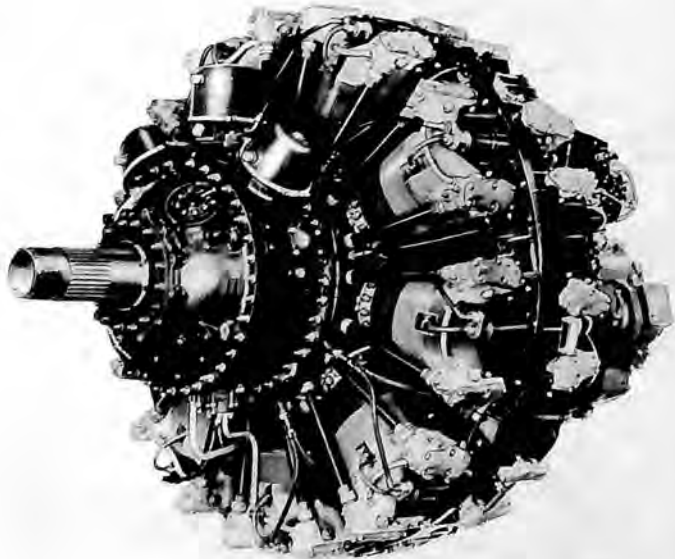
Still in military and commercial service, the R2800 Double Wasp is an 18-cylinder, radial, air-cooled piston engine which powered many military aircraft in World War II. Between 1939 and 1960, 125,443 of these engines were manufactured.

Specifications (Model CB16)

Length 81.4 inches; diameter 52.8 inches; bore 5.75 inches; stroke 6 inches; displacement 2,804 cubic inches; compression ratio 6.75:1; dry weight 2,390 pounds.

Performance

Rating 2,400 brake horsepower (with water injection) at 2,700 revolutions per minute.



R4360 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

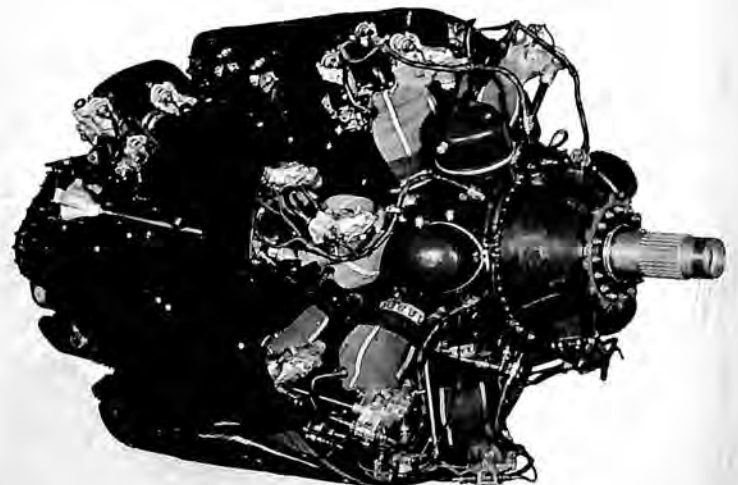
A 28-cylinder, radial, air-cooled piston engine, the R4360 was the most powerful engine of its type produced. It was developed during World War II and still powers the Boeing C-97, Fairchild C-119, and Douglas C-124 Globemaster transports and the Boeing 377 Stratoliner.

Specifications (Model B6)

Length 96.5 inches; diameter 55 inches; bore 5.75 inches; stroke 6 inches; displacement 4,363 cubic inches; compression ratio 6.7:1; dry weight 3,584 pounds.

Performance

Rating 3,500 brake horsepower (with water injection) at 2,700 revolutions per minute.



R-316



RJ-43-MA-3 MILITARY RAMJET

Prime Contractor: The Marquardt Company

Remarks

Developed for the Air Force, the RJ-43-MA-3 engine is a complete nacelle-type supersonic ramjet engine with a conical shock inlet. Cruise propulsion for the Boeing Bomarc A interceptor missile is provided by 2 of these ramjet engines.

Specifications

Length 173.4 inches; diameter 28.1 inches; conical spike; external compression ram inlet; weight 503 pounds; fuel 80/87.

Performance

Cruise thrust 1,650 pounds net jet; maximum thrust 7,500 pounds net jet.



RJ-43-MA-11 RAMJET

Prime Contractor: The Marquardt Company

Remarks

The RJ-43-MA-11, produced for the Air Force, is a complete nacelle-type supersonic ramjet engine with a high compression inlet spike. This engine (2 units) provides the cruise propulsion source for the Boeing Bomarc B interceptor missile.

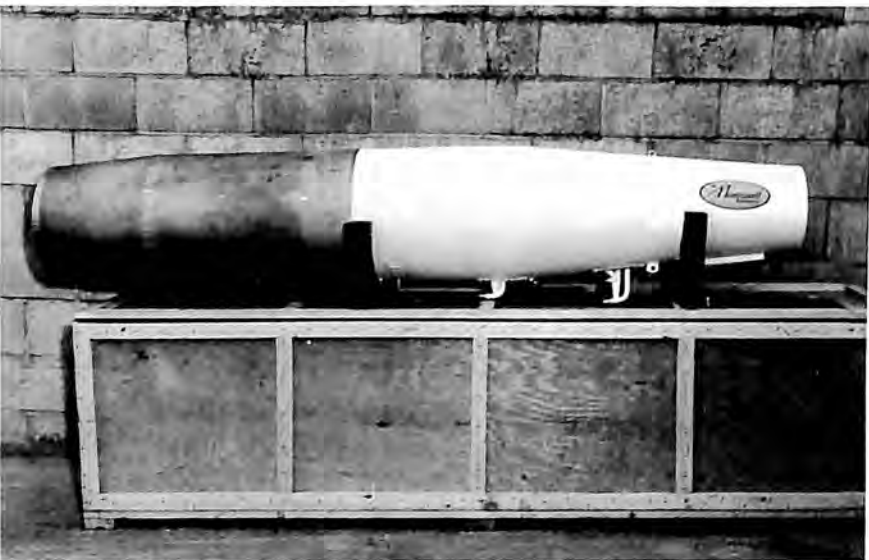
Specifications

Length 171.8 inches; diameter 28.1 inches; semi-isentropic spike, external compression ram inlet; weight 525 pounds; fuel JP-4.

Performance

Cruise thrust 1,685 pounds net jet; maximum thrust 13,300 pounds.

ENGINES (RAMJET)



MA74-ZAB RAMJET

Prime Contractor: The Marquardt Company

Remarks

Developed for Army use, the MA74-ZAB is a nacelle-type subsonic and supersonic ramjet engine with normal shock inlet. It is the cruise propulsion source for North American Rockwell's Roadrunner target missile system for low-altitude application.

Specifications

Length 90.7 inches; diameter 16.5 inches; weight 110 pounds; fuel JP-4; convergent sonic exit.

Performance

Thrust 1,790 pounds net jet.



MA150-XAA RAMJET

Prime Contractor: The Marquardt Company

Remarks

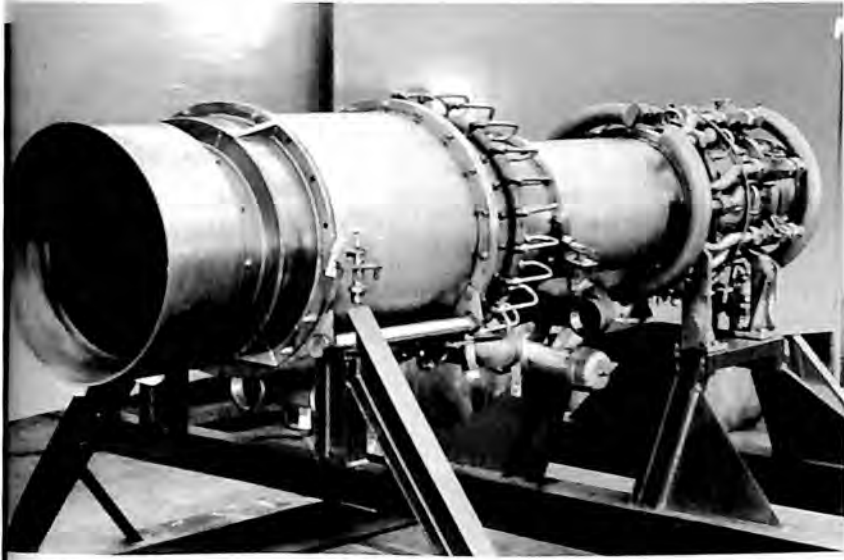
The MA150-XAA is a nacelle-type subsonic and supersonic ramjet engine with normal shock inlet. It provides the cruise propulsion for the Army's North American Rockwell Advanced Roadrunner target missile system for high- and low-altitude application.

Specifications

Length 104.5 inches; diameter 19 inches; weight 165 pounds; fuel JP-4; convergent sonic exit.

Performance

Thrust 2,300 pounds net jet at low altitude, 575 pounds net jet at high altitude.

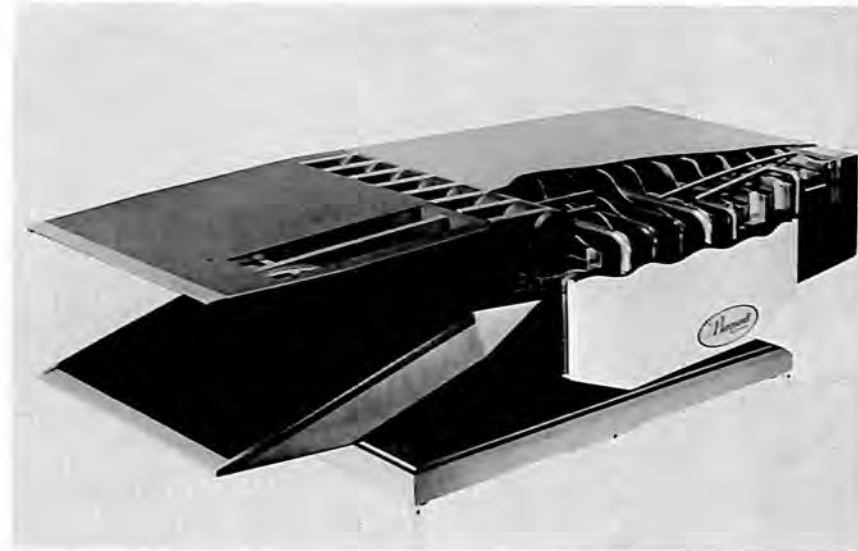


EJECTOR RAMJET

Prime Contractor: The Marquardt Company

Remarks

The ejector ramjet is a composite (rocket-ramjet) engine concept developed by Marquardt under Air Force sponsorship. It has potential application to missile propulsion, advanced high payload ratio orbital launch vehicles, and advanced next-generation aircraft. The engine concept combines rockets and ramjets into a simple, lightweight acceleration and cruise propulsion system which provides vehicle performance (1) superior to separate rockets and ramjets because of commonality of structure plus rocket thrust augmentation and (2) competitive with complex turbomachinery at hypersonic flight speeds.



SCRAMJET

Prime Contractor: The Marquardt Company

Remarks

Marquardt is developing a supersonic combustion ramjet for hypersonic acceleration and cruise performance. Applications include hypersonic cruise vehicles, recoverable launch vehicles, and defense and tactical missile systems.

ENGINES (TURBINE)



501-D13D COMMERCIAL TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

The 501-D13D is the power plant for the Convair 580, operating with 4 airlines, 14 corporations, the Federal Aviation Administration, the U.S. Air Force, and Canadian armed forces. A similar engine powers the Lockheed Electra.

Specifications

Length 145 inches; width 30 inches; height 43 inches; weight 1,756 pounds; compression ratio 9.25:1; compressor stages 14; turbine stages 4.

Performance

Rating 3,750 equivalent shaft horsepower.



250-C18 COMMERCIAL TURBOSHAFT

Prime Contractor: Allison Division of General Motors

Remarks

Model 250 powers the Bell JetRanger, the Fairchild Hiller FH-1100, and the Hughes 500 light helicopters.

Specifications

Length 40 inches; width 19 inches; height 22.5 inches; weight 139 pounds; compression ratio 6.2:1; compressor stages 6 axial, 1 centrifugal; turbine stages 4.

Performance

Rating 317 shaft horsepower.

250-C20 COMMERCIAL TURBOSHAFT

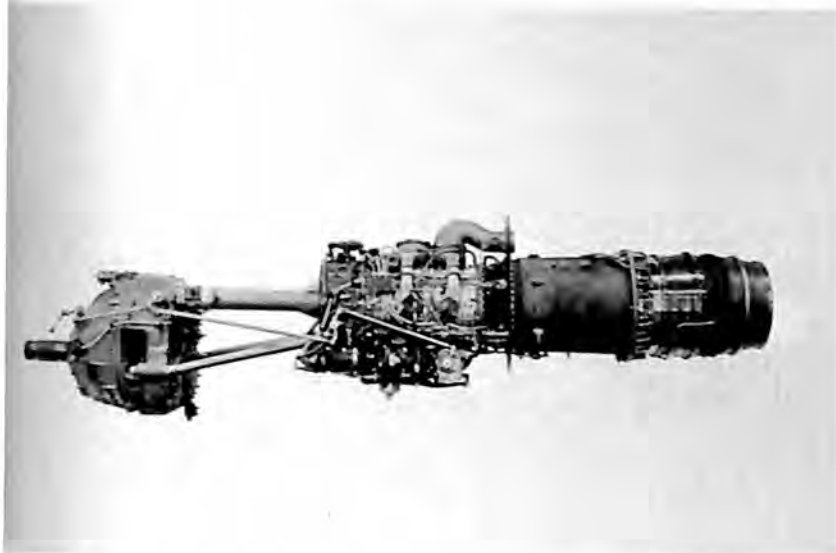
Prime Contractor: Allison Division of General Motors

Remarks

The 250-C20 is scheduled for production in early 1971 for light helicopters.

Performance

Rating 400 shaft horsepower.



501-D22 COMMERCIAL TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

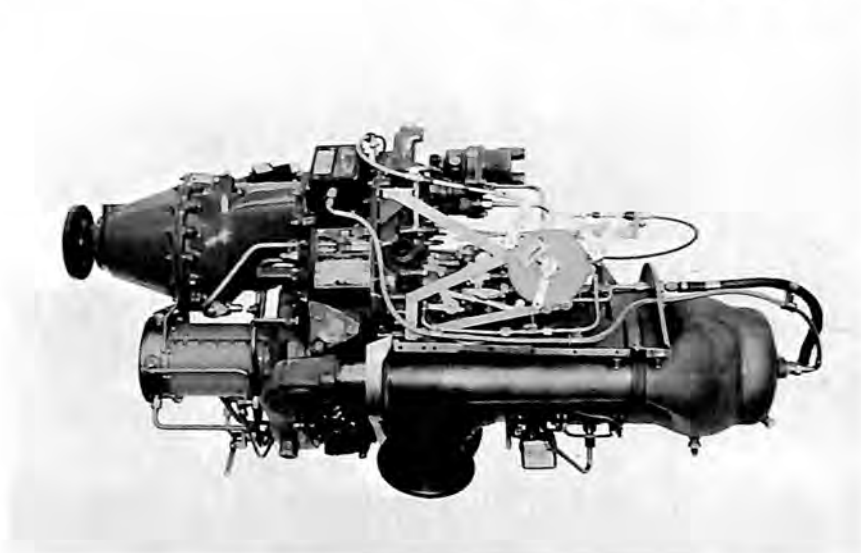
The 501-D22 turboprop engine powers the Lockheed 100, commercial version of the military Hercules.

Specifications

Length 146 inches; width 27 inches; height 39 inches; weight 1,833 pounds; compression ratio 9.55:1; compressor stages 14; turbine stages 4.

Performance

Rating 4,680 equivalent shaft horsepower.



250-B15 COMMERCIAL TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

The 250-B15 received its FAA Type Certificate in March 1969. It has been flight-proven in the Cessna 337, the Helio Courier, and the Siai Marchetti L1019.

Specifications

Length 44.5 inches; width 19 inches; height 22.5 inches; weight 144 pounds; compression ratio 6.2:1; compressor stages 6 axial, 1 centrifugal; turbine stages 4.

Performance

Rating 317 shaft horsepower.

250-B17 COMMERCIAL TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

The 250-B17 is scheduled for production in early 1971 for light single- and twin-engine aircraft.

Performance

Rating 400 shaft horsepower.

ENGINES (TURBINE)



T56-A-7 MILITARY TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

The T56-A-7 is a military engine operational in various versions of the Lockheed C-130 Hercules, serving the Air Force, the Navy, the Coast Guard, the Marine Corps, and the Military Airlift Command as well as the governments of 11 foreign nations. The T56-A-8 is used in the Grumman E-2A and C-2A aircraft.

Specifications

Length 146 inches; width 27 inches; height 39 inches; weight 1,833 pounds; compression ratio 9.55:1; compressor stages 14; turbine stages 4.

Performance

Rating 4,050 equivalent shaft horsepower.



T56-A-14 MILITARY TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

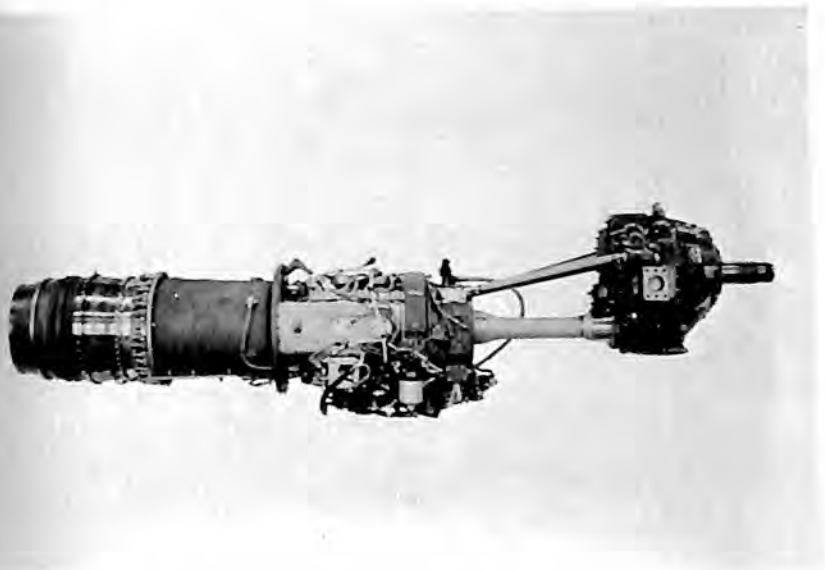
The T56-A-14 is a follow-on military engine for the Lockheed P-3 antisubmarine warfare plane.

Specifications

Length 146 inches; width 27 inches; height 44 inches; weight 1,885 pounds; compression ratio 9.55:1; compressor stages 14; turbine stages 4.

Performance

Rating 4,910 equivalent shaft horsepower.



T56-A-15 MILITARY TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

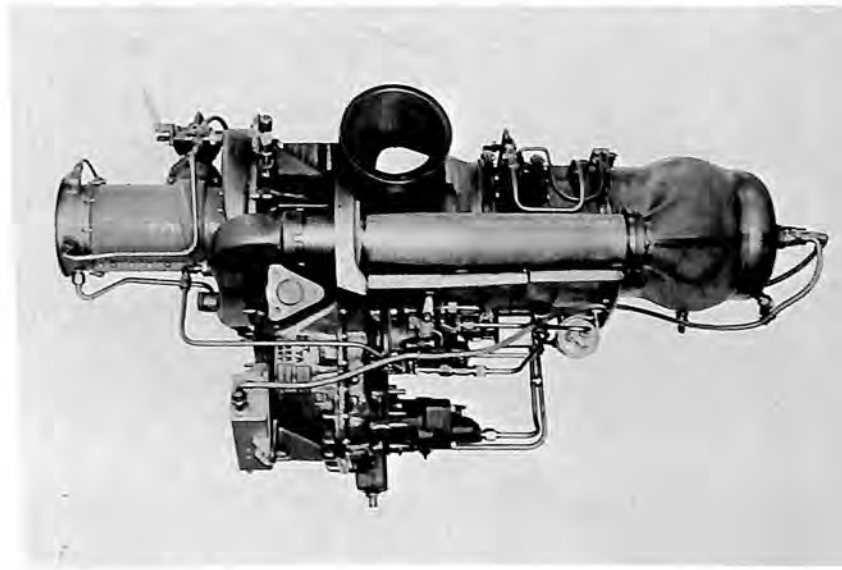
The T56-A-15 is in Air Force service as the power plant for the Lockheed HC-130H search, rescue, and recovery aircraft.

Specifications

Length 146 inches; width 27 inches; height 39 inches; weight 1,825 pounds; compression ratio 9.55:1; compressor stages 14; turbine stages 4.

Performance

Rating 4,910 equivalent shaft horsepower.



T63-A-5A MILITARY TURBOSHAFT

Prime Contractor: Allison Division of General Motors

Remarks

The T63-A-5A powers the Army OH-6A light observation helicopter.

Specifications

Length 40 inches; diameter 22.5 inches; weight 138 pounds; compression ratio 6.2:1; compressor stages 6 axial, 1 centrifugal; turbine stages 4.

Performance

Rating 317 shaft horsepower.

T63-A-700 MILITARY TURBOSHAFT

Prime Contractor: Allison Division of General Motors

Remarks

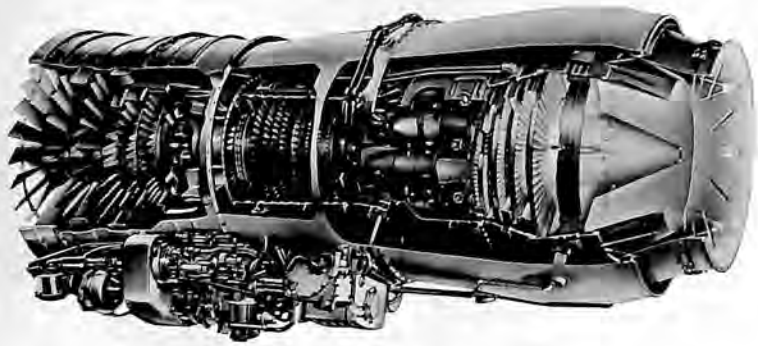
The T63-A-700 powers the Army OH-58A light observation helicopter.

Specifications

Length 40 inches; diameter 22.5 inches; weight 138 pounds; compression ratio 6.2:1; compressor stages 6 axial, 1 centrifugal; turbine stages 4.

Performance

Rating 317 shaft horsepower.



TF41 MILITARY TURBOFAN

Prime Contractor: Allison Division of General Motors

Remarks

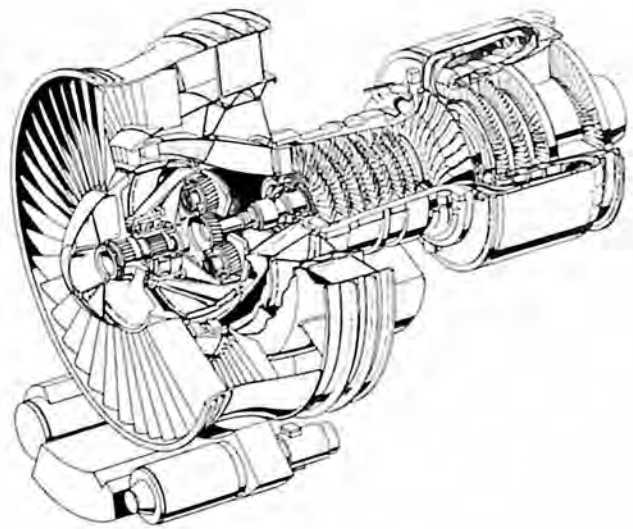
Allison undertook the TF41 development jointly with Rolls-Royce Ltd. The TF41-A-1 is in production for the U.S. Air Force A-7D close-support tactical fighter. The TF41-A-2 is an updated version with minor changes to accommodate Navy specifications. The Military Qualification Test for the TF41-A-2 was completed in July 1969; the engine is in production for the Navy A-7E Corsair carrier-based attack fighter.

Specifications

The TF41 is a 2-shaft turbofan with a 3-stage front fan, bypass, and 2-stage low-pressure compressor. It also incorporates an 11-stage high-pressure compressor, can-annular combustor, and 4-stage turbine. Length 106 inches (TF41-A-1).

Performance

Thrust 14,250 pounds (TF41-A-1), 15,000 pounds (TF41-A-2).



AVCO LYCOMING TURBOFAN

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

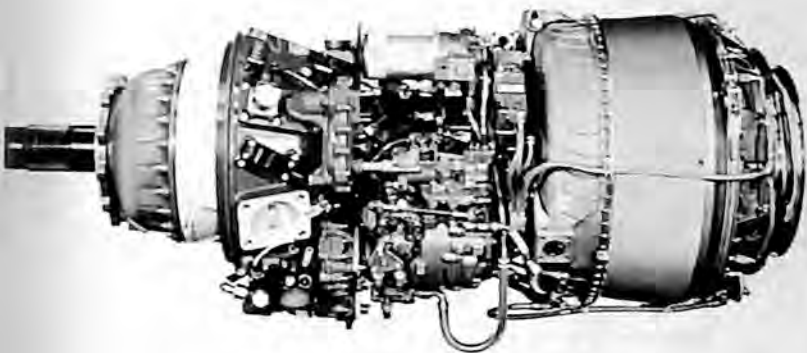
Avco Lycoming's gas turbine design philosophy centers about a "universal" concept which permits a basic power producer to be wed to a variety of output configurations. One significant result of this approach has been the development of a new series of turbofan engines in which a high bypass ratio fan has been mated to T53 and T55 power producers. The most obvious benefit of this concept is that these new turbofans feature an already proven core engine backed by millions of hours of operating experience. Thus the operator can be assured in advance of improved specific fuel consumption, low noise levels, high reliability, and low initial and operating costs. These new turbofans are ideally suited to both standard and steep gradient aircraft which require substantial operating economies and operate in the medium-altitude, Mach .8 and below range. Medium-size business jets and long-range patrol craft are potential applications. The series includes the ALF-301 and the ALF-501 (photo).

Specifications

ALF-301: length 50 inches; diameter 35.2 inches.
ALF-501: length 52.3 inches; diameter 43 inches.

Performance

ALF-301 (T5319A core engine): thrust 2,600 pounds; specific fuel consumption .45 pound per shaft horsepower per hour. ALF-501 (T55-L-11 core engine): thrust 5,800 pounds; specific fuel consumption .417 pound per shaft horsepower per hour.



T53 TURBOPROP GAS TURBINE ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

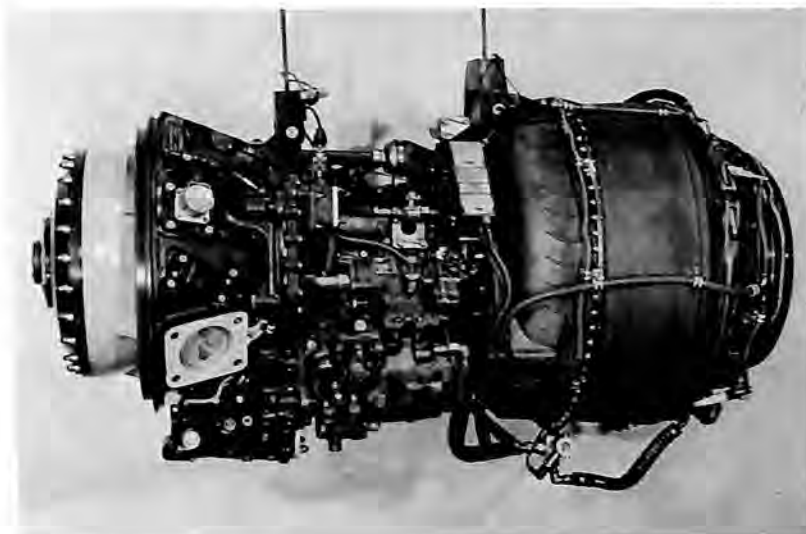
Turboprop versions of the T53 power the Army/Grumman OV-1 Mohawk STOL surveillance aircraft and the Swiss C3504 training and tow target aircraft. These engines are basically the same as the shaft versions except for the front-end gearing which mates the engine to a propeller. The 1,400-shaft-horsepower model, T53-L-701 (photo), is the latest military production configuration; it will be installed on advanced Mohawks. The ALP-101 is a new growth version rated at 1,800 shaft horsepower.

Specifications

Length 59 inches; diameter 23 inches; compressor stages 5 axial, 1 centrifugal; compressor turbines 2 (1 in L-7 version); power turbines 2 (1 in L-7 version).

Performance

ALP-101: 1,800 shaft horsepower; specific fuel consumption .57 pound per shaft horsepower per hour. T53-L-701: 1,400 shaft horsepower; specific fuel consumption .59 pound per shaft horsepower per hour. T53-L-15: 1,160 shaft horsepower (flat rated); specific fuel consumption .62 pound per shaft horsepower per hour. T53-L-7: 1,100 shaft horsepower; specific fuel consumption .69 pound per shaft horsepower per hour.



T53 TURBOSHAFT GAS TURBINE ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

Two newly developed, higher-rated models in the T53 series of gas turbine engines have been developed as growth versions of the T53-L-13, the Army's prime helicopter power plant. The more powerful version, T53-19A (photo), provides 28 percent more power with only a 24-pound weight increase and delivers a horsepower-to-weight ratio of 3.2. A second version, T53-17A, retains the T53-L-13 reduction gear and is flat rated at 1,500 shaft horsepower for exceptional hot day performance. T53 models power Army, Navy, and Air Force versions of the Bell UH-1 Huey tactical helicopter, the Army/Bell AH-1G attack helicopter, and the Air Force/Kaman HH-43 rescue helicopter. The engine also powers the commercial Bell Models 204 and 205. Two 1,500-shaft-horsepower T53s are installed on the Canadair CL-84 tilt-wing V/STOL.

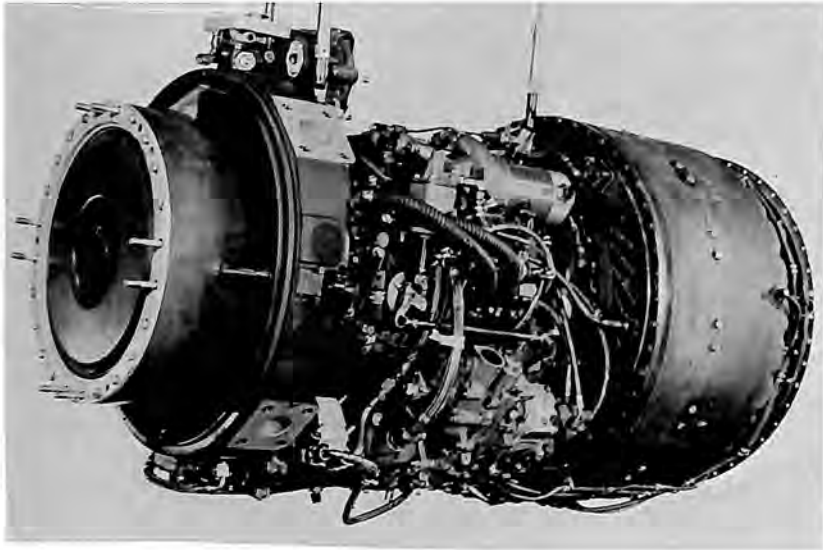
Specifications

Length 48 inches; diameter 23 inches; compressor stages 5 axial, 1 centrifugal; compressor turbines 2 (1 in L-11 version); power turbines 2 (1 in L-11 version).

Performance

T53-19A: 1,800 shaft horsepower; specific fuel consumption .57 pound per shaft horsepower per hour. T53-17A: 1,500 shaft horsepower (flat rated); specific fuel consumption .59 pound per shaft horsepower per hour. LTCIK-4C: 1,500 shaft horsepower; .58 pound per shaft horsepower per hour. T53-L-13: 1,400 shaft horsepower; specific fuel consumption .58 pound per shaft horsepower per hour. T53-L-11: 1,100 shaft horsepower; specific fuel consumption .68 pound per shaft horsepower per hour.

ENGINES (TURBINE)



T55 TURBOSHAFT GAS TURBINE ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

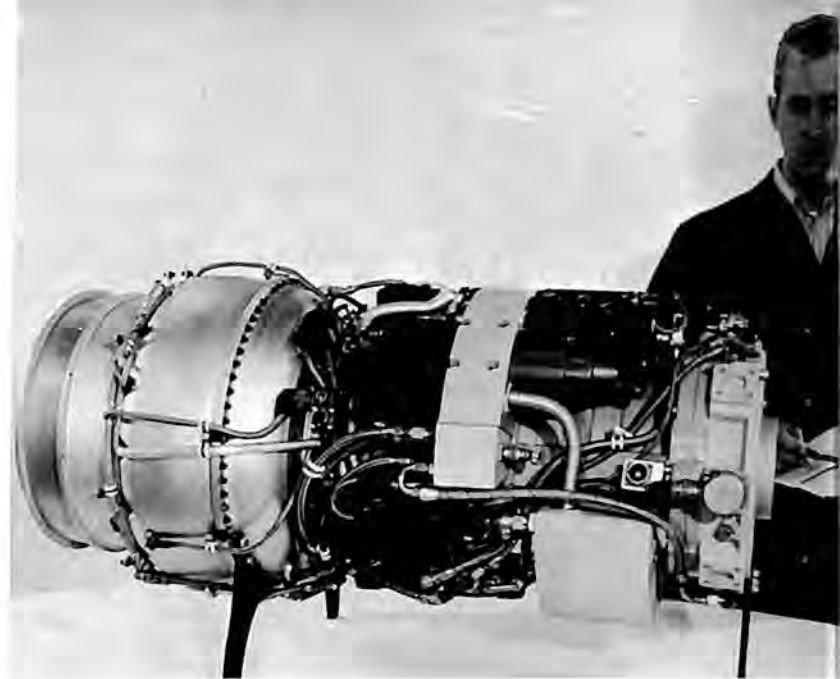
Continuing the proven design philosophy of the T53 series, the T55 series is the more powerful of Avco Lycoming's 2 families of gas turbine engines. Twin 3,750-shaft-horsepower T55-L-11s power the Army/Boeing-Vertol CH-47C Chinook medium transport helicopter, providing it with substantially increased payload and cruising speed. A growth version of the T55, LTC4B-12 (photo), has been developed with special application to power advanced close air support aircraft. The LTC4B-12, which develops 4,370 shaft horsepower on a hot day, provides a horsepower-to-weight ratio of over 6.4. Like the T53 series, all T55 models feature modular construction to minimize field maintenance downtime.

Specifications

Length 44 inches; diameter 24.25 inches; compressor stages 7 axial, 1 centrifugal; compressor turbines 2 (1 in L-7 version); power turbines 2.

Performance

LTC4B-12: 4,370 shaft horsepower (hot day rated); specific fuel consumption .504 pound per shaft horsepower per hour. T55-L-11: 3,750 shaft horsepower; specific fuel consumption .52 pound per shaft horsepower per hour. T55-L-7C: 2,850 shaft horsepower; specific fuel consumption .6 pound per shaft horsepower per hour.



ADVANCED-TECHNOLOGY TURBOSHAFTS

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

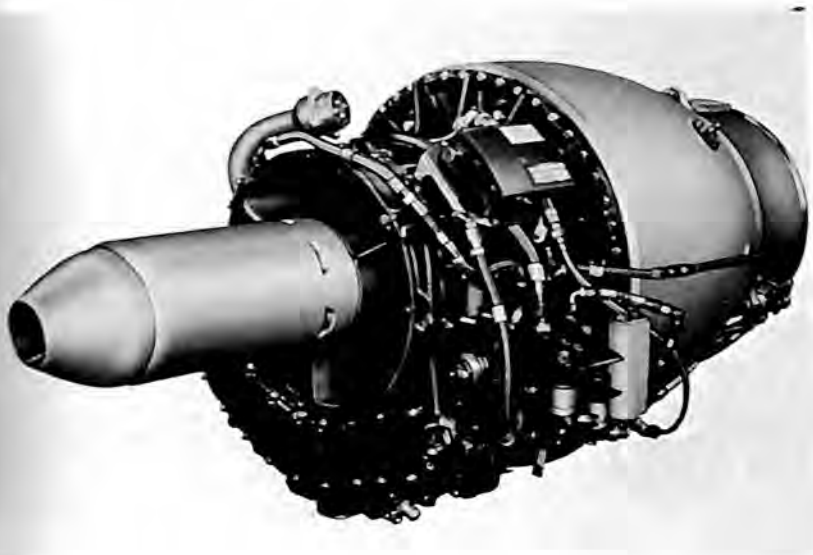
Two new advanced-technology engine models are being developed for VTOL, STOL, and V/STOL applications in the early 1970s. The Avco Lycoming PLT-27, developed to succeed the famed T53 series, is designed for application to UTTAS, commercial transports, and advanced V/STOLs. The LTC4V-1, successor to the T55 series, is designed for application to light transports, heavy logistics helicopters, compound helicopters, V/STOLs, and compound/convertible stowed rotorcraft.

Specifications

PLT-27: length 33.5 inches; diameter 16.9 inches; weight 280 pounds. LTC4V-1: length 41.32 inches; diameter 22 inches; weight 570 pounds.

Performance

PLT-27: 1,950 shaft horsepower. LTC4V-1: 5,000-plus shaft horsepower.



J69-T-25 TURBOJET

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

Current production installation: Cessna T-37 USAF jet trainer.

Specifications

Length 50 inches; diameter 22.3 inches; compression ratio 3.8:1; compression stages 1; turbine stages 1; weight 364 pounds.

Performance

Maximum thrust 1,025 pounds; normal rated thrust 880 pounds; specific fuel consumption 1.12; oil consumption .5 pound per hour.

J69-T-29 TURBOJET

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

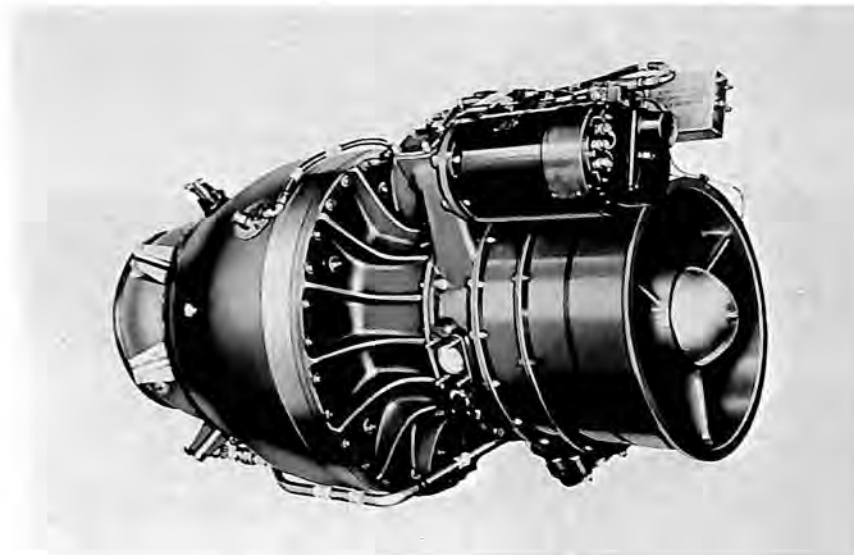
Current production installation is Ryan BQM-34A Firebee.

Specifications

Length 44.8 inches; diameter 22.3 inches; compression ratio 5.3:1; compression stages 2; turbine stages 1; weight 340 pounds.

Performance

Maximum thrust 1,700 pounds; normal rated thrust 1,375 pounds; specific fuel consumption 1.1; oil consumption 1 pound per hour.



J69-T-41A TURBOJET

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

Advanced drone application.

Specifications

Length 46 inches; diameter 22.3 inches; compression ratio 5.85:1; compressor stages 2; turbine stages 1; weight 350 pounds.

Performance

Thrust 1,920 pounds; specific fuel consumption 1.1.

J69-T-406 TURBOJET

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

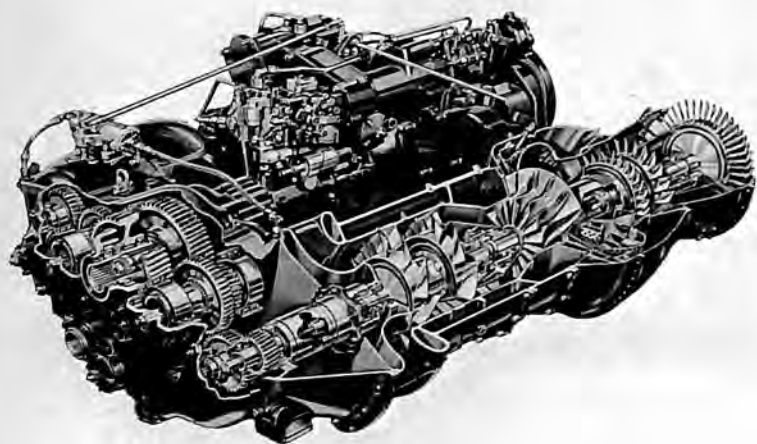
Current production installation is the BQM-34E drone.

Specifications

Weight 360 pounds; compression ratio 5.5:1.

Performance

Thrust 1,920 pounds military rating, 1,719 pounds normal; airflow 30.5 pounds per second; specific fuel consumption 1.1.



T67-T-1 TWIN TURBOSHAFT

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

Featuring 2 independent engines combined with automatic power-sharing system, the T67-T-1 has been flight tested in a UH-1D helicopter.

Specifications

Length 52 inches; 21 inches high by 38 inches wide; compression ratio 7.5:1; compression stages 3 per engine; turbine stages 2 gas generator plus 1 power turbine per engine; weight 540 pounds.

Performance

1,700 shaft horsepower maximum, 1,540 continuous; specific fuel consumption .55.

J100-CA-100 TURBOJET

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

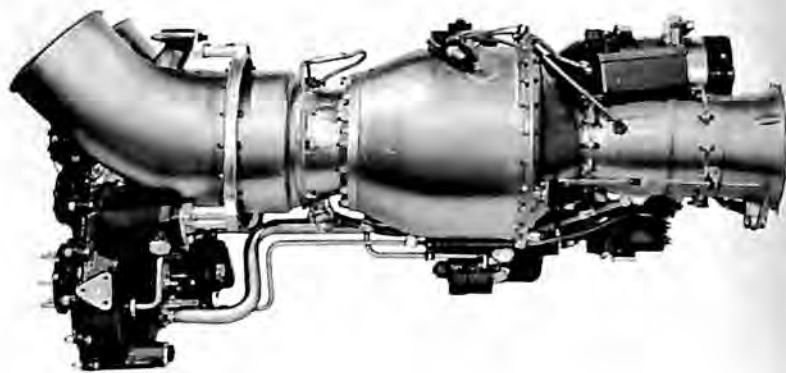
The J100-CA-100 turbojet is a rugged, dependable engine intended for propulsion of unmanned aircraft. It has a 2-stage transonic axial compressor plus a single-stage centrifugal compressor.

Specifications

Weight 430 pounds; compression ratio 6.3:1.

Performance

Thrust 2,700 pounds; airflow 44.5 pounds per second; specific fuel consumption 1.1; operational altitude 75,000 feet.



T65-T-1 TURBOSHAFT

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

Commercial Model TS325-1, FAA Type Certificate Number E6CE.

Specifications

Length 34.2 inches; diameter 18.3 inches; compression ratio 6:1; compression stages 2; turbine stages 2 gas generator plus 1 power turbine; weight 136 pounds.

Performance

310 shaft horsepower at .67 specific fuel consumption.



TS120-G6 TURBOSHAFT

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

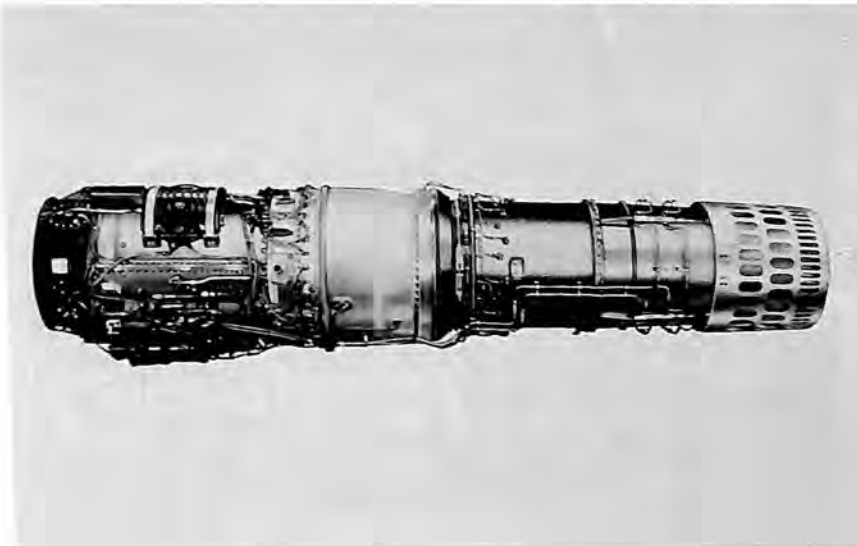
Model TS120 industrial gas turbine engine is being developed under contract to U.S. Army Mobility Equipment Research & Development Center.

Specifications

Length 29.2 inches; 29.8 inches wide by 21.6 inches high; compression ratio 5.6:1; compression stages 2; turbine stages 1; weight 215 pounds.

Performance

180 shaft horsepower at .65 specific fuel consumption.



J65-W-16A ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

The J65-W-16, used by the military in the A-4A, A-4B, A-4C series aircraft, is a single-spool, axial-flow, compressor-type jet power plant.

Specifications

Length 108 inches; diameter 37.5 inches; weight 2,757 pounds; fuel JP-4.

Performance

Takeoff rating at sea level 7,700 pounds thrust.

J65-W-7 ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

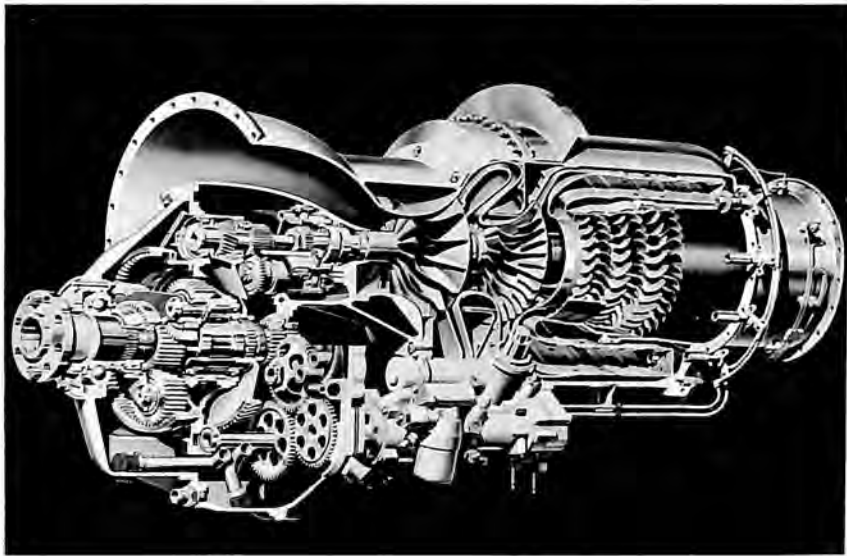
The J65-W-7, used by the military in the F/RF-84F aircraft, is a single-spool, axial-flow, compressor-type jet power plant.

Specifications

Dry weight 2,795 pounds; length 115 inches; diameter 37.5 inches; fuel JP-4.

Performance

Takeoff power at sea level 7,800 pounds thrust.



T76 MILITARY TURBOPROP

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Company of Arizona

Remarks

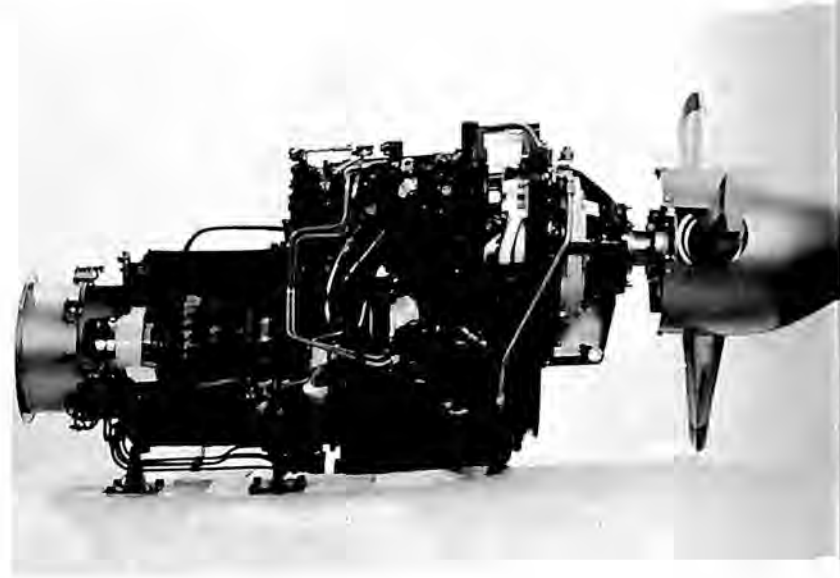
The AiResearch T76 military turboprop engine powers the North American Rockwell OV-10A aircraft, in service with Air Force and Marine Corps units. Among the features of this engine are opposite counterrotation props for twin-engine installations, immediate response to load requirements, and rapid reverse thrust.

Specifications

Length 44.5 inches; width 19.25 inches; height 27 inches; weight 336 pounds; compressor 2-stage centrifugal; turbine 3-stage axial.

Performance

715 shaft horsepower; specific fuel consumption .6 pound per shaft horsepower per hour; power-to-weight ratio 2.13.



TPE 331 COMMERCIAL TURBOPROP

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Company of Arizona

Remarks

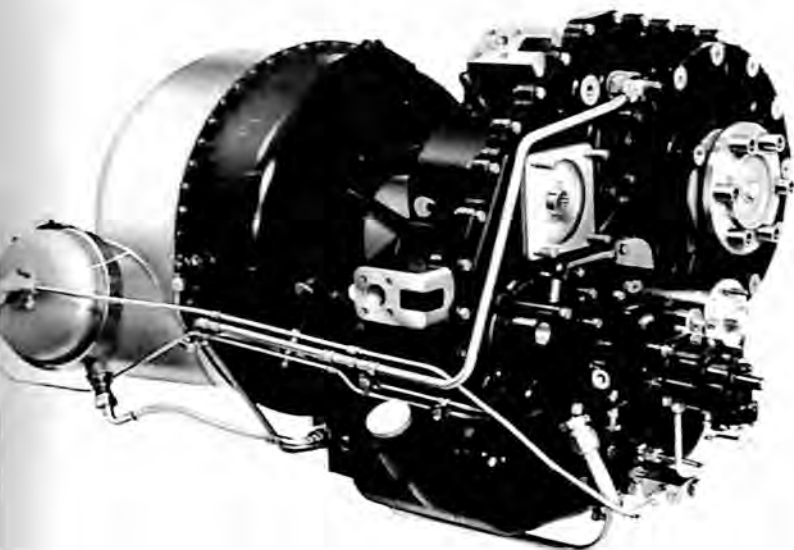
The Garrett-AiResearch TPE 331 commercial turboprop engine powers 17 different models of military and commercial aircraft in service throughout the world. The military aircraft are the Handley Page Jetstream C-10A and the Argentinian AX-2 COIN aircraft. Commercial aircraft are the Swearingen/Fairchild FS-226 Metro, the Short Brothers Skyvan, the Mitsubishi MU-2, the Pilatus Turbo Porter, the Swearingen Merlin IIB, the Volpar Turboliner, the Carstedt Jetliner, the Conroy Stolifter, the Interceptor 400, the Fairchild Hiller Porter, the Aero Commander Turbo Commander and Hawk, the Volpar Super Turbo 18, the Air Parts FU-24, and the Turbo-Beaver DHC 2.

Specifications

Dimensions vary with model: length from 42.69 inches to 46.01 inches, width from 19.3 inches to 21.18 inches, height from 25.85 inches to 27.07 inches; weight from 331 to 343 pounds; compressor 2-stage centrifugal; turbine 3-stage axial.

Performance

575 shaft horsepower (TPE 331 series), 665 shaft horsepower (TPE 331-1 series), 715 shaft horsepower (TPE 331-2 series), 840 shaft horsepower (TPE 331-3 series); optimum specific fuel consumption from .588 to .665 pound per shaft horsepower per hour; power-to-weight ratio from 1.98 to 2.45.



TSE 36 COMMERCIAL TURBOSHAFT

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Company of Arizona

Remarks

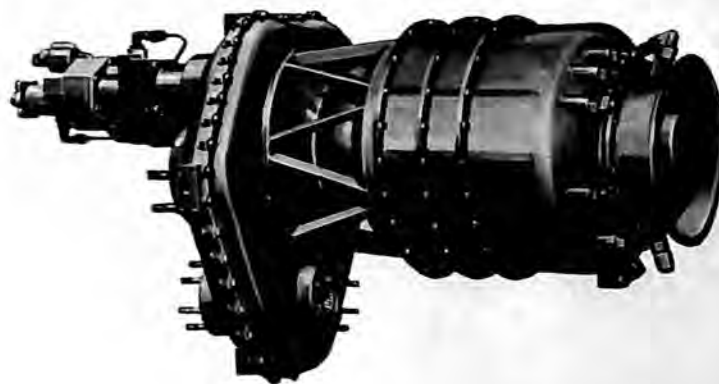
The Garrett-AiResearch TSE 36 commercial turboshaft engine powers 2 new light helicopters, the Enstrom T-28 and the Verticraft VC-1.

Specifications

Length 30.2 inches; width 27 inches; height 21 inches; weight 178 pounds; single-stage, single-entry centrifugal compressor; single-stage, radial-inflow turbine.

Performance

240 shaft horsepower; specific fuel consumption .83 pound per shaft horsepower per hour; power-to-weight ratio 1.35.



TSE 231 COMMERCIAL TURBOSHAFT

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Company of Arizona

Remarks

The Garrett-AiResearch TSE 231 commercial turboshaft engine will power the new Gates Twinjet helicopter.

Specifications

Length 41 inches; width 20.8 inches; height 22.93 inches; weight 174 pounds; free turbine engine with the power turbine gas coupled to the gas generator; straight-through airflow design.

Performance

474 shaft horsepower; specific fuel consumption .605 pound per shaft horsepower per hour; power-to-weight ratio 2.73.

ENGINES (TURBINE)



TFE 731 COMMERCIAL TURBOFAN

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Company of Arizona

Remarks

The Garrett-AiResearch TFE 731 will be available on the Learjet 25 and the Swearingen SA-28T in 1972.

Specifications

Length 54.4 inches; width 32.6 inches; height 38.3 inches; weight 620 pounds; 2-spool geared front fan engine will enable 6- to 10-place aircraft to fly non-stop across the United States.

Performance

Thrust 3,406 pounds; specific fuel consumption .49 pound per pound thrust per hour; power-to-weight ratio 5.7.



ATF 3 COMMERCIAL TURBOFAN

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Company of Los Angeles

Remarks

The Garrett-AiResearch ATF 3 will be available on the North American Rockwell Series 60 Sabreliner in 1971.

Specifications

Length 95 inches; width 32 inches; height 32 inches; weight 800 to 850 pounds; first 3-shaft gas generator engine to be tested in the United States will enable 10- to 12-place aircraft to fly nonstop coast to coast at high subsonic speeds.

Performance

Thrust 4,000 to 5,000 pounds; specific fuel consumption .44 pound per pound thrust per hour; power-to-weight ratio 4.7.



J79 MILITARY TURBOJET

Prime Contractor: General Electric Company

Remarks

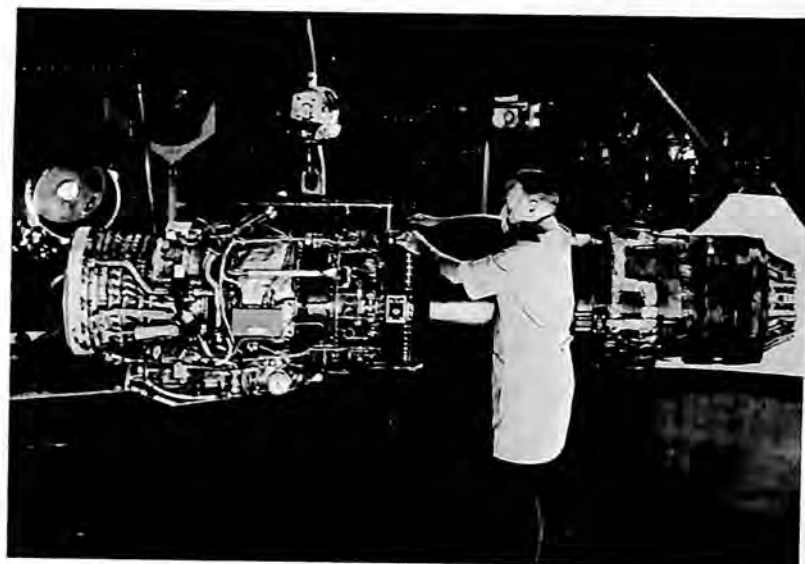
A military turbojet engine, the J79 is widely used on Air Force, Navy, and NATO aircraft, including the Lockheed F-104, the Convair B-58, the North American Rockwell RA-5C, and the McDonnell Douglas F-4 Phantom. Current production models are the J79-10, J79-17, and J79-19.

Specifications

Length 208.69 inches; diameter 39.6 inches; weight 3,800 pounds; compressor stages 17; turbine stages 3.

Performance

Thrust with afterburner 17,900 pounds.



J85 MILITARY AFTERBURNING TURBOJET

Prime Contractor: General Electric Company

Remarks

Featuring a higher thrust-to-weight ratio than any other production turbojet in its class, the afterburning J85 provides added aircraft speed capabilities with minimum weight and frontal area penalties. The fully modulating variable exhaust nozzle permits optimum nozzle area over the entire operating envelope. Current applications include the Northrop supersonic T-38, F-5, and CF-5 and the Fiat G.91Y fighter aircraft. The J85-21 (photo), 5,000-pound-thrust higher airflow version, evolved as a result of the extensive flight experience of the J85-5, -13, -15 power plants and the successful component development of a 9-stage variable-stator compressor. By late 1969, the -21 had completed 125 flight-test hours in a modified F-5A aircraft and was expected to be available in 1970.

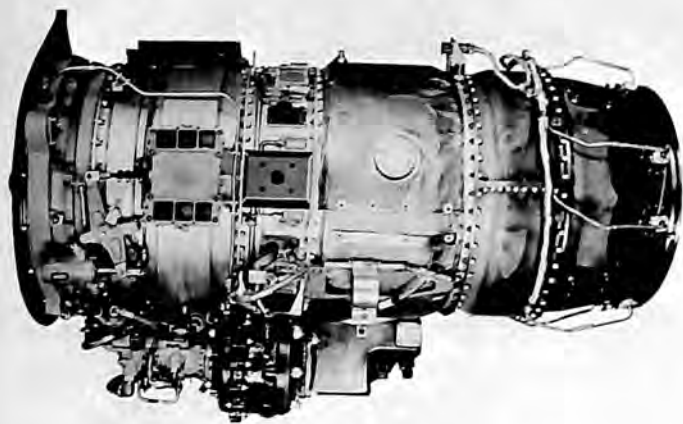
Specifications

Compressor stages 8 (9 stages in J85-21); annular combustor; turbine stages 2; length 112.5 inches (-21), 104.6 inches (-5), 105.6 inches (-13, -15); maximum diameter 21 inches (all models); weight 670 pounds (-21), 584 pounds (-5), 597 pounds (-13), 615 pounds (-15); thrust-to-weight ratio 7.5 (-21), 6.6 (-5), 6.8 (-13), 7 (-15).

Performance

Maximum thrust 5,000 pounds (-21), 3,850 pounds (-5), 4,080 pounds (-13), 4,300 pounds (-15).

ENGINES (TURBINE)



J85 NON-AFTERBURNING TURBOJET

Prime Contractor: General Electric Company

Remarks

The dry J85 turbojet is a compact, lightweight design which makes an ideal power plant for transports, trainers, fighters, VTOL aircraft, missiles, and takeoff boost applications. This engine provides power for the SAAB 105, the North American T-2C and OV-10Z, the Canadair CL-41G, the Cessna A-37B, the McDonnell Douglas ADM-20, the GE/Ryan XV-5B, the Bell X-14A, and the Fairchild Hiller AC-119K and C-123K aircraft. There are 2 versions, J85-4 and J85-17.

Specifications

Compressor stages 8; annular combustor; turbine stages 2; length 40.5 inches; maximum diameter 17.7 inches; weight 404 pounds (-4), 398 pounds (-17); thrust-to-weight ratio 7.3 (-4), 7.2 (-17).

Performance

Maximum military thrust 2,950 pounds (-4), 2,850 pounds (-17).



TF39 MILITARY TURBOFAN

Prime Contractor: General Electric Company

Remarks

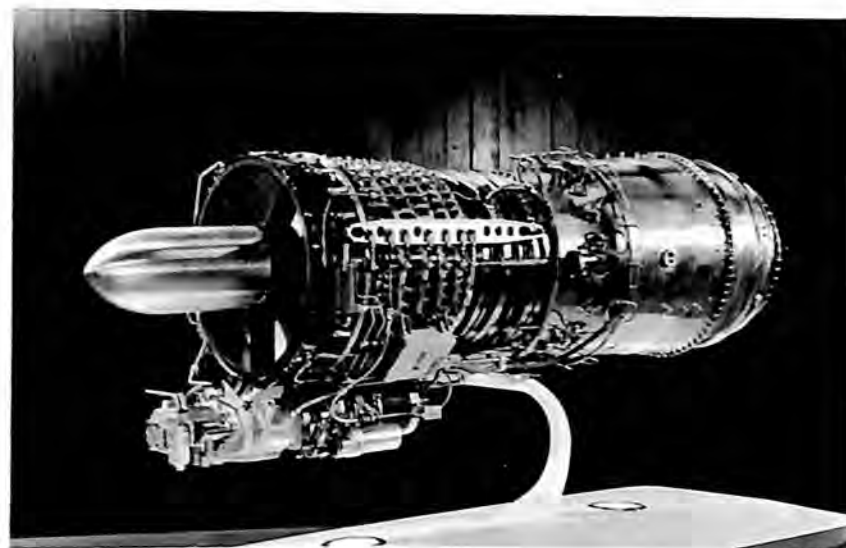
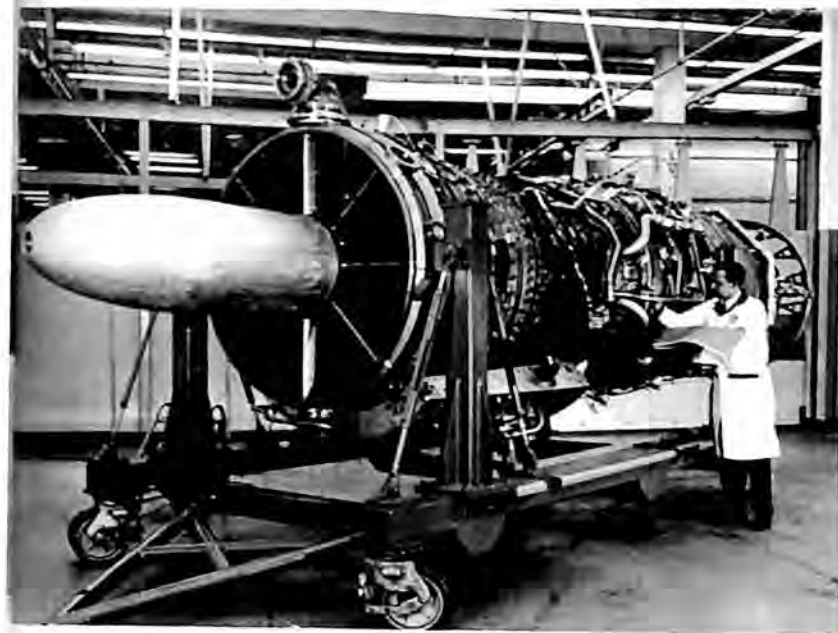
The TF39 is a high bypass ratio turbofan powering the Air Force/Lockheed C-5 heavy logistics transport over exceptionally long distances. Engine parts are designed for unusually long life.

Specifications

Length 189.5 inches; maximum diameter 100 inches; thrust-to-weight ratio 5.85:1 plus; bypass ratio in the 8:1 class; pressure ratio at cruise altitude in the 25:1 class.

Performance

Maximum thrust 41,100 pounds.



GE4 COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

The GE4 is the augmented turbojet engine which will power the U.S. supersonic transport. The GE4 incorporates proven design features of the J79 and YJ93 engines as well as advanced technology. Full-scale engine testing began in mid-1966 and is continuing along with major component testing. Several hours of Mach 2.7 cruise operation have been completed in an altitude test facility.

Specifications

Length 296 inches; inlet diameter 63.2 inches; maximum exhaust nozzle diameter 90 inches; weight 11,300 pounds; fuel commercial aviation kerosene.

Performance

Takeoff thrust 67,000 pounds.

GE1 MILITARY/COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

The GE1 building-block approach provides for one gas generator as the basis of a family of advanced propulsion systems. Building-block components—turbofans, afterburners, thrust vectoring devices—are added to the GE1 gas generator to provide performance and configurations tailored to specific aircraft missions and designs. The GE1 features application versatility, time and cost savings, and hardware standardization.

Specifications

The GE1, as compared with the earlier J47 engine, represents a 51 percent reduction in length and 79 percent reduction in volume, with reduced weight and fuel consumption.

Performance

The GE1 is in the same thrust class as the J47 and has a versatility of thrust size spanning a range of almost 6 times the basic gas generator thrust.

ENGINES (TURBINE)



CF700 COMMERCIAL TURBOFAN

Prime Contractor: General Electric Company

Remarks

An aft-fan version of the J85/CJ610 turbojet family, the CF700 has been in service since 1965. Applications include the Fan Jet Falcon 10-passenger business jet aircraft. It is used also in the Bell lunar landing training vehicle to equalize the forces of gravity and rockets for pilot control movements.

Specifications (CF700-2D)

Length 53.6 inches; fan diameter 33.1 inches; weight 725 pounds; compressor stages 8, axial flow; turbine stages 2, axial flow.

Performance

Takeoff thrust 4,250 pounds; maximum continuous thrust 4,120 pounds.

CJ610 COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

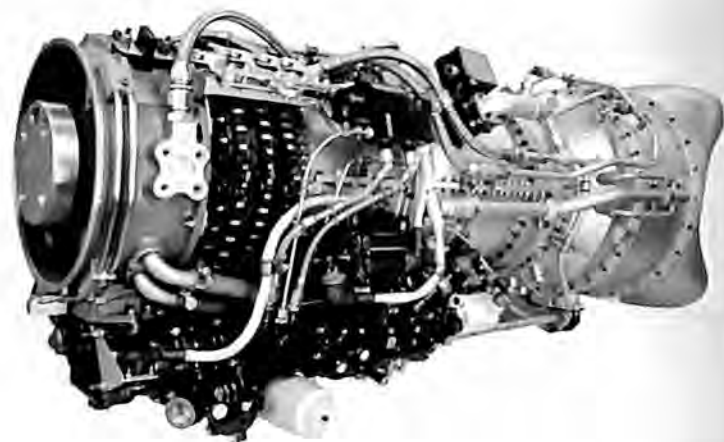
The CJ610, a derivative of the J85 turbojet, has been produced in 4 configurations. Twin CJ610 engines power the Commodore Jet, the Hansa Jet, and the Learjet business aircraft.

Specifications (CJ610-6)

Length 51.1 inches; flange diameter 17.7 inches; weight 392 pounds; thrust-to-weight ratio 7.5:1; compressor stages 8; turbine stages 2.

Performance

Takeoff thrust 2,950 pounds.



T58 MILITARY TURBOSHAFT

Prime Contractor: General Electric Company

Remarks

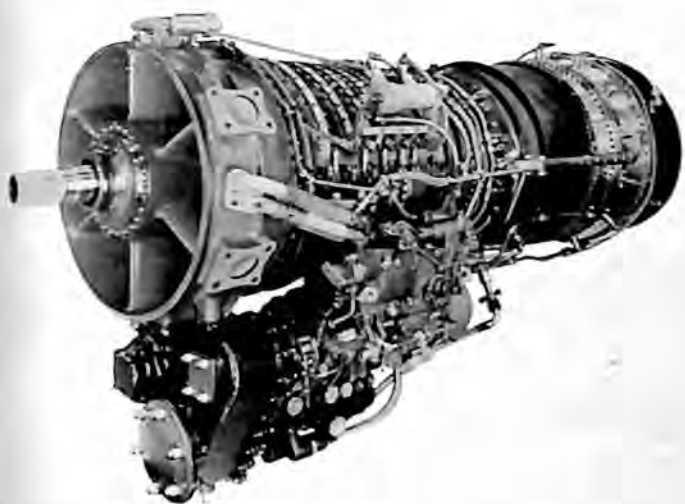
The T58 turboshaft engine is produced in several configurations for a wide variety of helicopters and VTOL aircraft. Applications include the Sikorsky SH-3A/D, CH-3C/E, HH-52A, and HH-3E/F, the Boeing-Vertol CH/UH-46A/D, the Kaman UH-2A/B/C, the Bell Helicopter UH-1F, the Agusta Bell 204B, and the Bell Aerospace X-22A. Engine models currently in service are T58-1, -3, -5, -8, and -10; a higher-rated version, the T58-16, is under development.

Specifications

The T58 engine employs a 10-stage axial-flow compressor with variable-geometry stator, annular combustor, 2-stage gas generator turbine, and 1-stage (free) power turbine; length 59 inches; diameter 21 inches; weight 340 pounds. The T58-16 engine utilizes the same compressor and combustor and employs air-cooled gas generator turbine and 2-stage (free) power turbine; length 64 inches; diameter 24 inches; weight 440 pounds.

Performance

1,300 to 1,500 shaft horsepower (in-service models), 1,870 shaft horsepower (T58-16).



T64 MILITARY TURBOSHAFT/TURBOPROP

Prime Contractor: General Electric Company

Remarks

The T64 is a free turbine power plant for helicopter and V/STOL aircraft. Produced in turboprop and turboshaft configurations, major design considerations were low fuel consumption, high reliability, ease of maintenance, and growth potential. Initial models produced up to 2,850 shaft horsepower; as a result of growth development, current production engines are rated to 3,925 shaft horsepower. Applications include the Sikorsky CH-53A/C/D and HH-53B/C, the Lockheed AH-56A, the de Havilland Buffalo, the Fiat G.222, the Kawasaki P2-J, the Shin Meiwa PS-1, the Ling-Temco-Vought XC-142A, and the VFW VC-400.

Specifications

The basic engine consists of a 14-stage axial-flow compressor, through-flow annular combustor, 2-stage gas generator turbine, and 2-stage axial-flow power turbine. Power output is provided by an axial forward extending drive shaft. Addition of a planetary speed decreaser gear allows creation of a turboprop configuration with a centerline above or below the engine centerline. The T64-16 is 68 inches long; maximum diameter 20.1 inches; horsepower-to-weight ratio 4.9; weight 700 pounds.

Performance

Maximum 3,080 shaft horsepower (T64-3), maximum 2,850 shaft horsepower (T64-6), flat rated to 3,370 shaft horsepower at 92 degrees Fahrenheit (T64-16), 3,925 shaft horsepower (T64-7, -413), takeoff 3,060 equivalent shaft horsepower (CT64-820-1/-2).



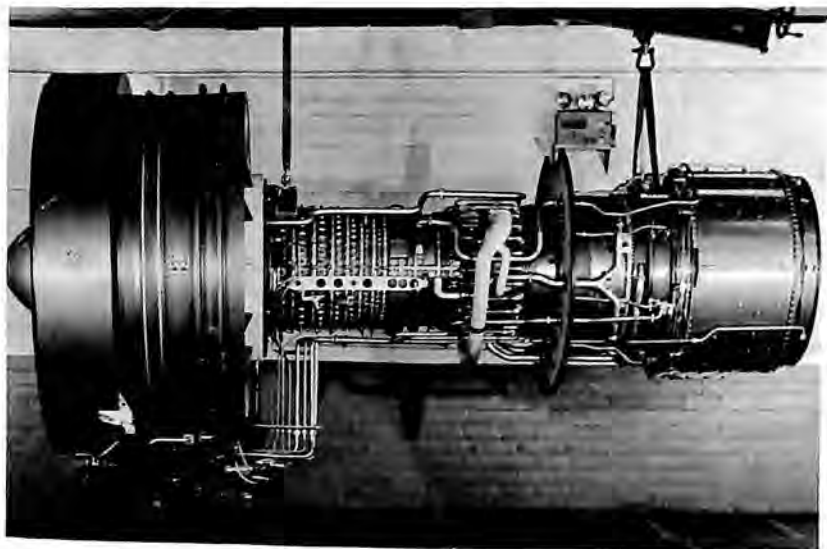
TF34 HIGH BYPASS TURBOFAN

Prime Contractor: General Electric Company

Remarks

The TF34-GE-2, a new General Electric high bypass ratio turbofan, is under development for the Navy/Lockheed S-3A (VSX) antisubmarine warfare aircraft. The engine provides low specific fuel consumption over a broad operating range and utilizes a variable stator compressor, annular combustor, and air-cooled turbine, features which have proved so successful on other GE engines.

ENGINES (TURBINE)



CF6 COMMERCIAL TURBOFAN

Prime Contractor: General Electric Company

Remarks

The CF6 engine is an advanced-technology, high bypass turbofan selected to power domestic and intercontinental versions of the DC-10 trijet. Two basic engines are being developed, the CF6-6 for the DC-10 Series 10 and the CF6-50A for the DC-10 Series 30. Both engines have built-in growth capability for increased thrust without change in external configuration or major internal rework. The engines are very similar in design, sharing the same front fan, compressor, annular combustor, 2-stage high-pressure turbine, and 5-stage low-pressure turbine. However, the CF6-6 employs a single set of booster stages to supercharge the core engine while the CF6-50A uses 3 sets of booster stages and a bypass valve system. Both engines are designed to meet stringent commercial standards of long life and reliability, easy maintenance, very low specific fuel consumption, low sound levels, and no visible smoke. The CF6-6 is being manufactured and will be available for 1971 deliveries; the CF6-50A will be available for delivery in 1973.

Specifications

Length 172.5 inches; diameter 92 inches; weight 7,350 pounds (CF6-6), 8,100 pounds (CF6-50A).

Performance

Takeoff thrust 40,000 pounds (CF6-6), 49,000 pounds (CF6-50A).



CJ805-3 COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

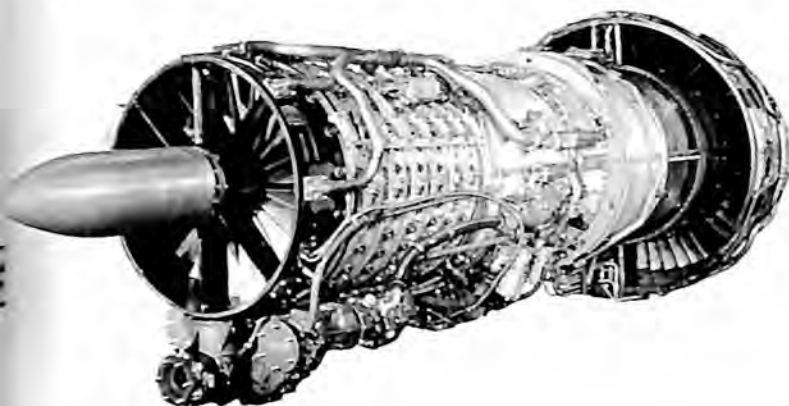
The CJ805-3 turbojet is a single-rotor compressor and turbine engine which features split compressor, combustion, and turbine casings for easy access and maintenance. Its conical construction reduces engine weight and assures optimum strength-to-weight ratio. Other features include variable stators, hydro-mechanical externally mounted control systems, and single-rotor compressor and turbine requiring only 3 main bearings. Following an extensive testing program, the CJ805-3 entered commercial airline service in May 1960; it is in service with 6 operators.

Specifications

Length 110.4 inches (engine only); maximum diameter 31.6 inches; engine weight 2,817 pounds.

Performance

Takeoff thrust 11,650 pounds.



CJ805-23 COMMERCIAL TURBOFAN

Prime Contractor: General Electric Company

Remarks

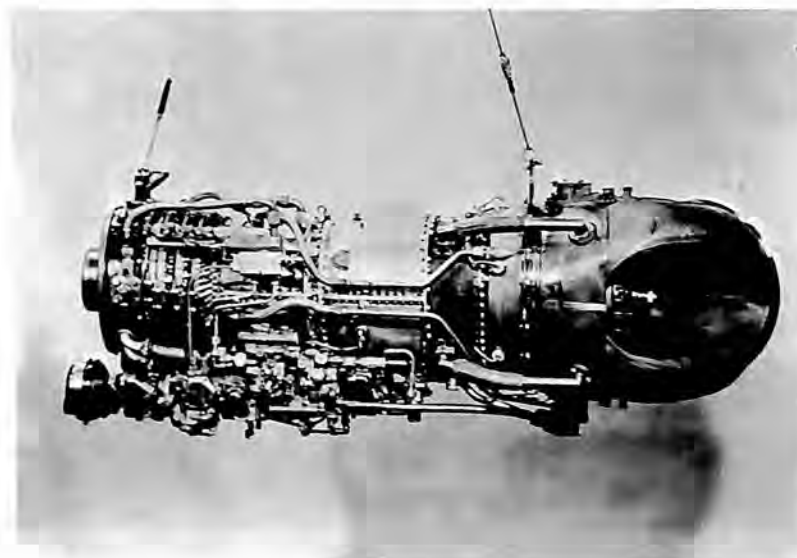
The CJ805-23 is a turbofan version of the CJ805-3 turbojet. It features split compressor, combustion, and turbine section casings for ease of maintenance. Conical construction reduces engine weight. Its single-rotor compressor and turbine require only 3 main bearings. Other features include variable stators and external hydromechanical control systems for easy servicing. The addition to the basic CJ805-3 of an aft fan with a single-stage turbine compressor increases takeoff thrust by over 35 percent and fuel economy by 10 to 15 percent. The CJ805-23 is in service with 10 domestic and overseas carriers.

Specifications

Length 130.6 inches (engine only); maximum diameter 56 inches; engine weight 3,766 pounds.

Performance

Takeoff thrust 16,100 pounds.



CT58 COMMERCIAL TURBOSHAFT

Prime Contractor: General Electric Company

Remarks

The CT58-110 configuration, serving a variety of helicopter applications, has been succeeded by the higher-rated CT58-140, which began production in 1965. Modification of the -110 engines to the higher power rating is accomplished through kit conversion. Applications include the Boeing-Vertol 107 and the Sikorsky S-61 and S-62.

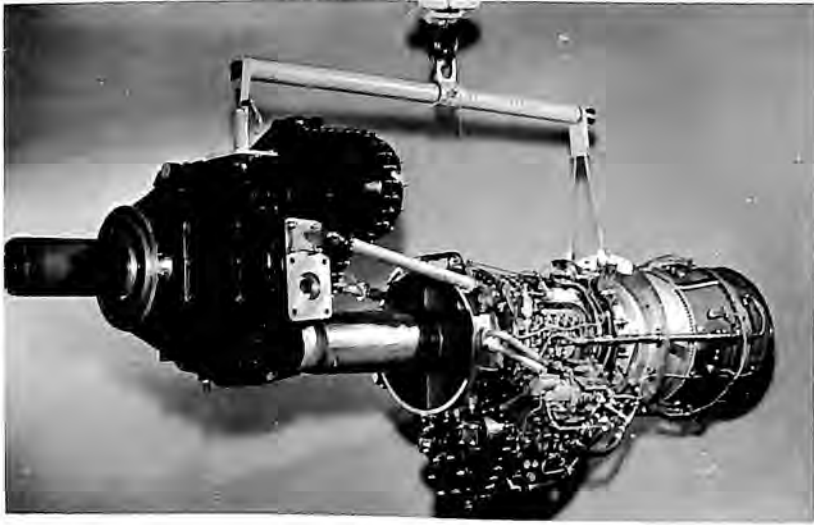
Specifications

Length 59 inches; maximum width 21 inches; weight 340 pounds (CT58-140).

Performance

Takeoff rating 1,400 horsepower (CT58-140), 1,250 horsepower (CT58-110).

ENGINES (TURBINE)



CT64 COMMERCIAL TURBOSHAFT/TURBOPROP

Prime Contractor: General Electric Company

Remarks

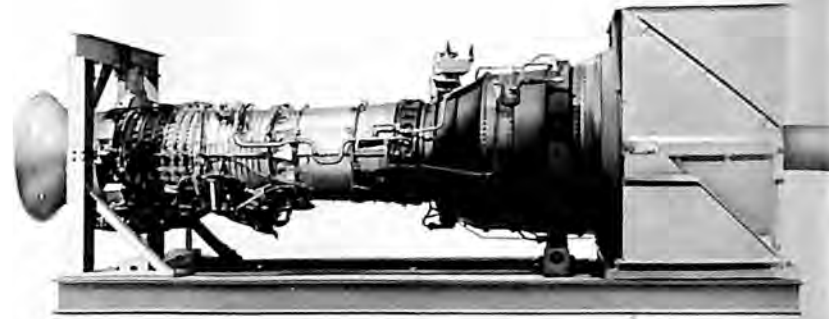
Commercial configurations of the military T64 turboshaft/turboprop are in production and certified for civil use. The CT64-410-1 and CT64-810-1 are turboprop engines; the CT64-610-1 is a direct-drive power plant.

Specifications (CT64-810-1 turboprop)

Length 112.9 inches; maximum height 46 inches; weight 1,167 pounds; compressor stages 14; turbine stages 4.

Performance

Maximum equivalent shaft horsepower 2,850.



LM1500 GAS TURBINE

Prime Contractor: General Electric Company

Remarks

Available as a shaft power engine or as a gas generator, the LM1500 is derived from the J79 aircraft engine. It supplies high-speed propulsion for new Navy patrol motor gunboats and powers the Navy's hydrofoil ship USS *Plainview*. The LM1500 is used also for gas pipeline pumping and power generation for electric utilities.

Performance

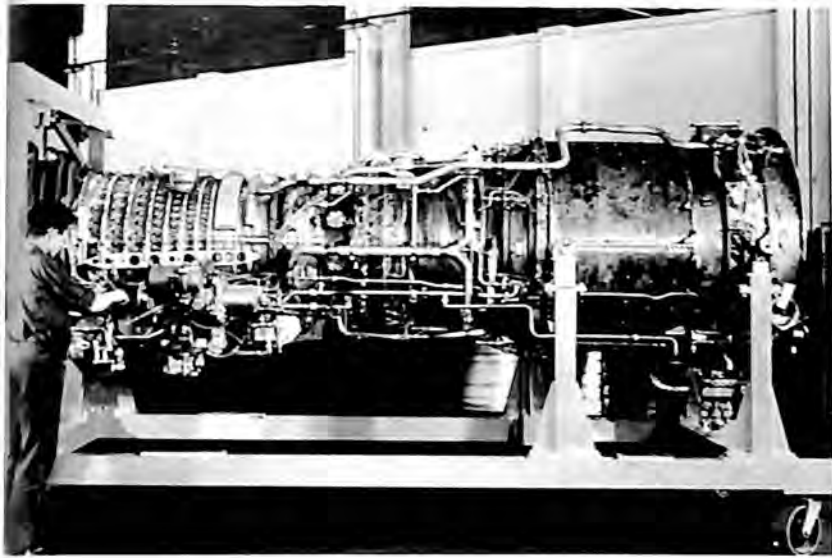
14,000 horsepower at normal 80 degrees Fahrenheit.

LM100 GAS TURBINE

Prime Contractor: General Electric Company

Remarks

Derived from the T58 aircraft engine, the turboshaft LM100 for marine and industrial uses develops up to 3 horsepower per pound of weight. It occupies less than 10 cubic feet and can be installed in many places where a reciprocating engine of comparable power would not fit. The LM100 provides main propulsion for the H. S. *Victoria* hydrofoil and the Bell SK-5 air-cushion vehicle. The engine is also used in oil well fracturing units, gas pipeline pumping, and emergency power generation applications. Performance is in the 1,100-horsepower class.



LM2500 GAS TURBINE

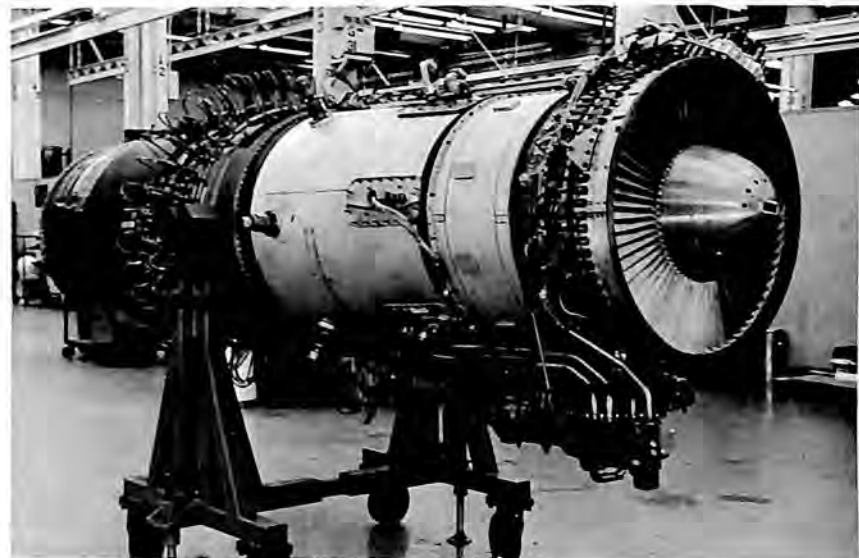
Prime Contractor: General Electric Company

Remarks

The LM2500 is derived from the GE TF39 high bypass turbofan engine. The LM2500 marine power plant has a fuel rate approximately 25 percent better than current production marine gas turbines of the same power class.

Performance

25,000 horsepower class.



GE1/10 AUGMENTED TURBOFAN

Prime Contractor: General Electric Company

Remarks

The GE1/10 augmented turbofan engine is a derivative of the GE1 turbojet engine first tested in 1963. It provides the technological basis for the XF100-GE-100, the GE-proposed power plant for the Air Force F-15 air superiority aircraft, and for the F400-GE-400, the GE-proposed power plant for the Navy's new air superiority/fleet defense fighter, the F-14B. The GE1/10 is approximately 38 inches in diameter and 152 inches long.

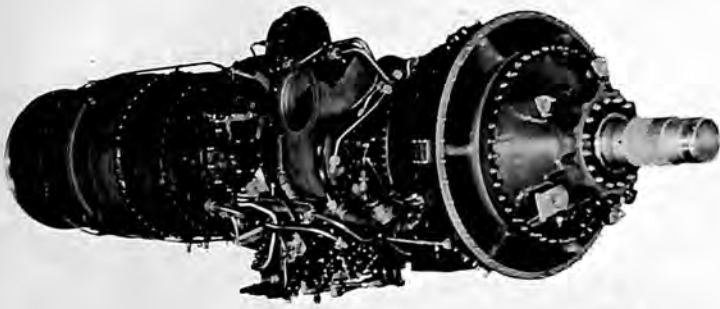
LF1 "TURBOTIP" LIFT-FAN SYSTEM

Prime Contractor: General Electric Company

Remarks

A convertible "Turbotip" propulsion system, the LF1 is designed to power high-speed vertical take-off and landing aircraft. The "Turbotip" fan system consists of 2 wing-mounted lift fans and a nose fan to control pitch of the aircraft. The lift fans, installed in the NASA XV-5B VTOL research aircraft, nearly triple the gas generator thrust of the twin J85 power plants.

ENGINES (TURBINE)



T34 MILITARY TURBOPROP

Prime Contractor: Pratt & Whitney Aircraft

Remarks

Development of the T34 (PT2) axial-flow turboprop engine began in 1945. The engine was put into production in 1953. It powers the Douglas C-133 Cargomaster.

Specifications

Length 155.12 inches; diameter 34.06 inches; weight 2,870 pounds; overall pressure ratio 6.25:1; axial flow, single rotor; compressor stages 13; turbine stages 3.

Performance

Thrust 7,500 shaft horsepower wet, 6,500 dry.



JFTD12 COMMERCIAL TURBOSHAFT

Prime Contractor: Pratt & Whitney Aircraft

Remarks

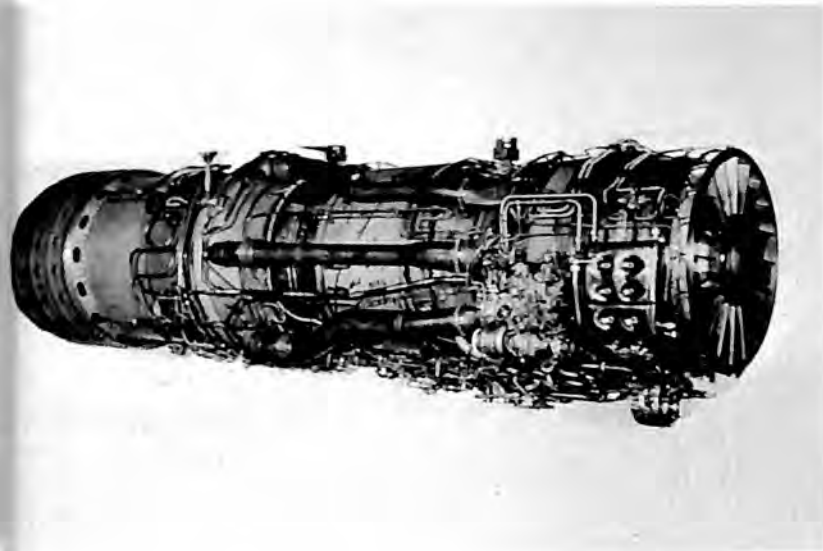
A turboshaft adaptation of the JT12 engine, the JFTD12 has a 2-stage free turbine added in the rear. Two of these engines power the Sikorsky S-64 Skycrane, an all-purpose, heavy-lift transport helicopter.

Specifications (JFTD12A-5A)

Length 107 inches; diameter 34 inches; weight 935 pounds; overall pressure ratio 6.85:1; free turbine drive; compressor stages 9; turbine stages 4.

Performance

Rating 4,800 shaft horsepower.



J58 MILITARY TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

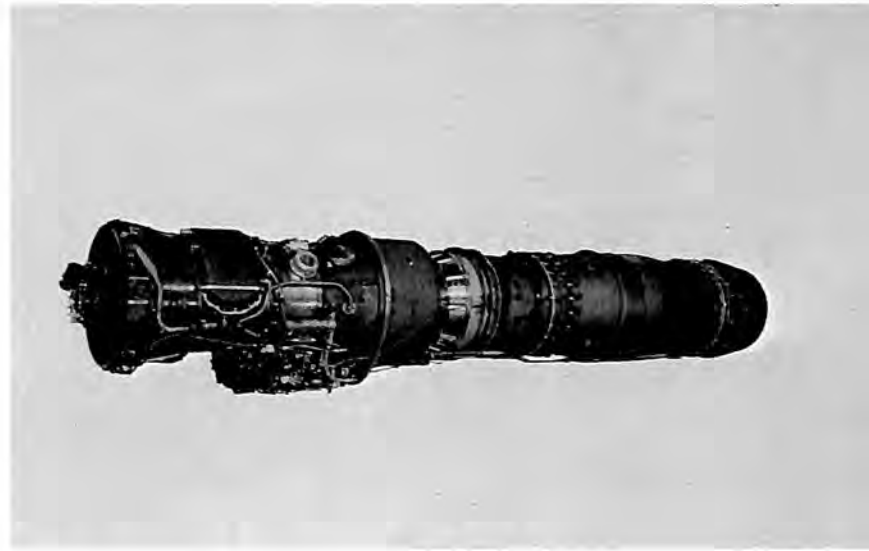
The J58 powers the twin-engine Mach 3 Lockheed YF-12A interceptor and the SR-71 strategic reconnaissance aircraft.

Specifications

Classified.

Performance

Thrust in the 30,000-pound class.



J57 MILITARY TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

The J57 turbojet, which put American military aircraft into supersonic flight, was produced from 1951 to 1965. Winner of the 1952 Collier Trophy, it was the first engine to reach 10,000 pounds of thrust. Among the craft it powers are the Boeing B-52 bomber, KC-135 tanker-transport, and C-135A transport, the North American F-100, the McDonnell Douglas F-101, F-6, and A-3, the Convair F-102, and the Ling-Temco-Vought F-8. Over 54,000,000 operating hours have been accumulated by the more than 21,000 J57s produced.

Specifications (J57-P-43 WB)

Length 167.3 inches; diameter 38.9 inches; overall pressure ratio 12.5:1; weight 3,870 pounds; axial flow, dual rotor; compressor stages 16; turbine stages 3.

Performance

Thrust 13,750 pounds, afterburning versions 18,000 pounds.

ENGINES (TURBINE)



J75 MILITARY TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

Design work on the J75 (JT4 commercial) began in 1952. To design an engine with 50 percent more output but only slightly larger than the similar J57 (JT3) at the time, engineers took the advanced step of increasing the hub-to-tip ratio. This essentially reduced the diameter of the hub which reduced weight and increased the airflow. The engine is used in the Republic F-105 and the Convair F-106. More than 1,500 engines were shipped between April 1957 and July 1964.

Specifications

Length 237.6 inches (J75-P-17), 259.3 inches (-P-19W); diameter 43.5 inches; overall pressure ratio 11.9:1; axial flow, dual rotor; compressor stages 15; turbine stages 3; total weight 5,875 pounds (-P-17), 5,960 pounds (-P-19W).

Performance

Thrust, afterburning (-P-17) 24,500 pounds, afterburning plus water injection (-P-19W) 26,500 pounds.



J52 MILITARY TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

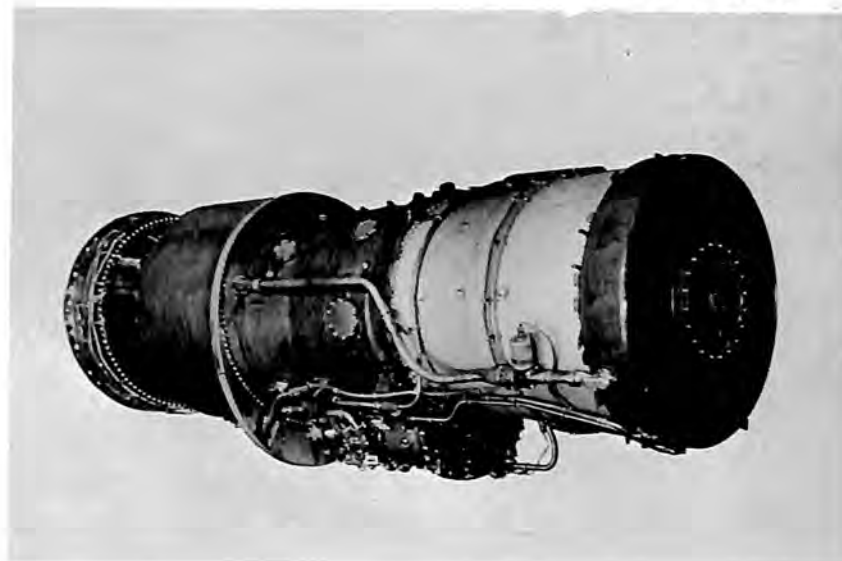
Similar in design to the larger J57 and J75, the J52 was introduced in 1957. Configurations of this engine power the McDonnell Douglas A-4F and TA-4F Skyhawk, the Grumman A-6A, and the North American Rockwell Hound Dog missile.

Specifications (J52-P-8A)

Length 116.9 inches; diameter 30.15 inches; overall pressure ratio 13.1; weight 2,118 pounds; axial flow, dual rotor; compressor stages 12; turbine stages 2.

Performance

Thrust 9,300 pounds (-P-8A).



JT3 COMMERCIAL TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

On October 26, 1958, the JT3 Turbo Wasp ushered in the American commercial jet age. A commercial version of the J57, this engine was produced from 1958 to 1961. Configurations are in wide service on the Boeing 707-120 and 720 and the McDonnell Douglas DC-8-10.

Specifications (JT3C-6)

Length 138 inches; diameter 38.8 inches; weight 4,234 pounds; overall pressure ratio 13; axial flow, dual rotor; compressor stages 16; turbine stages 3.

Performance

Thrust 13,500 pounds with water injection.

JT4 COMMERCIAL TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

A larger, advanced configuration of the JT3, the JT4 (military version J75) is used in the long-distance Boeing 707-320 and McDonnell Douglas DC-8-20, -30 airliners. Built between 1959 and 1961, it has attained a time between overhauls of 13,400 hours.

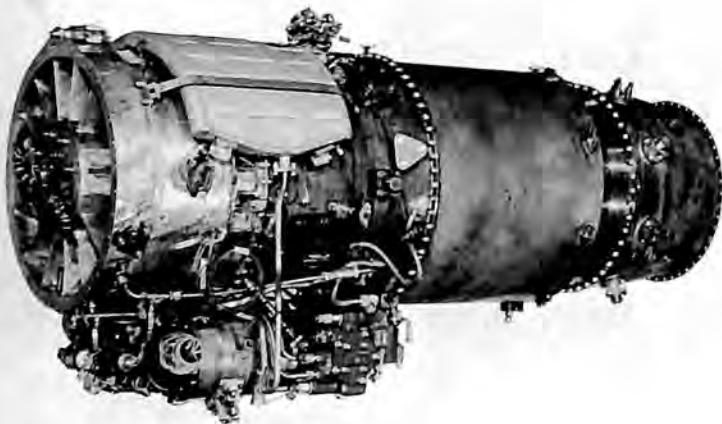
Specifications (JT4A-11)

Length 144.1 inches; diameter 43 inches; weight 5,100 pounds; overall pressure ratio 12; axial flow, dual rotor; compressor stages 15; turbine stages 3.

Performance

Thrust 17,500 pounds.

ENGINES (TURBINE)



JT12/J60 TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

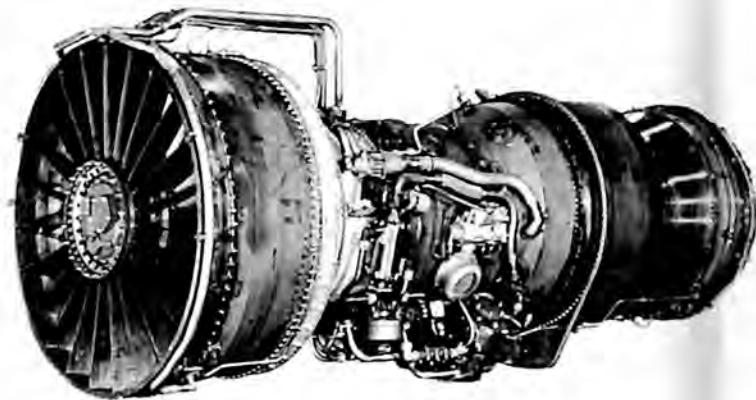
The JT12A-8 (military designation J60), smallest in the company's jet engine family, powers the 4-engine Lockheed JetStar and the twin-engine North American Rockwell Sabreliner business aircraft.

Specifications (JT12A-8)

Length 76.9 inches; diameter 21.9 inches; weight 468 pounds; overall pressure ratio 6.7:1; axial flow, single rotor; compressor stages 9; turbine stages 2. J60-P-4 same except for length: 70.6 inches.

Performance

Thrust 3,300 pounds, both versions.



JT3D COMMERCIAL TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

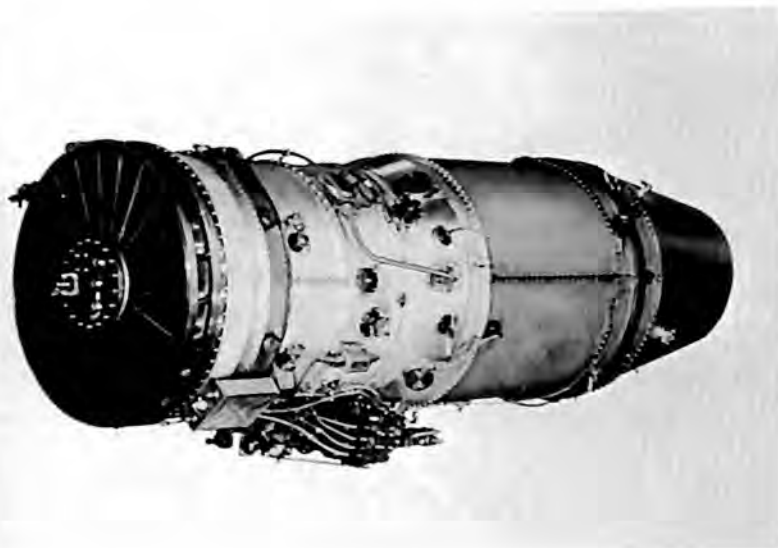
A widely used turbofan engine and the winner of endurance records, the JT3D evolved from the J57. It features improved thrust ratings and lower fuel consumption. Configurations of this engine power the Boeing 707-120B, 720B, and 707-320B/C and the McDonnell Douglas DC-8-50, DC-8F, and Super Sixty series.

Specifications (JT3D-7)

Length 134.4 inches; diameter 53 inches; weight 4,260 pounds; overall pressure ratio 13.5; axial flow, dual rotor; compressor stages including fan 15; turbine stages 4.

Performance

Thrust 19,000 pounds.



JT8D COMMERCIAL TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

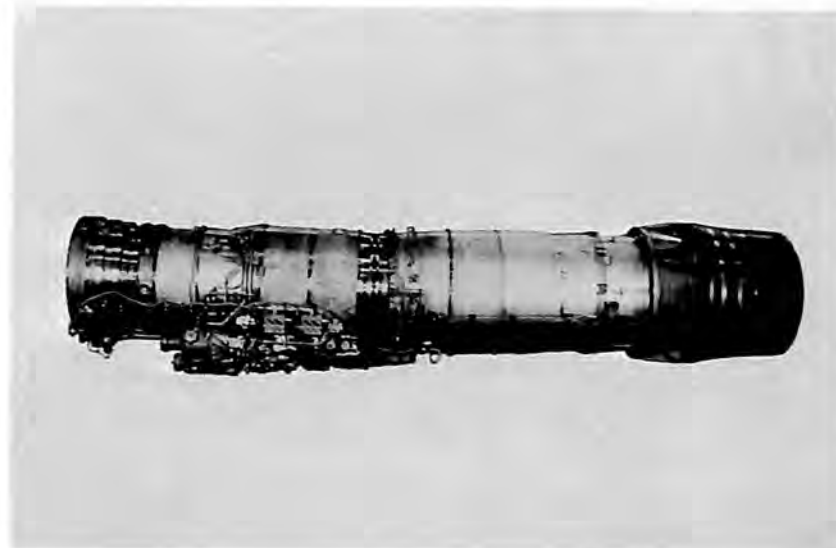
The company-financed JT8D was designed and developed from the outset for application to short- and medium-range aircraft. This engine has reached a maximum time between overhauls of 11,450 hours. The JT8D turbofan engine powers the Boeing 727 and 737, the twin-engine McDonnell Douglas DC-9, and the Sud-Aviation Super Caravelle 10B, 10R, and 11R.

Specifications (JT8D-11)

Length 120 inches; diameter 42.5 inches; weight 3,310 pounds; overall pressure ratio 17.5:1; axial flow, dual rotor; compressor stages including fan 13; turbine stages 4; full-length fan duct.

Performance

Thrust 14,500 pounds.



TF30 MILITARY TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

The 20,000-pound-thrust-class TF30 was the first afterburning turbofan engine to complete an official 150-hour qualification testing. Configurations of this engine power the twin-engine General Dynamics/USAF F-111A variable-sweep-wing supersonic fighter. A non-afterburning version is the power plant for the LTV A-7A/B/E aircraft. Specifications for afterburning versions are classified.

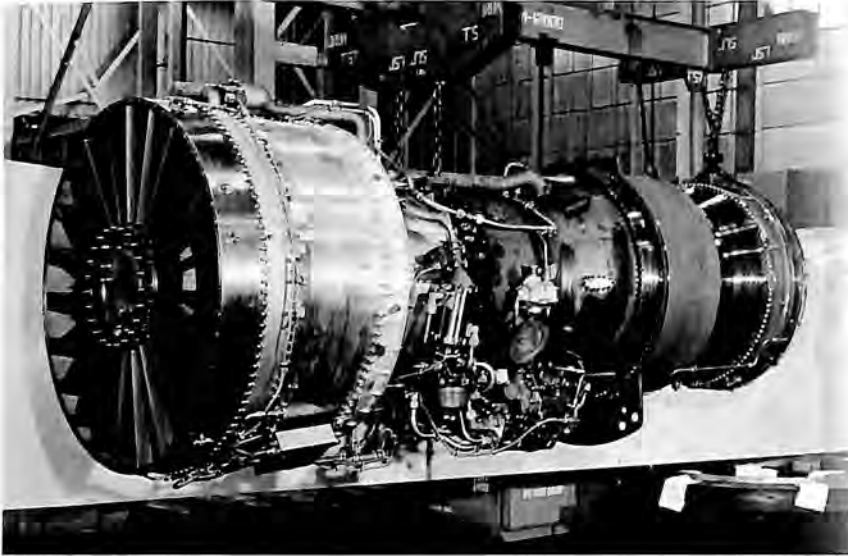
Specifications (TF30-P-8)

Length 128.1 inches; diameter 42.1 inches; weight 2,526 pounds; overall pressure ratio 18.1:1; axial flow, dual rotor; compressor stages including fan 16; turbine stages 4.

Performance

Thrust 12,200 pounds (non-afterburning).

ENGINES (TURBINE)



TF33 MILITARY TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

Configurations of the TF33 (JT3D in the commercial version) power the Boeing B-52H, C-135B, and KC-135B and the Lockheed C-141A.

Specifications (TF33-P-7)

Length 142.3 inches; diameter 53 inches; weight 4,675 pounds; overall pressure ratio 16.1:1; axial flow, dual rotor; compressor stages including fan 16; turbine stages 4.

Performance

Thrust 21,000 pounds.



JT9D COMMERCIAL TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

The Pratt & Whitney Aircraft JT9D, which powers the 490-passenger Boeing 747, is a turbofan engine of an advanced design producing 43,500 pounds of thrust. The JT9D has an 8-foot-diameter inlet—almost twice that of the 19,000-pound-thrust JT3D turbofan engine which is the workhorse of the long-range Boeing 707 and McDonnell Douglas DC-8 jet fleets and the military Lockheed C-141 StarLifter. In spite of its size, the JT9D is quieter than earlier jet engines and is only 128 inches long—6 inches shorter than the JT3D. The new engine weighs 8,470 pounds. The JT9D utilizes advanced cycle and design concepts which have been under development for several years. New combustion chamber components substantially shorten the combustion section and, by making individual compressor stages produce higher pressure, also reduce the number of compressor stages required. The JT9D uses a rotary spinner to improve airflow conditions and has a plug nozzle in the exhaust section. The engine has a total airflow of 1,495 pounds per second, an overall pressure ratio of 22:1, and a bypass ratio of 5.1:1. It has one fan stage, 15 compressor stages including the fan, and 6 turbine stages. The low-speed compressor section has 3 stages; the high-speed compressor section, 11 stages. The low-speed turbine section has 4 stages; the high-speed section, 2 stages. The turbine section is air-cooled, and the engine has both titanium and high-alloy nickel steel parts. The JT9D has 23 percent better specific fuel consumption than the JT3D-3B now used in the intercontinental-range jetliners. On takeoff, the fan bypass airflow will develop 77 percent of the thrust; at cruise altitudes, 61 percent.

Sounding rockets are listed under system contractor, giving manufacturer's nomenclature, type, stages and thrust, launch weight and overall length, performance, remarks, and using organizations.

**AEROJET-GENERAL CORPORATION,
SPACE DIVISION**

AEROBEE 150, 150A

Boosted single-stage sounding rocket; sustainer liquid IRFNA and aniline-furfuryl-alcohol mixture; engine (4,100 pounds thrust for 51.8 seconds), booster Aerojet 2.5KS-18,000 solid motor; weight 1,943 pounds (150), 1,941 pounds (150A); length 29.67 feet (150), 30 feet (150A); payload 150 pounds to altitude of 152 miles; maximum acceleration 10.3 g; tower-launched; 3 fins (150), 4 fins (150A); attitude control and recovery systems available in both vehicles; NASA, Air Force, Navy, Kitt Peak Observatory.

AEROBEE 170

Boosted single-stage sounding rocket; sustainer liquid IRFNA and aniline-furfuryl-alcohol mixture; engine (4,100 pounds thrust for 51 seconds), booster Nike M-5 solid motor; vehicle weight 2,760 pounds; length 36.3 feet; payload 150 pounds to altitude of 199 statute miles; maximum acceleration 19 g; tower- or rail-launched; attitude control and recovery system available; NASA, Air Force, Navy, Kitt Peak Observatory.

AEROBEE 300, 300A

Two-stage sounding rocket; 1st—Aerobee 150 or 150A, 2nd—solid Aerojet Sparrow 1.8KS-7800; weight 2,103 pounds; length 33 feet (300), 33.3 feet (300A); payload 35 pounds to altitude of 300 miles; maximum acceleration 63.8 g; 300A has 4 fins; NASA, Air Force.

AEROBEE 350

Nike M-5 boosted, single-stage, liquid sounding rocket; 4 Aerobee 150 thrust chambers, 18,844 pounds of vacuum thrust; payload weights from 150

to 500 pounds to altitudes of 294 and 207 miles, respectively; peak acceleration 15.2 g; tower-launched; overall length including booster 603 inches; diameter 22 inches; developed for NASA.

NIRO

Two-stage, unguided, solid sounding rocket; 1st—Nike M-5 45,000, 2nd—Iroquois; 40 to 180 pounds to altitudes of 180 to 85 miles, respectively; boom-launched, under development AFCRL; maximum acceleration 36 g; length 336.2 inches; weight at lift-off without payload 1,591 pounds; payload area 79 inches by 7.75 inches diameter.

**ATLANTIC RESEARCH CORPORATION,
A DIVISION OF THE SUSQUEHANNA
CORPORATION**

ARCAS

Single-stage solid sounding rocket; more than 6,000 flown; ARC 29KS-336; weight 65 pounds; length 7.5 feet; payload 10 pounds to altitude of 44 miles; all services and NASA, Germany, France, Argentina, Canada, Brazil, and Israel.

BOOSTED-ARCAS II

Two-stage solid sounding rocket; 1st—ARC MARC 42 A1 (3KS-2740), 2nd—ARC HV ARCAS (29KS-324); weight 135.3 pounds plus payload; length 13 feet 3 inches; payload 12 pounds to 86 miles; tube or rail launch; Army, NASA, ESSA, ESRO.

ARGO A-2 (PERCHERON)

Boosted single-stage solid research rocket; Thiokol Castor TX-33 with 2 Thiokol Recruit TE-29 (122,000 pounds total thrust); weight 10,000 pounds; length 21 feet; payload 500 pounds to altitude of 200 nautical miles; first stage Shotgun; NASA.

ARGO B-1 (NIKE-CAJUN)

Two-stage solid sounding rocket; 1st—Hercules M-5 Nike (48,700 pounds thrust), 2nd—Thiokol Cajun TE-82 (9,600 pounds thrust); weight 1,550 pounds; length 23 feet; payload 50 pounds to altitude of 94 miles; all services and NASA.

ARGO B-2 (NIKE-APACHE)

Two-stage solid sounding rocket; 1st—Hercules M-5 Nike (48,700 pounds thrust), 2nd—Thiokol Apache TE-307 (5,900 pounds thrust); weight 1,550 pounds; length 23 feet; payload 50 pounds to altitude of 163 miles; all services and NASA.

ARGO B-7 (HONEST JOHN-NIKE)

Two-stage solid sounding rocket; 1st—Hercules M-6 Honest John (86,000 pounds thrust), 2nd—Hercules

SOUNDING ROCKETS

M-5 Nike (48,700 pounds thrust); weight 5,464 pounds; length 40 feet; payload 250 pounds to altitude of 57 miles; Army, Air Force, NASA.

ARGO B-10 (SWIK)

Two-stage solid research rocket; 1st—Thiokol Castor TX-33 (55,000 pounds thrust), 2nd—Hercules X254 (14,100 pounds thrust); weight 13,200 pounds; length 35 feet; payload 300 pounds to altitude of 750 miles; Army, Air Force.

ARGO C-22 (HONEST JOHN-NIKE-NIKE)

Three-stage solid sounding rocket; 1st—Hercules M-6 Honest John (86,000 pounds thrust), 2nd and 3rd—Hercules M-5 Nike (48,700 pounds thrust); weight 6,784 pounds; length 47 feet; payload 250 pounds to altitude of 118 miles; Army, Air Force, NASA.

ARGO C-23

Three-stage solid sounding or research rocket; 1st—Thiokol TX-33 with 2 Thiokol TX-77 (147,000 pounds total thrust), 2nd—Thiokol TX-261 (57,000 pounds thrust), 3rd—Thiokol TX-306 (11KS-13430); weight 14,300 pounds; length 41.3 feet; payload 150 pounds to altitude of 2,000 nautical miles; Mach 21.

ARGO D-4 (JAVELIN)

Four-stage solid research rocket; 1st—Hercules M-6 Honest John (86,000 pounds thrust), 2nd and 3rd—Hercules M-5 Nike (48,700 pounds thrust each), 4th—Hercules X-248 (3,000 pounds thrust); weight 7,400 pounds; length 48.7 feet; payload 100 pounds to altitude of 550 nautical miles; NASA, Air Force, DASA.

ARGO D-8 (JOURNEYMAN A)

Four-stage solid research rocket; 1st—Thiokol XM-20 with 2 Thiokol 1.5KS-3500 Recruits (121,000 pounds total thrust), 2nd and 3rd—Lockheed Lance (47,000 pounds thrust each), 4th—Hercules X-248 (3,000 pounds thrust); weight 14,000 pounds; length 62 feet; payload 135 pounds to altitude of 1,260 nautical miles; Mach 24; holds record for highest altitude (1,269 nautical miles) for recovered payload; NASA, Sandia.

METARC

Single-stage low-altitude meteorological rocket; reusable; ARC 0.72KS-177; weight 6.7 pounds with net payload and parachute; length 3 feet 8.5 inches; altitude 5,000 feet; Army.

NIKE-ARCHER

Two-stage solid sounding rocket; 1st—Hercules M-5 Nike (48,700 pounds thrust), 2nd—ARC Archer

35KS-1375; weight 1,650 pounds; length 25 feet; payload 40 pounds to altitude of 230 miles; all services and NASA.

SIDEWINDER-ARCAS

Two-stage sounding rocket; 1st—Sidewinder Mk 17 Mod 1A, 2nd—ARC HV ARCAS (29KS-324); weight 166.4 pounds plus payload; length 14 feet 2 inches; payload 12 pounds to 72 miles; all services, NASA, and Norway.

SPARROW-ARCAS

Two-stage sounding rocket; 1st—Acrojet Sparrow Mk 6 Mod 3, 2nd—HV ARCAS (29KS-324); weight 206 pounds plus payload; length 12 feet 6 inches; payload 12 pounds to 109 miles; all services and ESRO.

TRAILBLAZER I

Six-stage (including 3 downward-thrust packaged in reverse in 3rd stage) solid research rocket; 1st—Hercules M-6 Honest John (86,000 pounds thrust), 2nd—Hercules M-5 Nike (48,700 pounds thrust), 3rd—either Lockheed Lance (47,000 pounds thrust) or Thiokol TX-77 (46,000 pounds thrust), 4th—Thiokol T-40, 5th—Thiokol T-55 (4,650 pounds thrust), 6th—NASA/Langley 5-inch spherical motor; weight 7,500 pounds; length 56 feet; 3 stages up to altitude of 200 nautical miles; 3 stages down attain 24,000 feet per second (a “gun-fired” pellet fired downward has reached 35,000 feet per second); NASA.

TRAILBLAZER II

Four-stage solid research rocket; 1st—Thiokol Castor TX-33 with 2 Thiokol Recruit TE-19 (122,000 pounds total thrust), 2nd—Lockheed Lance (47,000 pounds thrust), 3rd—Hercules Altair X-248 (3,000 pounds thrust), 4th—Thiokol 15-inch spherical (5,000 pounds thrust); weight 13,344 pounds; length 50 feet; 2 stages up, 2 stages downward to achieve reentry velocity of 22,000 feet per second; payloads weighing from 5 to 65 pounds have been flown with 2 additional stages (a 5-inch spherical motor and a pellet accelerator), and reentry velocities of 55,000 feet per second have been achieved; NASA, Air Force.

SUPER ARCAS

Simple, versatile vehicle for probing the mesosphere and ionosphere; single-stage system with separable payload; employs a MARC 60A rocket motor of 370 pounds thrust, burning time 32.6 seconds; payloads from 8 to 25 pounds; vehicle weight 95.8 pounds at launch, 40.5 pounds at burnout; National Science Foundation.

HERCULES INCORPORATED**DEACON (POGO-HI)**

Single-stage Hercules X-220 solid motor (6,400 pounds thrust); weight 200 pounds; length 9.7 feet; payload weight versus altitude varies with each program; Army, Navy, NASA, ARPA.

LANGLEY RESEARCH CENTER, NASA**METEOR SIMULATION VEHICLE (1)**

Modified Trailblazer II, 6-stage solid research rocket; 1st—Thiokol Castor XM33E8 with 2 Thiokol Recruit XM-19 (122,000 pounds thrust total), 2nd—Thiokol TX-77 (47,000 pounds thrust), 3rd—Hercules Altair X-248 A-10 (3,000 pounds thrust), 4th—NASA Cygnus-15 (3,200 pounds thrust, 15-inch diameter spherical), 5th—Cygnus-5 (550 pounds thrust, 5-inch diameter spherical), 6th—Firestone Tire and Rubber Company shaped-charge accelerator and reentry pellet; ARC spin-stabilized velocity package contains last 4 stages; 13,500 pounds; 51.5 feet; 2 stages to altitude of 300 kilometers, remaining stages packaged in reverse to achieve 20-kilometer-per-second reentry velocity, 15 degrees off vertical, at altitude of 75 kilometers; NASA.

METEOR SIMULATION VEHICLE (2)

Modified Nike-Cajun, 4-stage solid research rocket; 1st—Nike-Ajax (53,000 pounds thrust), 2nd—Thiokol Cajun TE-82 (8,600 pounds thrust), 3rd—NASA Cygnus-5 (550 pounds thrust, 5-inch diameter spherical), 4th—Army Ballistics Research Laboratory shaped-charge accelerator and reentry pellet; Zimmey Corporation spin-stabilized velocity package contains 2 sets of the 3rd and 4th stages mounted in reverse; 1,575 pounds; 27.5 feet; 2 stages to altitude of 120 kilometers, 2 separate reentries of different pellet materials each with 11-kilometer-per-second reentry velocity, 15 degrees off vertical, at altitude of 75 kilometers; NASA.

**NAVAL MISSILE CENTER,
POINT MUGU, CALIFORNIA****TERRIER/551C**

Ground-launched 2-stage research rocket; 1st—A.B.L. Terrier Mk 12 booster, 2nd—NWC Mod 551C; launch weight 2,750 pounds plus payload; payload 250 pounds to 250 nautical miles; in flight test.

HYDRA-IRIS

Two-stage research rocket capable of remote water-launch from free-floating launcher; 1st—NavMisen-designed cluster of 3 Aerojet Sparrow III motors, 2nd—Atlantic Research Corporation Iris; payload 200 pounds to 100 nautical miles; booster and launcher being modified.

SANDIA LABORATORIES**NITEHAWK 9**

Two-stage solid propulsion sounding rocket; 1st—Nike M-5 (48,700 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,500 pounds thrust); diameter 9 inches; payload 125 to 175 pounds to altitudes between 165 and 200 miles; Mach 8.5; Atomic Energy Commission.

NITEHAWK 12

Two-stage solid propulsion sounding rocket; 1st—Nike M-5 (48,700 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,500 pounds thrust); diameter 12 inches; payload 200 to 260 pounds to altitudes between 95 and 110 miles; Mach 6; Atomic Energy Commission.

ADVANCED TERRIER TOMAHAWK 9

Two-stage solid propulsion sounding rocket; 1st—Hercules BT-3 Advanced Terrier (66,800 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,500 pounds thrust); diameter 9 inches; payload 175 pounds to altitude of 245 miles; Mach 9; Atomic Energy Commission.

NIKE CAJUN

Two-stage solid propulsion sounding rocket; 1st—Nike M-5 (48,700 pounds thrust), 2nd—Thiokol TE-M-82-1 Cajun Mod 1 (8,800 pounds thrust); diameter 6.5 inches; gross payload 70 pounds to altitude of 85 miles; Mach 5; Atomic Energy Commission.

*Nitehawk 12*

SOUNDING ROCKETS

NIKE APACHE

Two-stage solid propulsion sounding rocket; 1st—Nike M-5 (48,700 pounds thrust), 2nd—Thiokol TE-M-307-2 Apache (5,300 pounds thrust); diameter 6.5 inches; gross payload 75 pounds to altitude of 100 miles; Mach 5.5; Atomic Energy Commission.

SANDHAWK

Single-stage solid propulsion sounding rocket; Thiokol TE-M-473 Sandhawk (24,500 pounds thrust); diameter 13 inches; length 24.1 feet; gross payload 200 pounds to altitude of 110 miles; Mach 6; Atomic Energy Commission.

ADVANCED TERRIER-SANDHAWK

Two-stage solid propulsion sounding rocket; 1st—Advanced Terrier (66,800 pounds thrust), 2nd—Thiokol TE-M-473 Sandhawk (24,500 pounds thrust); diameter 13 inches; length 38 feet; gross payload 200 pounds to altitude of 263 miles; Mach 8.9; Atomic Energy Commission.

DUAL HAWK

Two-stage solid propulsion sounding rocket; 1st—Thiokol TE-M-473 Sandhawk (24,500 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,500 pounds thrust); diameter 9 inches; length 35.7 feet; gross payload 175 pounds to altitude of 340 miles; Mach 10; Atomic Energy Commission.

TALLEY INDUSTRIES, INC.

HOPI CHAFF DART

Single-stage RPI 2.4-5600 HOPI-II solid motor; weight 95 pounds; length 11 feet; payload 11.5 pounds to altitude of 380,000 feet; NASA.

JUDI BALLOON DART

Single-stage RPI 1.9KS-2150 JUDI-I solid motor; weight 33.7 pounds; length 9 feet; payload (standard AF Mylar Robin Sphere) 10 pounds to 200,000 feet; all services and foreign governments.

JUDI CHAFF (OR PARACHUTE) DART

Single-stage RPI 1.9KS-2150 JUDI-I solid motor; weight 33.7 pounds; length 8.6 feet; payload 10 pounds to altitude of 240,000 feet; all services, NASA, and foreign governments.

JUDI INSTRUMENTED DART

Single-stage RPI 1.9KS-2150 JUDI-I solid motor; weight 33.7 pounds; length 9 feet; payload 10 pounds to altitude of 220,000 feet; all services and foreign governments.

PHOENIX-I

Two-stage solid sounding rocket; 1st—RPI 5.5KS-6100 KIVA-I, 2nd—RPI 3.0KS-4000 HOPI-I; weight 320 pounds; length 18 feet; payload 10 pounds to altitude of 225 miles; all services.

RAVEN

Single-stage RPI 7.8KS-1945 HOPI-IV solid motor; weight 107 pounds; length 10.8 feet; payload 10 pounds to altitude of 225,000 feet; under development for meteorological use by all services and NASA.

SIDEWINDER-RAVEN

Two-stage solid sounding rocket; 1st—Naval Propellant Plant, Sidewinder 1A, 2nd—RPI 7.8KS-1945 HOPI-IV; weight 208 pounds; length 17 feet; payload 20 pounds to altitude of 400,000 feet; all services.

THIOKOL CHEMICAL CORPORATION, ASTRO-MET DIVISION

NIKE-TOMAHAWK

Two-stage solid sounding rocket; 1st—Hercules M-5, M-5E1, or M-88 Nike (48,700 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,500 pounds thrust); weight 1,850 pounds; length 23.83 feet; payloads 80 to 290 pounds, 6.75 to 12 inches in diameter, to altitudes between 95 and 300 miles; NASA, Air Force, Navy, Sandia, University of Michigan, McDonnell Douglas Corporation.

TOMAHAWK

Single-stage solid sounding rocket; Thiokol TE-416 Tomahawk (10,500 pounds thrust); weight 531 pounds; length 11.75 feet; payload 125 pounds to altitude of 60 miles (low-drag configuration with payload of 60 pounds to altitude of 130 miles and high-drag configuration with payload of 80 pounds to altitude of 74 miles); NASA, Sandia, Navy.

TOMAHAWK-DART

Single-stage solid sounding rocket; Thiokol TE-416 Tomahawk (10,500 pounds thrust); weight 671 pounds; length 14.75 feet; payload (Dart) 140 pounds to altitude of 57 miles; NASA, Sandia.

ADVANCED TERRIER TOMAHAWK

Two-stage solid sounding rocket; 1st—Hercules Mark 12 Mod 1 Terrier (17,000 pounds thrust); 2nd—Thiokol TE-473 Sandhawk (24,500 pounds thrust); weight 3,899 pounds; length 41.5 feet; payload 100 pounds to 350 miles or 350 pounds to 225 miles; approximately 500 seconds flight time above 300,000 feet.

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