THE 1968 AEROSPACE YEAR BOOK

FORTY-SIXTH EDITION

AIA

Official Publication of the

AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.

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FOREWORD

by Karl G. Harr, Jr.

President,
Aerospace Industries Association

The aerospace industry during 1967 continued its record-setting pace.

Measurements of progress showed:

• Sales in 1967 reached $27.3 billion, a 13 percent gain over the previous year.

• Employment in the industry in 1967 was 1,407,000 persons, making the industry the nation's largest manufacturing employer.

• Exports totaled more than $2.2 billion in 1967, a $575 million gain over 1966. Importantly, the principal aerospace export product was civilian aircraft which rose from $552,000,000 to $733,000,000 a 32.8 percent increase between 1966 and 1967.

• Backlog of the industry, which stood at $26.9 billion at the end of the third quarter of 1966, rose to $29.2 billion at the end of the same period in 1967.

These brief economic facts of industry progress fall far short of telling the dramatic accomplishments that came from the industry.

In space exploration, the Apollo 4 was without doubt the most important unmanned space operation ever launched by the U.S. It was a "text book" test that proved the spaceworthiness and compatibility of the Saturn V/Apollo design and it served as the initial rehearsal for the lunar landing.

The fifth and final Lunar Orbiter successfully completed its task of completely photographing the moon, and the companion Surveyor program, nearing completion, scored new successes.

The Manned Orbiting Laboratory project continued to progress, and its value to the nation when it becomes operational is vital.

The fourth Intelsat II communications satellite was launched and the spacecraft's 240 voice channels were being utilized for both government and commercial traffic.

A firm go-ahead to build a supersonic transport was given during 1967 and its impact on commercial aviation in the next decade will be comparable to the effects of subsonic jet transports.

The dramatic increase in turbine-powered transport sales is a major factor in overall aerospace growth. From 1965 sales of about $1.2 billion to sales of nearly $2.5 billion in 1967, the increase was 105 percent, and from the 1965 sales to expected sales of $3.8 billion in 1968, the increase is 218 percent. The industry's backlog of transport aircraft rose 51 percent between June 30, 1966 and 1967.

Production of general aviation aircraft continued at a high level and the industry today builds nearly 100 models of these versatile aircraft, many of them turbine-powered.

First production models of the F-111 were delivered, and advanced development continued on the AH-56A (Cheyenne) helicopter.

Contracts were let for the Sentinel anti-ballistic missile system with its Sprint and Spartan missiles and their electronic gear and radar.

The aerospace industry fulfilled its task of providing equipment for the Vietnam conflict while attaining a high production level of civil aircraft and continuing a broad program of space exploration.

The accomplishments of 1967 clearly illustrate the ever-increasing involvement of the aerospace industry in the mainstream of American life.

The nation has learned much about the true value of what is happening in the course of technological advance spearheaded by our aerospace activities. During 1967, significant elements of leadership, both here and abroad, came to realize the implications of this country's technological and managerial surge ahead. It is obvious that the leadership of other nations, both intellectual and governmental, has seen this with great clarity.

Jean Jacques Servan-Schreiber, the noted French editor and political commentator, has put the gap between European and U.S. industrial capability in sharp focus. "The war is being fought against us not with dollars, oil, tons of steel nor even modern machines, but with creative imagination and a talent for organization," he said.

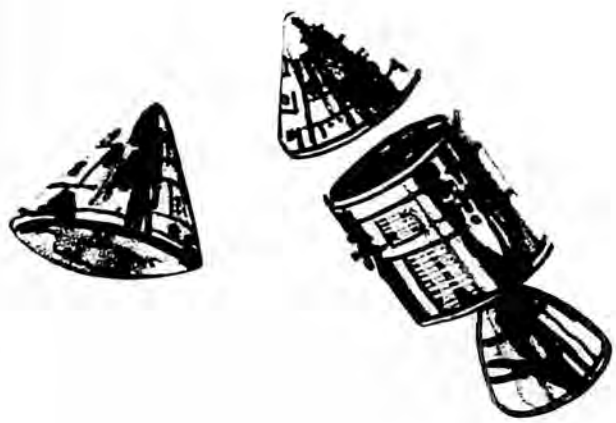
This testimonial is not just to absolute technological advance or techniques for managing this advance, it is rather to the total vitality and dynamism of our system. The continued progress of the U.S. rests upon sustaining the broadest possible base of creative and innovative talent, energy and organization.

The aerospace industry is translating its technological advances, techniques and talents to solving stifling problems in various socioeconomic areas. The industrial revolution brought about by the challenges of defense and space requirements is permeating more and more of our total economy.

Many of the identifiable problems facing our nation inevitably are going to be solved primarily by aerospace-generated technology. Such problems include air and water pollution control, the multiple problems arising from urban congestion, providing adequate transportation systems for a growing population, insuring adequate food and water supply and distribution systems and even providing the housing and school systems which a burgeoning population will demand.

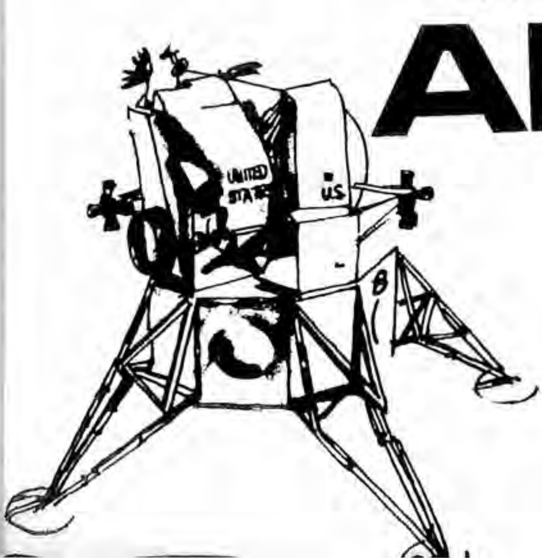
In sum, during 1967 the aerospace industry has continued to demonstrate that it is the cutting edge to our national technological and managerial advance.

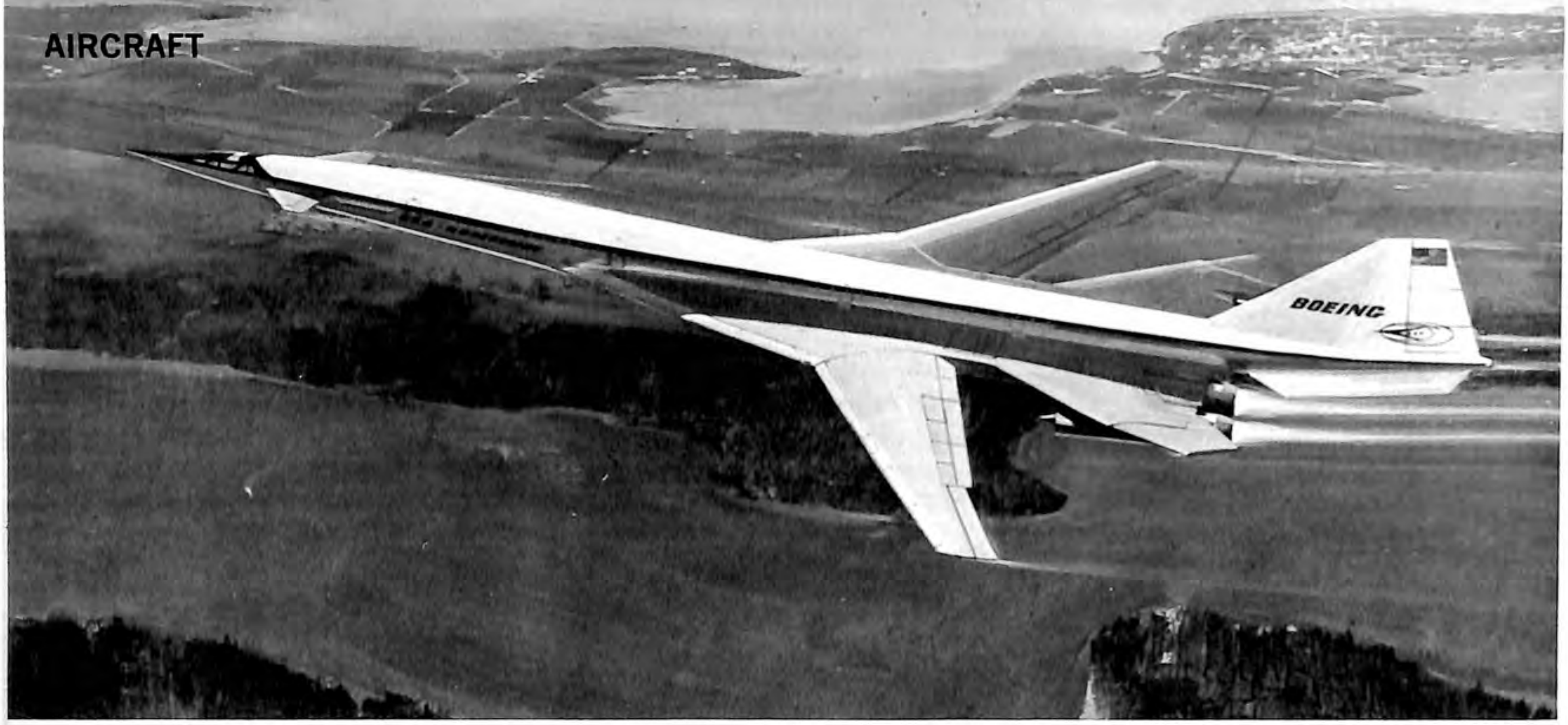

NAVY



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

1967 AEROSPACE EVENTS





BOEING SUPERSONIC TRANSPORT

Design work continued in 1967 on the U.S. supersonic transport, being built by the Boeing Company under a cost-sharing contract with the Federal Aviation Administration. A new design addition was the canard wings aft of cockpit. Two prototypes were scheduled to fly by 1971. Boeing's teammates included General Electric Company, Fairchild Hiller Corporation, AVCO Corporation, LTV's Vought Aeronautics Division, Martin Marietta Corporation, Northrop Corporation and North American Rockwell Corporation.

BOEING 747

Construction started on the first Boeing 747 "jumbo-jets" and initial flight was targeted for late 1968. The largest commercial airplane ever designed, the 747 will weigh 710,000 pounds and carry 350 to 490 passengers.

BOEING 737

Smallest of the Boeing airliner family, the 737 made its first flight in April; first airline delivery was made late in the year. Boeing was producing 3 versions at Seattle: the 737-100, 94 feet long, up to 101 passengers; the -200, 100 feet long, 113 passengers; and the -200C, a convertible cargo/passenger airliner.

DOUGLAS DC-9/DC-10

Douglas Aircraft Company, which became a component company of McDonnell Douglas Corporation during the year, introduced the Series 40, largest model of the DC-9 series. First flight came late in the year. The Series 40 is 6.3 feet longer than the Series 30 first delivered in January 1967, carries 125 passengers compared with 115. McDonnell Douglas also announced plans for the DC-10, "a large, 3-engine jetliner capable of accommodating well over 300 passengers."

DOUGLAS SUPER DC-8s

The Douglas DC-8 Super 63 (photo), high density jetliner, first flew April 10, saw service introduction on July 27 and was the largest commercial jet flying during the year. Super 61, medium range version carrying 259 passengers, started in service early in the year. Super 62, with increased range and speed but lower capacity, went into service at mid-year.

FAIRCHILD 228

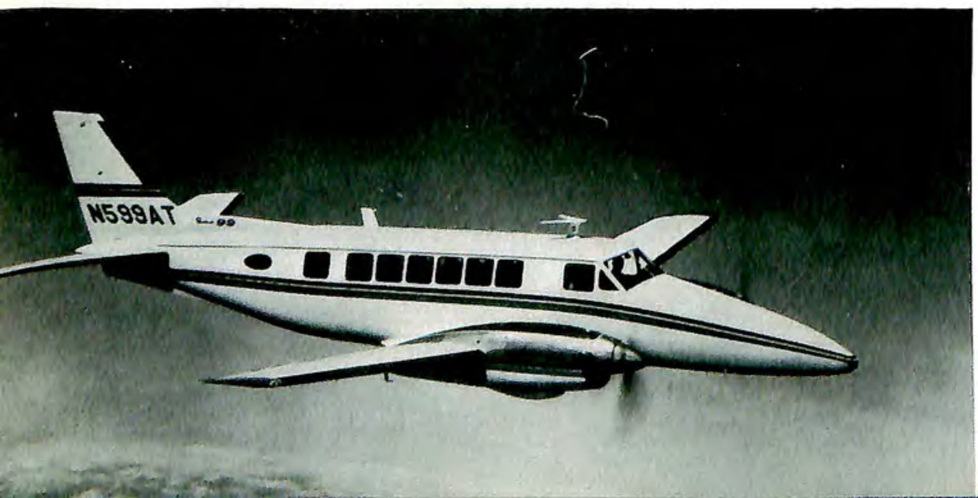
Fairchild Hiller started work on the Fairchild 228, a jet transport specifically designed for the short trip requirements of the regional airlines. West Coast Airlines will introduce it in 1970. The twin fanjet seats 50–60, cruises at 500 miles per hour.

LEAR JET MODEL 25

Lear Jet received FAA certification for its Model 25. The 10-passenger craft is 4 feet 4 inches longer than its predecessor, the Model 24.

PIPER PA-35 COMMUTER

In development at Piper Aircraft's Vero Beach, Florida, facility, was the Piper PA-35 commuter liner, an 18-passenger plane designed for short haul service. The PA-35 is powered by 2 470 horsepower turbosupercharged engines, cruises at 200 to 230 miles per hour.



BEECHCRAFT 99

Newest addition to the Beech Aircraft Corporation line was the Beechcraft 99, a 250 mile per hour 17-passenger turboprop airliner.

CESSNA CARDINAL

Representative of the new Cessna line was the Cardinal, which features a 4-cylinder 150-horsepower engine and an easy handling control system incorporating new ailerons, wide-span flaps and a one-piece stabilator.

NORTH AMERICAN ROCKWELL TURBO II COMMANDER

North American Rockwell Corporation introduced the Turbo II Commander (photo) and continued production of the prop-driven Commanders. The Jet Commander was sold to Israel Aircraft Industries as a condition of the merger between North American and Rockwell Standard.

McDONNELL PHANTOM

The first production model of the F-4E Phantom, USAF version which features a multiple barrel 20 millimeter cannon in addition to missile armament, made its initial flight at McDonnell Douglas Corporation's St. Louis plant on June 30.

GENERAL DYNAMICS F-111

On May 22, 2 USAF F-111As (photo) demonstrated their long range capabilities by flying from U.S. to Europe without refueling and without external tanks. In the summer, the FB-111A fighter-bomber version logged its first flight of 45 minutes, including a supersonic run. By year-end, 5 F-111Bs delivered to the Navy had accumulated more than 700 test hours.

LTV CORSAIR II

Late in the year, Vought Aeronautics Division of LTV Aerospace Corporation started production of the A-7B Corsair II, which features a more powerful engine than the predecessor A-7A. The company was gearing for production of the A-7D (USAF) (photo) and the A-7E (USN), both of which have improved avionics systems.

DOUGLAS A-4F SKYHAWK

Newest version of the ageless Skyhawk, the A-4F, became operational with the Navy on June 20 when the first delivery was made to training squadron VA-125 at Lemoore Naval Air Station, California.

GRUMMAN TC-4C

The Grumman TC-4C made its first flight on June 14. Conceived as a training aircraft for A-6A Intruder pilot and bombardier/navigator crews, the plane is based upon the proven Gulfstream I airframe and engines.

CESSNA A-37

Cessna started deliveries of the A-37A attack aircraft, modified from the airframes of T-37 trainers with the inclusion of larger engines and other changes. By fall, a squadron was operational in Southeast Asia. Later in the year Cessna began production of a "B" version.

CESSNA 0-2

The Cessna 0-2, military version (USAF) of the Super Skymaster, was introduced to operational service in Vietnam. 0-2A (shown) is used for forward air control operations. 0-2B, fitted with a loudspeaker and leaflet dispenser, is a psychological warfare craft.

LOCKHEED C-5A

First model of the C-5A neared completion at the Lockheed-Georgia plant. The USAF heavy logistics transport, world's largest airplane at 350 tons, was expected to be operational in 1969.

EWR FAIRCHILD US/FRG FIGHTER

EWR Fairchild International, a joint venture of Fairchild Hiller Corporation and Entwicklungsring Sud of Germany, neared completion of the systems definition phase of the US/FRG V/STOL tactical fighter. The plane features swing-out engines and variable sweep wings; in artist's conception, engines and wings are in typical very short take-off mode.

DOUGLAS C-9A

The Air Force contracted with McDonnell Douglas Corporation for 8 flying hospital aircraft. The planes are essentially off-the-shelf DC-9s modified to carry 30 litter or 40 walking patients. First plane was to be completed in June 1968.

BOEING/DOUGLAS A/RIA

First of the fleet of 8 bulbous-nosed Apollo/Range Instrumented Aircraft was delivered in August. The A/RIA planes will serve as high altitude flying communications relay stations for Apollo flights; they are Boeing C-135 transports modified by Douglas Aircraft Modification Division for USAF Systems Command's Electronic Systems Division.

LOCKHEED XV-4B

Lockheed-Georgia Company's XV-4B Hummingbird, experimental direct lift, diverted thrust VTOL craft, was being readied for 1968 flight test with initial test tentatively scheduled for June.

SIKORSKY HH-3E

Sikorsky HH-3E helicopters of the USAF Aerospace Rescue and Recovery Service made the first non-stop helicopter crossing of the Atlantic in May.

BELL AH-1G HUEYCOBRA

Bell Helicopter Company started deliveries of the AH-1G Army strike helicopter in late spring and by early fall the HueyCobra was in action in Vietnam. The Army ordered 744 of the company-developed ships.

LOCKHEED AH-56A CHEYENNE

The Army's AH-56A Cheyenne compound helicopter, built by Lockheed-California Company, made its first flight in September and at year-end the company received a production order. The AH-56A, capable of speeds of more than 250 miles per hour, is designed to "ride shotgun" for troop-carrying helicopters and provide suppressive fire in the combat landing zones.

SIKORSKY HH-53B

The Sikorsky HH-53B, a long range search and rescue helicopter for use by the USAF Aerospace Rescue and Recovery Service, made its first flight in the spring and in a matter of months was operating in Vietnam.

SIKORSKY HH-3F

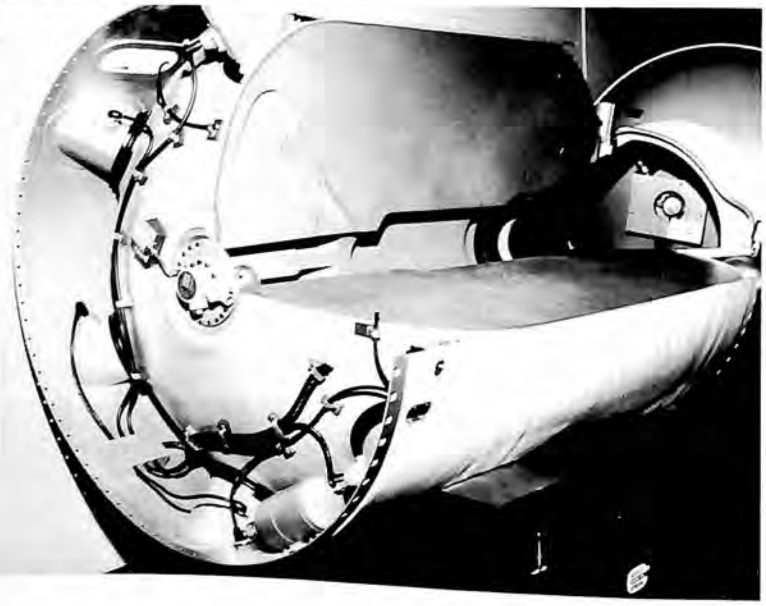
The HH-3F, a special Coast Guard version of the HH-3 rescue helicopter, made its first flight late in 1967. The "F" contains the most sophisticated electronics, navigation and instrument systems ever carried by a helicopter of this type.

FAIRCHILD HILLER FH-1100

Fairchild Hiller added floats to its FH-1100 commercial light helicopter. Weighing only 62 pounds, the floats give the helicopter higher touch-down speeds than previously possible; they can be attached in less than half an hour.

SENTINEL

Late in 1967 the Department of Defense announced plans to deploy an antiballistic missile defense system known as Sentinel and derived from the Nike-X developmental program. A "thin" defense, Sentinel is to consist of 2 complementary missiles, the Martin Marietta-built Sprint (shown) and the Western Electric/McDonnell Douglas Spartan, together with batteries of surface computers and radars.



MINUTEMAN III

In development was the newest member of the Air Force's Minuteman family, Minuteman III. Being developed by Boeing, Minuteman III features an improved third stage, increasing payload and allowing the weapon to carry more penetration aids to counter enemy defenses. In photo, a cutaway model of the Aerojet-General Stage III solid rocket motor.

POSEIDON

Work progressed on the Navy's newest sub-launched ballistic missile, Poseidon, under development by Lockheed Missiles & Space Company. By year-end, the system was nearing first firing. In photo, a dummy is being loaded into launch tube for pop-out test in which the missile is caught in mid-air by a giant crane.

ADVANCED ARM (No photo)

The Department of Defense announced plans to proceed with development of a new anti-radiation missile known as Advanced ARM.

LANCE

While the basic Lance was in advanced development, the Army gave the green light for the Extended Range Lance (XRL). The Navy awarded an exploratory development contract for a Landing Force Support Weapon known as Sea Lance. In photo, simulated firing exercise.

PERSHING

Twice, in March and in August, Army troops staged a simultaneous launch of 2 Pershing missiles from Utah into the White Sands Missile Range. From ground positions less than 100 yards apart, the missiles were sent aloft together to follow identical flight patterns and impact side by side on target nearly 400 miles away.

SAM-D (No photo)

The Army initiated development of a new system known as SAM-D, to be a field army defense against either aircraft or missiles in the '70s. Development of the mobile, radar-guided, solid-fueled missile was assigned to Raytheon Company.

CHAPARRAL

The Army's new low altitude air defense weapon, Chaparral, was publicly displayed for the first time in October. Built by Aeronutronic Division of Philco Ford, Chaparral is an adaptation of the air-to-air Sidewinder. It is shown here in a 4-missile turret mount on the XM-730 vehicle.

TOW

Hughes Aircraft technician displays TOW launcher at left and the missile itself at right. TOW, in production as an Army antitank weapon, was also being tested by Army Missile Command as a helicopter weapon.

SHILLELAGH

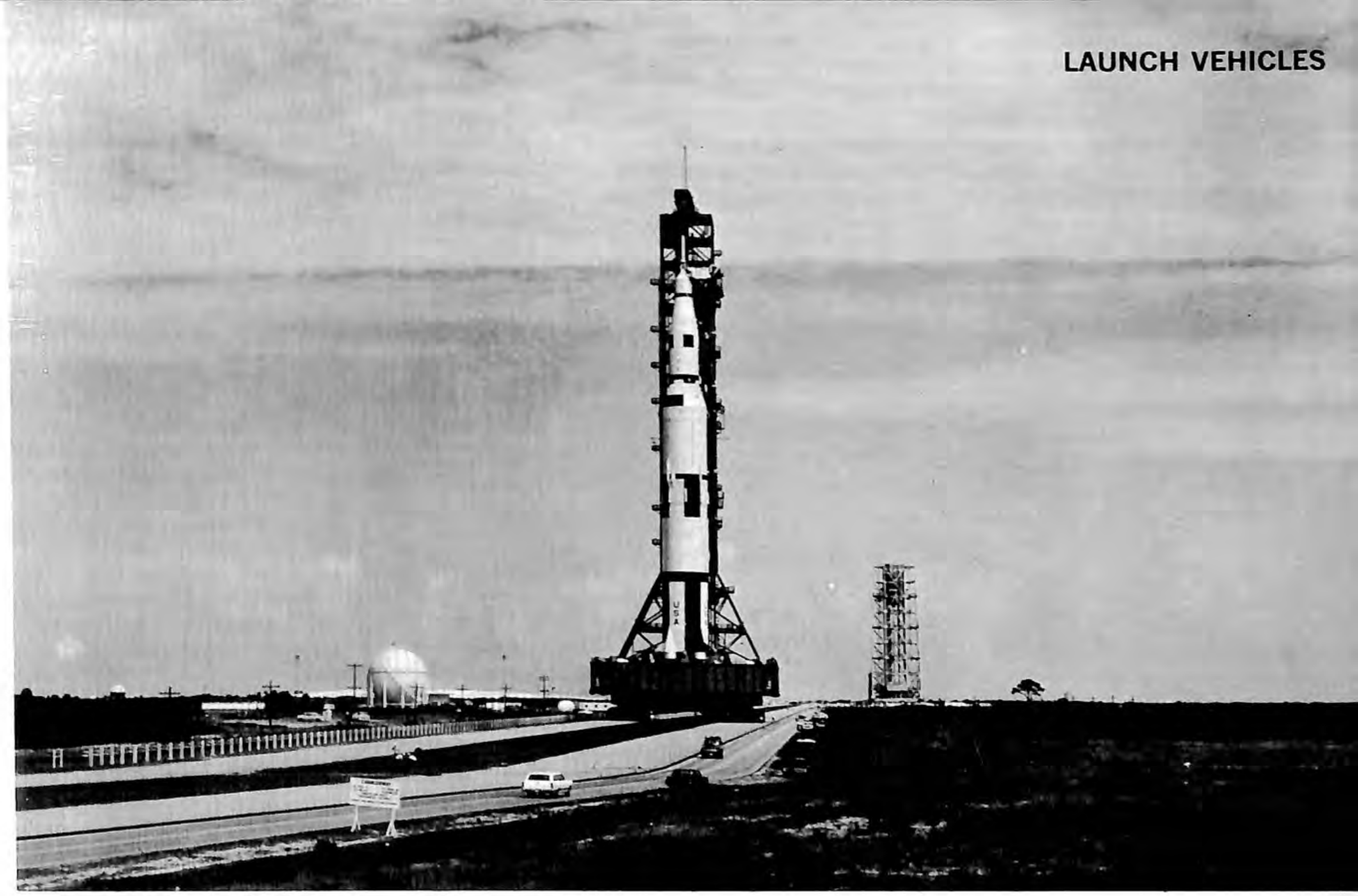
The short range close support missile Shillelagh, built by Aeronutronic Division of Philco Ford, went into service with the Army during 1967. Aeronutronic also made the first foreign shipment, to Australia for operational evaluation. Shillelagh is shown here in firing test from the General Sheridan armored reconnaissance vehicle, on which it is standard armament.

DRAGON

Engineering development continued for the Army Missile Command on the McDonnell Douglas antitank weapon once known as MAW but renamed Dragon in March. In photo, center soldier prepares to fire the recoilless, tube-launched, 27-pound missile.

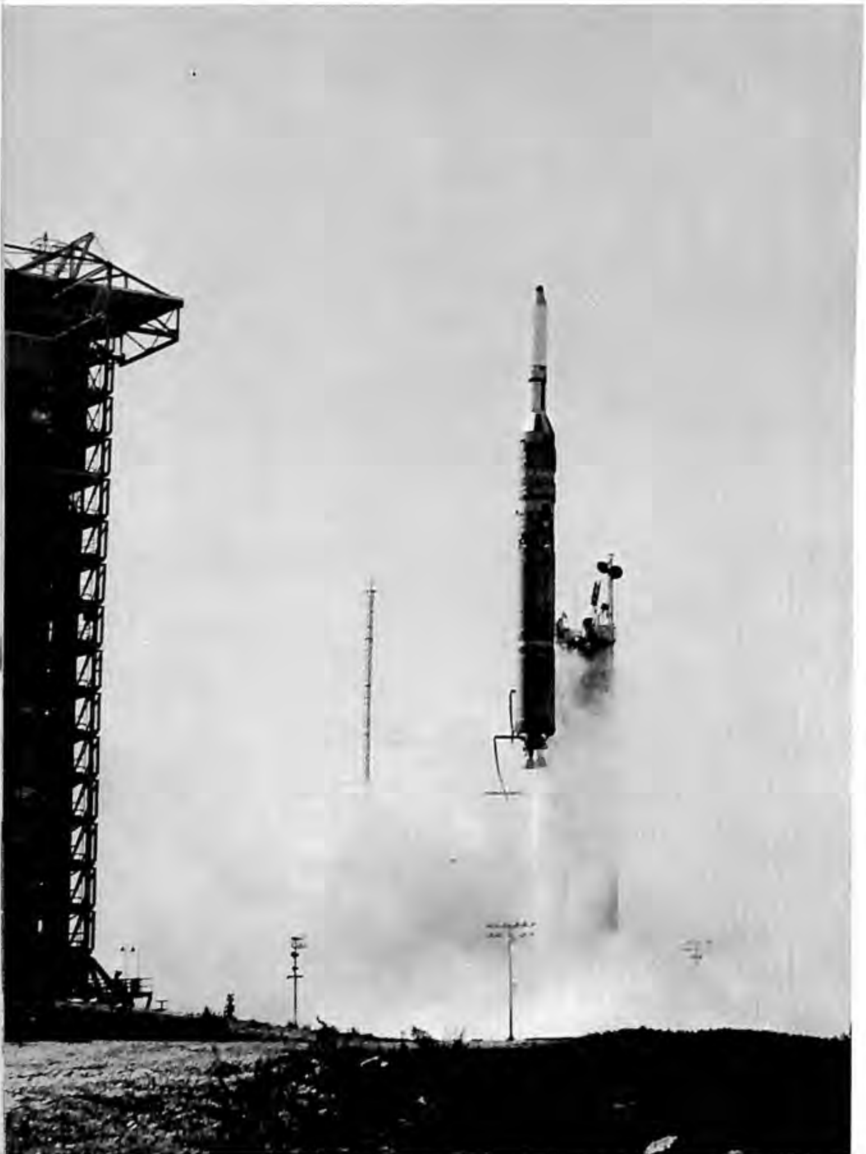
PHOENIX

The AIM-54A Phoenix air-to-air missile, being developed by Hughes Aircraft for the Navy, made its first launch from a General Dynamics F-111B in March at Point Mugu, California, and hit a drone target. Phoenix scored 5 complete successes and one partial success on 6 1967 flights.



SATURN V

One of the major highlights of the year was the November 9 launch of Saturn V, boosting a flight-rated unmanned Apollo spacecraft to an important space test (see Spacecraft). From the launch vehicle standpoint, the flight was particularly significant: both the first and the second stages had never before been test flown. This justified NASA's new "all-up" concept in which a number of lunar landing preliminaries are compressed into one flight. The mission marked the first flight of Saturn V as an integrated 4-segment system: the S-IC basic stage, 7,500,000 pounds thrust, built by Boeing with the F-1 engines supplied by Rocketdyne; the S-II second stage, built by North American Rockwell's Space Division and powered by 5 Rocketdyne J-2 engines developing more than 1,000,000 pounds thrust; the S-IVB upper stage, built by Douglas Missile & Space Systems Division, powered by one J-2; and the launch vehicle's brain, the IBM-built 3-foot-tall Instrument Unit atop the upper stage. All segments performed perfectly on the November flight known as Apollo 4. In photo, the Saturn V/Apollo "stack" is transported on its mobile launcher to the launch pad.

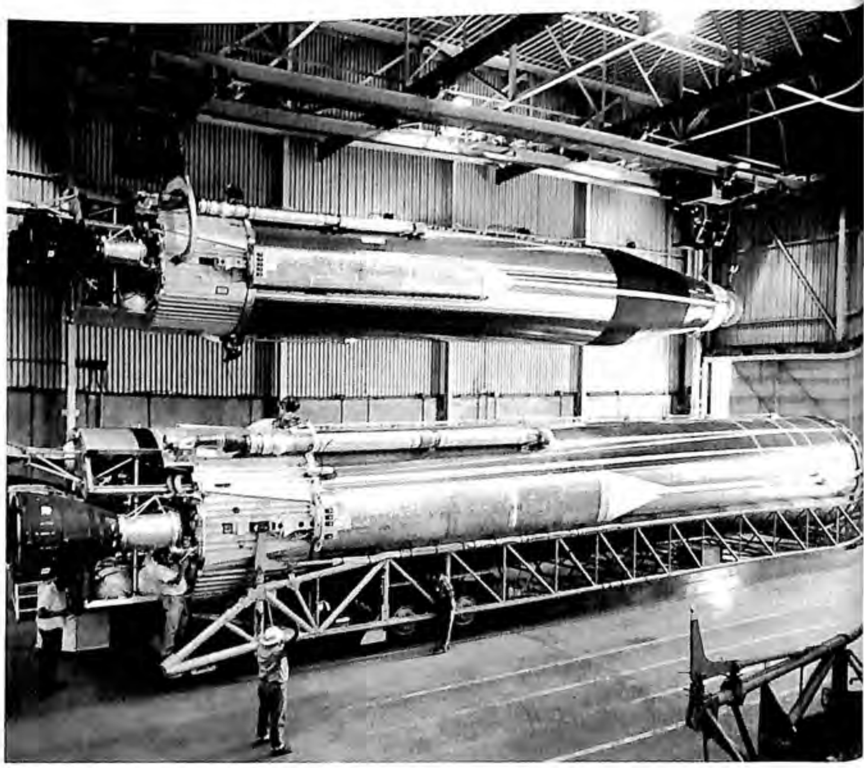


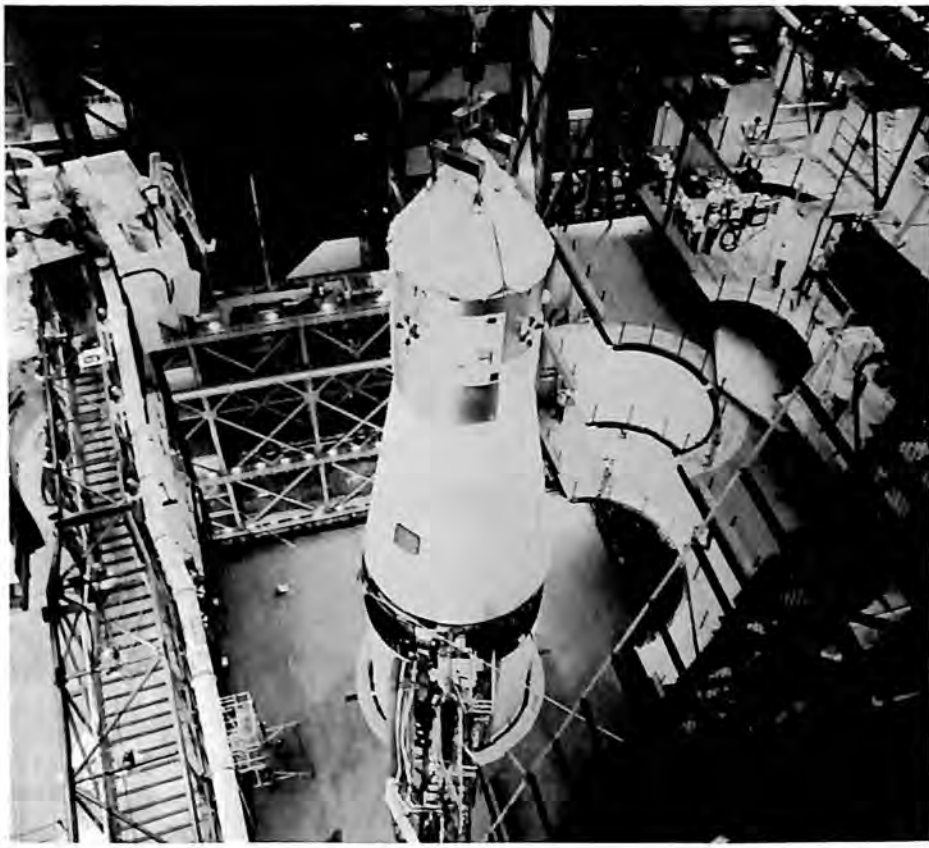
TITAN III-B

Newest member of the Titan launch family, Titan III-B, joined the USAF inventory in 1967. III-B, used for a number of classified missions, does not have the III-C's solid strap-on rockets. Redundant systems and special features such as the Malfunction Detection System have been removed to save weight and dollars. In photo, III-B takes off with the standard USAF Agena D upper stage. It can, however, fly with Centaur, Burner II or other upper stages.

ATLAS SLV-3

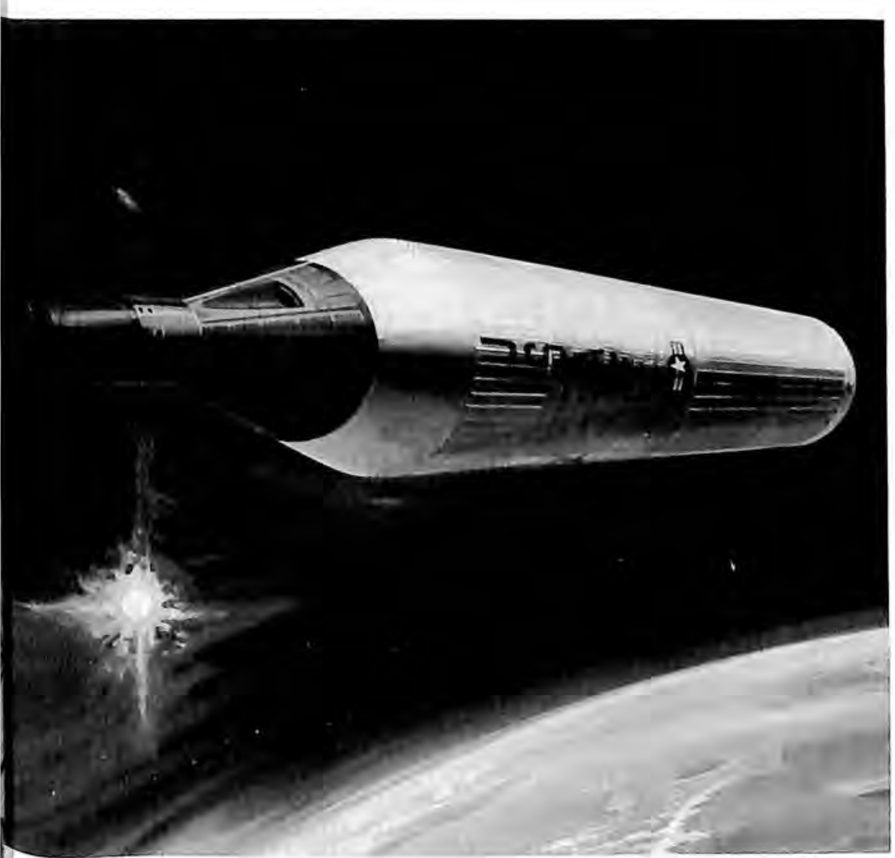
Convair Division of General Dynamics Corporation completed production of the last of its first generation Atlas SLV-3 space launch vehicles and started turnout of advanced successors. In the spring, the USAF took delivery of the first SLV-3C and launched it in September with a Surveyor payload. In October, Convair delivered the first SLV-3A. Both new models are 117 inches longer, have uprated power plants and a number of other advancements. In photo, last SLV-3 (top) passes new SLV-3C on the way to delivery.





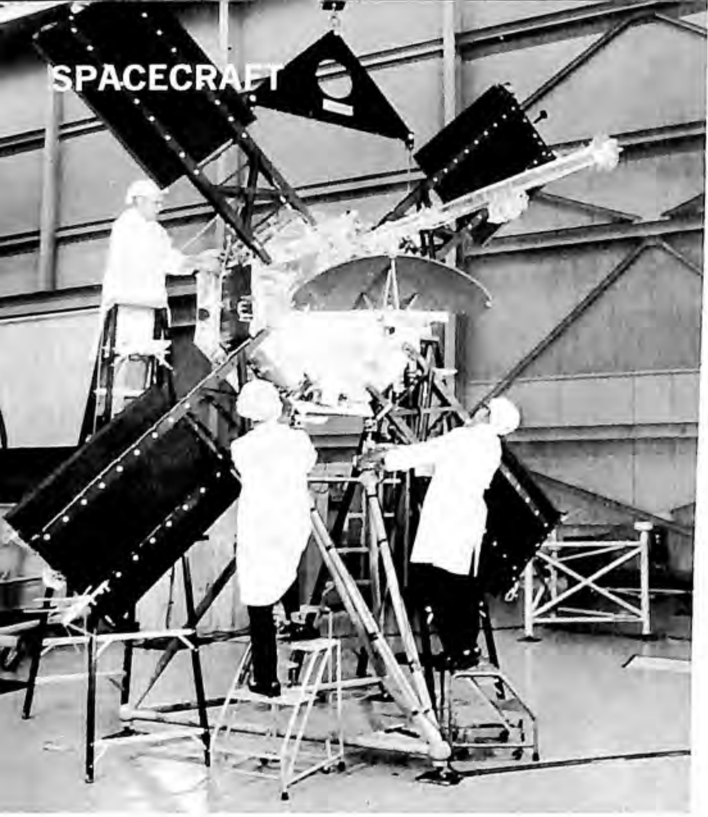
APOLLO

The fourth in a series of unmanned tests of Apollo hardware preparatory to first manned flights in 1968 took place on November 9. Saturn V boosted a payload consisting of the North American Rockwell-built Command and Service Modules plus an adapter enclosing a dummy Lunar Module into a 115-mile parking orbit, then thrust the spacecraft into a simulated lunar trajectory that took it more than 11,000 miles from earth. Apollo 4 was a flawless, "text book" mission. Among the major tests successfully conducted were the spacecraft's first exposure to "deep space" conditions, first 2-burn operation of the Aerojet-General Service Module Propulsion System, and a check of the heat shield at lunar return velocity of 25,000 miles per hour. In photo, the 2 modules and adapter are crane-lowered toward mating with the upper stage of Saturn V.



MANNED ORBITING LABORATORY

In full-scale hardware development following completion of revised system definition studies was the Manned Orbiting Laboratory, the 30,000 pound military space laboratory which consists of a modified Gemini plus a 41-foot laboratory canister. McDonnell Douglas is USAF's prime contractor; General Electric handles experiment integration. First manned flight was scheduled for 1970.



MARINER V

The third successful U.S. planetary visitor, Mariner V made a close (2,480 miles) fly-by of Venus October 19, more than 4 months after launch. The 540-pound probe, built by Jet Propulsion Laboratory, successfully transmitted atmospheric and magnetic field data and then continued on in solar orbit.

SURVEYOR

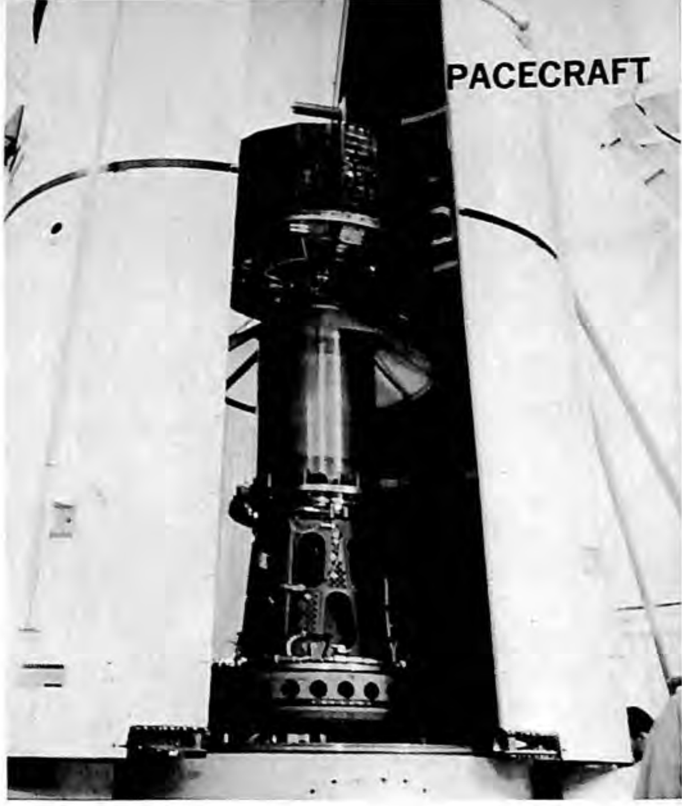
In photo, a test model of Surveyor 7 is checked out prior to launch of the last of the series early in 1968. During 1967, NASA successfully soft-landed Surveyors III, V and VI on the moon; Surveyor IV was a failure. The 3 successfully-landed craft returned excellent photos and data. The Surveyor spacecraft were built by Hughes Aircraft.

LUNAR ORBITER

Teaming with Surveyor in a highly successful lunar exploration program during 1967, Lunar Orbiters III, IV and V went into orbit around the moon and sent hundreds of detailed photos of the lunar surface, to be coordinated with Surveyor data in selection of a manned lunar landing site. Lunar Orbiter V completed the program; including 2 successful 1966 missions, the Boeing-built Orbiter scored a perfect 5 for 5.

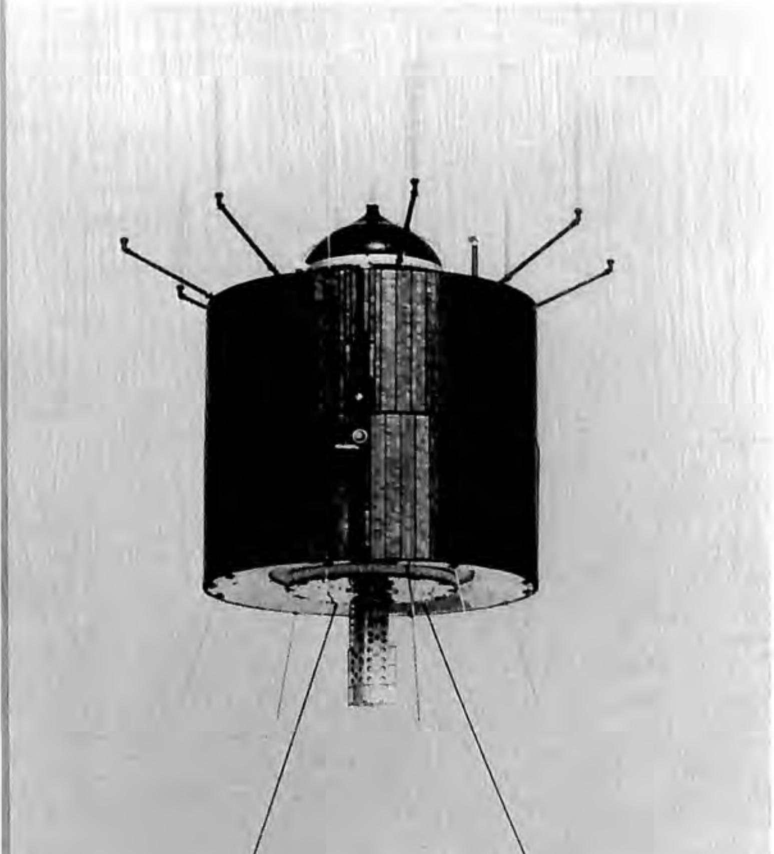
ESSA

The Environmental Science Services Administration of the Department of Commerce continued to replenish its weather satellite network with 3 successful 1967 launches: ESSA IV on January 26, ESSA V on April 20 and ESSA VI on November 10. The ESSA spacecraft, also known as Tiros Operational Satellites, are built by Radio Corporation of America. In photo, ESSA VI is being shroud-enclosed.



INTELSAT II

Communications Satellite Corporation launched 3 more of the Hughes-built Intelsat II series of synchronous comsats designed to provide communications service across the Atlantic and Pacific. Launched on January 11 was Intelsat II-B, also known as Pacific 1; Intelsat II-C, or Atlantic 2, went into orbit on March 22; and Intelsat II-D, Pacific 2, was orbited September 27. All 3 spacecraft were successful.

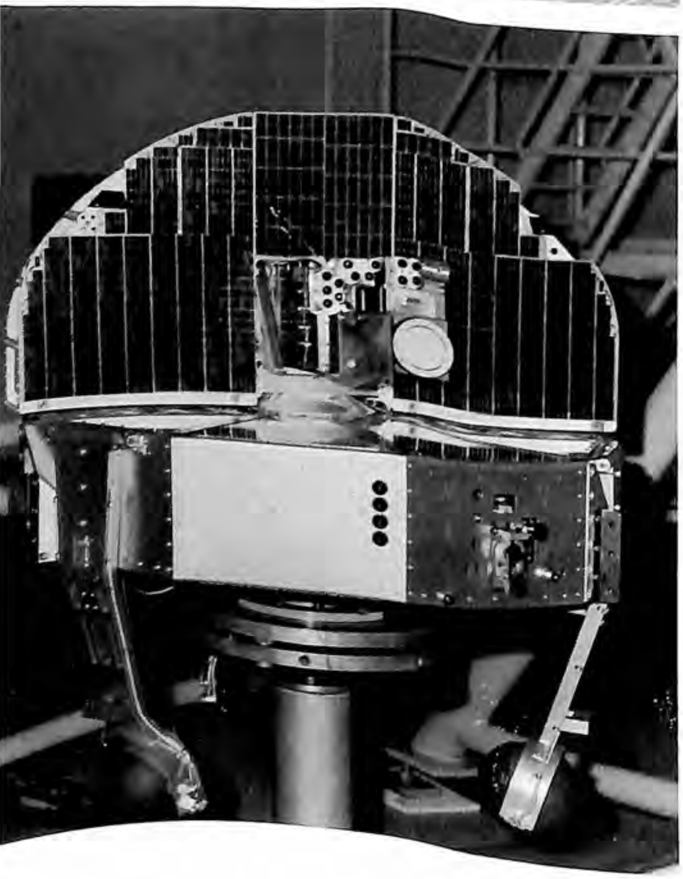


APPLICATIONS TECHNOLOGY SATELLITE

NASA's attempt to orbit Applications Technology Satellite II on April 4 ended in failure, but on November 5 ATS III was successfully launched. ATS, also built by Hughes, is a multipurpose spacecraft designed to handle a number of experiments in the applications field; the program includes 5 launches.

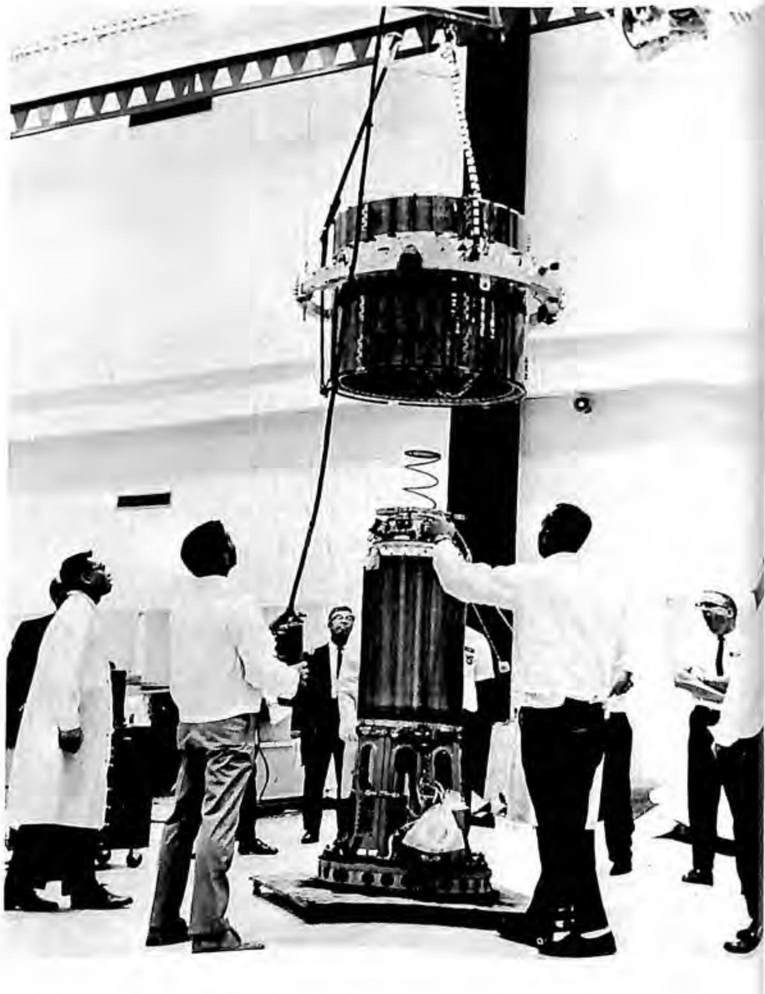
ORBITING GEOPHYSICAL OBSERVATORY

The fourth of NASA's Orbiting Geophysical Observatory series was successfully launched July 28. The 1,240-pound OGO-IV carried 18 experiments. The OGO satellites, designed to investigate the relationship between the sun, earth and the space environment, are built by TRW Systems Group of TRW Inc.



ORBITING SOLAR OBSERVATORY

In 1967, NASA successfully orbited 2 more of the Orbiting Solar Observatory series of satellites, designed to study the sun and its influence in interplanetary space near the earth. OSO is built by Ball Brothers Research Corporation. OSO III was launched March 8, OSO IV on October 18.

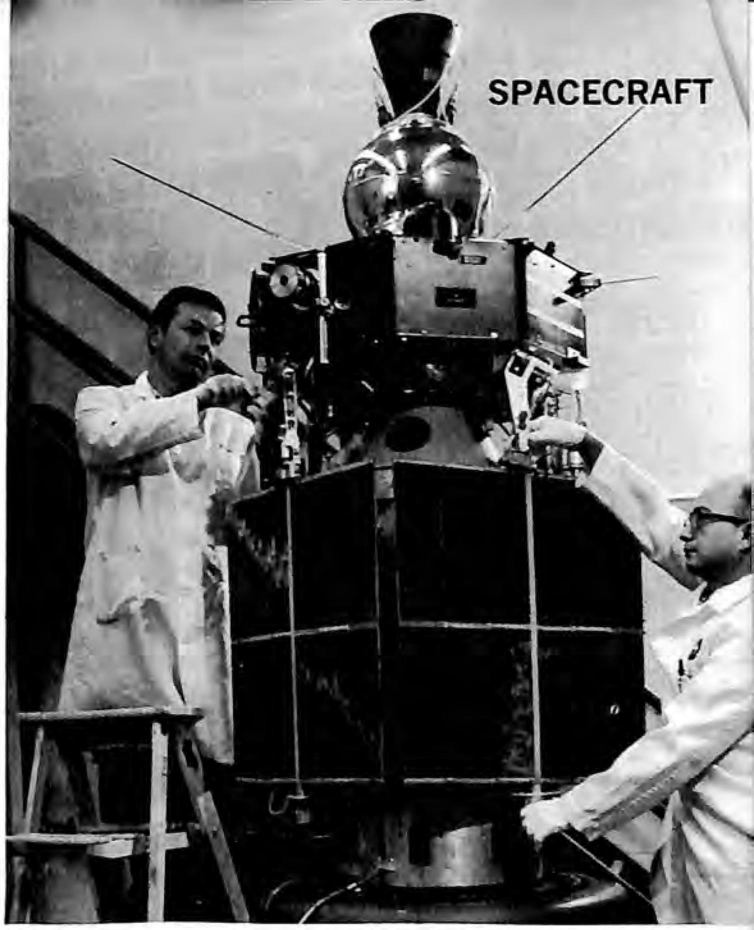


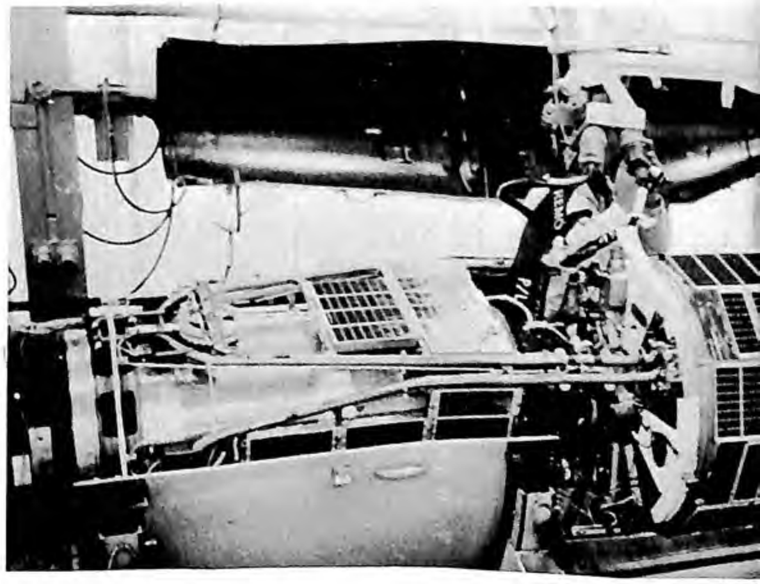
PIONEER

In photo, Pioneer 8 is readied for boom deployment test prior to its successful launch on November 10. Pioneer 8 is seeking to define clearly the tail of earth's magnetosphere, and it will monitor solar events as the sun reaches the climax of an 11-year cycle in 1969. Built by TRW Systems, Pioneer is an interplanetary spacecraft operating in solar orbit.

EXPLORER

NASA continued its Explorer series of scientific spacecraft with launches of Explorers XXXIV (May 24) and XXXV (August 19). The 2 Explorers were also known as Interplanetary Monitoring Platforms F and E, respectively. Explorer XXXIV carried 11 experiments to measure solar and galactic cosmic rays; Explorer XXXV (shown), had 7 experiments to collect data on interplanetary solar wind and magnetic fields. NASA's Goddard Space Flight Center managed the programs.





ARIEL

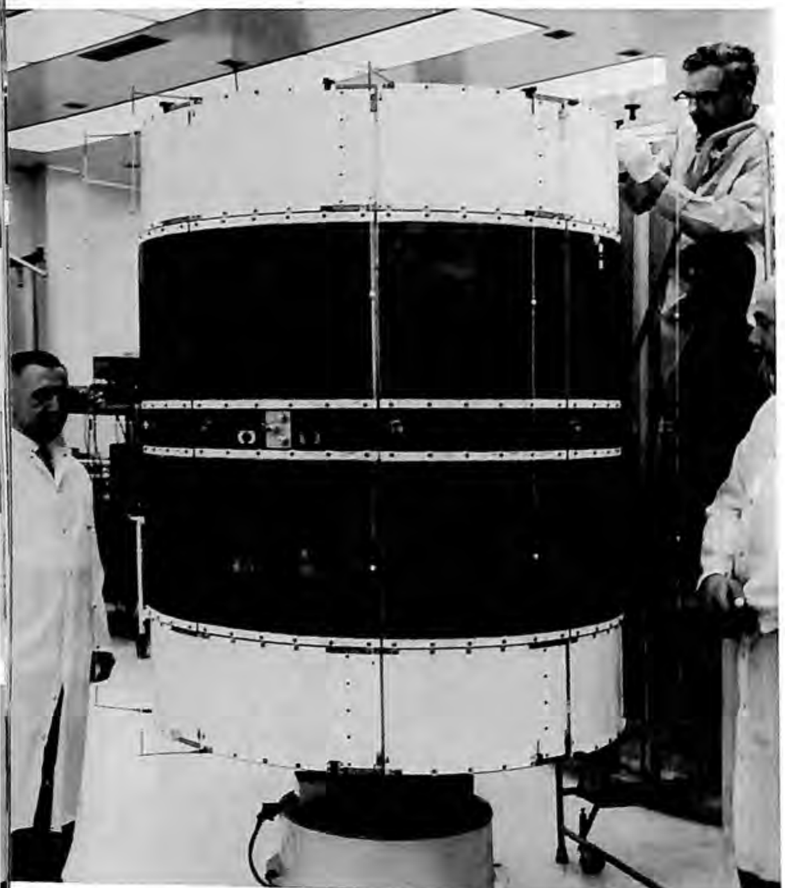
A cooperative U.S.-United Kingdom satellite also known as UK-3, Ariel III was successfully launched May 5. The spacecraft is one of a series designed to study electron temperature and composition, positive ion temperature and mass spectrum, galactic noise, ozone content and micrometeoroids.

SAN MARCO

Another cooperative program, San Marco II was launched April 26 from a platform anchored in the Indian Ocean. The satellite, designed and built by Italians, was launched by a NASA-trained Italian crew using a U.S. Scout booster. San Marco II is an air density explorer.

IDCSP

The interim military comsat network known as Initial Defense Communications Satellite Program (IDCSP) was rounded out with 2 1967 launches. In January, a Titan III-C sent 8 satellites into orbit to join 7 launched in 1966. In July 1967, the USAF filled out the 18-satellite system with a 3-spacecraft launch. Artist's conception shows sequential dispensing of comsats by the Transtage vehicle, upper stage of Titan III-C. Philco-Ford builds the satellites.



LES-5

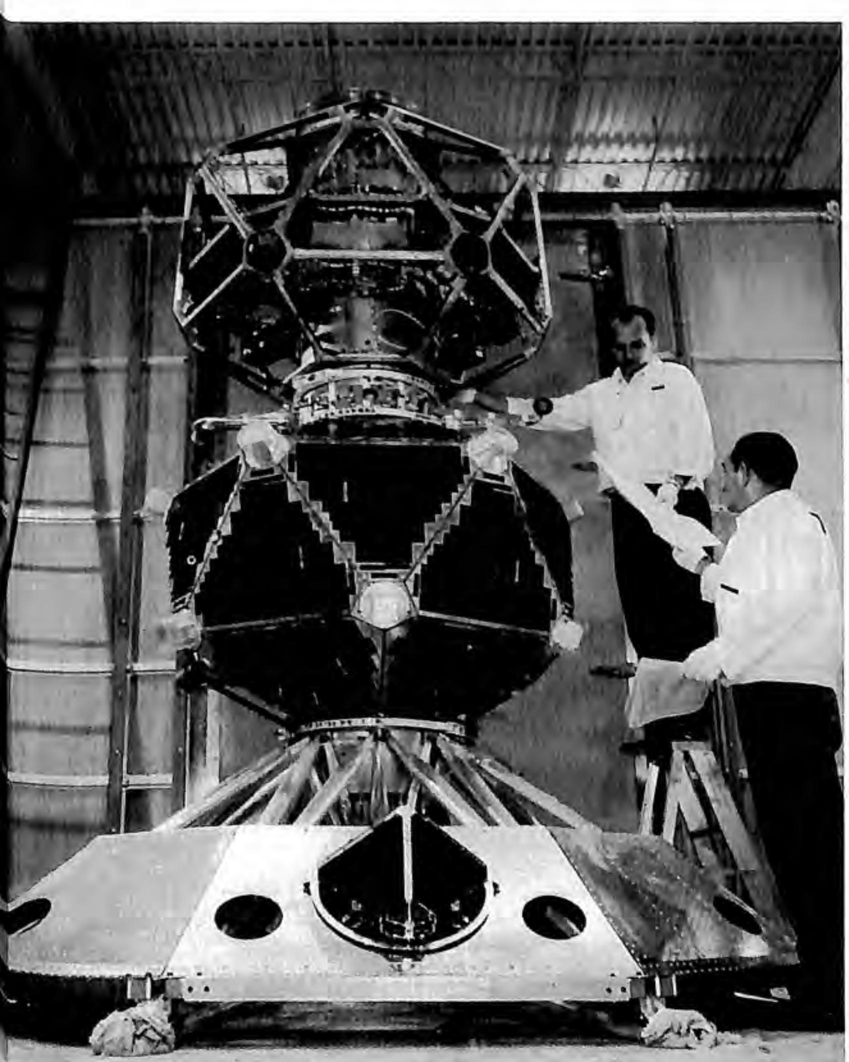
One of a series of spacecraft built by Lincoln Laboratory of Massachusetts Institute of Technology, Lincoln Experimental Satellite-5 was a developmental spacecraft for an eventual tactical comsat system for the Department of Defense. LES-5 was launched July 1.

BIOSATELLITE

In photo, Biosatellite II descends by parachute just before mid-air recovery by a USAF aircraft flying at 12,000 feet. The 400-pound NASA satellite, built by General Electric's Re-entry Systems Department, carried 13 plant and insect experiments to be studied for the effects of weightlessness and radiation. The spacecraft was launched September 7 and recovered on September 9.

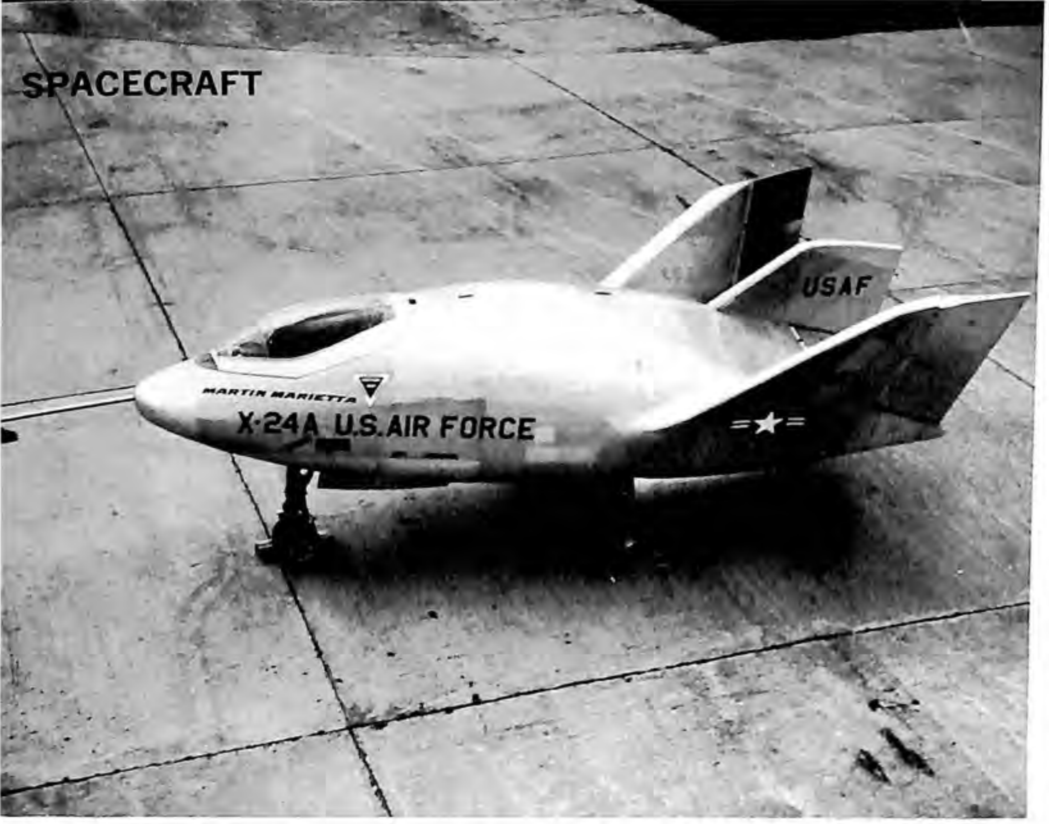
TTS-1

Launched piggyback on the boost of Pioneer VIII, the 40-pound TTS-1 (for Test and Training Satellite) was built for NASA by TRW Systems for use as a target vehicle to exercise and test the Apollo tracking and communications network.



MILITARY PAYLOADS

Representative of a number of varieties of spacecraft launched by the military service during 1967 were the twin nuclear detection satellites Vela 7/8, launched April 28 into orbits in the neighborhood of 70,000 miles altitude. The Velas (shown) are built by TRW Systems Group. During the year, the Department of Defense sent more than 60 payloads into orbit (including the 12 comsats). Most of these payloads were of a classified nature, but among the others were several of the USAF's Orbiting Vehicle series, part of a program to put low-cost experimental packages of many types into orbit, usually by "piggybacking" them on a launch where the primary payload weighs less than the booster's launch capability; ERS, a radiation research satellite; Surcal, a surveillance calibration sphere; GGSEs 4 and 5, gravity gradient stabilization experiments; the Army's SECOR 9 geodetic satellite; the Navy's Aurora 1, an investigator of the aurora borealis; DATS, a mechanically de-spun antenna test satellite; and DODGE, for Department Of Defense Gravity-gradient Experiment. Many of the spacecraft were carried on multiple (5 to 9 at a time) launches of the Titan III-C.

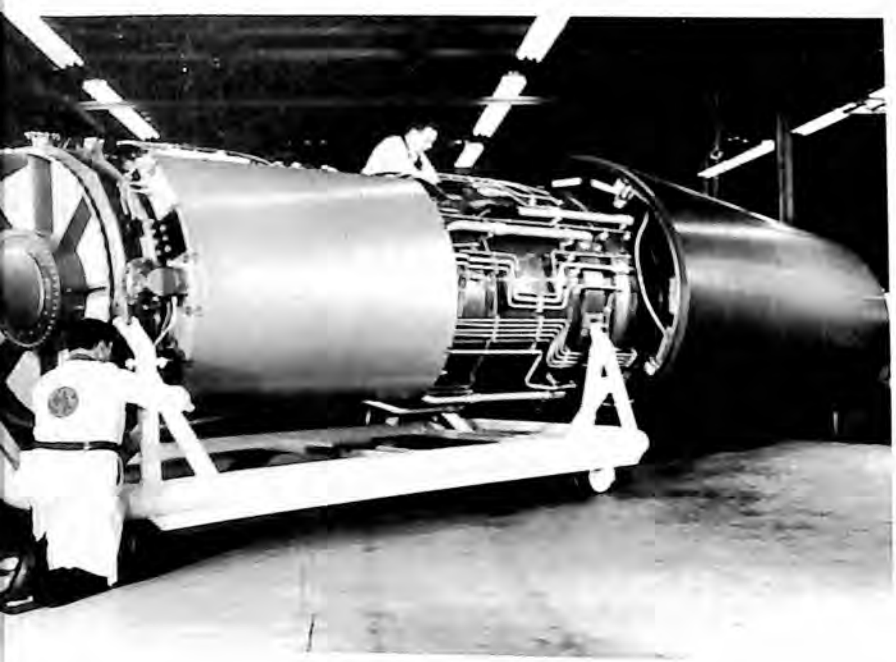


PRIME/PILOT

Completed in 1967 was the USAF's PRIME project, involving 3 flights of a wingless lifting body spacecraft as an unmanned program to study re-entry maneuverability of this type of vehicle. All 3 flights of the thumbnail-shaped SV-5D vehicles, built by Martin Marietta, were successful and the program ended with the third flight on April 19. The USAF then started preparations for PILOT, an investigation of the lower end of the re-entry/landing speed spectrum with a manned lifting body vehicle, also built by Martin Marietta, called the X-24A (photo). To start flying in 1968, the X-24A will explore lifting body flight and maneuverability at speeds from Mach 2 down to touchdown speed, where the SV-5D investigated the hypersonic range.

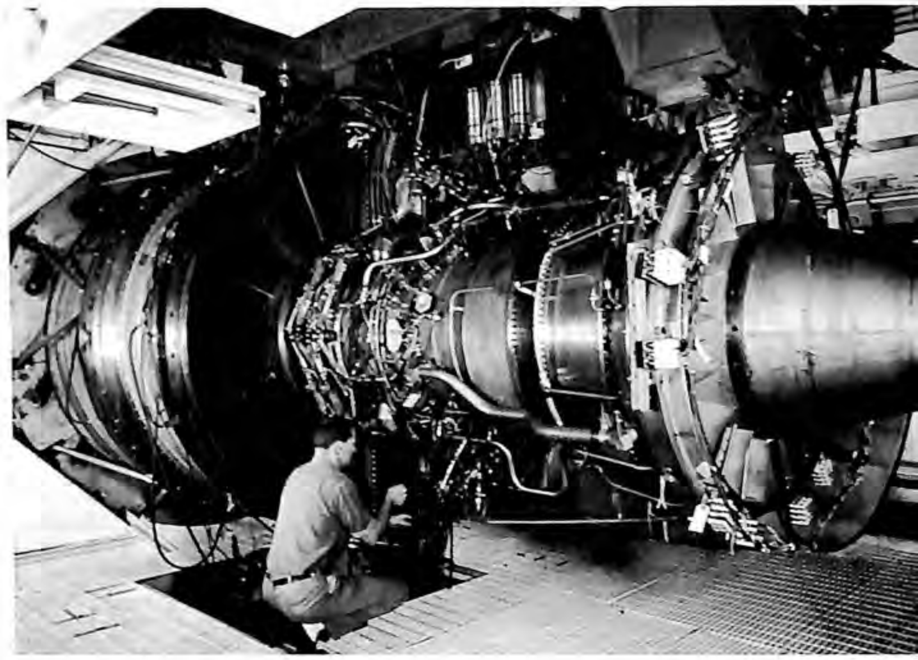
APOLLO APPLICATIONS

In 1967, NASA started letting the first hardware contracts for its Apollo Applications program, follow-on to the lunar landing project. One of the most important early projects is the S-IVB Orbital Workshop, to be launched in 1970. This is a 2-story space laboratory for manned habitation in "shirtsleeve" environment for long periods. The space station is a modified upper stage of the Saturn V, being converted by Douglas Missile & Space Systems Division. The airlock (top center) is being provided by McDonnell Astronautics Company. Both contractors are components of McDonnell Douglas Corporation.



GENERAL ELECTRIC GE4

General Electric Company started component tests of the GE4 engine designed for the Boeing U.S. supersonic transport. Some 25 feet long and 6 feet in diameter, GE4 is in the 60,000 pound thrust class.



PRATT & WHITNEY AIRCRAFT JT9D

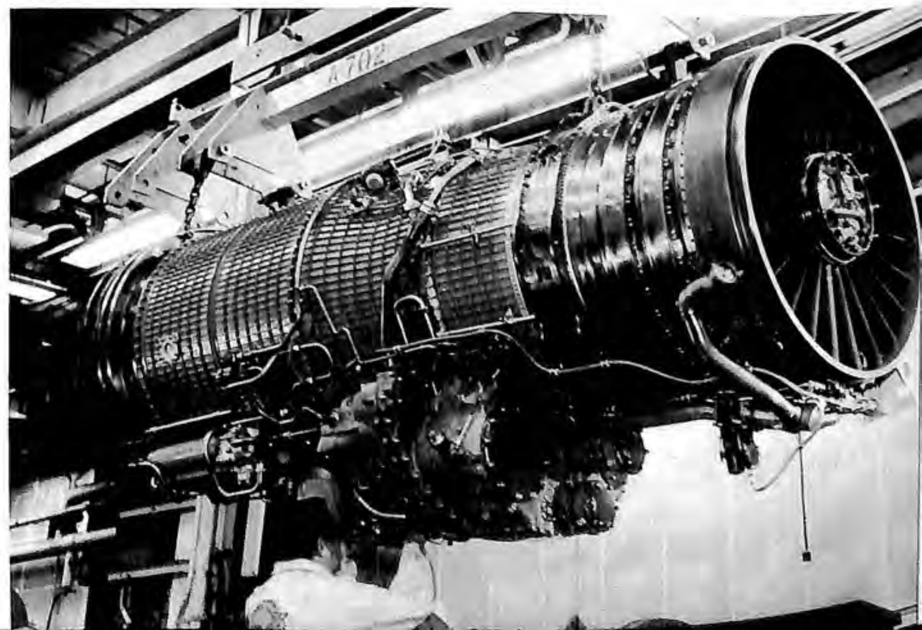
Pratt & Whitney Aircraft's JT9D turbofan reached the 400-hour mark during the year. The engine, being developed for the Boeing 747 jumbo jet, made a thrust gain in 1967 from 42,000 to 43,500 pounds.

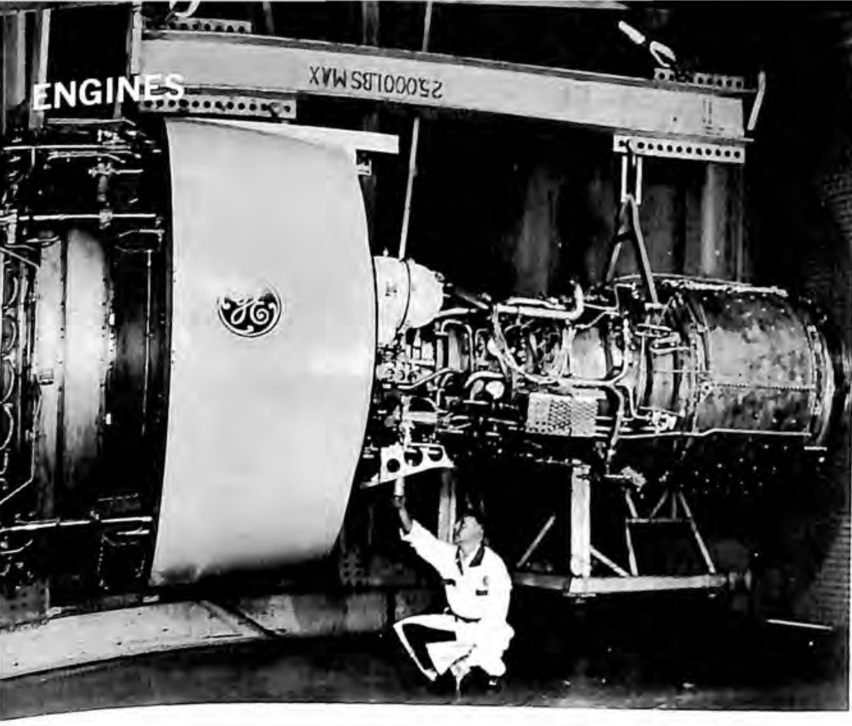
ALLISON T63

The regenerative T63 turboshaft engine, first regenerative system to be sole source of power in any aircraft, was being tested in the Hughes YOH-6A helicopter. Photo shows the regenerators and a portion of the engine.

PRATT & WHITNEY AIRCRAFT TF30

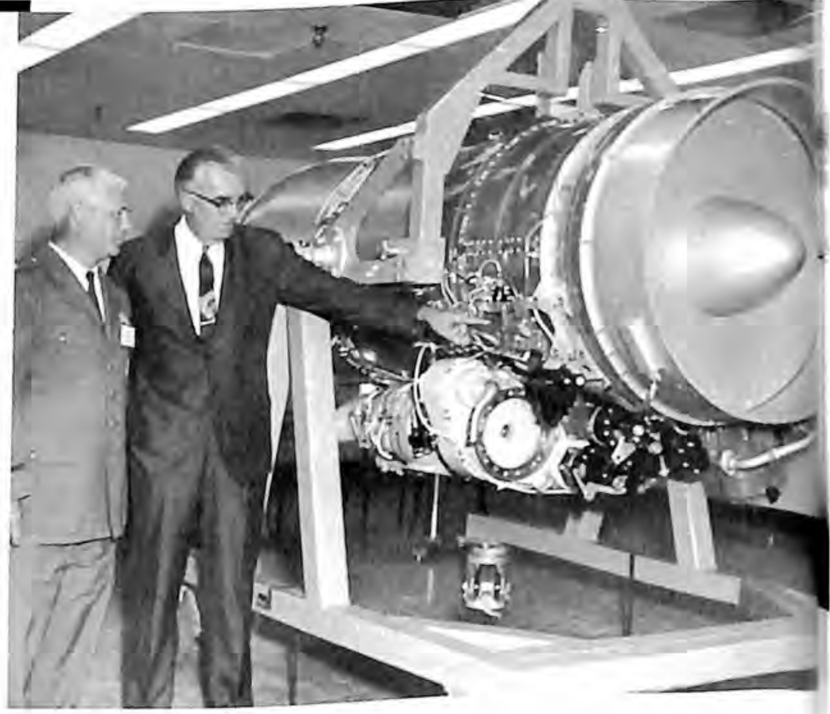
Pratt & Whitney Aircraft was delivering the TF30, power plant for the LTV A-7A Corsair II. The TF30 is in the 10,000 pound thrust class. In photo, non-afterburning version is checked prior to shipment.





GENERAL ELECTRIC XTF39

General Electric's Flight Propulsion Division delivered the first XTF39 engine, ground test version of the power plant for the Lockheed C-5A. The engine, in the 41,000 pound thrust class, will be tested at Lockheed-Georgia's plant. First flight of a TF39-powered C-5A was scheduled for mid-1968.



ALLISON TF41

Completed 6 months ahead of schedule was this mock-up of the TF41 turbofan engine being developed by Allison Division of General Motors Corporation with Rolls Royce Ltd. The TF-41 will power the A-7D tactical attack aircraft.

UNITED TECHNOLOGY HYBRID

The nation's largest, most powerful hybrid rocket engine is lowered into position during a 1967 test firing by United Technology Center, its developer. The hybrid, combining a solid fuel and a liquid oxidizer, was built under contract from the Air Force Rocket Propulsion Laboratory.

AVCO LYCOMING T55 (No photo)

A new version of Avco Lycoming's T55 turboshaft engine, the T55-L-11 rated at 2,850 shaft horsepower, entered production. Also in production was Avco Lycoming's T53-L-15 turboprop.

THIOKOL 156-INCH MONOLITHIC ROCKET

Working under contract from the Air Force Rocket Propulsion Laboratory, Thiokol Chemical Company built and test-fired a 156-inch monolithic rocket.

ROCKETDYNE AEROSPIKE

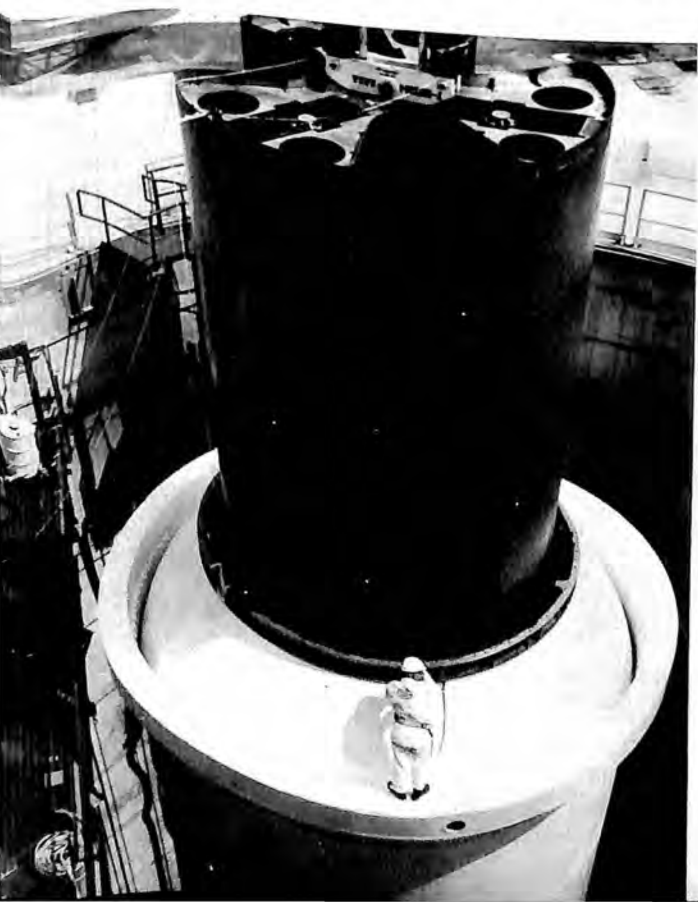
Rocketdyne continued development of the Aerospike, a new rocket engine concept which uses a combustion ring assembled around the upper circumference of a truncated center cone. The full-scale engineering model shown is in the 250,000–400,000 pound thrust class.

AEROJET-GENERAL 260-INCH SOLID

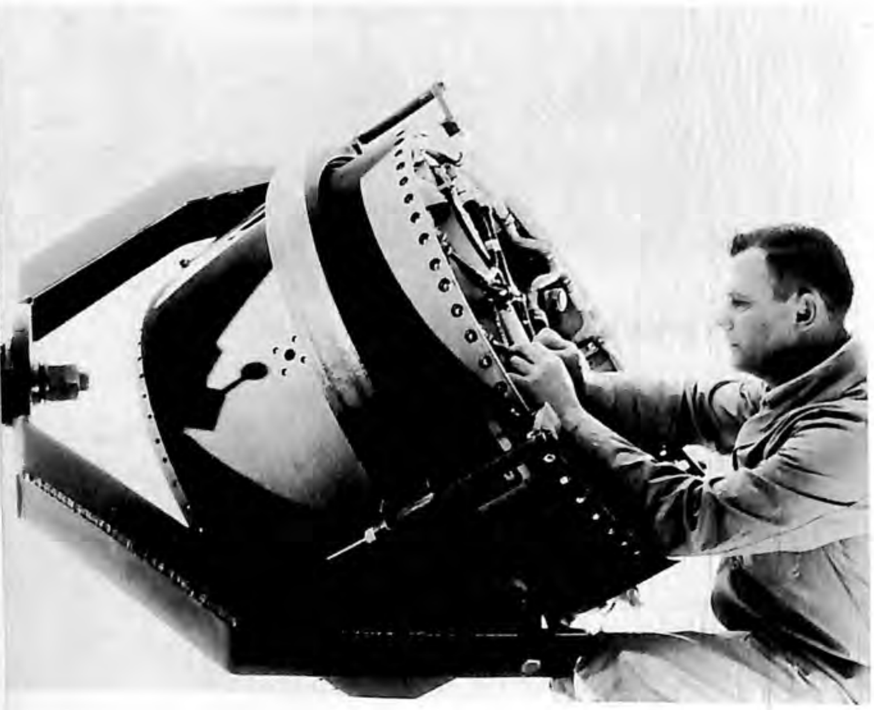
In June 1967, Aerojet-General test-fired a 260-inch diameter solid rocket motor. This was the third 260-inch motor built and fired in NASA's Large Solid Rocket Technology Program. In the June firing, the motor produced 5,700,000 pounds of thrust, compared with 3,500,000 pounds thrust in the 2 earlier firings.

HAMILTON STANDARD MONOPROPELLANTS

Hamilton Standard Division of United Aircraft Corporation was developing a family of monopropellant engines ranging from .05 to 200 pounds thrust for space vehicle attitude and orbit control. In photo, HamStan technician installs hydrazine-fueled rocket in computer-controlled test stand.

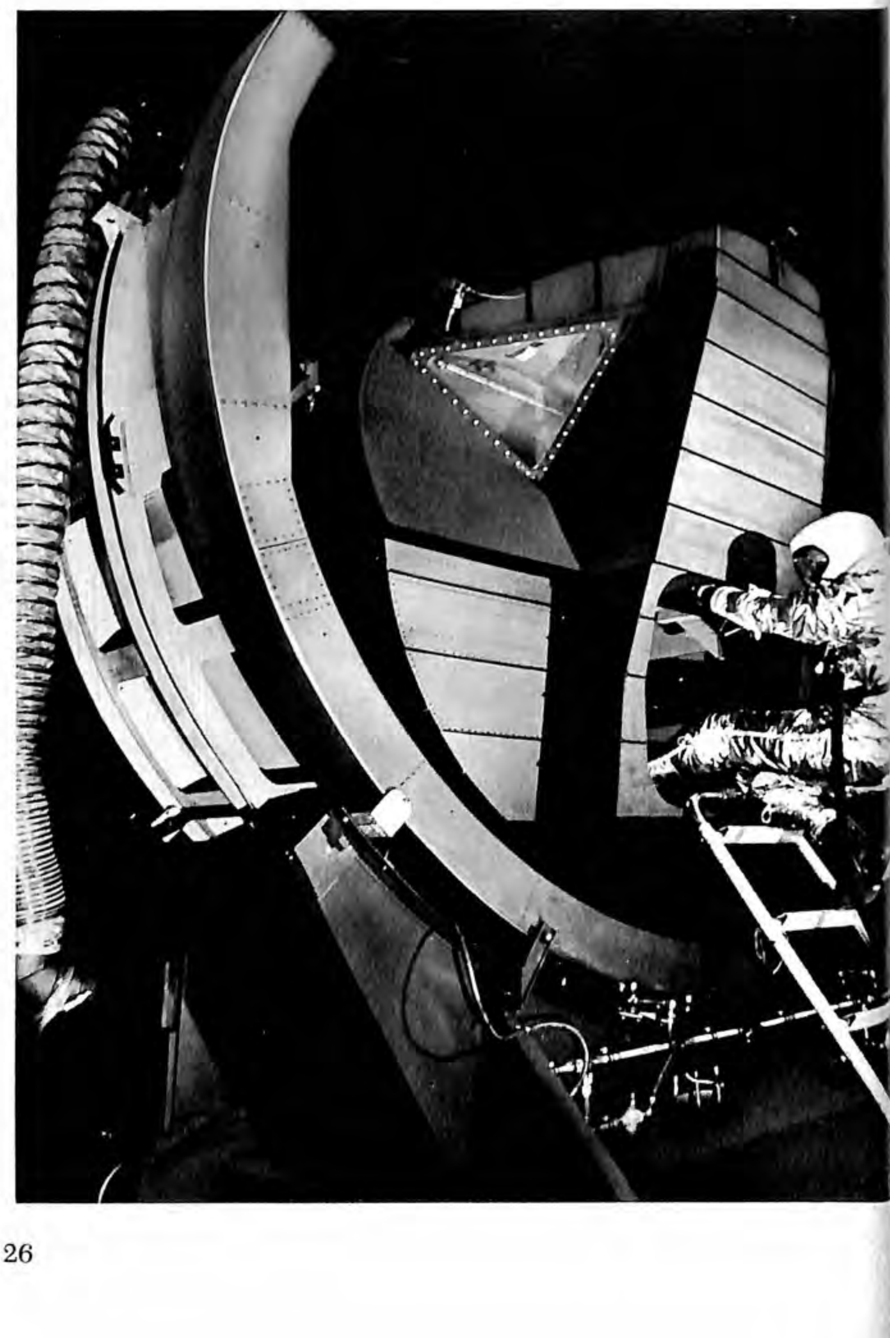


The term "systems" is used here to cover the wide range of equipment built by the aerospace industry other than primary products, such as aircraft, missiles and spacecraft. The systems shown here are random selections representative of the extremely broad industry product line.



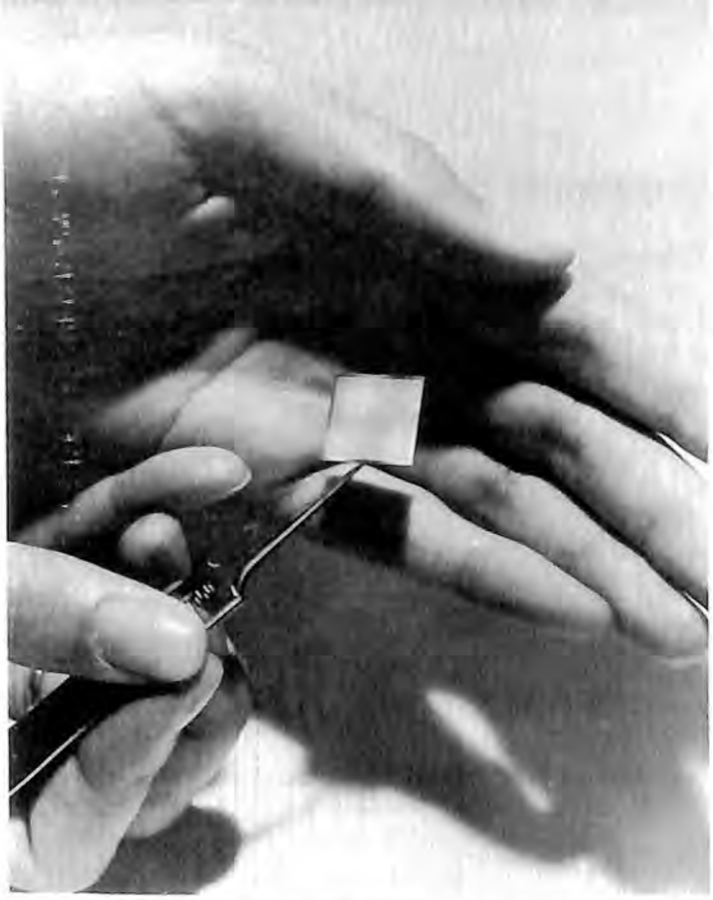
AVCO PENETRATION AIDS

Avco's Missile Systems Division completed prototype hardware, here undergoing check in flight simulation chamber, on a $65,000,000 contract for development and production of the Mark I ICBM Penetration Aids System for the USAF's Minuteman ICBM.



REPUBLIC TRAINER

Republic Aviation Division of Fairchild Hiller Corporation developed an Apollo docking trainer. The simulator will allow Apollo astronauts to practice the docking maneuvers they will perform on a lunar mission.

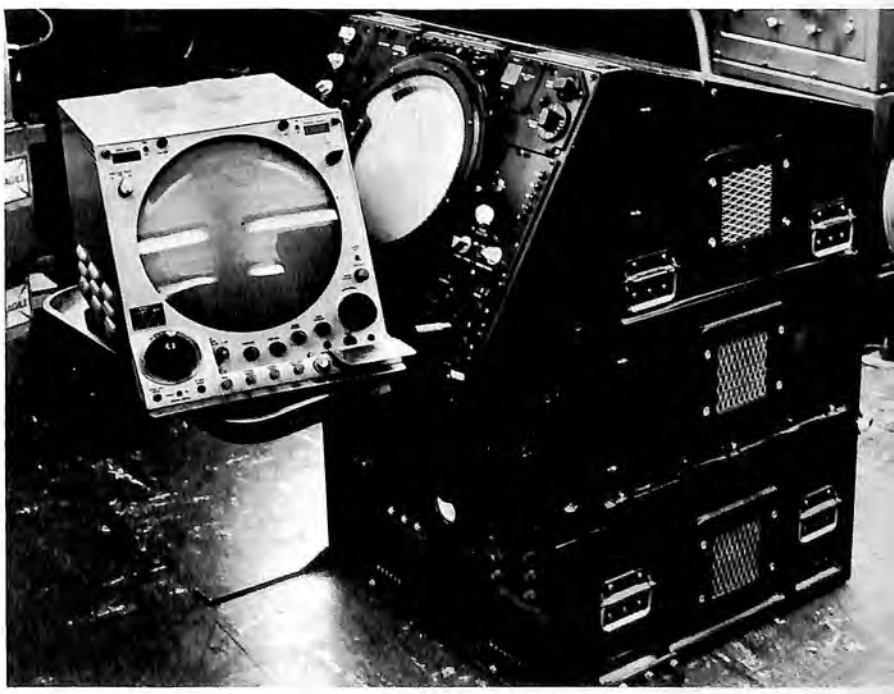


WESTINGHOUSE IMAGE CONVERTER

Under NASA contract, Westinghouse Defense and Space Center's Aerospace Division developed a tiny, half-inch by half-inch solid state image converter which is made up of 12,800 phototransistors mounted on a silicon substrate. Such a mosaic may in the future be used in place of a vidicon tube for special applications.

HAMILTON STANDARD OXYGEN PRODUCER

Hamilton Standard built and shipped to NASA for test a prototype oxygen-producing system for astronauts flying extended space missions. A molten carbonate cell, it uses a molten salt bath at 1,200 degrees Fahrenheit to break down carbon dioxide so oxygen can be reclaimed.



GENERAL ELECTRIC MIRAGE

General Electric delivered to the USAF at Rome Air Development Center the MIRAGE (Microelectronic Indicator for Radar Ground Equipment), which will replace an earlier radar indicator. MIRAGE offers savings of $10,000 in operations and maintenance costs for each indicator replaced.

NORTHROP COMPUTER

Northrop Corporation's Nortronics Division was manufacturing a new computer for the USAF C-5A, world's largest airplane. The computer is part of a navigation system being built by Northrop for Lockheed-Georgia Company, prime C-5A contractor.

GOODRICH WHEEL

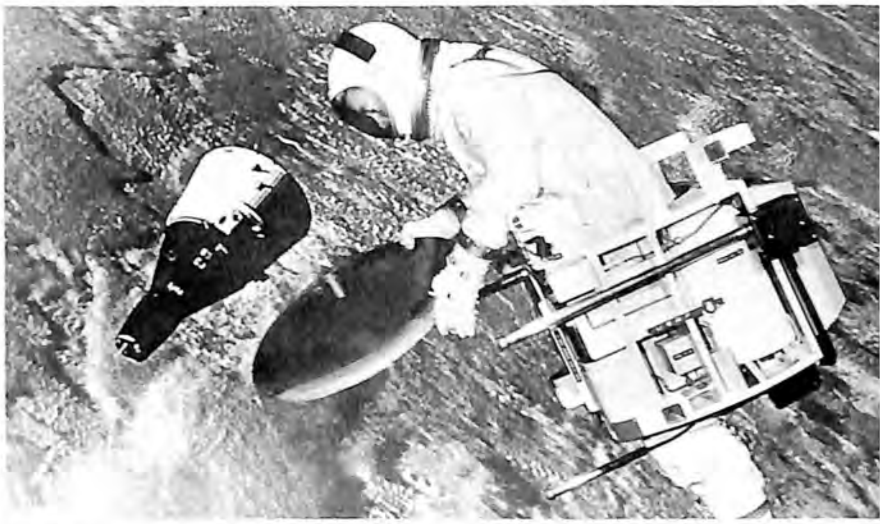
Another product for the C-5A is a lightweight forged aluminum nose wheel, developed by The B. F. Goodrich Company. Goodrich was supplying tires, wheels and brakes for the new plane.

GOODYEAR CHUTE

Among new parachute designs developed by Goodyear Aerospace Corporation was this sombrero-shaped nylon chute which weighs only 40 pounds but can handle payloads of more than 1,000 pounds. It was designed for recovery of reentering spacecraft and other airborne vehicles.

BELL DUAL MANEUVERING UNIT

In development for the Air Force Aero Propulsion Laboratory by Bell Aerosystems Company was the Dual Maneuvering Unit, which can provide mobility for an astronaut in space or can be remotely controlled from a spacecraft. Photo simulation shows astronaut using DMU to erect an antenna.



RYAN SOLAR ARRAY

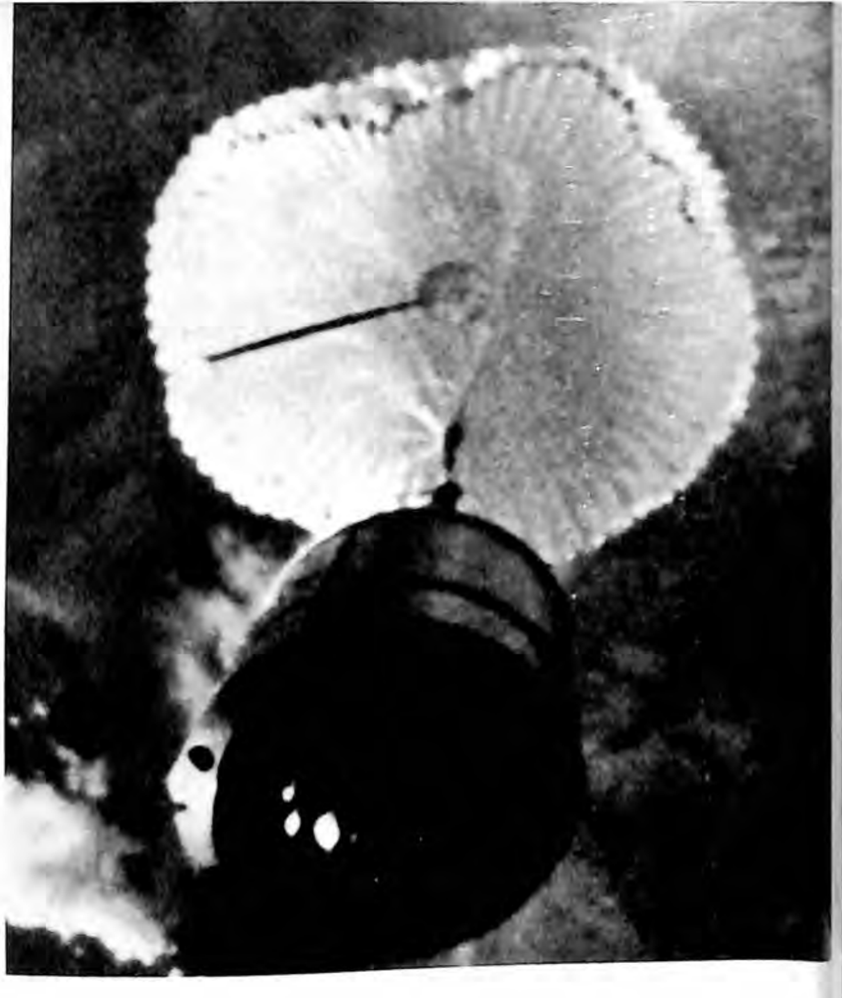
Under contract to Jet Propulsion Laboratory, Ryan Aeronautical Company developed a roll-out type of solar array for more electric power in space. Ryan's deployable technique features titanium support beams and fiberglass substrate for larger, lighter arrays.

HUGHES TERMINAL

For use with the military satellite communications system, Hughes Aircraft Company developed for the Army the Mark IB, AN/MSC-46 air transportable ground-link terminal. Terminal components are protected from the weather by a dual-walled, inflatable, cocoon-like radome.

MARTIN BRAKING SYSTEM

Martin Marietta conducted a flight program aimed at development of a parachute design suitable as an aerodynamic braking device to help decelerate unmanned spacecraft to soft landings on planets of low-density atmosphere. Photo shows descent of a disk-gap-band design chute carrying cylindrical spacecraft in the Planetary Entry Parachute Program at White Sands Missile Range.

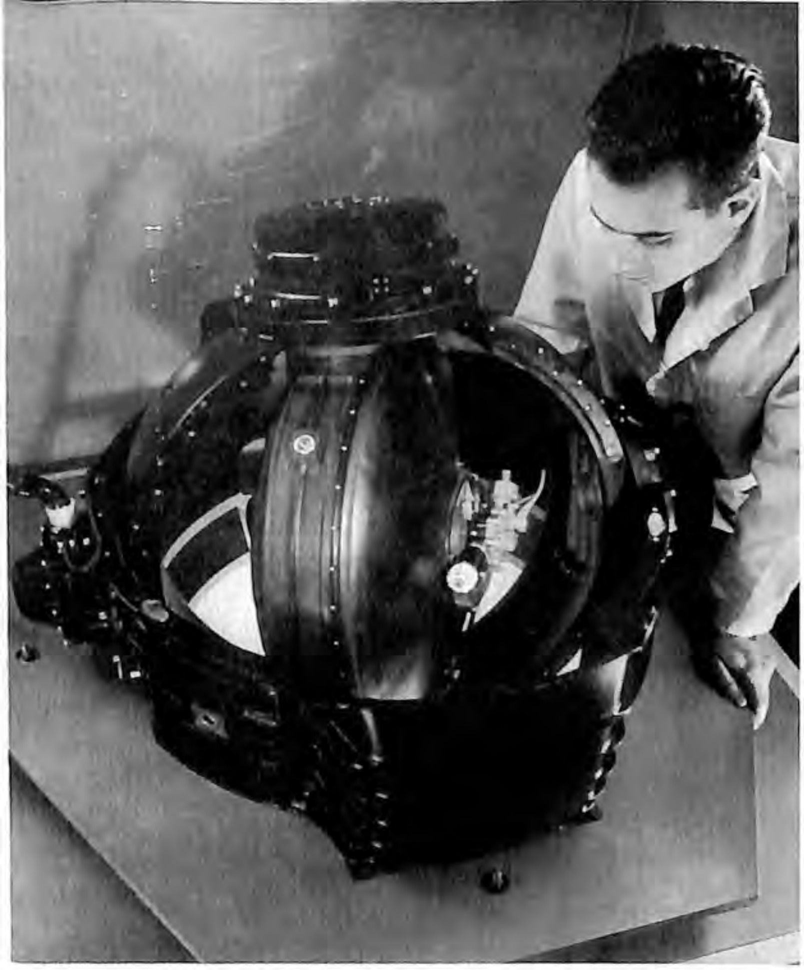


GENERAL ELECTRIC VIDICON CAMERAS

NASA was evaluating for possible use on its Apollo Telescope Mount, a manned spacecraft in the Apollo Applications program, the UVR-700 Focus Projecting Scanning vidicon camera developed by GE's Aerospace Electronics Department. Weighing just over 5 pounds, the camera has a resolution of more than 1,000 lines (a good quality home TV picture represents 350 lines).

CHRYSLER NO-LENS TELESCOPE

For photographing the distant reaches of space from a manned orbital research laboratory, Chrysler developed a prototype no-lens telescope which uses only mirrors to study the heavens. Lens-type telescopes filter out high intensity ultraviolet rays, but the Chrysler scope will make possible surveys in the far ultraviolet spectrum.

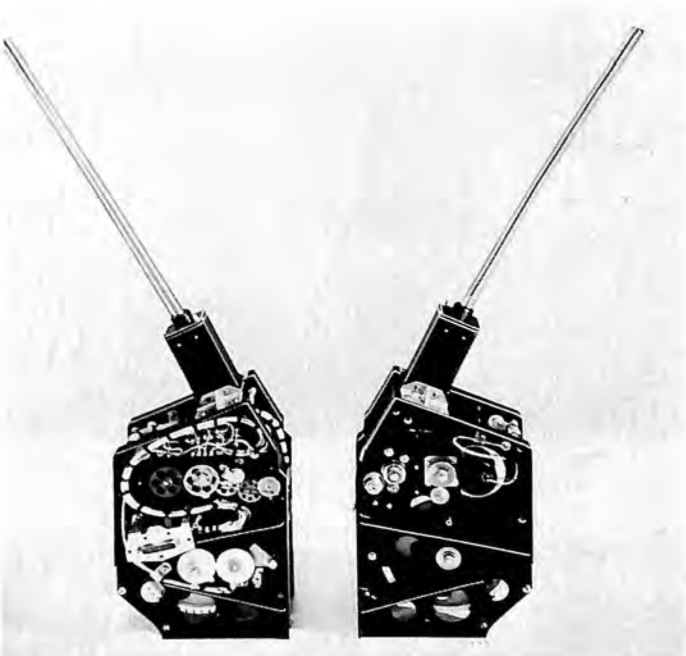


BENDIX GYRO

Three Control Moment Gyros, built by the Navigation & Control Division of The Bendix Corporation, will stabilize and control the Apollo Telescope Mount, the manned orbiting astronomical observatory in the Apollo Applications program. The CMG's will operate in space for 56 days.

FAIRCHILD HILLER ANTENNA

For the new Radio Astronomy Explorer satellite, Fairchild Hiller's Space and Electronics Systems Division developed the Tubular Extendible Antenna system. Antennas on the satellite emerge from a football-sized motorized mechanism to reach out 750 feet.



ITT RENDEZVOUS AND DOCKING SYSTEM

ITT Federal Laboratories—Aerospace built for NASA a super-accurate Spacecraft Optical Rendezvous and Docking System. The laser guidance system is capable of finding a target in space and then generating signals to control the spacecraft to an automatic docking. Angular tracking accuracies are within 0.1 milliradian (0.006 degrees), and range can be measured to an accuracy of 4 inches.

BELL POGO

Continuing its development of small rocket mobility systems, Textron's Bell Aerosystems Company successfully flight tested in 1967 a 2-man "Pogo" with a variety of applications on earth and in the lunar environment. Tested version produces 600 pounds thrust for 21 seconds.

NORTHROP PARAWING

Northrop Corporation's Ventura Division was designing and testing the parawing, originally conceived by NASA's Langley Research Center, to extend recovery capabilities for Apollo Applications spacecraft of the 1970s. Two basic configurations, single and twin keel, were being wind tunnel tested toward development of a single 15,000 pound capacity system.

BENDIX MOONBUGGY

Bendix Aerospace Systems Division developed the Local Scientific Survey Module, an experimental lunar vehicle which would enable exploration within a 5-mile radius of a shelter. Electrical motors and transmission systems are located in the hub of each wheel and together they provide an average speed of 9 kilometers per hour.

PRATT & WHITNEY AIRCRAFT FUEL CELL

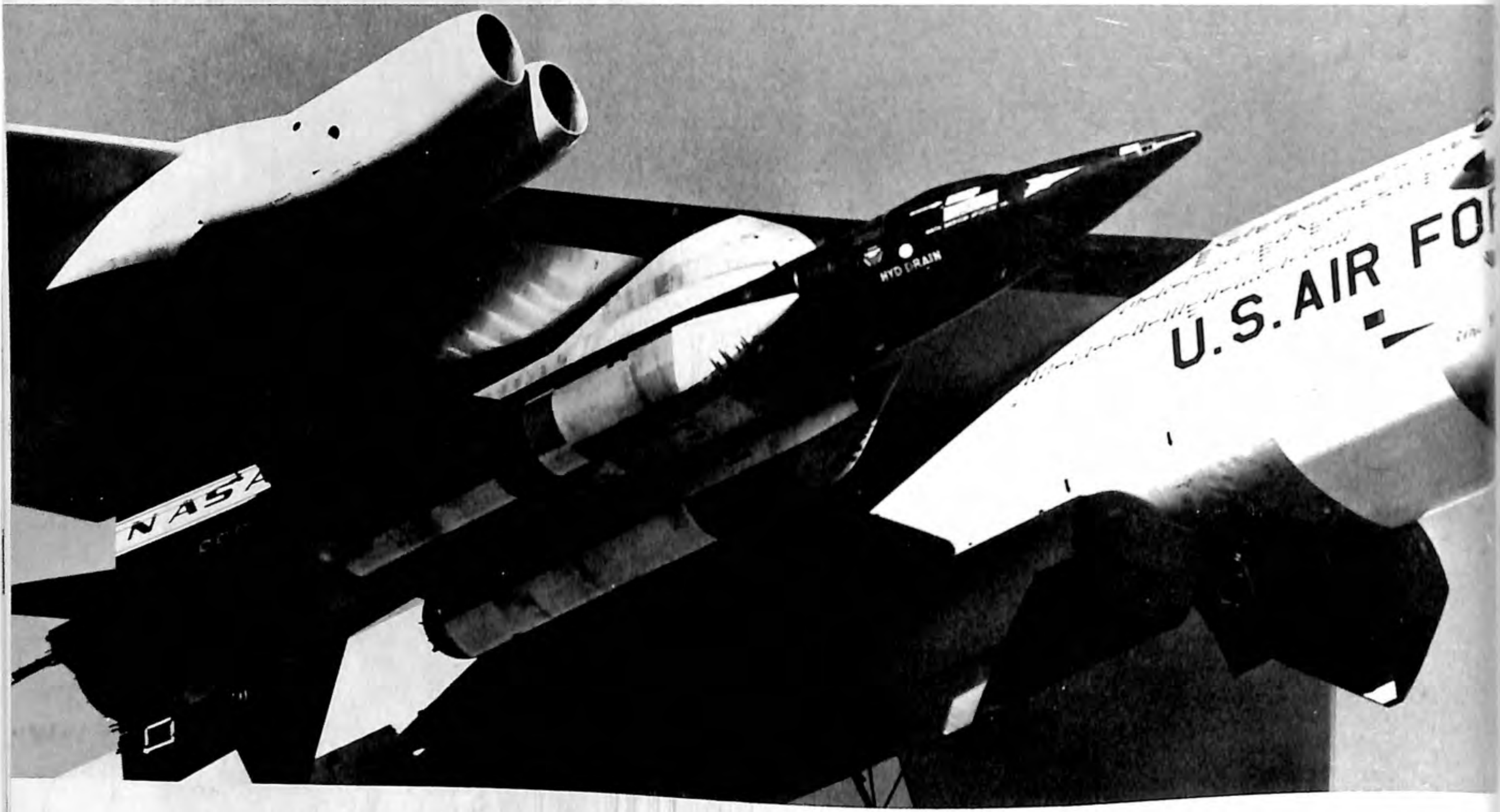
In addition to fuel cell powerplants for the Apollo spacecraft and the USAF's Manned Orbiting Laboratory, Pratt & Whitney Aircraft was developing several units for commercial application. The one shown runs on natural gas and provides more than 3,750 watts of electricity.

GOODRICH SEAL

The B. F. Goodrich Company developed an inflatable rubber seal that eliminates the need for wheel-well doors on the Boeing 737 jetliner. The seal, when inflated, combines with wheel and tire to form a door for the landing gear well. The system saves about 150 pounds of weight per plane.

BELL NO-WHEEL GEAR

On August 4, Textron's Bell Aerosystems Company successfully flew an airplane fitted with Air Cushion Landing Gear (ACLG). The doughnut-shaped ACLG inflates to a thickness of 2 feet for take-off or landing but hugs tightly and aerodynamically to the plane's underside in flight. The no-wheel gear permits operations from water, ice, snow, mud or earth.



NORTH AMERICAN ROCKWELL X-15

The X-15A-2, shown here beneath the wing of its B-52 "mothership," continued its record-shattering ways in 1967. During a NASA research flight on October 3, it set a new unofficial world speed record of 4,534 miles per hour. USAF Major Pete Knight was at the controls of the North American Rockwell-produced rocket craft on the flight from Edwards AFB, California.

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 U.S. in order that they may be officially recognized by other nations. NAA's Contest Board compiled this list of records completed during 1967 by U.S. participants.

CLASS	DATE	AIRCRAFT	PILOT	RECORD DESCRIPTION	RECORD
BUSINESS JET AIRCRAFT					
Class CJ—1.c (17,636-26,455 pounds)				**Speed over recognized courses:**	
CJ—1.c	5/26/67	North American Sabreliner	Arthur D. Knapp	St. Johns/Lajes	571.1 mph
CJ—1.c	5/26/67	North American Sabreliner	Arthur D. Knapp	Lajes/Lisbon	554.18 mph
CJ—1.c	5/26/67	North American Sabreliner	Arthur D. Knapp	St. Johns/Lisbon	531.4 mph
PISTON ENGINE AIRCRAFT					
Class C—1, Group I (Unrestricted weight)				**Speed over a recognized course:**	
C—1	7/30/67	Beech Baron	James F. Nields	Portland, Oregon/Portland, Maine	216.93 mph
Class C—1.a, Group I (Under 1102 pounds)					
C—1.a	5/22/67	Lesher "Teal"	Edgar J. Lesher	Speed in a 500 kilometer closed circuit	181.55 mph
C—1.a	6/30/67	Lesher "Teal"	Edgar J. Lesher	Speed in a 1000 kilometer closed circuit	169.2 mph
C—1.a	10/20/67	Lesher "Teal"	Edgar J. Lesher	Speed in a 2000 kilometer closed circuit	141.83 mph
Class C—1.c, Group I (2,204-3,858 pounds)					
C—1.c	5/13/67	Cessna T-210G	Walter D. Cable	Altitude	42,344 feet
				Speed over recognized courses:	
C—1.c	6/14/67	Navion Model A	S. Dan Brodie	Atlantic City/Oakland	136.46 mph
C—1.c	9/21/67	Aero Commander 200	Miss Susan Oliver	New York/Goose Bay	121.64 mph
C—1.c	9/24-25/67	Aero Commander 200	Miss Susan Oliver	Goose Bay/Reykjavik	55.76 mph
C—1.c	9/27/67	Aero Commander 200	Miss Susan Oliver	Reykjavik/Prestwick	142.65 mph
C—1.c	9/28/67	Aero Commander 200	Miss Susan Oliver	Prestwick/Copenhagen	177.99 mph
C—1.c	9/21-28/67	Aero Commander 200	Miss Susan Oliver	New York/Copenhagen	22.95 mph
C—1.c	4/30/67	Aero Commander 200	Barry Schiff	Los Angeles/Las Vegas	190.44 mph
C—1.c	9/15/67	Helio Courier	Alvin Marks	Sacramento/Wichita	123.49 mph
C—1.c	9/15-17/67	Helio Courier	Alvin Marks	Sacramento/Hamilton, Bermuda	90.71 mph
C—1.c	9/15-18/67	Helio Courier	Alvin Marks	Sacramento/Santa Maria	80.11 mph
C—1.c	9/15-18/67	Helio Courier	Alvin Marks	Sacramento/Madrid	69.37 mph
C—1.c	9/15-20/67	Helio Courier	Alvin Marks	Sacramento/Athens	54.09 mph
C—1.c	9/15-22/67	Helio Courier	Alvin Marks	Sacramento/Teheran	41.82 mph
C—1.c	9/15-25/67	Helio Courier	Alvin Marks	Sacramento/Karachi	33.91 mph
C—1.c	12/24-25/67	Cessna 182	John Everett	Los Angeles/Miami	134.8 mph
Class C—1.d, Group I (3,858-6,614 pounds)					
C—1.d	5/20/67	Beech Bonanza	Dr. Francis Sommer	New York/Paris	181.06 mph
C—1.d	6/19/67	Beech Bonanza	Dr. Francis Sommer	Tokyo/Pt. Barrow	125.43 mph
C—1.d	6/23/67	Beech Bonanza	Dr. Francis Sommer	Pt. Barrow/New York	139.39 mph

CLASS	DATE	AIRCRAFT	PILOT	RECORD DESCRIPTION	RECORD
HELICOPTERS **Class E—1. (Unrestricted weight)**					
E—1	6/1/67	Sikorsky HH-3E	Major Donald B. Maurras, USAF	New York/London	118.14 mph
E—1	6/1/67	Sikorsky HH-3E	Major Herbert Zehnder, USAF	New York/Paris	118.03 mph
AUTOGIROS **Class E—3 (Unrestricted weight)**					
E—3	5/15/67	Bensen B-8M	Igor B. Bensen	Distance in a straight line	82.76 miles
E—3	5/15/67	Bensen B-8M	Igor B. Bensen	Distance in a closed circuit	74.3 miles
E—3	5/15/67	Bensen B-8M	Igor B. Bensen	Altitude	7,275 feet
E—3	6/15/67	Bensen B-8M	Igor B. Bensen	Speed over a 3 kilometer course	73.29 mph
E—3	6/15/67	Bensen B-8M	Igor B. Bensen	Speed over a 15/25 kilometer course	79.00 mph
E—3	5/15/67	Bensen B-8M	Igor B. Bensen	Speed in a 100 kilometer closed circuit	51.34 mph
Class E—3.a (Under 1,102 pounds)					
E—3.a	5/15/67	Bensen B-8M	Igor B. Bensen	Distance in a straight line	82.76 miles
E—3.a	5/15/67	Bensen B-8M	Igor B. Bensen	Distance in a closed circuit	74.3 miles
E—3.a	5/15/67	Bensen B-8M	Igor B. Bensen	Altitude	7,275 feet
E—3.a	6/15/67	Bensen B-8M	Igor B. Bensen	Speed over a 3 kilometer course	73.29 mph
E—3.a	6/15/67	Bensen B-8M	Igor B. Bensen	Speed over a 15/25 kilometer course	79.00 mph
E—3.a	5/15/67	Bensen B-8M	Igor B. Bensen	Speed in a 100 kilometer closed circuit	51.34 mph
SAILPLANES **Class D—1 (Single-place)**					
D—1	8/19/67	Libelle	Elemer Katinszky	Speed in a 500 kilometer triangular course	75.488 mph
SAILPLANES **Class D—2 (Multi-place)**					
D—2	6/26/67	Prue IIA	Edward G. Minghelli	Distance to a goal and return	366.88 miles
U.S. NATIONAL RECORDS **Commercial Airlines**					
Commercial	5/9/67	Douglas DC-9	Captain W. B. Grubb Southern Airlines	Long Beach/Charleston	520.27 mph

AIA LEADERSHIP

In November, Karl G. Harr, Jr., (top) was re-elected president of Aerospace Industries Association. E. Clinton Towl (lower left), chairman of the board of Grumman Aircraft Engineering Corporation, was elected chairman of the AIA board for 1968. He succeeded Courtlandt S. Gross (lower right), who retired as chairman of Lockheed Aircraft Corporation during the year.

WRIGHT BROTHERS MEMORIAL TROPHY

The Wright Brothers Memorial Trophy, administered by the National Aeronautic Association, was presented to Igor I. Sikorsky, consultant to Sikorsky Aircraft division of United Aircraft Corporation. The trophy was presented by NAA president James Nields at the Wright Memorial Dinner in Washington on December 14. Sikorsky was cited for his 3-way pioneering in rotary-wing flight, multi-engine aircraft and long range flying boats. In photo, left to right, Eugene Norris, president of the Aero Club of Washington, dinner sponsor; Sikorsky; Nields; and dinner emcee Senator George Murphy (R., California).

COLLIER TROPHY

The 1967 Robert J. Collier Trophy was awarded to James S. McDonnell, board chairman of McDonnell Douglas Corporation, for significant achievement in aeronautics and astronautics. The trophy was presented on May 24 by Vice President Hubert H. Humphrey at the Smithsonian Institution's National Air and Space Museum in Washington, D.C. In photo, the Vice President chats with McDonnell after presentation.

HARMON INTERNATIONAL AVIATORS TROPHIES

Harmon International Trophy trustees named 3 winners for 1967. The Aviator's Trophy (Airplane) was awarded to Al White, former chief test pilot of the North American Rockwell XB-70A Mach 3 research plane. Co-winners of the Aviator's Trophy (Spacecraft) were Gemini astronauts Captain James A. Lovell, USN, and Lieutenant Colonel Edwin E. Aldrin, Jr. The trophies were presented by President Johnson in the Rose Garden of the White House. In photo foreground, the recipients accepting award certificates from the President are, left to right, White, Aldrin and Lovell.

BREWER TROPHY

The Frank G. Brewer Trophy, top award in aerospace education, went to Dr. Mervin K. Strickler, Jr. (left), Special Assistant for Aviation Education, Office of General Aviation Affairs, Federal Aviation Administration for "his imaginative and energetic leadership in national programs of aviation education." James Vercellino, Director of the Arizona Department of Aeronautics, made the presentation at a banquet climaxing the National Aerospace Education Council's 1967 National Conference in Tucson.

AMERICAN HELICOPTER SOCIETY AWARDS

The American Helicopter Society's Dr. Alexander Klemin Award went to Dr. Anselm Franz, vice president and assistant general manager, Lycoming Division of Avco Corporation, "for leading the development of a noteworthy series of gas turbine engines for helicopters and other VTOL aircraft." (Photo A, Franz, right, accepts award from Robert I. Lichten, AHS board chairman). Recipient of the Captain William J. Kossler Award was Major General Keith B. McCutcheon, Deputy Chief of Staff (Air), U.S. Marine Corps (photo B). General McCutcheon was honored for pioneering the vertical envelopment concept. Accepting the Igor I. Sikorsky International Trophy in behalf of Hughes Tool Company, Aircraft Division, was vice president/general manager Rea Hopper (right, in photo C, with Lichten). The company was cited as designer and builder of the record-setting OH-6A helicopter. Other AHS awards included: the Frederick L. Feinberg Award, to Robert G. Ferry, Hughes Tool Aircraft Division; the Grover E. Bell Award, to the USAF Aerospace Rescue and Recovery Service; the Paul E. Haueter Memorial Award, to Hawker-Siddeley Aviation. AHS Honorary Fellowships were awarded to Woodrow W. Cook, Ames Research Center, NASA, and Ralph B. Lightfoot, engineering manager of Sikorsky Aircraft.

ARMY AVIATION ASSOCIATION AWARDS

The James H. McClellan Aviation Safety Award was presented to Captain Gary F. Ramage, USA, 1st Cavalry Division (Airmobile). In photo A, Captain Ramage accepts the trophy from the Honorable Howard E. Haugerud, president of the James H. McClellan Foundation. In other awards of the Army Aviation Association of America, Chief Warrant Officer Jerome R. Daly, 121st Aviation Company, was named Army Aviator of the Year. In photo B, Daly, left, receives the AAAA medallion from Dr. Russell D. O'Neal, Assistant Secretary of the Army. In photo C, Secretary of the Army Stanley R. Resor presents the Aviation Soldier of the Year Award to Specialist Fifth Class Dennis L. Falo, 1st Cavalry Division (Airmobile). The AAAA Outstanding Army Aviation Unit Award went to the 1st Aviation Brigade operating in Vietnam.

HOYT S. VANDENBERG TROPHY

The Air Force Association's highest education award, the Hoyt S. Vandenberg Trophy, was presented to Dr. B. F. Skinner, of Harvard University, with the following citation: "For his pioneering efforts in the development of programmed instruction and the science of human behavior . . . Cornerstones upon which programmed instruction techniques have matured into the Instruction Systems Engineering Program of the United States Air Force." In photo, Dr. Skinner (right) accepts the trophy and citation from Brigadier General Robert W. Smart, USAF (Ret.), president of the Air Force Association.

KINCHELOE AWARD

The 1967 Iven C. Kincheloe Award, presented annually by the Society of Experimental Test Pilots, went to Richard L. Johnson, director of flight and quality assurance at General Dynamics Corporation's Fort Worth division. Johnson was cited for having "consistently flown F-111 aircraft on their most demanding missions, those that require the highest skills of the professional pilot." Johnson is shown in F-111 cockpit.

NATIONAL URBAN LEAGUE AWARD

J. L. Atwood, president of North American Rockwell Corporation, received the National Urban League Award for his company's work in racial relations. Presentation was made in November.

AIAA AWARDS (No Photo)

Three jet propulsion engineers, Robert Bullock, Irving Johnsen and Seymour Lieblein, were the 1967 recipients of the American Institute of Aeronautics and Astronautics Goddard Award, for their "long-term and continuous contributions in the field of compressor design, with directly resultant large-scale advancement in . . . aircraft jet propulsion." Bullock is with AiResearch Manufacturing Company, Johnsen and Lieblein with NASA at Lewis Research Center. AIAA's Louis W. Hill Space Transportation Award went to Dr. Abe Silverstein, NASA/Lewis; and the de Florez Training Award was presented to Edwin A. Link, founder of Link Aviation, now a division of General Precision. Other AIAA award winners included Adelbert O. Tischler, Wyld Propulsion Award; Derek F. Lawden, Mechanics and Control of Flight Award; Edward H. White II, the Haley Astronautics Award; Milton O. Thompson, Octave Chanute Award; Charles I. Barron, John Jeffries Award; and Elmar R. Reiter, Robert M. Losey Award.

FLIGHT SAFETY FOUNDATION AWARD

In recognition of distinguished service by test pilot Fisher in achieving safer utilization of aircraft and flight equipment, Herbert O. Fisher, special assistant to the Port of New York Authority, was presented the Flight Safety Foundation's Distinguished Service Award (the award is co-sponsored by Aviation Week and Space Technology Magazine). In photo, left to right, Major General Joseph D. Caldara, USAF (Ret.), president of Flight Safety Foundation, Fisher, and FSF board chairman Secor Browne.

JAMES FORRESTAL MEMORIAL AWARD

Selected to receive the James Forrestal Memorial Award for 1967, to be presented in 1968, was William M. Allen, president of The Boeing Company. The award is bestowed annually by the National Security Industrial Association in honor of the person who has most effectively applied Forrestal's principles to the requirements of national security.

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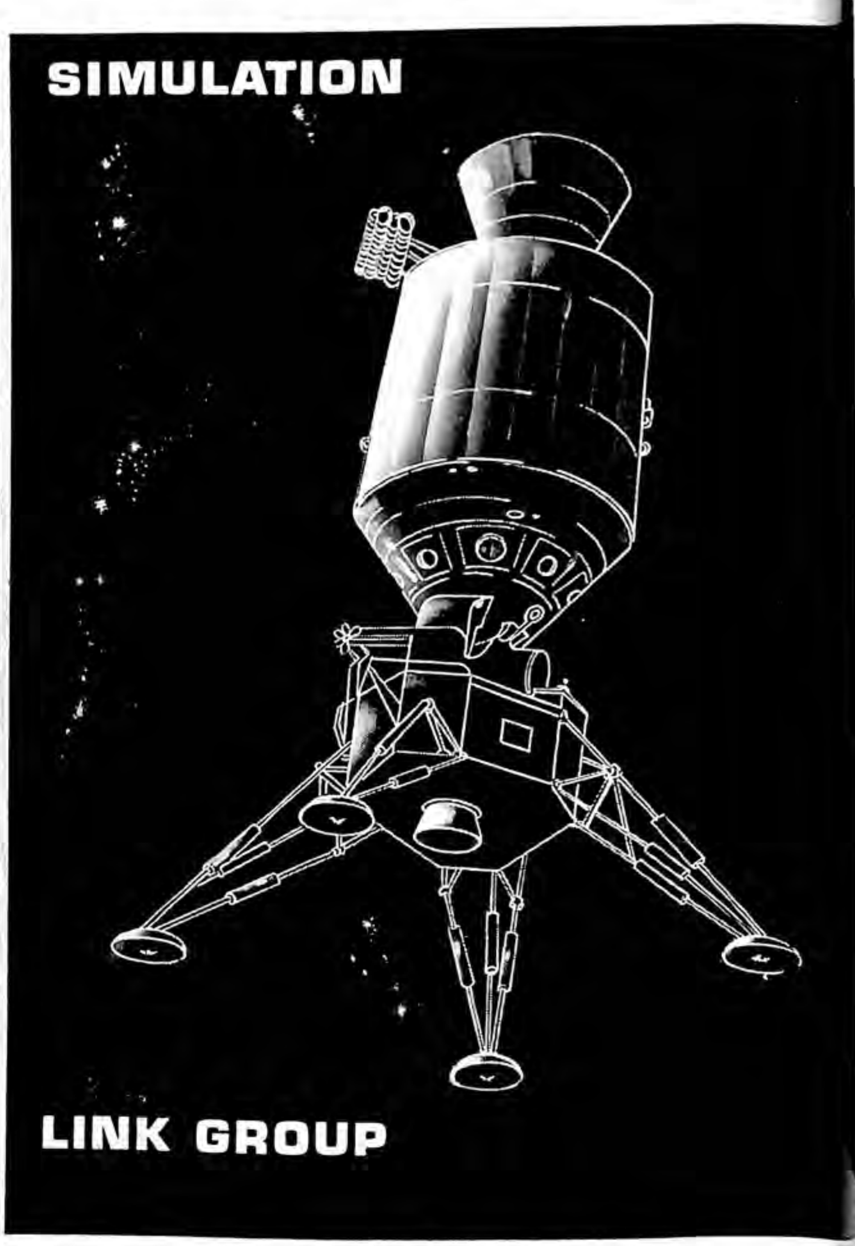

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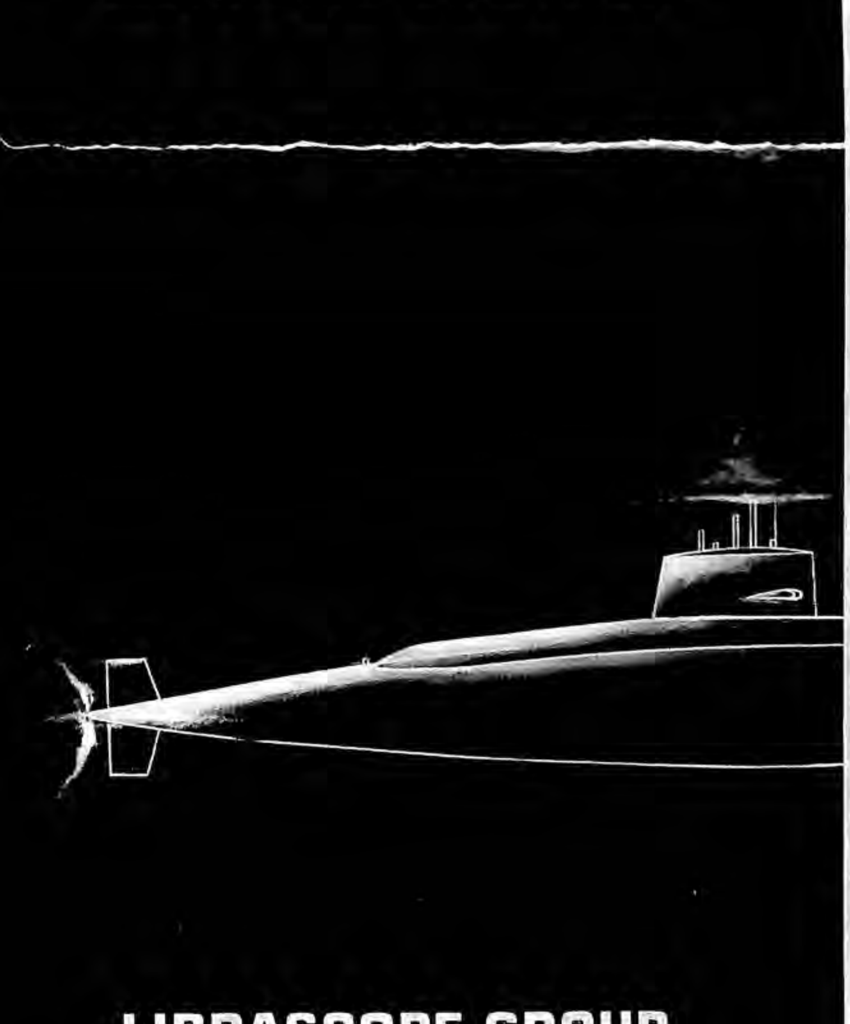

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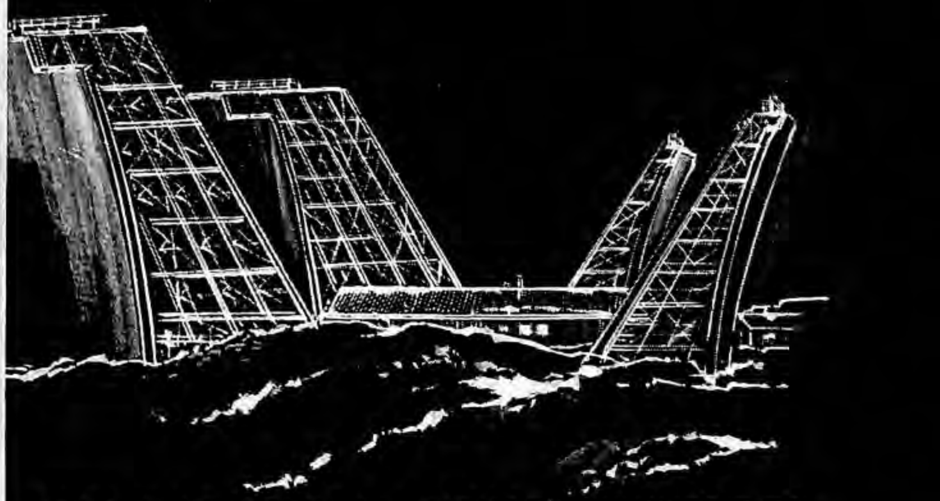

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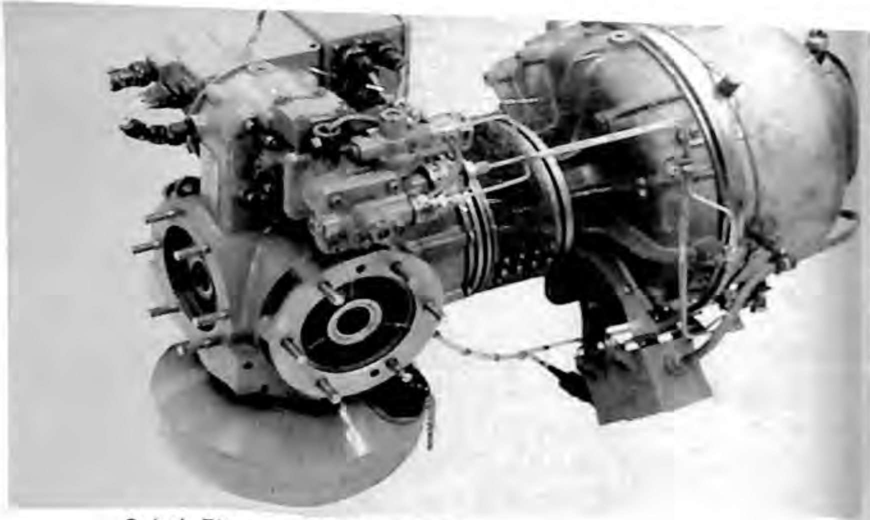
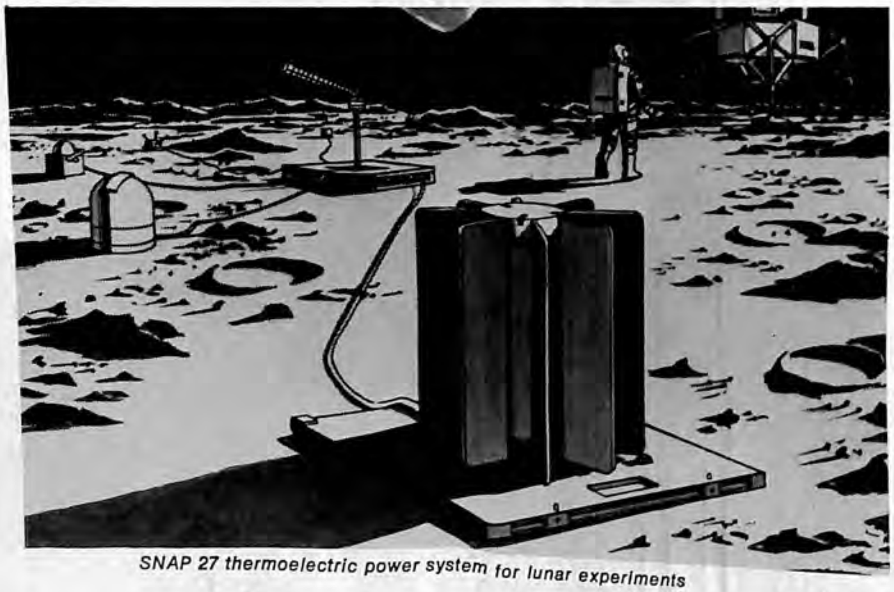


Solar's Titan gas turbine engine



SNAP 27 thermoelectric power system for lunar experiments

Beryllium structure built by Solar for lunar power system

Vietnam to Outer Space

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A recognized leader in the design, manufacture and production of gas turbine engines for industry and the military, Solar has turned out more than 2500 *Titan*® turbine engines for use as auxiliary power units in every major U. S. military cargo helicopter program. The reliability of this 80 to 150 hp engine has been proven by years of service in the field under the most rugged combat conditions.

Now under development at Solar is a revolutionary new portable 10 kw gas turbine generator set and 30 kw and 60 kw generator sets designed to supply electrical power for "up-front" tactical and support operations.

In addition, Solar scientists and engineers have demonstrated outstanding capabilities in the area of hard-to-work metals and materials. The firm today is highly experienced in the forming, joining, welding, brazing, machining and processing of stainless steels, super alloys, as well as titanium, aluminum, and beryllium. One example is the advanced beryllium structures for the SNAP 27 thermoelectric power system that is designed to be left behind on the moon's surface by Apollo astronauts to enable experimental instruments to transmit data back to earth. Solar is building many other components, including space communication antennas, for the Apollo/Saturn space project.

For further information on Solar's gas turbine engines and aerospace products and capabilities, write: Solar, Dept. Q-409, San Diego, California 92112.

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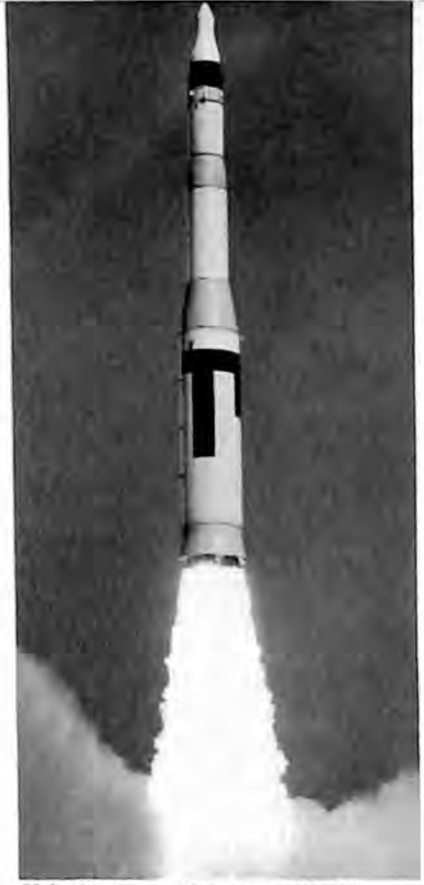

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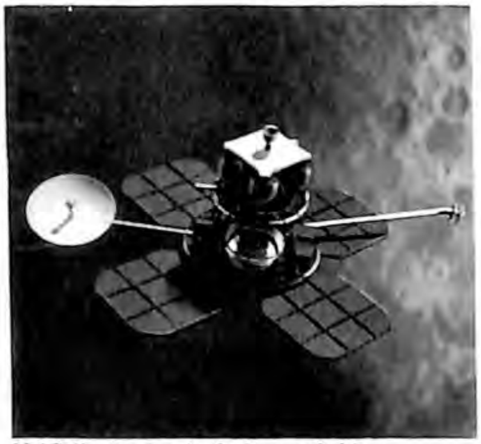

NASA's Boeing-built Lunar Orbiter

Boeing helicopter

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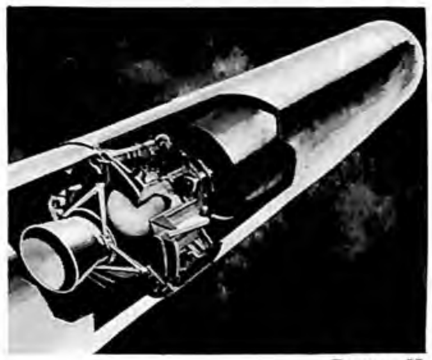
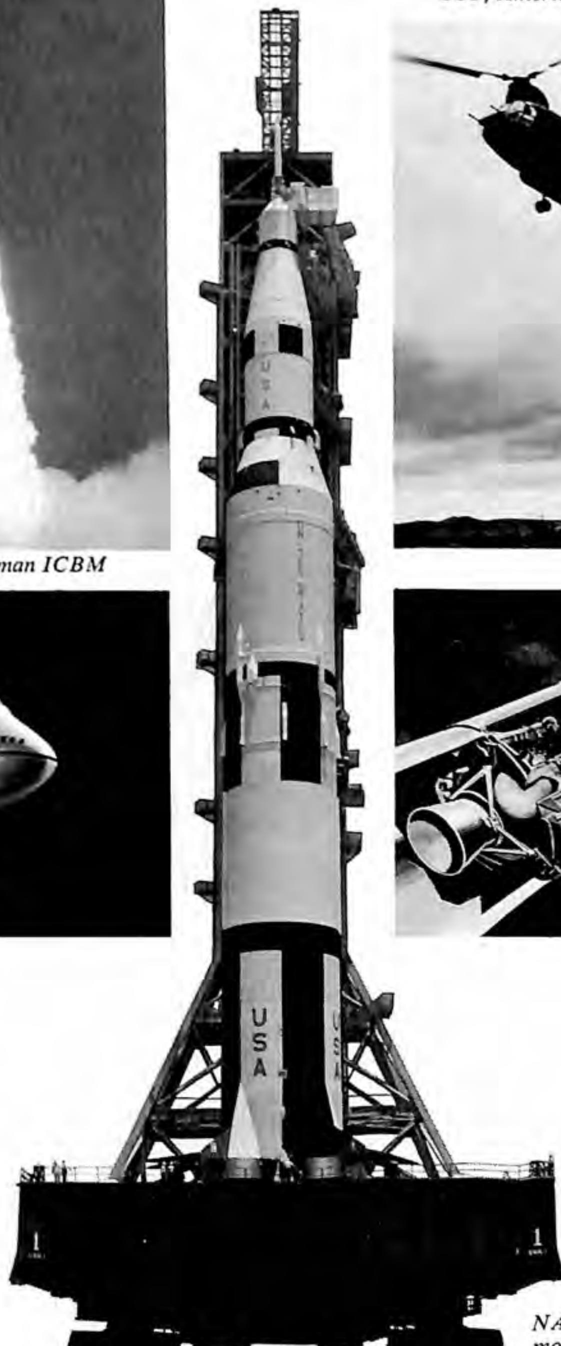


Burner II



NASA's Apollo/Saturn V moon rocket

Capability has many faces at Boeing.

737 is world's newest, most-advanced short-range jetliner. When it enters service this year, it will be the first airliner to bring big-jet comfort to short-haul routes.

NASA's Boeing-built Lunar Orbiter was the first U.S. spacecraft to orbit the moon and photograph back side of moon. Orbiters have photographed thousands of square miles of the lunar surface to help NASA scientists select best landing site for Apollo astronauts.

747 superjet, the world's largest commercial jetliner, will carry from 350 to 490 passengers, and usher in new era of spaciousness and comfort in jet travel. Deliveries begin in 1969.

Minuteman is U.S. Air Force's quick-firing, solid-fuel ICBM. Boeing is weapon system integrator, responsible for assembly, test, launch control and ground support systems.

SST. Boeing won competition for U.S. supersonic transport. Sweep wing retracts for supersonic cruise, opens for landings, approaches.

Twin turbine Boeing helicopters, built by Vertol Division, are deployed to Vietnam. They serve with U.S. Army, Navy, Marine Corps.

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.

NASA's Apollo/Saturn V moon rocket, largest, most powerful in world, will launch first Americans to moon. Boeing builds first stage booster, integrates Saturn V with Apollo command, service and lunar modules, and performs systems engineering, launch and integration support for NASA on entire Saturn V system.

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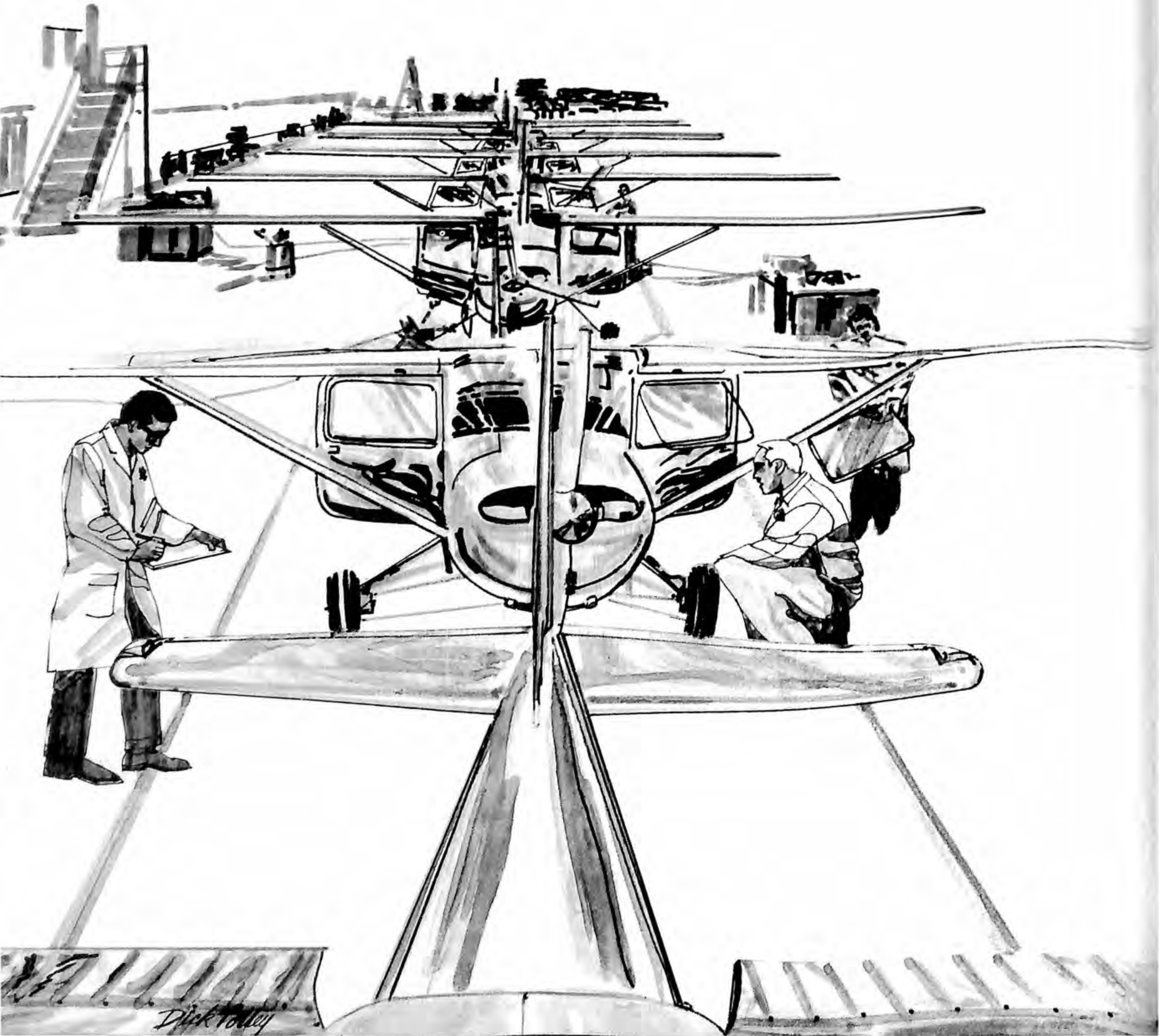


THE AEROSPACE INDUSTRY

Aerospace industry sales in 1967 totaled $27.3 billion, a 13 percent increase over the $24.2 billion in sales for 1966, the Aerospace Industries Association reported. Total aerospace sales were expected to increase 6.8 percent between 1967 and 1968 to $29.2 billion, according to a report by AIA's Economic Data Branch.

Two major areas of activity—commercial transport aircraft production and Defense Department procurement—showed significant increases in 1967.

Commercial aerospace sales, including jet transports, executive and utility fixed-wing aircraft, helicopters, aircraft engines and spare parts, rose from $3.663 billion to $4.940 billion, a 34.6 percent increase.

The dramatic increase in turbine-powered transport sales was a continuing major factor in over-all aerospace growth. From 1965 sales of $1.197 billion to 1967 sales of $2.458 billion, the increase was 105.3 percent, and from the 1965 sales to expected sales of $3.808 billion in 1968, the increase works out to 218.1 percent.

Production of general aviation aircraft declined between 1966 and 1967 from a record 15,747 units to 14,375, and the total value of shipments dropped from $444,000,000 to $338,000,000.

Civilian helicopter production increased from 390 units in 1966 to 465 in 1967. Value of this production rose from $40,000,000 in 1966 to $43,000,000 in 1967. Primary civil use of helicopters was again for corporate activities, although increasing numbers were being used for highway patrol and police surveillance.

Sales by the aerospace industry to the Department of Defense in 1967 were $15.9 billion, up from $13.3 billion in 1966, a gain of 19.5 percent.

Military aircraft sales rose from $8.4 billion in 1966 to $10.4 billion in 1967, largely due to Vietnam requirements for helicopters, fighter and attack aircraft.

In the same period, missile sales rose $500,000,000, from $4 billion to $4.5 billion. Included in this total was work on the Poseidon missile, the antimissile missile system and the Minuteman III, as well as several missiles being used in Vietnam.

Military space programs in 1967 remained stable at $1 billion. Non-military space sales declined in 1967 to $4.1 billion from the 1966 peak of $4.9 billion.

Sales of nonaerospace products and services increased slightly between 1966 and 1967 from $2.323 billion to $2.350 billion. These sales represented the utilization of technological skill gained in aerospace activities which was being applied in a variety of nonaerospace areas. Work taking place in this area during 1967 included oceanography, water desalination, systems analysis, rapid transit, urban problems, job retraining and other areas.

Aerospace industry sales in 1968 were anticipated to rise to $29.2 billion, a 6.8 percent increase over 1967.

Commercial aerospace sales were expected to increase from $4.9 billion in 1967 to $6.6 billion in 1968. Transport production should reach a record high of 762 units valued at $3.8 billion.

Utility and executive aircraft production was expected to score new records in 1968. Total general aviation production in 1968 should total 16,900 units, valued at $450,000,000. Increasing numbers of student pilots, growing business utilization, air taxi and private flying were anticipated stimulants to general aviation production in 1968.

Helicopter production should reach a record 500 units in 1968.

Department of Defense sales in 1968 were expected to reach $16 billion, up from $15.916 billion in 1967, despite an anticipated $500,000,000 decrease in military aircraft sales. Primary area of increase was to be missile sales, which should increase by $700,000,000 during the year.

AIA said that non-military space sales would approximate $4.1 billion in 1968 and nonaerospace sales would continue their upward trend showing a continuance of diversification among aerospace firms.

ABEX CORPORATION

In 1967 the Aerospace Division of Abex Corporation manufactured hydraulic pumps, motors, servovalves and components for a wide variety of military aircraft operating in Southeast Asia. The increasing demands of military agencies for these products resulted in further expansion of the facilities of the Oxnard, California, plant. Abex hydraulic components were being used on helicopters, fighter bombers and interceptors assigned to the Air Force, the Marine Corps, the Navy and the Army.

In addition to these military applications, Aerospace Division products were receiving wide acceptance by commercial and foreign airline operators of jet transports because of their high reliability and low overhaul cost. Over 40 different airlines were using Abex products. The Aerospace Division was delivering equipment to airframe manufacturers of business and executive jet aircraft. The Falcon executive jet manufactured by Marcel Dassault of France and distributed in the North American continent by Pan American is equipped with Aerospace pumps. The new Gulfstream II being manufactured by Grumman Aircraft Engineering Company is completely equipped with Aerospace hydraulic pumps.

The West German subsidiary of Aerospace Division, Aerohydraul GmbH, was making shipments to European aircraft customers of the hydraulic pumps and servovalves that were designed in the main plant in California. These products were being used by Sud Aviation for the Concorde SST transport, SAAB in Sweden for military aircraft and by West Germany for the Lockheed F-104G fighter. In addition, Abex equipment was being shipped to Fokker in the Netherlands and to Agusta-Bell, the Italian licensee of Bell Helicopter Company. A licensee of the Aerospace Division, H.M. Hobson Ltd., of Wolverhampton, England, continued production of Abex hydraulic pumps for use on the British F-4K airplane that will be used by various military agencies in the United Kingdom.

The Jarry Hydraulics Division continued production of the CH-47A Chinook helicopter landing gear and was named "Supplier of the Month" by Boeing Vertol in July. Demand increased for the General Dynamics F-111 Wing Sweep Actuator System, a Jarry design, and additional machining capacity was installed to meet the program requirements. The Fokker F-28 power flight controls, also designed and manufactured by this division, were proven successful during the flight test program and delivery of production units was initiated. Engine-driven pumps for the ship were supplied by Aerospace Division. Production of landing gear for the Boeing 737, De Havilland DHC-4 Caribou, DHC-5 Buffalo, the Northrop F-5 and Canadair CF-5, used the total capacity of the landing gear manufacturing facilities.

The Denison Division of Abex continued to support the space program by furnishing hydraulic components and systems for test equipment, ground support equipment, handling devices and fuel pumping equipment. The 5,500,000 pound crawler transporter at John F. Kennedy Space Center 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 checkout, as well as powering ground support stands for jet aircraft checkout.

At the Abex Research Center, the foundry development program on large superalloy castings continued. Production of spin-test discs to evaluate these alloys for application to gas turbine motors has been completed, and testing of the discs is in progress. Basic piloting of large airframe structural parts was completed, and these castings were to be vacuum melted and poured by year-end. Several test programs were under way on application of heat resistant polybenzothiazole to aerospace needs.

AERODEX, INC.

Major additions in the company's first pure jet overhaul contract and the hiring of 1,700 additional employees highlighted the Aerodex year.

Contract add-ons from the Air Force in July and August totaled $5,300,000 and called for the overhaul of 474 additional Pratt & Whitney Aircraft J57 engines, used on B-52s, F-100s, F-101s, and F-102s.

A December order from the Air Force brought to $5,000,000 the total for overhaul of J57 engine accessories. This increment brought the total J57 contract allotment to $23,940,000. The contract was expected to run to $29,498,798.

The company also signed new contracts with the Air Force for the overhaul of 2 reciprocating engines. In November an initial order of $4,199,944 on an estimated contract total of $24,683,556 maximum was signed for work on R-4360 engines and components. The contract was an extension of an earlier one which totaled in excess of $16,000,000.

The initial order on a new overhaul contract for the R-3350 engine was for $849,375 and was expected to run to $6,600,000. This extension contract followed one which totaled $5,900,000.

In addition to the major Air Force work, Aerodex was overhauling R-985, R-1300, R-1820, R-1830, R-2000, R-2600 and R-2800 engines. Besides the Air Force, Aerodex's U.S. customer list included Zantop Air Transport, Capitol Airways, International Aerodyne, California Airmotive Corporation, Airlift International, Alaska Airlines, Saturn Airways, American Flyers Airlines, Standard Airways, Overseas National Airlines, Pacific Northern Airlines and the Federal Aviation Administration. Among the foreign customers were Nordair Limited of Canada, the Indian Air Force, Brazilian Air Force, Nationalist Chinese Air Force, AREA Airlines of Ecuador, Conair of Denmark, AVIANCA of Colombia, Transair of Canada, Pacific Western of Canada, the Argentine Navy, the Peruvian, Venezuelan and Guatemalan Air Forces and Lebca of Venezuela.

At year-end, Aerodex was overhauling an average of 355 Air Force engines a month. The total workforce had spiraled to 5,700.

AEROJET-GENERAL CORPORATION

Aerojet-General Corporation thrust into its second quarter century during 1967. The small pioneer rocket firm which began life in Pasadena, California, in 1942 had grown to a major diversified space age corporation 25 years later. In the tradition of its distinguished founder, the late Dr. Theodore von Karman, Aerojet was busy directing its main energies toward putting technology to work for the betterment of man.

While maintaining a position as a major producer of rocket propulsion systems of all kinds—liquid fuel, solid fuel and nuclear—Aerojet by the end of 1967 had made important inroads into such wide ranging fields as:

- water desalting and purification,
- isotopic power sources and controlled thermonuclear energy research,
- microelectronics,
- automatic materials handling systems,
- medical technology,
- waste management and anti-pollution activity,
- ordnance and oceanographic defense systems.

There were also these significant developments in propulsion during the year:

The Aerojet-built Service Propulsion System (SPS) engine for the Apollo spacecraft performed flawlessly on the Apollo 4 unmanned mission in November. The system fired twice as programmed, first to send the spacecraft to the desired altitude and later to increase its speed to nearly 25,000 miles per hour for a high-speed reentry that tested heat shield capabilities.

The Air Force awarded Aerojet a contract calling for the first follow-on production of first, second and third stage liquid rocket engines for 8 Titan III-C standard space launch vehicles. Along with 4 of the 17 original research and development Titan III-Cs still remaining to be flown, the 8 production models are expected to support mission requirements through the 1969–1971 period. Three Titan III-Cs were launched in 1967.

Aerojet also received contracts from the Air Force for the production of first and second stage liquid rocket propulsion systems for the Titan III-B and III-D standard space launch vehicles. The Titan III-B and -D versions will be used for unmanned military space missions. The Titan III-B was used in several Air Force space missions during 1967.

A full-scale development program on liquid rocket engines for the Titan III-M, launch vehicle for the Air Force Manned Orbiting Laboratory, went on at Aerojet in 1967.

A veteran Aerojet sounding rocket, the Aerobee, rounded out its first 20 years of service in 1967. In that time its altitude capability had been raised from 35 to 350 miles and its thrust increased by approximately 600 percent. Aerobee was still in wide use for space research missions and it was being launched at the rate of nearly one a week.

Another Aerojet research rocket, NIRO, saw extensive use in 1967, with 32 launches during the year. Developed in 1965 for the Air Force, NIRO first flew in 1966. An unguided, 2-stage solid propellant rocket, it is designed to carry small payloads of 40–180 pounds to altitudes of 85–180 miles.

Aerojet-General installed the largest U.S. electron beam welding unit and vacuum chamber at Aerojet Downey's Fullerton, California, facility.

Aerojet advanced its capabilities in spacecraft tankage fabrication in 1967, while continuing the production of important titanium propellant tanks for the ascent engine of the Apollo Lunar Module. Engineers developed a novel approach to insulation of spacecraft tankage for liquefied gases—use of a series of barriers in a vacuum zone around the tank, plus a thin, heat-reflecting coating on all surfaces in the vacuum. Early tests indicated only about one percent of outside heat radiated through the vacuum to the inner tank. The company also made progress in development of metallic bladders as positive expulsion devices for propellant tanks. The concept offers several advantages, including weight reduction, over nonmetallic devices.

A new throttling liquid rocket engine designated XLR-66-AJ-2 was announced by Aerojet. Developed and tested for the Navy, it demonstrated a versatility suiting it for a wide variety of space tasks. Less than 90 pounds in weight, the high-performance system is capable of the most rapid transient responses of any engine in its thrust class.

The third of 3 260-inch solid propellant rocket motors developed for NASA's large solid rocket technology program was successfully test-fired in June 1967. The 2 chief contributors to the Aerojet achievements in the program, Richard Cottrell and Paul Datner, were honored for their efforts at NASA's awards ceremonies in October, when they received the space agency's Public Service Award.

A major contribution to the national defense program in 1967 was the high-volume production of ordnance at Aerojet facilities in California as well as in Arkansas. Two plants were established in Arkansas in 1965 to create employment in a surplus labor area which had an unemployment rate of 22 percent.

Largest defense rocket activity was in the Polaris and Minuteman programs. Production continued throughout the year on solid rocket motors for the Polaris A-3 first stage and the second stage of Minuteman II. Rocketry experts also worked on Aerojet's development and production program on the advanced Stage III motor for Minuteman III.

The company entered a new defense area with a multi-million dollar 4-year contract for production of the Navy's new advanced Mark 56 mine. The sophisticated weapons system has both target sensing and target discrimination capabilities.

A program was begun in 1967 to develop an advanced version of the Air Force 2.75-inch air-to-ground rocket. Aerojet will upgrade the weapon's performance considerably by employing a composite case-hardened solid propellant and making maximum use of existing hardware.

Early in the year, work began on a new facility containing 24,000 square feet of space to accommodate research and development activities for a huge unmanned space technology program. The computer-controlled test complex will contain the most modern equipment and facilities. When opened next year, it is expected to cut test times from hours to minutes. Some of the facility will also be devoted to microelectronic production.

Largest producer of the Navy's Mark 46 antisubmarine torpedo, Aerojet completed delivery on contracts for the MOD-0 early version of the "underwater guided missile" in 1967 and was in production on the advanced MOD-1 model.

In another diversification effort, Aerojet moved into fabrication of components for jet engines under substantial contracts for production of fan stator components for the General Electric TF39, supporting frames for GE's LM1500 power turbine and afterburner diffuser and nozzle/ejector assemblies for Pratt & Whitney Aircraft's TF30. Work was also under way on development of titanium intermediate compressors and fan exit cases for Pratt & Whitney Aircraft's JT9D.

Further diversification included receipt of an important contract from Cleveland Pneumatic Tool Company of Cleveland to produce landing gear components for the Boeing 747 superjet.

Aerojet's nuclear activities expanded during the year with its move into the reactor fuel field. Work was begun on an AEC contract to make 34,000 fuel elements for the EBR-II experimental breeder reactor and plans were announced to offer utilities fuel design/fabrication and management services for central station power reactors.

Development continued on NASA's 35 kilowatt SNAP-8 system to convert nuclear energy into electrical power over 10,000 hours of continuous unattended operation. A new, improved turbo alternator for the system was well past its first 1,000 hours of continuous test operation as the year ended.

In nuclear rocket propulsion, highly successful qualification tests of the Phoebus-2 rocket nozzle demonstrated successful development of a 250,000-pound thrust liquid oxygen/liquid hydrogen thrust chamber assembly. NERVA nuclear rocket engine development and system integration was also conducted throughout the year.

Development of nuclear power conversion systems for space, earth and undersea applications went on vigorously. In 1967, Aerojet's ORACLE organic rankine cycle system, largest in the world, was put into full scale operation successfully. Designed to convert nuclear energy into electricity, ORACLE can be adopted readily to operate with other heat sources and is suited to supply up to several hundred kilowatts over several years of operating life.

Aerojet's URIPS, one-watt undersea radioisotopic power supply, was chosen by Industrial Research magazine as one of the 100 most significant technical products of 1967. The Navy has acquired 2 for ocean evaluation.

Fruitful experiments were performed in Aerojet's important controlled nuclear fusion research program. Working under Air Force sponsorship, the company's scientists were attacking the problems of utilizing controlled nuclear fusion to provide low cost electrical energy to serve indefinitely the needs of mankind.

Watts Manufacturing, a subsidiary Aerojet formed in 1966 to create jobs in the riot-torn Watts district of Los Angeles, could report significant progress as its first year of operation ended in November. With 500 workers busy in its tentmaking, metalworking, and woodworking operation, the new company is expected to become a profitable enterprise in its second year. Wide interest was generated nationwide by Aerojet's experience with Watts Manufacturing. A number of large industries have expressed their intention to attempt similar enterprises to relieve hard-core unemployment in various parts of the country.

In Aerojet's work on the improvement of human environment, Fresno County, California, was the proving ground for systems analysis solutions of socio-economic problems. A solid waste management study under way there effected substantial improvements in the county during 1967, although completion of the study was not scheduled before March 1958. Adoption of recommendations in an interim study report eliminated several sources of serious air and soil pollution. A county-wide water resources management study was also being conducted in the county in 1967.

Aerojet's Reverse Osmosis water purification technology was advanced significantly during the year. At the close of 1967, a 50,000-gallon-per-day plant built for the Office of Saline Water was undergoing qualification tests. Success of the project was expected to lead to plants with daily capacities of 250,000 gallons or more. In a 1967 limited production effort, Aerojet made 5 10,000-gallon-per-day plants, all of which were put into service for operational or research uses.

The year was one of continued growth for Aerojet's activities in automated materials handling, with its systems operating in an increasing number of post offices, warehouses and baggage terminals in the United States and overseas.

Aerojet's complex medical simulator for anesthesiological training was completed during the year and used for training the first class of students. The system uses a computerized lifelike manikin to simulate human patient response to anesthetics and drugs, and greatly reduces the time required for training. The simulator also won Aerojet another 1967 Industrial Research award for technical excellence.

Three new programs which broadened Aerojet's technology in the medical-surgical area were:

• development and production of a simplified, economical X-ray unit for early detection of breast cancer among women;

• a conceptual design study on radioisotope power source for implantation in the body to serve as a power source for artificial human hearts;

• an investigation of the suitability of Aerojet's semi-permeable membrane (used in its Reverse Osmosis water program) for use in artificial kidney systems.

AERONCA, INC.

After nearly 3 years of drastic rehabilitation, Aeronca, Inc., entered 1968 with new posture, products, and prospects.

Effective on New Year's Day of 1968, Aeronca's corporate headquarters were moved to Los Angeles from Middletown, Ohio, so its top management could work more closely with the center of the aerospace industry, where two-thirds of its business originates.

Aeronca simultaneously joined the West Coast financial community by listing its common stock on the Pacific Coast Stock Exchange as the new year began, supplementing its listing on the American Stock Exchange.

Principal manufacturing activities were on the upswing both in Middletown, Ohio, and Torrance, California, as well as in the Buensod-Stacey subsidiary in New York which designs and manufactures highly-engineered environmental control systems.

From a 1965 loss of $3,085,136 on sales of $34,-826,147, Aeronca executed a profits turnaround which saw it netting $1,029,998 in 1966 on sales of $48,-336,867, and further gains in 1967.

Estimates at year-end were for 1967 earnings of more than $1,400,000 and even better financial performance in 1968.

Sparkplug of Aeronca's resurrection from the brink of failure to a new prosperity has been Albert G. Handschumacher, board chairman and president, who came to Aeronca early in 1965 after having been president of Lear Siegler, Inc.

Handschumacher's overhaul began in 1965 when the company experienced substantial writeoffs on government contracts, began weeding out unprofitable operations, and moved to rebuild its shaky finances.

Military business was de-emphasized in favor of more profitable commercial contracts. In 1966, only 40 percent of the firm's business was on the commercial side. This increased to 55 percent during 1967 and in 1968 it was expected to amount to 60 percent, with Handschumacher aiming at a 70–30 ratio favoring the commercial side by 1970.

Aeronca at year-end was no longer dependent on military contracts. Only 3 percent of its business would be subject to cancellation in the event of a sudden peace in Vietnam.

"But it takes more working capital to undertake commercial business than to perform military contracts," Handschumacher pointed out.

Aeronca went about raising this capital in 2 ways. In 1967, the company completed placing $3,500,000 by a rights offering to common shareholders and a $2,000,000 private placement by Smith, Barney & Company with institutional investors. It also established a revolving credit of $5,000,000 with a group of banks headed by United California Bank and including Chase Manhattan, Central National Bank of Cleveland, and the North Carolina National Bank.

Late in 1967, Aeronca took an important step to clear up arrearages of $1,033,156 on 2 classes of preferred stock. The company offered to exchange common stock for the preferred in order to conserve its cash position. By the time this was done in December, the market value of the common stock had risen to a point where Aeronca could make a very attractive offer to the preferred stockholders, and the offering was well received.

These financial moves put the company on solid footing for further advances into its principal fields: subcontracting for commercial aircraft builders and the building of environmental control systems, especially for commercial and industrial structures, including the textile industry and the tobacco industry. At year-end the company's ratio of current assets to current liabilities was approximately 2 to 1, compared to a year-end ratio in 1966 of 1:1.

Buensod-Stacey Corporation, a wholly-owned subsidiary based in New York, accounted for about one-third of Aeronca's sales volume with its highly-engineered environmental control systems and industrial air conditioning products. Largest contract was a $3,800,000 program for the new Westinghouse Electric Corporation nuclear turbine plant in Charlotte, North Carolina.

At the end of 1967, Buensod-Stacey was doing about 80 percent of its business in contract sales, but Handschumacher was guiding the subsidiary into a greater volume in manufactured products related to its expertise.

Cash acquisitions of Air Devices, Inc., and Agitair Products were steps in this direction, giving Buensod-Stacey complete lines of registers, grills, ceiling, and strip line diffusers, among the largest-selling hardware items in the air distribution field.

However, Aeronca's basic business of aerospace subcontracting still centered on its 2 main plants at Middletown and Torrance.

Aeronca at year-end held more than $50,000,000 of program commitments for advanced aircraft structures for Boeing jetliners, including the huge new 747. By late 1969, Handschumacher estimated, shipments to Boeing alone will amount to $2,000,000 per month, principally for the 747 superjet and the supersonic transport.

Huge wing ribs for the 747 began moving in November 1967 from the Torrance plant to Seattle in one of the major phases of this program.

The wing ribs, up to 20 feet in length, were as long as the whole fuselage of the Aeronca C-3, which was Aeronca's first product in 1928. Other 747 subassemblies included 203 sets of wing tips, flap track fairings, and exhaust plugs.

The Middletown Division, besides being a production center for aircraft, space vehicles, and satellite products in 1967 became headquarters for the Aeronca Aerospace Group, which was organized to qualify for the acceptance of large-scale contracts.

In becoming a first-line aircraft subcontractor, Aeronca developed special capabilities in bonding various metals. It fabricated the hi-temp stainless steel structural panels of the Apollo command module, built the antennae reflectors for the first international TV satellite, and produced armament pylons, blast panels, and brazed stabilator subassemblies for the McDonnell F-4.

Other Aeronca products included brazed stainless steel brake doors for the Grumman A-6A; underwing external fuel tanks for the Northrop F-5; subassemblies for the Lockheed C-141; bonded honeycomb aluminum panels for Bell helicopters; and wings and control fins for the Walleye glide bomb.

Aeronca's research accomplishments included development of high temperature structures for supersonic and other advanced aircraft, including work on titanium fabrication and joining, high-temperature adhesives, brazing of such metals as Inconel 718 and Rene 41, beryllium fabrication, brazing of aluminum without flux, and advanced composite structures using high-strength fibers and whiskers.

Along with its expansion in the field of commercial airframes, Aeronca was also getting ready to supply a potentially huge market in air cargo. It was building fiberglass cargo igloos for American Airlines, made especially to fit into the tapered tail sections of the Boeing 707, along with special automated hydraulic devices to stow and unload the cargo igloos. Full fruition of this project awaited action by the Air Transport Association standardizing the requirements for cargo modifications in the tail sections.

AEROSPACE CORPORATION

In 1967, the Board of Trustees of The Aerospace Corporation undertook an over-all appraisal of the company's work since incorporation 7 years ago.

The objectives of the corporation are incorporated in each succeeding annual contract between the corporation and the Air Force, which provides in part: "The mission of the Aerospace Corporation is to aid the United States Air Force in applying the full resources of modern science and technology to the problem of achieving those continuing advances in ballistic missile and military space systems which are basic to national security."

In the view of the Board, the mission of Aerospace Corporation remained unchanged.

Aerospace performs its responsibilities through advanced systems analysis and planning, general systems engineering, and research and experimentation. Aerospace does not build prototypes nor manufacture hardware.

Aerospace always works with government-industry teams and, while the team record has been superb, the particular contribution of any member including Aerospace is hard to measure. Nevertheless, Aerospace Corporation made significant contributions in 1967 to the following programs:

Titan III, a program of over $1.3 billion, was carried forward on schedule, essentially within budget, to a highly successful, near-operational status. The Manned Orbiting Laboratory, which began its definition at Aerospace in 1961, constituted the Air Force's largest space program in 1967. ABRES, a very complex research and development program in ballistic missile penetration aids and reentry systems, was organized and was being technically directed by Aerospace with, again, good progress and success in analysis, design, and flight testing.

The Vela program for the detection of nuclear bursts proved so successful that only 3 out of 5 scheduled launches were required; the anticipated 3-month life for the satellites was extended to 50 months. Communication satellites were orbited as a part of the development testing for Titan III launch vehicles, and were providing an operational military system which was proving helpful in the Southeast Asia conflict. Other examples are the satellites of the 461/949 programs. In ballistic missiles, improvements to the basic Minuteman system were defined by Aerospace and reentry vehicles, with penetration aids to ensure their effectiveness, were developed under Aerospace leadership.

Including the 107 successes with no failures of SLV II (Thor) and 109 successes with only 4 failures of SLV III (Atlas), the score on space boosters for programs in which Aerospace shared responsibility read at year-end 252 successes, 2 partial successes, and 10 failures. Corporate experience across the complete spectrum of satellite systems was effectively applied in the planning and development of the on-orbit tracking and control system including worldwide tracking stations, the Satellite Control Facility, and the associated software system.

The Board's conclusion was with a keen awareness that: both ballistic missile systems and military space systems will continue in the foreseeable future to play major roles in providing for national security. Much remains to be done in increasing accuracy, perfecting geodesy, improving reliability, and assuring survivability of basing and penetrability of reentry systems. In military applications of space, the first 7 years of Aerospace Corporation's participation have been a transition from faltering experiments to quasi-operational systems. The Board was convinced that the "mission" is clearly present and will continue, and further, that the technique of performing this "mission" of Aerospace Corporation has been proved successful, is accepted both by the military and industrial structures, and is capable of adjustment to accomplish the tasks of the future.

ALLISON DIVISION
GENERAL MOTORS CORPORATION

The successful initial run of its new TF41 turbofan engine 13 days ahead of schedule came as a major highlight in gas turbine development programs at the Allison Division of General Motors during 1967.

Designed to produce 14,250 pounds thrust, the TF41 on its maiden run exceeded 85 percent of rated output for extended periods and was later operated at full power.

Allison was awarded a $227,300,000 contract by the Air Force Systems Command to develop the TF41 engine. The development is being done jointly with Rolls-Royce, Ltd., of Derby, England. Scheduled for production in 1968, the TF41 will power the USAF's new swept-wing Ling-Temco-Vought A-7D close-support fighter-bomber.

Allison in preparation for TF41 production added nearly a quarter-million square feet of new floor space to its principal engine manufacturing facility in Indianapolis.

Allison added nearly 250,000 square feet of manufacturing area to its principal gas turbine engine production facility.

In another significant engine development, Allison conducted a series of flight tests with a regenerative T63 turboshaft engine in a helicopter—the first regenerative gas turbine ever to power an aircraft of any kind as the sole source of power.

Using one of the U.S. Army's OH-6A Light Observation Helicopters as a test bed, the tests were conducted at the Allison Flight Test Facility under the technical direction of the U.S. Army Aviation Materiel Laboratories. From the tests Allison and the Army gained valuable experience in the improved range and performance capabilities made possible by regeneration. The T63 in its non-regenerative form was developed originally as the powerplant for the OH-6A which is now in quantity production.

A major growth pattern continued to evolve in 1967 for 317-horsepower commercial versions of the T63. Sales of the 136-pound Model 250-C18 showed a marked increase for helicopters being sold worldwide by Bell, Hiller and Hughes. Allison also announced availability of a 156-pound turboprop version, the Model 250-B15, with production deliveries targeted for late 1968.

This small gas turbine line will be expanded to include 2 more powerful 370-horsepower turboshaft and turboprop engines for growth versions of light helicopters and for light fixed-wing aircraft. The 17 percent power boost from 317 to 370 horsepower results in a weight increase of only 4 pounds.

New, more powerful T56 Series turboprops that incorporate air-cooled blades and vanes were in full-scale production for the USAF Lockheed C-130 Hercules transport and the Navy's P-3B antisubmarine warfare plane. T56s also power the carrier-based Grumman E-2A radar picket plane and a cargo-carrying adaptation, the C-2A.

Sales of the 501-D13D turboprop engines for the Allison 580 conversion program and industrial gas turbines for stationary installations also showed an increase. At year-end, 5 airlines were flying the twin-engine Convair 340/440 aircraft converted from piston engines to Allison gas turbines. By the end of 1967, 123 of the 580s had been delivered to airlines, 14 corporate operators, the U.S. Air Force, Federal Aviation Administration and Royal Canadian Air Force. On order were 41 more.

Extending further the horsepower growth of T56 Series engines was the T56-A-18 being developed with Navy funds and logging time on an Allison test stand. Equipped with air-cooled blades and vanes in its first 2 turbine stages, the A-18 at a rating of 5,325 equivalent shaft horsepower will be approximately 350 pounds lighter and 30 inches shorter than the original T56-A-1 rated at 3,750 equivalent shaft horsepower.

Two other engines were in development, one a turbojet lift engine for vertical take-off and landing aircraft. It is being developed as a joint project by the United States and United Kingdom. The development is being done by Allison and Rolls-Royce. Test run of the first thrust-producing version was successfully completed and an advanced design was being tested. Allison also was developing a new high-bypass turbofan engine for the next generation of Navy carrier-based antisubmarine warfare aircraft. The engine will offer high thrust-to-weight ratio combined with low fuel consumption.

Aerospace pressure vessels continued in production for the Apollo space program.

The year also marked the unveiling of the radically new MBT-70 Main Battle Tank of the 1970s. Developed jointly by the United States and the Federal Republic of Germany the vehicle incorporates many innovations that make the MBT-70 unique among tanks. These include an environmental control capsule for the 3-man crew and a novel suspension system that permits the vehicle to adjust to any type of terrain requirements. The vehicle is capable of operating completely submerged. Prototypes of the vehicle, developed jointly by the Allison Military Vehicles Organization and the German Development Corporation, are being built by Allison at the Cleveland Army Tank-Automotive Plant.

Also at the Tank Plant, production continued on the M551 General Sheridan armored reconnaissance airborne assault vehicle and the M109 self-propelled 155 millimeter howitzer. Both vehicles are equipped with Allison transmissions and the M551 also incorporates a unique Allison-developed gun-launcher breech mechanism.

At year's end, divisional employment at Indianapolis, Cleveland and Warren, Michigan, totaled approximately 20,000 employees.

ALUMINUM COMPANY OF AMERICA

In 1967, Aluminum Company of America announced: use of perforated aluminum tube to help force-feed weightless liquid fuel to rocket engines in outer space; production of huge, high-strength aluminum forgings to house the nuclear "heart" of a new breed of rocket engine; formation of Alcoa Castings Company, a new wholly owned subsidiary responsible for manufacturing and selling die and permanent mold castings; casting of a 3½-ton aluminum disc that will be transformed into a 100-inch diameter mirror to test new telescope components; start-up of a second 50,000-ton potline at its modernized Badin (North Carolina) Works smelter; delivery of titanium forgings from new facilities at its Cleveland (Ohio) Works; plans to expand aluminum forging and ingot casting capabilities at Cleveland Works, the free world's largest aluminum forging facility; purchase of approximately 10 percent of the stock of Ocean Science and Engineering, Inc.; production of giant forgings to help form the skeleton of the world's largest aircraft, the C-5A Galaxy; publication by the American Society for Metals of a 3-volume reference directed at users of aluminum and written by 96 Alcoa engineers and scientists; casting of parts to form a huge fixture for testing Apollo mooncraft guidance units; supply of more than a million pounds of aluminum for use in the USS *John F. Kennedy*, world's largest conventionally powered aircraft carrier; plans to increase the rated primary smelting capacity of its Rockdale (Texas) Works by adding a 50,000-ton seventh potline; use of an Alcoa-developed "zipping" technique to assemble aluminum panels into a new thermal vacuum chamber designed to help man's exploration of space; development of a breakthrough aluminum casting alloy that compares with the highest strength aluminum casting alloys in everything except price; increased guaranteed minimum strength levels for sheet and plate in aerospace alloy 7075-T6, T651, and T7351; supply of aluminum products for the PG(H)-1 *Flagstaff*, a prototype hydrofoil patrol gunboat; and supply of 800,000 pounds of aluminum products for use in the construction of 3 guided missile destroyers.

An aluminum tube with 740 half-pinhead-size perforations is an integral part of a positive-expulsion propellant system for spacecraft. The tube is encased in a deflated Teflon bladder and is installed lengthwise through the center of a cylindrical liquid fuel tank. Prior to launch the bladder is expanded inside the tank by gas flown through the tiny tube openings. Rocket fuel then is sprayed into the container through the same holes. As the fuel level rises, the gas is driven off through a vent. When the engine is fired in space, the area between the Teflon skin and tank wall first is flooded with helium. The gas compresses the flexible bag, forcing the liquid back through the aluminum tube to the engine combustion chamber. Aluminum's light weight, ease of fabrication and compatibility with rocket fuel and oxidizer make it ideal for the unique system. Twenty highly sophisticated, positive-expulsion fuel and oxidizer tanks are scheduled for use in the Apollo mooncraft.

Huge, high-strength aluminum forgings will house the nuclear reactor "heart" of a new breed of rocket engines. Alcoa's Cleveland (Ohio) Works produced the unusual forgings which resemble giant, high-sided bowls. Two such parts joined together form a pressure vessel—a tough aluminum shell—to contain an operating nuclear reactor. Heat generated by controlled atom-splitting in the reactor transforms the quiescent energy of liquid hydrogen into roaring power for the Atomic Energy Commission's Phoebus-2 nuclear rocket. With the aid of special tooling and operating procedures, the pressure vessel halves are forged on one of the world's largest presses, a 35,000-ton behemoth operated for the Air Force. An alloy 7039 biscuit, 12½ feet in diameter and 4½ inches thick, is formed by a greatly magnified draw punch operation into a 54-inch deep bowl, having an inside diameter of 78 inches and wall thickness of 4½ inches. The curved bottom portion is removed from one bowl and the remaining tubular section is welded to the open end of a second forging doubling the length of bowl sides. The aft end is machined to form a large flanged opening to receive the nuclear rocket engine nozzle. A finished pressure vessel is 90 inches long and weighs 5,300 pounds.

Alcoa formed a new subsidiary designed to increase the efficiency of the company's participation in the growing market for aluminum die and permanent mold castings. The new, wholly owned subsidiary represents a corporate decision to concentrate manufacturing and selling responsibilities for die and permanent mold castings in an operation encompassing a total "package of services" under a single authority. The complete facilities of the parent company's Edison (New Jersey) Works and Chicago (Illinois) Works, also the new company's headquarters, have been transferred to the new subsidiary. Alcoa Castings Company will produce and market die and permanent mold castings at the 2 locations and will market permanent mold castings turned out by Alcoa's Cleveland (Ohio) Works.

A huge aluminum "soupbowl" was being machined, plated, and polished—a year-long task—to form a 100-inch diameter mirror for Kitt Peak National Observatory. Its short focus (soup bowl) design will be used to test components required for a new 150-inch telescope to be installed at the observatory site, 60 miles west of Tucson, Arizona. The aluminum part was cast with a slightly concave surface which will be deepened further by machining until it matches the desired contour to within 1/1,000th of an inch. Final grinding and polishing will increase dimensional accuracy of the curved surface to 1/100,000th (.00001) of an inch. The alloy 356 sand casting is 22 inches thick and weighs approximately 7,600 pounds. Kitt Peak National Observatory, which The Association of Universities for Research in Astronomy, Inc. (AURA) operates for the National Science Foundation, will utilize the new telescope to investigate phenomena occurring over the entire range of astronomy.

Alcoa started up the second 50,000-ton potline at its modernized Badin Works smelter approximately 4 months ahead of the originally announced timetable. The $10,000,000 Badin expansion provided 125 new jobs, bringing total employment to about 670. Doubling Badin Works' annual capacity to 100,000 tons brings Alcoa's total installed primary aluminum ingot capacity to 1,100,000 tons a year. This will rise in 1968 to 1,150,000 tons with the completion of a 50,000-ton potline now under construction at the company's Wenatchee (Washington) Works.

Installation of titanium forging facilities at Alcoa's Cleveland Works was completed and initial production began in the fourth quarter. The company's marketing effort will concentrate on large and medium-size titanium forgings produced on hydraulic presses in the 8,000 to 50,000-ton range—parts used primarily by the aircraft and aerospace industries.

Alcoa announced plans to expand forging and ingot-casting facilities at Cleveland, the free world's largest facility for forging aluminum. The multi-million dollar expenditure will be for a new building, 2 hydraulic forging presses of intermediate capacity, a melting furnace, and auxiliary equipment. One of the new presses will be used to produce precision flat die and hand forgings to the tolerances required by Alcoa's customers. The other press will be in the new building along with associated equipment. Installation of the facilities is in addition to Alcoa's preparations necessary to enter the titanium forging business.

Alcoa purchased approximately 10 percent of the stock of Ocean Science and Engineering, Inc., a firm engaged in oceanographic research, design, construction, and exploration. The sale will provide financing for OSE's entry into new technical areas, and expansion of its operations in various parts of the world. John D. Harper, president of Alcoa, said the aluminum producer made the move because the emerging oceanographic industry has a long and promising growth period ahead. Besides its corporate headquarters in Washington, OSE operates branch offices in Long Beach, California; Palm Beach, Florida; and Saigon, Vietnam. Its wholly owned subsidiary, Ocean Science Ships, Inc., operates fleets on both coasts, in Vietnam, and in Australia for special surveys, mineral prospecting, drilling, and university research. OSE also jointly owns Ocean Mining, A. G., a pioneer in undersea exploitation of mineral deposits (diamonds, gold and tin), and presently is prospecting its concessions in Australia, Malaysia, Thailand and the Philippines.

Huge aluminum forgings were being used by Lockheed-Georgia Company to form the skeleton of the world's largest aircraft—the Air Force C-5A transport. Five main frame parts help shape the giant plane's structural backbone. The primary support for the forward unit of the craft's 28-wheel landing gear system is 23 feet long and weighs 2,700 pounds. Alcoa's Cleveland Works produces the massive aluminum parts on a 50,000-ton press operated for the Air Force.

Alcoa was supplying huge aluminum forgings as structural elements of the USAF's Lockheed-Georgia C-5A transport.

"Aluminum," a comprehensive, highly readable, 3-volume reference published by ASM, includes most of the information about aluminum that should be known to users. Ninety-six Alcoa engineers and scientists, with 2,289 man-years of professional experience in aluminum, exhausted nearly 25,000 man-hours over a period of 39 months writing, editing, reviewing, and revising to complete the monumental task. Edited by Dr. Kent R. Van Horn, Alcoa vice president in charge of research and development, the work is the first extensive treatment of the design, application, and fabrication of aluminum products since 1930. In all, the 3 volumes contain 1,920 pages, 889 illustrations (photographs, charts, and graphs), and 301 tables. Volume I deals with properties, physical metallurgy and phase diagrams; Volume II is concerned with design and application; and Volume III treats fabrication and finishing.

A massive Alcoa aluminum structure, designed by North American Rockwell Corporation's Space Division, is a 2-legged assembly that functions as a rigid fixture for testing Apollo mooncraft guidance units. Seven sand castings form the 1,762-pound structure. A 93-inch diameter ring section weighs 1,330 pounds, and each curved support checks in at 214 pounds. Four one-pound adapters complete the assembly. When helped to stand erect, the huge part is 6 feet high. The 7 alloy 356F cast parts were machined, welded together, and heat treated to construct the unusual fixture.

The *USS John F. Kennedy,* world's largest conventionally-powered aircraft carrier, employs more than 1,000,000 pounds of Alcoa aluminum. The nation's newest carrier (designated CVA 67), is a product of the Newport News Shipbuilding and Dry Dock Company, Newport News, Virginia. Most of the aluminum is used in 4 150-ton elevators which will lift some of the world's fastest fighter jets to the flight deck in just one minute. Each elevator measures 4,000 square feet. The aluminum elevator units are built individually around 3 load-carrying structural systems, all distinguished by the size of their main members—Alcoa aluminum I-beams. The *Kennedy,* a modified *America* class ship, is slightly larger than conventionally-powered predecessors in the class. It is scheduled to carry 100 aircraft.

The company planned to increase the rated primary smelting capacity of its Rockdale (Texas) Works from 175,000 to 225,000 tons a year by adding a seventh potline. Construction began during 1967, with initial production of ingot aluminum scheduled for the fall of 1968.

An unusual "zipping" technique for sealing aluminum-clad buildings is featured in Martin Marietta Corporation's new thermal vacuum chamber. Called the Space Simulation Laboratory, the modern test facility is enclosed with Alply panels, an aluminum sheet-polystyrene foam sandwich. The insulated wall sections are joined with Alcoa's unique Snug Seam system, a vapor tight, weatherproof connection employing aluminum extrusions and a neoprene gasket. More than 1,000 Alply panels, ranging in size from one-by-4 to 4-by-14 feet, were used to complete the 6-story, 100-foot-high structure. Exterior walls in the Alumalure finish, in antique gold, promise long-lasting, easy-care beauty. A special gold anodized finish on interior walls provides good appearance and low maintenance qualities. The vacuum chamber will be used to duplicate the extreme cold and sunlight radiation intensities expected in space. It is capable of handling specimens weighing as much as 25,000 pounds, and as large as 20 feet in diameter and 34 feet in height.

A breakthrough aluminum casting alloy, developed by Alcoa, compares closely with the highest strength aluminum casting alloys in everything except price. New premium strength alloy X149 eliminates costly silver and achieves high strength with commonly used copper, magnesium, zinc, and manganese alloying elements. Tests of alloy X149 parts produced by premium casting facilities at Alcoa's Cleveland and Vernon Works have shown minimum properties exceeding 60,000 pounds per square inch tensile strength, 50,000 pounds per square inch yield strength, and 5 percent elongation. The new alloy has good resistance to stress corrosion cracking in a saline environment and good mechanical properties at moderately elevated temperatures. Castings have been produced at Cleveland and Vernon in green sand, dry sand, plaster, and composite molds. The value of the new alloy is enhanced beyond the direct advantage of lower cost as a result of government and industry demands on the nation's silver supply. Alloy X149 is readily available, and its applications are not likely to be restricted because of shortages of alloying elements.

The guaranteed minimum strength levels of sheet and plate in widely used aerospace alloy 7075 were increased for the T6, T651, and T7351 tempers. Both bare and alclad forms of alloy 7075-T6,T651 and bare forms of 7075-T7351 were upgraded. In certain thickness ranges, tensile and yield strengths were increased 1,000 to 4,000 pounds per square inch and elongation was raised one to 3 percent. Alloy 7075 has been one of the principal aerospace materials of construction since its introduction by Alcoa in 1953. Several of the newer military aircraft—the Navy's A-7A Corsair 2 and OV-10A—are built almost entirely of alloy 7075. Its success in aircraft has carried over to the space age, and it is used extensively for structural applications in missiles, rockets, and spacecraft, including the Saturn/Apollo space vehicle.

The PGH-1 *Flagstaff*, a prototype hydrofoil patrol gunboat built by Grumman Aircraft Engineering Corporation for the U.S. Navy Ships Systems Command, is constructed of Alcoa aluminum. The sleek 13-man craft is 73 feet long with a beam of 21 feet 5 inches, and displaces 60 tons. Its construction components utilized 43,600 pounds of aluminum; including 27,000 pounds of integrally stiffened, extruded panels up to 24 inches wide in bottom, side, deck and bulkhead applications. The superstructure has 10,000 pounds of sheet and plate; and 6,600 pounds of contoured hand forgings were specified for the hydrofoils, which are controlled by an autopilot system.

Three guided missile destroyers—utilizing nearly 800,000 pounds of Alcoa aluminum in their superstructures—were under construction at Bath Iron Works Corporation. They are the first ships to be built in the United States for the Federal Republic of Germany. The destroyers—each 440 feet long with a beam of 47 feet—were designed and are being built under government specifications that call for liberal use of aluminum wherever possible. Since destroyer-type vessels are designed for high performance in speed and maneuverability, shipyard officials say aluminum's light weight and high strength qualities make it an ideal material. Five products are used in the superstructures: 517,000 pounds of plate; 326,000 pounds of flat sheet; 31,000 pounds of extrusions; 2,000 pounds of drawn tube; and 2,000 pounds of rivets.

AMPHENOL CONNECTOR DIVISION
AMPHENOL CORPORATION

Amphenol Connector Division, a long-established leader in complex aerospace system development, was involved in several key aerospace projects during 1967. Division engineers worked closely with major aerospace contractors in developing special cable assembly systems and umbilical and interstage connectors.

Of particular interest was the interstage connector developed for Minuteman. A pyrotechnic actuated release mechanism in the connector deadfaces more than 100 electrical circuits as it effects a zero force physical separation on release. This connector was designed to meet the strict requirements of limited space, weight restriction, ultra-reliability and a high standard of environmentally sealed integrity.

Amphenol also continued to supply the cable assemblies used in the guidance control system of Minuteman III.

Production of an umbilical cable/internal harness system for the Shrike air-to-ground was stepped up during 1967. The Amphenol-developed umbilical cable connects the missile to the aircraft. At the missile's surface, this cable connects to one end of the internal harness, which in turn links Shrike's guidance system to its controls.

The Saturn V, which set space records in November, had over 350 Amphenol connectors aboard. Amphenol 69 Series cryogenic units, the connecting link for the missile's on-board power systems, are designed to withstand operating temperatures of minus 300 degrees Fahrenheit.

Other aerospace space interconnection system work under way in 1968 included special high temperature 500 and 1,000 degrees Fahrenheit connectors for the supersonic transport program, cable assemblies for shipboard launchers and an ultra-reliable umbilical connector for submarine launched missiles.

Amphenol Connector Division is headquartered in Broadview, Illinois. The Division's Space and Missile Systems operation is located in Chatsworth, California.

AVCO CORPORATION
AVCO AEROSTRUCTURES DIVISION

The year 1967 was one of important achievements for Avco Aerostructures Division, as it became a major subcontractor on The Boeing Company's supersonic jet transport and delivered the first wing sections for the Lockheed C-5A Galaxy military jet transport. It also expanded other areas of both its commercial and military business.

Boeing selected Avco to build the center wing for its SST. This is the section of the aircraft to which movable outer wings will be attached. Titanium alloys will be employed in construction of this aircraft because of their high strength, heat resistance and light weight. The largest titanium forgings ever made have been ordered for Avco to use in the center wing.

Avco makes the center, inner and outer wing sections for the C-5A. The 3 structures have a total length of 220 feet.

The division also signed a contract to produce more wings for the Grumman II business jet transport. Another contract was signed with the Globe-Wernicke Company, a subsidiary of the Sheller-Globe Corporation, to continue producing metal office furniture.

The division continued production of tail sections for the C-130 Hercules turboprop transport; tail boom and cabin roof assemblies for the Bell Helicopter Hueys, used extensively by the U.S. military services in Vietnam; and thermal conditioning panels for delicate, temperature-sensitive instruments used aboard rocket space boosters and spacecraft.

Late in the year work began on structural parts for the Bell HueyCobra.

Employment at the division, located in Nashville, Tennessee, was at about 4,000 at year-end.

AVCO ELECTRONICS DIVISION

The Electronics Division continued its leadership in high frequency (HF) communications technology for both ground and airborne applications. In 1967, it received add-on contracts for the AN/ALR-23 infrared system and the AN/ARC-123 high frequency transceiver for the F-111A fighter aircraft. It also got orders for antennas, advanced radio receivers, and forward looking infrared (FLIR) sensors.

Avco designed and built command and receiving equipment was being produced for a variety of military and space programs. Its Digital Uplink Assembly, built under several contracts in 1967, will update the Apollo Lunar Module guidance computer for moon landing, and will also provide backup communication for the whole LM system.

The division's work in radar technology resulted in an Air Force contract for design, production and installation of a missile-warning display subsystem to be used with a large sea-launched ballistic missile warning system. The warning system, too, was under development by Avco.

Avco's Tulsa, Oklahoma, plant continued to operate one of the country's 3 mass spectrometer laboratories certified by the Atomic Energy Commission. The laboratory offers complete isotopic analysis of gases and solids by electric bombardment. The Tulsa facility also designs and builds mass spectrometers to special order.

In field engineering, the division developed a method, undergoing patent at year-end, to determine the optimum emplacement of sites for microwave terminal and relay station equipment.

At the Huntsville, Alabama, operation, an information systems group was formed to manufacture and market computer-controlled data processing equipment.

The division's commercial operation, which designs and produces home intercom systems under subcontract, expanded into the field of educational aids.

AVCO EVERETT RESEARCH LABORATORY

During 1967, the Avco Everett Research Laboratory widened even further its research and development in advanced technologies.

From the National Institutes of Health, the laboratory received a contract to perfect the Avco Intra-aortic Pump. It had developed the heart assist device in collaboration with the Massachusetts General Hospital and Harvard Medical School. Commonly called the "balloon" pump, the device is designed to give immediate aid to patients suffering from heart failure after a heart attack. It is inserted into the main artery, the aorta, through an incision in the thigh. The laboratory also continued its development of the Kantrowitz/Avco auxiliary ventricle, which is a permanently implantable heart assist device, and research in blood flow.

In the important area of MHD (magnetohydrodynamic) power generation, where the laboratory has played a prominent role, it began developing several types of MHD generators for the Air Force. MHD generators produce electric power by forcing an ionized gas through a magnetic field at high velocities.

The laboratory also delivered to the Air Force a superconducting energy-storage system and developed a new family of composite superconductors called Avco Supergenic Multicore, which offer maximum flexibility in superconducting coil design. The multicores mark an advance in a technique developed by Avco during 1966 which made superconductive devices practicable.

In the field of gas laser research, the laboratory developed and placed on the market a pulsed nitrogen laser.

The laboratory began its third missile reentry vehicle monitoring program for the Air Force. To carry out these contracts, Avco airborne personnel in the Atlantic and Pacific missile ranges record the last moments of a reentry vehicle's descent through the atmosphere. Data gathered is later analyzed by the laboratory.

The laboratory also expanded its research in plasma physics to include a study of a heavy ion plasma accelerator for the Atomic Energy Commission.

AVCO LYCOMING DIVISION

Although activity at Avco Lycoming Division was again centered on increased production of gas turbine engines for helicopters and fixed wing aircraft, several "breakthroughs," both in terms of new markets and in research and development, were also achieved during 1967.

Engine production, which was centered around the division's newly introduced T53-L-13 engine, reached new all-time proportions, and employment climbed to a record 9,300 persons. Correspondingly, the division's new plant in Charleston, South Carolina, accelerated its growth and at year-end more than 1,700 persons were actively engaged in the modern 400,000 square foot facility.

The T53-L-13 engine, rated at 1,400 shaft horsepower, was placed in volume production during the second half of 1967, replacing the lower rated T53-L-11. The newer model is used to power the new Bell AH-1G HueyCobra, which made its combat debut in Vietnam in the fall. The HueyCobra is the world's first helicopter designed from the outset as an armed helicopter, and when deployed in full strength will take over the escort missions previously performed by Bell UH-1B helicopters.

The engine also powers the Bell UH-1H, latest version of the famed Huey family, and will power the new 15 place commercial Bell 205A helicopter to be available early in 1968.

Also placed into production during 1967 were 2 other advanced models of gas turbine engines, the T53-L-15 turboprop engine and the T55-L-11 helicopter engine. The T53-L-15, counterpart of the L-13 helicopter model, will power the advanced version of the Army's high speed observation aircraft, the Grumman OV-1D Mohawk.

The T55-L-11 engine, rated at 2,850 shaft horsepower, entered production in the latter months of 1967 and will power the Boeing CH-47C Chinook helicopter, the latest version of the Army's prime transport helicopter. The additional power provided by the higher rated Lycoming engines provides a 25 percent increase in the Chinook's payload.

Avco Lycoming continued the production of reciprocating engines for fixed wing and helicopter use. While the total engines shipped in 1967 was somewhat less than in 1966, the year 1967 stood out as the second best sales year in the division's history. A new major aircraft manufacturer joined the Avco Lycoming family of customers during the year; and at year-end Avco Lycoming numbered among its customers every major domestic aircraft manufacturer in the general aviation field using reciprocating engines, as well as many other aircraft manufacturers throughout the world.

Anticipating an increased demand for reciprocating engines, 86,000 square feet of manufacturing space was added during the year, together with new machinery to increase production capabilities. Several new engine models, provided with turbocharging and provision for cabin pressurization, were added during the year to take care of the increased demand for high altitude operation. A new 470 horsepower, 8 cylinder, turbocharged engine was also added to the line as being especially adaptable for commuter type airlines. Helicopter engine production continued for use in training and utility helicopters. Manufacture of landing gears also continued during 1967.

Avco Lycoming entered into an agreement with Bernard Moteurs, Europe's second largest manufacturer of industrial engines, to market lightweight diesel engines in the 4 to 40 horsepower range and gasoline engines in the 1½ to 10 horsepower range in the United States, Canada, and Mexico. These engines are applicable for auxiliary powerplants with possible use at mobile missile sites.

Avco Lycoming scored its first major successes in the marine and industrial areas with the selection of Lycoming turbines for several new applications with high volume potential.

The first of these, with a dollar value of approximately $1,200,000 for prototype units only, calls for Avco Lycoming to provide the complete prime propulsion system for a new 50 foot shallow draft boat for the U.S. Navy. Known as the Assault Transport Craft (ATC), it will utilize a Lycoming TF-12 marine engine, a controllable pitch propeller and a hydrodrive. A second version of this same vehicle, called Command and Communications Boat (CCB), will use the same propulsion system.

Prototype units for both vehicles were being delivered at year-end with initial test programs scheduled to begin in February.

A third program also selected Avco Lycoming propulsion systems as its prime propulsion source. This one, called the Inshore Undersea Warfare boat (IUW), will be 65 feet long and will use the Lycoming designed CODAG (Combined Diesel and Gas Turbine) system which incorporates the more powerful TF-20 engine for high "dash" speed and a smaller diesel engine for economical cruise speed.

All 3 contracts are with Seward Seacraft, of New Orleans, Louisiana, under contract with the U.S. Navy.

In the industrial field, Avco Lycoming also recorded its first sale—this to Delta Projects Limited, for a gas burning TF-25 engine for use as a power source for a gas pumping unit in Winnipeg, Canada. Delivery of this first unit was scheduled for late 1968.

The market potential for the application of both marine and industrial gas turbines appeared extremely bright. Prime among the potentials was the oil industry for use in drilling, water flooding and as the main power source for portable drill rigs. Other fields included generator sets, air cushion vehicles and auxiliary power in large naval vessels.

Other Avco Lycoming activities also increased during 1967, notably the production of constant-speed drives. The LD6-10A model, which had already accumulated more than 750,000 hours of flight experience by year-end, was to be delivered at an even more accelerated rate during 1968 and used on the Navy's Douglas A-4E, A-4F and TA-4F aircraft. Other versions are being used by the Marine Corps and by the Australian, Israeli and British navies.

In addition, an experimental constant-speed drive was being evaluated on the tri-service XC-142 aircraft developed by Ling-Temco-Vought.

In the missile area Lycoming continued production of the Mark 11 series of reentry vehicles as well as on the Mark 1 penetration aids program for the Minuteman II and III intercontinental ballistic missiles.

The division also continued its highly sophisticated subcontract manufacturing efforts and included among its programs was the main rotor hub for the Sikorsky CH-53 helicopter. This particular unit represents the largest titanium forging used on any helicopter in the world.

Lycoming was also employing its extensive 3-dimensional milling equipment to produce the main cabin fittings for the CH-53. This particular component, of aluminum, would be virtually impossible to produce through conventional machining methods.

Under contract with the Sun Shipbuilding Company, Avco Lycoming was engaged in the Deep Submergence Rescue Vehicle Program, producing steel hemispheres which when welded together form the main operational cabin of the vehicle. These 90 inch units are among the largest of their type and because the vehicle must be capable of submerging to a depth of 6,000 feet, the machining must be accomplished with a tolerance of plus or minus .002 inches, unheard of for components of this size.

Other subcontract programs include a 54 inch transfer tank for the same deep submergence program, and rotor pylons for Kaman HH-43 helicopters.

Avco Lycoming also continued its research and development efforts, the major one being the AGT-1500 gas turbine engine for use in tanks and other large surface vehicles. Under this contract, won by the division in 1965 over 15 competitors, Lycoming was required to install 2 prototype engines in 2 tanks for test purposes. Installation of the first unit was commencing as the year closed and the test program, to be conducted on a special test track constructed in Stratford, was scheduled to begin early in January.

Other development efforts centered around both the aircraft and marine versions of the division's 2 main facilities of engines, including the continued development of turbofan versions of both families and increased power.

The testing of a company developed mechanical servo actuator on an F-100 flight simulator was completed during the year and proved the feasibility of the system for an all-mechanical flight control system.

The Charleston plant, in addition to producing approximately 20 percent of the manufactured parts for the T53 engine, was slated to produce about 40 percent of the parts for the T55 engine. It also established a final assembly line where it was assembling new commercial engines as well as overhauled engines. Its growth also continued in ground support equipment activity, including water dynamometers, complete mobile test trailers and engine test stands. Development of new ground support equipment also began at the new facility.

AVCO MISSILE SYSTEMS DIVISION

The Missile Systems Division's leadership in the field of penetration aids—extremely complex devices that help intercontinental ballistic missiles reach their targets—led to its selection by the Air Force to develop and flight-test the country's first penetration aids system, the Mark I. Hardware will be produced by the Avco Lycoming Division, Stratford, and other components by the Avco Electronics and Avco Ordnance Divisions.

An important milestone in the development of the country's missile defense system took place in 1967 with the installation of the full complement of 1,000 Minuteman II ICBMs along the North American perimeter. All of these missiles carried Avco-produced reentry vehicles, end products of Avco's long association with the Air Force in the development of missile technology.

Avco received a contract during the year to produce the Mark 17, an advanced reentry vehicle.

In cooperation with Avco Space Systems Division, the Missile Systems Division was engaged in materials technology research. Using the space division's process by which composite materials are woven 3-dimensionally (3-D), the missile division developed an integrated wall concept for reentry vehicle structures which eliminates the need to bond ablative heat-shield material to reentry vehicles.

The division designed a test facility to simulate ballistic reentry heating in the laboratory more accurately than had been previously possible. It will be built under Air Force funds. The division also began operating a test apparatus which measures the effects of simulated wind and rain on pellets fired at high speed. Its purpose is to determine the effect of changing weather on high-speed vehicles entering or traveling through the earth's atmosphere.

The division's advanced programs office increased its activities in the study of strategic and tactical missile systems and advanced reentry vehicles and penetration aids. The staff was also working with the Air Force on aspects of the proposed anti-ballistic missile system.

AVCO ORDNANCE DIVISION

The Avco Ordnance Division achieved a breakthrough in ordnance technology during 1967 with the acceptance by the U.S. armed forces of the principle of rocket-boosted ammunition, developed by Avco. Avco Ordnance had been working on the ammunition, called Avroc, for about 5 years, and had conducted numerous test firings and demonstrations. Late in 1967, the division received 3 contracts for further development of Avroc, which will be used by Army ground forces with the M-79 grenade launcher, as well as in helicopter weapons. Avroc gives increased range, accuracy, shorter time to the target and a flatter trajectory. It was being made in the 40 millimeter size.

The bulk of the division's business continued to be the manufacture of bomb and rocket fuzes, bomb parts, mortar shells, and other non-nuclear weapons. The division received new orders and extensions of existing contracts on these materials, the demand for which generally reflects the requirements of the U.S. forces in Vietnam.

Arming and fuzing the Navy's Polaris missile and the Air Force Minuteman missile continued as an important division activity.

AVCO SPACE SYSTEMS DIVISION

As a result of its work in designing and producing the thermal protective system, or "heat shield," for the Apollo spacecraft, the division last year developed a new low density ablator with less than half the weight of the present Apollo shield. Heat shield manufacturing for the Apollo project continued on 13 moon-mission spacecraft in the NASA lunar landing program. The last of 8 capsules scheduled to orbit the earth were delivered during the year to North American Rockwell Corporation, prime contractor for the spacecraft.

The division devoted considerable effort to the study of small, unmanned scientific satellites. During the year it received several important study contracts for this type of spacecraft. The division was selected by Jet Propulsion Laboratory to study sending a spacecraft to probe the Venusian atmosphere. It also designed an Orbiting Astronomical Explorer satellite, under contract to the Kitt Peak National Observatory.

The division's Resistojet propulsion system, a lightweight unit designed to maneuver scientific satellites in orbit, was flight-qualified in 1967.

Avco supervised and designed at JPL's facility in Pasadena a full-scale Sterilization Assembly Development Laboratory. Its purpose is to define procedures to sterilize spacecraft of possible extra-terrestrial life. This laboratory is the only one of its kind in the country. The division was also conducting other space sterilization work.

The division increased its efforts in the young and fast-growing field of composite materials, whose high strength-to-weight properties have special significance in the aerospace and defense fields. Besides continuing to produce boron filament for the Air Force, the division was conducting research on other high-strength filament materials and processes. The division's involvement in composite materials technology now embraces non-destructive testing of materials. It has been able, for instance, to pioneer techniques for testing graphite to enhance its present use as a heat-protective liner for rocket nozzles and nozzle throats.

In another area, the division in 1967 delivered to NASA an electronic framing camera able to take 8 separate pictures in a single shutter action as fast as one-hundred millionth of a second.

Other work by the division from outside and intra-company contracts included the fields of infrared technology, ferrohydrodynamics, coal conversion and air pollution.

BEECH AIRCRAFT CORPORATION

Observing its 35th anniversary year, Beech Aircraft Corporation in 1967 marked the second successive all-time high in fiscal year sales. The more than $174,000,000 total included approximately $104,000,000 in commercial product sales, which was a new company record, and more than $70,000,000 in military and aerospace sales, representing a 10 percent increase over fiscal 1966.

During the year, Beech delivered 17 commercial models, ranging from the single-engine, 2-place Musketeer Sport III to the pressurized, turbine-powered King Air A90 corporate transport, and including the new 290 mile per hour Turbo Baron.

Introduced in October 1967 were the new 1968 models. Newest additions to the line were the all-new pressurized Model 60 Duke, a medium twin, and the turbine-powered 17-place Beechcraft 99 Airliner. The product line of 19 models was the largest in the history of the company.

Acceleration of activity in the commuter airline field resulted in further advances in both sales and new product development. The Queen Airliner, in operation for more than a year, was in the service of 6 United States and 7 foreign commuter airlines in 15 countries.

The Beechcraft 99 Airliner was scheduled for production in spring 1968, and it was to be supported by an Airline Marketing Department. As the first unit neared completion on the final assembly line, advance orders for the new airliner, largest airplane yet to be marketed by Beech, approached $35,000,000.

With a total of 314 deliveries scheduled by the end of fiscal 1967 on September 30, the Beechcraft King Air continued as the sales leader among all corporate turbine-powered aircraft. Figures compiled by the Aerospace Industries Association indicated that the King Air accounted for more than 80 percent of all turbine aircraft sales in its class since its introduction in 1964.

Accumulative King Air sales exceeded $101,000,000 with multiple owners—some operating as many as 6 King Airs—including 23 leading United States and European corporations and government agencies.

The ordering of 7 tri-gear Beechcraft Super H18s by Japan Air Lines in 1967, for use as a basic multi-engine training airplane, extended production of the Model 18 series into its 31st year—the longest continuous production span in aviation history.

In recognition of its foreign sales expansion, Beech Aircraft received President Johnson's Export "E" award in September. Presentation of the award was made to Beech officials in the office of the Secretary of Commerce at a ceremony attended by Kansas congressmen and representatives of the FAA and the Department of Transportation.

The Beech export program spanned a network of nearly 100 distributors and dealers in 100 countries. Beech export sales in the last 5 years increased 168 percent, totaling more than $24,500,000 during fiscal year 1967.

Production and first delivery of the U.S. Army U-21A turbine-powered utility transport highlighted Beech military aircraft activity in 1967. The Army increased orders for the U-21A to a total of 129. Total contracts extended U-21A deliveries through the spring of 1968, and, with spares and training of pilots and mechanics, amounted to more than $35,000,000.

The Army accepted delivery of the first U-21A at a special ceremony at the Beech factory, and production continued during the year at the rate of 10 a month.

Just 3 months after delivery of the first airplane, the U-21A was introduced to combat zone flying in Vietnam. With the first group of U-21As to arrive at an Army airfield in South Vietnam were Beech training specialists and a team of pilot and mechanic instructors.

The Beech family of missile targets was expanded in 1967 with development of the Sandpiper, a high-performance, rocket-powered target missile, for the U.S. Air Force Armament Laboratory. The Sandpiper testbed vehicle combines the airframe of the Beech-designed AQM-37A supersonic target missile and the newly-developed engine which uses both solid and liquid propellants. The Sandpiper is designed to reach speeds to Mach 4 and altitudes to 90,000 feet to simulate a wide variety of aircraft and missile threats of the next decade.

Production of the AQM-37A missile target in 1967 continued under contract to the U.S. Navy and with the first sale to a foreign government. The Defense Ministry of the United Kingdom purchased an export version of the AQM-37A, designated the Model 1072.

The U.S. Army Missile Command extended a contract for an additional quantity of Beech Model 1025 Cardinal target missiles. Nearly 2,500 of the versatile Cardinal targets, designated MQM-61A by the military, have been delivered to the Army and the Navy over the past 7 years.

Subcontract production was highlighted in 1967 with the awarding of $2,600,000 contract for fabrication of the complete airframe for the Model 206 JetRanger helicopter manufactured by Textron's Bell Helicopter Company. The 5-place, turbine-powered JetRanger is to be produced primarily for air taxi operation.

Production was continued on assemblies for the McDonnell Douglas F-4 Phantom II and for the Bell Helicopter UH-1 Huey series helicopter. For exceptional quality in the production of panels for the UH-1, Beech received Bell's "Gold Rotor Award."

During 1967, Beech completed delivery of 285 ship sets of major assemblies and spares for the Air Force/Lockheed C-141 StarLifter, under contracts which totaled approximately $44,000,000.

Continuing its support of the nation's space exploration program, in which it has designed, developed and produced ground support and on-board systems for the Gemini and Apollo projects, Beech Aircraft also delivered the last of 5 conditioning assembly units under a $4,500,000 contract for the Apollo Lunar Module (LM) program.

The Beech-built ground support units are used in the filling of helium tanks in the Lunar Module. Beech Aircraft's Boulder Division shipped the units to the Grumman Aircraft Engineering Corporation.

Overall employment at corporate headquarters in Wichita and at the Liberal, Boulder and Salina divisions during 1967 reached 10,429, the highest figure since Korean war production in 1953.

BELL AEROSYSTEMS COMPANY

A TEXTRON COMPANY

Marking its 25th anniversary as the company that built the nation's first jet airplane, Bell Aerosystems Company produced several important innovations in 1967.

The world's first Air Cushion Landing Gear (ACLG) was flown on August 4, 1967, at Niagara Falls (New York) International Airport adjacent to Bell's main plant.

Patented by Bell, the ACLG looks something like a fat black doughnut ringing the airplane's underside. It provides an air cushion on which the airplane rides during landing, take-off and taxiing. When airborne, the ACLG hugs tightly and aerodynamically to the airplane's underside.

Another important development at Bell during 1967 was the 2-man Pogo rocket flying device. The company successfully test flew this craft, proving its potential as a lunar or earthly small lift device.

Earlier, Bell developed the Flying Chair and a one-man version of the Pogo rocket. All are patterned after the famed Bell Rocket Belt, which has proved itself 100 percent reliable in more than 3,000 flights since 1961.

The one-man Pogo was flown successfully under lunar gravity conditions at the Langley Research Center, Virginia, in 1967, proving the craft's potential as a lunar flying device.

Progress continued to be made during 1967 toward development of the Bell Jet Belt, a one-man flying machine that will have far greater range than the rocket-powered devices.

A leader in Air Cushion Vehicles (ACVs), Bell started quantity production of these speedy amphibious craft in 1967. The initial production effort involved 65 vehicles, including 7-, 10- and 25-ton craft.

The 7-ton craft, known as the SK-5, returned to combat in Vietnam. The U.S. Navy, which operated 3 Bell SK-5s in Vietnam during 1966, had them modified and refurbished by Bell for another tour of duty. In addition, Bell expected to receive other military contracts for combat SK-5s.

In a related effort, Bell received a $125,000 contract from the federal Joint Surface Effect Ship Program Office to perform conceptual and parametric design studies of a high-speed surface effect ship test craft weighing about 100 tons.

Also in 1967, Bell took steps to further advance its ACV technology. It built a large Air Cushion Vehicle Technology Laboratory at its main plant, and started testing ACV models in 2 model test basins.

In the field of vertical/short take-off and landing (V/STOL) aircraft, Bell's X-22A continued to fulfill the contractual requirements set for it under the Tri-Service V/STOL research program.

The company also continued its important role in the U.S. effort to get a man on the moon. Bell was building propulsion systems, positive expulsion tanks for propellants and other liquids and vehicles for Apollo astronaut training.

Under contract to Grumman Aircraft Engineering Corporation and the National Aeronautics and Space Administration, Bell was developing the ascent rocket engine which will power the Lunar Module from the moon's surface to rendezvous with the orbiting Apollo Command and Service Modules.

In other rocket propulsion activity, Bell continued development and testing of small rocket motors and associated propellant tankage and controls for the Minuteman program. Bell's famed Agena rocket engine, known as the "work horse of the space age," continued to place many payloads in space, under NASA and Air Force programs.

NASA accepted the first of 3 Lunar Landing Training Vehicles built by Bell Aerosystems.

In avionics, Bell's All-weather Carrier Landing System (ACLS) played an important role in Vietnam through use of the system in landing aircraft under adverse weather conditions.

Bell received contracts to supply 3 additional ACLS systems for the Navy. When installed, these will bring to 15 the number of ACLS systems being operated by the Navy ashore and at sea.

Bell's BGM-2 gravity meter went into quantity production during 1967. The Navy will use the BGM-2 for preparing nautical maps, and oil companies plan to use it for oil exploration work.

Headed by William G. Gisel, Bell is one of the diversified manufacturing subsidiaries of Textron Inc., Providence, Rhode Island. Besides the main plant, Bell operates an avionics instrument laboratory in Cleveland, Ohio, and electronic research facilities in Tucson and Fort Huachuca, Arizona.

Employment at year's end exceeded 7,500, an increase of more than 1,500 over 1966, and Bell expected to hire additional employees to match its rise in new business.

Bell celebrated two important anniversaries in 1967:

• October 2, the 25th anniversary of the first flight of the Bell P-59, America's first jet airplane;

• October 14, the 20th anniversary of the date the Bell X-1 carried man past the speed of sound for the first time.

BELL HELICOPTER COMPANY
A TEXTRON COMPANY

The year 1967 was one of outstanding accomplishment for Textron's Bell Helicopter Company. It was marked by continuing on-time fulfillment of government contracts and impressive gains in commercial sales.

The company-developed HueyCobra, world's first strike helicopter, was delivered to the Army in late spring. By early fall it was in action in Vietnam. The Army already has ordered 744 of the high-speed, tandem-seat gunships.

Much of the company's effort during the year was devoted to the progression from prototype through production to actual deployment of the HueyCobra. But Bell also was busy filling demands from the U.S. and other free world governments for its UH-1 Iroquois series.

Large quantities of the troop-carrying UH-1H and heavily-armed UH-1C were delivered to the U.S. Army. The UH-1H is an upgraded version of the UH-1D, being powered by a 1,400 shaft horsepower engine. The UH-1C, equipped with the Bell 540 door-hinge rotor system, updated the B model. The UH-1C was being phased out by the HueyCobra.

Bell continued to produce the UH-1E in large numbers for the Marines. During the year the company fulfilled its contract with the Air Force for the UH-1F and a training version, the TH-1F.

All of the above, plus the Army OH-13S light observation aircraft, were operational in Vietnam except the Air Force helicopters.

Besides long-lead-time orders for the UH-1E, UH-1H, AH-1G HueyCobra and OH-13S, Bell received orders during 1967 for additional models of the 2-place TH-13T instrument trainer from the Army.

A co-production contract between Bell and the Federal Republic of Germany was designed to provide more than 380 UH-1Ds to the armed forces of that nation by the end of 1970. Under terms of the overlapping, 3-phase program, Bell was supplying several completely assembled ships, additional aircraft up to the point of final assembly, and finally, sets of dynamic components. Prime contractor in West Germany is Dornier, GmbH.

Canadian Forces (Army, Navy, Air Force) selected the Bell Iroquois as the first helicopter to be used in all-around ground support operations. In October, the forces announced signing of a contract for 10 of the utility-tactical transports.

Canada joined more than 20 nations around the globe whose armed forces were using versions of the UH-1 helicopter. Among those taking deliveries during 1967 were the Royal Australian Air Force and the Brazilian Air Force.

On the commercial market, the 5-place, turbine-powered JetRanger more than lived up to company predictions that it would generate the greatest demand for a new model in Bell's 21-year commercial history.

First customer deliveries were made in January and 9 months later the company had built more than 100 of the sleek JetRangers to meet the demand. But the flow of new and repeat orders continued at such a high level that Bell again stepped up its production schedule. It was anticipated that by March 1968, deliveries of this machine would reach the rate of 20 per month.

Bell Helicopter expanded production of its new 5-place JetRanger and completed deliveries of more than 100 of the craft.

Two new commercial models were announced for delivery early in 1968 as Bell continued to offer a widely diversified family of helicopters.

The turbine-powered, 15-place 205A will be the largest commercial helicopter ever manufactured by Bell. It is a civilian version of the military UH-1D utility transports. This business/utility jet is expected to receive widespread acceptance from corporations and fixed-wing air taxi operators as well as from helicopter charter operators. Its large cabin can be adapted for numerous uses. Several floor plans are offered, ranging from deluxe to cargo or high-density seating.

The 205A replaces the workhorse 204B, another commercial adaptation of a Vietnam-proved turbine ship, which had been on the market for 4 years, displaying tremendous reliability on jobs on every continent.

Compared with the 204B, the 205A is larger, roomier, has a more powerful engine and greater cargo and external load lift capabilities.

Also new for 1968 is the turbosupercharged model 47G-3B-2. It is an improved model of the 3B-1, a machine that flies more missions than any other 3-place helicopter in the world. The 3B-2 represents an increase in rate of climb, additional take-off power and lower specific fuel consumption.

Other commercial models in production at year-end were the 3-place 47G-4A utility model and the 47G-5, a 3-place utility helicopter also available as a 2-seater for aerial application use.

Bell helicopters were being built under license by Mitsui & Co. Ltd. of Tokyo, Japan, and Costruzioni Aeronautiche Giovanni Agusta of Milan, Italy. Agusta, like Bell, enjoyed great success during 1967 in sales of the JetRanger along with the rest of its product line. Mitsui's Kawasaki plant was progressing with production of the model 47KH-4 and the company was also producing a version of the UH-1 for the Japanese Self Defense Forces.

A far-reaching facility expansion program, designed to make Bell unsurpassed in rotary-wing research and development capabilities, was announced in the spring.

Included in the program are:

A new, modern flight test facility at nearby Arlington, Texas. This will contain, in addition to shops, hangars and offices, a computer data reduction area with a telemetry link for direct read-out of flight test data. Bell will move its flight test activities from Greater Southwest International Airport in Fort Worth to the 54-acre leased tract, where the project will cover approximately 80,000 square feet.

A 93,600-square-foot office structure at Bell's main facility at Hurst, which was completed in July.

In addition, Bell purchased 74 acres adjoining the Arlington tract. This land was expected to be used for a new experimental manufacturing building, a structure for testing large and small rotors, a wind tunnel and a research laboratory.

The company's research and development programs continued at a high level during the year.

Bell President E. J. Ducayet noted that during a 15-month period, Bell's contract equivalent level of effort of proprotor design and development was approximately $5,000,000. Fifty percent of this total was company sponsored.

In March, Bell was named one of 2 finalists in the Army's composite aircraft design competition and was awarded a $1,900,000 contract for advanced studies and other activity. Bell's entry was its low disc loading, tilt-rotor Model 266. Army evaluation of this latest data was completed during the year.

The company developed and successfully demonstrated a helicopter-borne fire suppression system with widespread military and civilian applications. It combines the helicopter's hover and propwash capabilities and use of light water concentrate to enable rapid rescue of persons from crashed, burning aircraft.

Bell was engaged in numerous other new or continuing research and development programs during the year. Included were several of classified nature.

Keeping pace with these accomplishments, employment all during the year was at or near its record high of more than 10,000.

A significant production milestone was reached in 1967. On November 8, in ceremonies at the Bell plant, the U.S. Army officially accepted the 5,000th turbine-powered UH-1 helicopter produced by Bell.

THE BENDIX CORPORATION
NAVIGATION & CONTROL DIVISION

During 1967 The Bendix Corporation's Navigation & Control Division continued as a major supplier to the free world's aerospace industry as both new and follow-on contracts covered a wide range of devices and systems for practically every major aviation, missile and space program.

In the aviation field the division climbed aboard the American supersonic transport (SST) and 747 airliner programs, moved into the giant C-5A military transport, and had a hand in developing key systems for the Anglo-French Concorde supersonic transport.

The division's first contract on the American SST program called for participation in developing the automatic flight control system specifications for the 1,800 mile per hour variable-sweep wing aircraft. For the 490-passenger 747 jumbo jet, The Boeing Company awarded contracts for automatic throttle servos, stability augmentation computers, mach trim couplers and the first air data computers to be used on commercial aircraft.

Navigation & Control's association with the Anglo-French Concorde supersonic transport was highlighted when the first Bendix-designed central air data computer, automatic flight control system and flight director computer were shipped abroad for installation on the prototype Concorde aircraft. The division also provided the Concorde with dual speed resolvers, rate gyros and vertical scale instruments.

The division was selected by Lockheed-Georgia Company to design and manufacture the flight and engine instruments for USAF's giant C-5A logistic transport. The compact, lightweight instruments included a peripheral command indicator, vertical scale type instruments for both engine and flight functions, and an attitude flight director indicator—all of which feature integral microcircuit electronics.

Awards for automatic flight control systems (AFCS) for both military and commercial aircraft added substantially to the total number of systems already on order.

The DeHavilland Company selected the PB-60 AFCS for installation on their DHC-5 transport. Additional PB-60s were contracted by the Nihon Aeroplane Manufacturing Company of Japan for their YS-11 short/medium-range commercial transport, while the British Aircraft Corporation ordered additional PB-20 AFCSs for their BAC 1-11 short-haul commercial transport.

The U. S. Navy contracted AFCSs for their T/A-4E attack trainer and their P-3A antisubmarine patrol aircraft.

Bolstering the division's general aviation AFCS program, the PB-60 won FAA approval for use on the Lockheed JetStar, Aero Commander's Jet Commander and the DeHavilland DH-125 aircraft. In addition, the Pan American Jet Falcon won FAA certification for landing in obscure weather conditions classified as Category II.

Progress in the field of automatic landing systems continued when the giant Boeing 707 jet transport equipped with the Boeing-Bendix Precision Approach and Landing System (PALS) was also certified for fully automatic landings under Category II weather and visual flight rule conditions. Later, on July 7, 1967, a PALS-equipped Pan American 707 flew from New York to London where it made the first automatic landing for a 4-engine jet commercial aircraft on a regular passenger-carrying scheduled flight.

The Microvision all-weather landing aid, which permits a pilot to "see" the runway through obscure weather and visually monitor his approach, began undergoing FAA tests and evaluations under actual operational conditions. When the system is granted FAA approval for commercial use, it is expected to reduce considerably the millions of dollars that airlines lose each year because of obscure weather conditions. To conduct the tests, the FAA installed Microvision runway beacons at its Atlantic City, New Jersey, testing center and installed Microvision airborne equipment in an FAA DC-7.

Navigation systems and equipment were ordered for USAF's F-4J and the Navy's F-4D fighter aircraft and for Navy's EKA-3B and EA-6A all-weather, low-level strike aircraft.

Follow-on contracts were awarded for vertical scale flight instruments for USAF's F-111/FB-111 aircraft. The division also won follow-on contracts to supply the variable-sweep wing, supersonic fighters with air data computers which provide precise atmospheric information needed by various aircraft subsystems.

Contracts were received for the Bendix weapons release system for the U.S. Navy's A-4C, A-4E and A-7E attack aircraft and USAF's F-100 fighter aircraft. With this aircraft-mounted system, the pilot can program the automatic release of stores from the weapons stations in whatever quantity, mode and drop intervals he desires.

In a new application, a dual-control version of the system with individual controls for pilot and gunner was ordered for the U.S. Army's 2-man AH-56A Advanced Aerial Fire Support System (AAFSS) helicopter. Also ordered for AAFSS were computer control panels which control and display readout information generated by the helicopter's central digital computers.

In the field of automatic checkout equipment, the AN/GSM-133 general-purpose programmer comparator was ordered by the military as the checkout system for both USAF's C-141 transport and the 350-ton C-5A heavy logistics transport. Other "133s" were ordered to check out 17 systems on the F-4 fighter aircraft, including the stabilized camera and radar mapping systems, and to check out various systems on USAF's new air-to-surface, short-range attack missile (SRAM). The versatile, compact and easily-movable "133" can check out aircraft, missile and space systems at all levels of test—factory, depot or flight line—and provide future growth capabilities for handling test checkout requirements throughout the next decade.

In the space field Navigation & Control not only was named a key member of NASA's planning team for Apollo missions but also entered the growing European space program as well, while its missile activities included a range of devices for land-, sea- and air-launched missiles that form the free world's defense system.

During the summer the Martin Marietta Corporation, with whom the division is teamed as principle subcontractor, won NASA's Apollo Applications Program (AAP) competition. The contract involves the extension of man's capabilities for working and exploring in space, using technology and vehicles under development in the Apollo lunar landing program. The program includes mission planning, integrating payload experiments, and launch operations support. The division is responsible for communications, displays and controls, and portions of experiments analysis and other electronics.

The European Space Research Organization awarded a contract to the division for reaction wheels to control and stabilize TD-Satellites. TD-Satellites will be used for experiments in space astronomy and radiation and in solar and atmospheric phenomena. Reaction wheels had been previously contracted for the U.S. Nuclear Detection Satellite, Orbiting Geophysical Observatory and Orbiting Astronomical Observatory.

NASA awarded a contract for control moment gyros to provide accurate and continuous attitude control and stabilization for the Apollo Telescope Mount (ATM). One of NASA's slated Apollo Applications missions will use the ATM during a 56-day experiment to study the sun in its most active stage.

NASA's Saturn program brought follow-on contracts for the rocket's inertial guidance platform. The platform generates velocity and acceleration information for accurate pitch programming and final insertion of the payload into orbit. Bendix platforms have successfully helped direct all previous inertially-guided Saturn I and IB flights and are scheduled for all future Saturn IB and V flights, culminating with man's landing on the moon.

Continuing into its 10th year of supplying inertial guidance systems for the Pershing missile program, the division was awarded contracts by the Martin Marietta Corporation and U.S. Army for engineering studies and evaluation of improvements to inertial guidance systems.

Contracts were received from North American Rockwell Corporation for additional liquid-floated pendulous integrating gyro accelerometers (PIGA) for USAF's advanced Minuteman II missile program. As key acceleration-sensing units in the missile's guidance and control system, the PIGA has been described as one of the most accurate velocity measuring devices in existence.

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

In other areas of missilery, the Massachusetts Institute of Technology contracted the division to provide gyros and accelerometers for the U.S. Navy's Poseidon missile's guidance system, and the production of Hawk missile antenna bases and pedestals at the division continued into the 11th year.

With its more than 10,000 employees the division remained the largest employer in New Jersey's populous metropolitan Bergen County and the largest defense contractor in the state.

AEROSPACE SYSTEMS DIVISION

The Bendix Aerospace Systems Division began development of the Apollo Lunar Surface Experiments Package (ALSEP) for NASA's Manned Space Flight Center. ALSEP is a series of scientific experiment instruments astronauts will deploy on the lunar surface in early Apollo missions. It will collect and transmit scientific and engineering data to the Earth for up to one year.

ALSEP represents the first significant step toward the development of a lunar surface scientific capability in the Midwest and is the result of a multi-million-dollar investment by Bendix to prepare for a continuing and expanding effort in the space program. The scientific community is deeply interested in the data to be returned by ALSEP. A wide range of scientific disciplines are involved, such as lunar magnetic field investigation, lunar seismic activity, solar wind investigations and subsurface gas studies.

The Revised ALSEP Program Schedule reflected the utilization of additional program time in order to obtain a serialization of the test effort. Instead of concurrent fabrication and test, with the resultant effect of higher technical risk, the more important phases of the test program are completed prior to the acceptance tests of the 4 flight systems.

These ALSEP flight systems, with the initially defined scientific experiments, were designed to support the first 3 Apollo launches. Additional development effort was proposed for future ALSEP hardware requirements. The Laser Ranging Retro-Reflector was being planned as an experiment for future systems.

Further study efforts were to be undertaken in the period from October 1967 to September 1968 to define the ALSEP requirements for the subsequent Apollo flights.

Lunar vehicle technology efforts continued at the division with the detailed design study of a Specified

LSSM. At the direction of NASA Headquarters, administered through Marshall Space Flight Center, the design restraints for the Baseline LSSM Design Study, conducted the previous year, were realigned toward a "stripped" or Specified LSSM. Although specifically designed to meet early, limited mission requirements, the vehicle design provides the capability to accept add-on equipments (communications and navigation) and design modifications to provide enhanced mission performance.

The full-scale, motorized model of the Specified LSSM saw extensive use. This model supported astronaut evaluations at contract briefings and provided visual evidence of Bendix lunar vehicle technology at the AIAA Conference in Boston. Additionally, the vehicle supported recent simulated 5-day lunar surface human factor evaluations.

Complementing the Specified LSSM Design Study, an engineering model of the transmission-motor drive assembly was built and tested. Performance characteristics and efficiency variation with torque load were being evaluated in the ambient and thermal-vacuum conditions.

Also complementing the Specified LSSM Design Study were Surveyor battery evaluations conducted with corporate funds. The battery modules were evaluated for possible direct application to LSSM and for performance data for silver-zinc batteries for lunar application.

In March, the division unveiled its new airborne Thermal Mapping and Infrared Imagery System. This system is believed to be the first commercially available unit of its kind and is being developed for such uses as: the detection of plant and tree disease epidemics, smoldering forest fires and water pollution in streams and lakes.

The system consists of 4 basic components: a scan head, control console, verticle reference and a power supply. It can be installed and serviced in a wide range of aircraft. The system is simple to operate; it uses readily available 70-millimeter, TRI-X film. The only moving parts are the scanning shaft and film drive. Power consumption is low, as the system operates on 10-amperes, 28 volts direct current aircraft power. Cooling is by liquid nitrogen contained in the scanner head.

Two systems, valued at approximately $115,000, were purchased—one by the University of Michigan, Ann Arbor, and one by Geotech Division of Teledyne, Austin, Texas. Negotiations were under way for the leasing of the system to other customers.

ELECTRIC POWER DIVISION

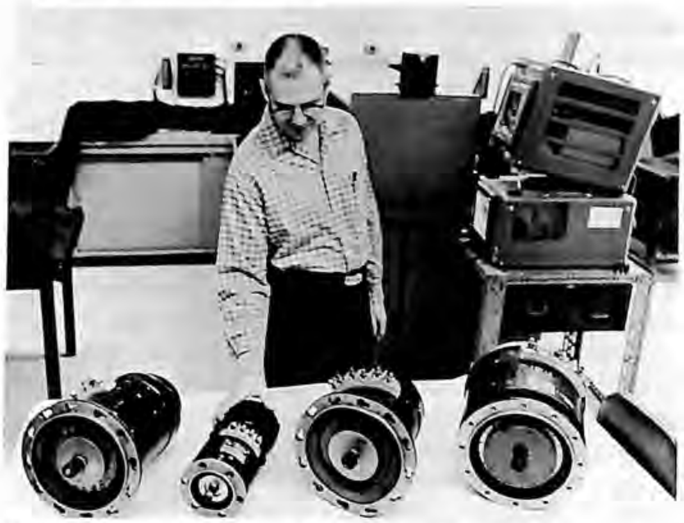
During 1967 the Electric Power Division won the award to supply the electric system for the Boeing 350–490 passenger 747 Superjet. The electric system, capable of producing 360,000 watts of electric power, is one of the most modern systems available and includes brushless-type generators and highly sophisticated control components. One of these components is a unique annunciator which checks out all parts of the system and which can be activated by simply pressing a button.

The initial contract award for the electric system was $6,000,000. Follow-on orders and support equipment over the next several years should exceed this amount.

Bendix continued to supply electric power systems for other commercial applications during the year. For the Grumman Gulfstream II aircraft, a complete system capable of producing 70,000 watts of both AC and DC power was being supplied.

For the military, Electric Power Division continued to supply electric systems for such applications as the F-4 Phantoms and A-4D Skyhawks. These systems, designed to withstand tough, rugged environments, have had an extremely-successful performance record in actual service.

During 1967 the division introduced a portable, engine-driven generator set designed for use in combat areas. In addition to supplying DC electric power for communications, these portable units provide power for starting helicopter engines. Also introduced in 1967 was a lightweight brushless generator capable of producing 1,200 watts per pound. This unit, weighing only 25 pounds, will produce 30,000 watts of electric power for Lockheed's new AH-56A Cheyenne "Rigid-Rotor" Aircraft.



Test engineer handles new compact brushless generator developed by Bendix Electric Power Division for the Lockheed AH-56A helicopter. Generator is compared with conventional design (far left) of similar output.

Some of the major programs under way at the division include the development of a small, lightweight DC generator for the general aviation market. Completely brushless, the unit will provide about 2,000 watts of DC power. It will incorporate its own "excitation system" and will not require an external power source to start power generation.

Other development programs include expansion of a family of environmental-free generators, design of new "library-quiet" static inverters for commercial aircraft, and design of complete check-out and support equipment for electric systems.

During 1967, Electric Power Division installed automated manufacturing equipment to speed up production operations. New equipment included automatic lathes, milling machines, brazing machines, wire-forming and insulation-wrapping machines. These new automated machines are part of an overall cost-reduction program initiated by the division several years ago to increase production efficiency and pass the savings on to customers.

A new 6,000-foot bake shop facility was added to the plant during the year and additional engineering and production facilities were being planned for 1968 and 1969.

Total employees at the division at year-end numbered 1,400 with about 25 percent working in engineering and other technical assignments.

ENERGY CONTROLS DIVISION

The Energy Controls Division of The Bendix Corporation at South Bend, Indiana, experienced a year of rapid business growth and facilities expansion during 1967.

A multi-million dollar program to furnish wheels and brakes for the giant 490-passenger Boeing 747, largest airplane ever designed for commercial service, was launched following an intensive competition. Each of the gigantic aircraft will have a total of 16 brakes and 18 wheels. Total airplane production, extending at least into the mid-1970s, is planned to be well in excess of 300 aircraft, and service repair and replacement of wheels and brakes was expected to extend the Bendix program far beyond this date.

Fabrication to watch-like tolerances of the landing gear for the world's largest airplane, the Lockheed C-5A, was well under way at the division. The 4 main landing gears, along with a nose gear, will support the 700,000 pound aircraft on a total of 28 wheels. Photoelastic stress determination technology has been significantly advanced as a result of its application during the development of these massive landing gear components.

Extensive material properties studies of unprecedented thoroughness are being conducted with the new 300M steel being used as a primary structural material in the highly-stressed C-5A landing gear. This special steel is produced by the vacuum-arc-melt method and then heat-treated to 280,000 to 300,000 pounds per square inch ultimate tensile strength. Fatigue characteristics, effects of surface roughness, advantages of peening surfaces, comparison of decarburized surfaces and surfaces with decarburization removed, and plain versus notched geometries are some of the properties investigated in these studies which have already utilized over 600 test specimens.

Production of wheels and brakes for Boeing 737 and 727-200 aircraft was commenced during 1967 to support Boeing production schedules. Both aircraft are now in the final phases of FAA certification flight test programs and are expected to receive airworthiness certifications before the end of the year. This expanded production capability will also be employed to support the planned replacement of wheels and brakes on some 727-100 aircraft with Bendix equipment.

Volume production of wheels and brakes for the Douglas DC-8-61, 62, and 63 airplanes was under way to support aircraft production schedules.

The fabrication of aircraft landing gear was maintained at high volume to support production of McDonnell F-4 fighters of Vietnam fame and other continuing programs.

One of the largest and most sophisticated landing gear test laboratories in the world was completed by the division during 1967. The test laboratory's 1500 cubic yards of concrete and 500 tons of soaring steel structure dwarf the world's largest drop test facility now located at this division. A massive block containing over 2,300,000 pounds of concrete absorbs earth-trembling impacts of simulated landings by multi-million pound aircraft. The new facility will provide the division with greater capability for the development, testing and production of landing gear for the new generation of aircraft.

A 140-ton numerically controlled milling machine, which can shape the intricate contours of aircraft landing gear components weighing up to 10 tons with an accuracy of 0.0001 inch, is typical of the new machine tools acquired during 1967 to produce massive landing gear for the giant aircraft now being designed.

The largest and most advanced heat treating facility possessed by any aircraft landing gear manufacturer —and one of the few such facilities in the world—went into operation during 1967. The towering gantry-type furnace rolls on rails to straddle 7 immense immersion chambers in a deep pit below to heat treat huge landing gear parts for the new generation of gigantic aircraft. The electrically heated furnace will ensure the design of minimum weight landing gear by providing a neutral-gas atmosphere to permit attainment of ultra-high material strength combined with maximum toughness.

Other facilities improvements included addition of the largest cadmium-titanium plating facility in the United States to permit plating landing gear parts with cadmium containing a percentage of titanium. This electro-plating process will provide landing gear parts surfaces with superior protection against corrosion.

Research and development programs were actively pursued during the year to advance the state-of-the-art of aircraft wheel and brake design. The use of beryllium and other exotic materials for brake heat sink components was receiving intensive study. Wheels and other landing gear components fabricated of titanium alloys were showing great promise as possible avenues towards reduced landing gear weight. The improvement of brake friction materials and surfaces was also the subject of concentrated concerted effort.

The division continued to develop composite material structural members for use in aircraft landing gear systems. Test and analysis effort during the year demonstrated the feasibility of fabricating landing gear structural members with end attachments from composite materials. These studies also showed that such parts can be made lighter with composite materials than with the conventional metals employed in landing gear manufacture.

Energy Controls Division, in conjunction with Navigation & Control Division, was awarded a contract to develop and manufacture microelectronic engine control systems for the Pratt and Whitney Aircraft Advanced Manned Strategic Aircraft (AMSA) demonstrator engine.

Production of engine control components for the TF30 engine which powers the F-111 aircraft continued at the division.

The Flygmotor RM-8 turbojet engine with full afterburning in Sweden's latest fighter aircraft, the Saab "Viggen," will be equipped with a fuel control developed by the division. A licensing arrangement provides for manufacture of the Bendix control in Sweden by Svenska Flygmotor Aktiebolaget.

A manual control was developed for Allison TF41-A1 turbojet engines in A-7D aircraft which permits the pilot to maintain control of engine power in the event that the main fuel control is damaged by enemy action or otherwise rendered inoperative.

Fuel control systems for the Hughes OH-6A helicopters were in production.

A new Propulsion Controls Engineering Laboratory provides under a single roof a full range of gas turbine engine control environmental and developmental test capabilities unexcelled in the industry.

A fluidic compressor bleed control for possible use on advanced Pratt & Whitney Aircraft gas turbine engines was under development. This device shows promise of being the forerunner of other fluidic components for future aircraft and industrial power plants.

The general aviation business potential of Energy Controls Division was increased as a result of having been selected by AiResearch Division of The Garrett Corporation to supply fuel systems for commercial applications of the TPE 33 turbine engine. This engine powers such aircraft as the Mooney MU-2B, the Turbo-Commander, and the Helio Stallion.

Fuel injection systems for Lycoming turbo-charged reciprocating engines were also being furnished by the division. The Mooney MK-22 Mustang is the first single-engine airplane of the light or business aircraft category with a pressurized passenger compartment, the Beech Turbo-Baron and the Piper Navajo are among aircraft in this growing market equipped with Bendix fuel injection systems.

Oil well drilling rigs were developed which are powered by Caterpillar gas turbines equipped with Bendix fuel control systems.

An expanding line of multiple-wire-strand helicopter blade tie bars capable of withstanding the metal-tearing centrifugal forces of whirling rotor blades—while constantly twisting as blade pitch changes during each rotation—was being furnished by the division for more production helicopters than any other single type of blade attachment. The Bell Huey helicopters are equipped with Bendix tie bars. In addition to the increasing demand for hovering aircraft, each year sees a widening share of the market being supplied with Bendix helicopter blade tie bars.

In the rapidly expanding spacecraft landing systems field, several major accomplishments by this division are worthy of note: An experimentally verified, 3-dimensional, Apollo Command Module landing dynamics computer program was completed for the NASA Manned Spacecraft Center. This computer program permits studying the earth landing characteristics of the command module when landing on either hard or soft (earth soil) surfaces.

A highly sophisticated landing dynamics computer simulation of the Surveyor Spacecraft was developed for the Jet Propulsion Laboratory. This simulation was used extensively in the analysis of telemetered data from Surveyors I, III, V and VI which were successfully landed on the moon.

The development of a semi-emperical footpad-soil interaction model was commenced for incorporation in a Lunar Module landing dynamics computer analysis. The computer analysis will permit the study and prediction of Lunar Module landing performance on the lunar soil surface, once the soil characteristics are established.

Landing dynamics analyses and preliminary design studies of landing systems for the proposed unmanned Mars soft-landing Voyager spacecraft were commenced during 1967.

Energy Controls Division assisted Bell Aerosystems with both analytical and experimental studies in the selection and design of landing gear for the Manned Flying System. The 2-man lunar spacecraft experimental studies utilized a specially designed one-third scale dynamic drop-test model to evaluate the effects of fuel "slosh" on the craft's landing characteristics. As a result of both design and experimental studies, considerable progress has also been made towards the design of a repeatable energy absorbing landing gear strut for the spacecraft.

Additional quantities of shock-absorbing landing struts were furnished in 1967 for the Bell Aerosystems/NASA Lunar Landing Training Vehicle. The effect of the astronaut free-flight training vehicle's structural flexibility on its landing dynamics had been studied by the division for the NASA Manned Spacecraft Center using analytical techniques developed earlier for the NASA Flight Research Center.

FUZING DEVICES DIVISION

The Fuzing Devices Division continued to broaden its activities with first production during the year of 2 mechanical fuzing devices for artillery use.

Special emphasis was placed on 2 product areas—printed circuit boards and aluminum dip brazed assemblies. The division is a supplier of custom designed printed circuit boards for military and commercial use. Facilities for fabrication were expanded with the addition of new equipment for art work layout, tape drilling, flushing and plating of complex circuit boards. Additional applications were found for aluminum dip brazing, with the increased demand resulting in an enlargement of production facilities.

The division was also engaged in analysis, development and production of fuzing systems, fabrication of microwave relay lines, R. F. striplines, special test and checkout equipment, and electromechanical assemblies and subassemblies.

INSTRUMENTS & LIFE SUPPORT DIVISION

During 1967, the Bendix Instruments & Life Support Division made significant state-of-the art advances in such product lines as aerospace flight instrumentation, cryogenic storage and control, life support and fluid measurement.

In the area of flight instrumentation, the year saw considerable development and production of automatic altitude reporting equipment by the division, in addition to an increased demand for its line of standard flight instruments. To meet this demand, the division established a production facility in Denver which supplements its manufacturing facilities in Davenport, Iowa.

Advancements made by the division in cryogenic storage and control systems for use aboard spacecraft included the development of a liquid-shrouded system. The technique permits storage of a cryogen for an extended period of time by surrounding it with a second cryogenic fluid. The system is especially suited for hard-to-store helium. By using liquid hydrogen as the shroud coolant, high-pressure gaseous helium can be stored at nearly 15 times its density at ambient temperature. The shrouded system is also lighter than a comparable liquid helium system and it greatly reduces loading problems because the storage vessel can be filled from a high-pressure gaseous helium source.

Study and development programs were carried out on various fluid measurement techniques. These include force-screen type cryogenic flowmeters, optical point sensors, liquid-level capacitance type sensors and a technique for measuring fluid mass under zero "g" conditions. In addition, the division developed an integrated-circuit version of its high-performance analog capacitance servo and an integrated-circuit digital servo was expected to go into production.

In the area of life support equipment, the division made significant strides toward the development of a universal survival kit. For over-water flying, the kit will feature a life raft that will inflate while the crew member is being lowered by parachute. The raft is designed so that the crew member is actually inside the raft before hitting the water.

THE BOEING COMPANY

Ten thousand people were added to The Boeing Company's payroll in 1967, expanding total company personnel to more than 140,000, highest in the company's history.

Unfilled orders at September 30, 1967, reported at \$5,794,000,000, compared with \$5,283,000,000 at December 31, 1966. Included in the September backlog was \$422,000,000 for military aircraft and \$375,000,000 applicable to missile and space programs. Commercial orders totaled \$4,997,000,000. Sales for the first 9 months of the year were \$2,092,868,000 compared with 1966 figures of \$1,729,165,000 for the same time period.

Boeing committed \$250,000,000 dollars for facilities where planes will be produced to keep pace with a magnifying demand. Included was \$200,000,000 for 747 Superjet facilities. Design, development, testing and tooling costs for the program will be \$500,000,000.

In terms of commitment, development of the 747 jetliner program is without parallel at Boeing. On January 3, 1967, 70 persons began work at the new facility at Everett, Washington. By October, 3,200 were working at the plant and the figure was projected to rise to 15,000 in 1969.

Included in the Everett complex is the world's largest volume building, containing 160,000,000 cubic feet. From that vast interior will emerge the 747—itself 231 feet, 4 inches long, with a 195-foot, 8-inch wingspread, its tail standing 63 feet above the ground—taller than most 5-story buildings. First rollout was scheduled for the fall of 1968.

By year-end, Boeing had more than 3,200 employees in its new 747 facility at Everett, Washington.

Congress approved the United States government's share in funding 2 supersonic transport (SST) prototypes and first metal was ordered in August. The first Boeing prototype was to fly in the late 1960s. Production SSTs, to cruise at 1,800 miles an hour or match subsonic speeds of today's jetliners, will be capable of carrying 350 passengers. SSTs are scheduled to enter service in the mid-1970s.

The first 737 short-to-medium range twin jet flew in April and by mid-October when FAA certification test work was begun, 6 737s had logged more than 800 hours in test flights.

Smallest of the Boeing jetliner family, the 737 is designed to serve short-to-medium range airline routes. Three versions were in production at the Seattle Branch of the Commercial Airplane Division, with major body construction at Wichita (Kansas) Division. The 737-100, 94 feet long, will be able to carry up to 101 passengers, while the -200, 100 feet long, will be able to carry up to 113 passengers. The third model, the -200C, is a convertible cargo/passenger version of the -200. A military 737M was under study and a business 737 model was also being offered. Fuselage of the 737 is the same wide body as that of the 707, 720 and 727 jetliners—12 feet, 4 inches. One or 2 deliveries of 737s were scheduled for late 1967.

First flight of the 727-200, a 20-foot longer-bodied version of the versatile 727 trijet, was made July 27 to begin a 5 month FAA flight test certification program. The -200 can carry 163 passengers at a lower seat-mile cost. The new model offers flexibility of a variety of mixed-class arrangements and provides a total of 1,450 feet of cargo space. It can operate from the same shorter-runway airports used by the smaller 727-100.

During the first 9 months of 1967, 86 model 707s and 720s were delivered to customers, as well as 116 Model 727s. Those included one 707 and 11 727s under lease arrangements. The company expects to meet its projected goal of delivering 118 707/720 models and 149 727s during the year.

Boeing signed a letter contract with the NASA for technical integration and evaluation support for the United States' Apollo/Saturn Moon program.

Late in 1967, a final report on Boeing's entry for the Voyager spacecraft was submitted to Marshall Space Flight Center. Voyager is to undertake unmanned scientific exploration of the planets.

A study series and demonstration continued on Solar ARRAY for hardware to improve solar panels for power sources in space. Panels were increased in size and efficiency over earlier panels by Boeing in the series being done for NASA's Jet Propulsion Laboratory.

Burner II, an upper stage rocket, designed, built and tested by Boeing, carried 2 satellites into earth orbit in June.

Boeing's missile activity saw the second full wing of Minuteman II take its place in the nation's deterrent force October 19 at Whiteman AFB, Missouri. On that date, the wing of 150 improved ICBMs (refined versions of Minuteman Is), was turned over to Strategic Air Command by Boeing. Wing VI, Grand Forks AFB, North Dakota, was the first fully equipped wing.

Work continued in field assembly, checkout and systems integration of Minuteman II by Boeing to update the Minuteman I missiles. The system is deployed over an area of 15,000 to 25,000 square miles across the nation. Range of Minuteman II is increased to more than 7,000 miles, along with greater accuracy and it can carry a larger payload because of its larger second-stage engine, with 34 percent more solid propellent. Study and development continued on an even more sophisticated Minuteman III.

Lunar Orbiter V completed the last of a 5-flight year-long series, photographing the surface of the moon in August. The Lunar Orbiter quintet took more than 2,000 photographs covering almost the entire moon's surface (about 14,000,000 square miles) providing detail at least 10 times better than earth-based telescopes. Some areas never had been seen before from directly above.

In the fall, the U.S. Air Force short-range attack missile, called SRAM, was moving through design, development and evaluation phases at the company's Space Center near Kent, Washington. Boeing was developing SRAM under management of the Air Force Systems Command's Aeronautical Systems Division. It is to be used aboard the FB-111 strategic fighter-bomber and is adaptable for use on the Boeing-built B-52 bomber.

On July 15, the Tucumcari, newest United States Navy hydrofoil, the PGH-2 (Patrol Gunboat Hydrofoil) was launched by Boeing. In autumn, foilborne testing began. Having no conventional propeller, the boat design incorporates a unique system of waterjet propulsion. Foils function as underwater "wings," to lift the hull above water, to achieve high speeds and great maneuverability in almost any type of sea. The first of its kind in U.S. Navy history, the PGH-2 may be forerunner of a fleet of swift special-mission craft. The Tucumcari displaces 57 tons, has a 20-foot beam. In foilborne operations it skims over the water, its water jet pumps driven by a 23,300 horsepower gas turbine engine. A smaller diesel driven engine-powered water jet propeller system is used for hullborne maneuvers. Armed, the Tucumcari will carry a 240 millimeter gun, an 81 millimeter mortar and 2 sets of 50-caliber machine guns.

Proposal stage was reached in 1967 for Boeing competition to begin in early 1968 for integration and electronic design on conceptual Airborne Warning and Control System (AWACS) for the U.S. Air Force. The company's largest 707-series jetliner, the 707-320 Intercontinental was used as the baseline in the AWACS studies.

At a combined rate of 30 per month, the Vertol Division in Pennsylvania delivered CH-47 Chinooks to the U.S. Marine Corps and Navy for use in Vietnam. Since 1960, facilities have been expanded at Vertol by more than 400 percent. Employment in that period increased from 2,000 to more than 12,000.

First production model of the heavier, faster "C" Model Chinook was scheduled for delivery to the U.S. Army in March 1968. The improved version of the Chinook has more powerful engines and an updated transmission. Design of the "B" models allows future conversion to "C" models. Test flights of the "C" confirm that installation of higher-powered engines bring a 25 percent increase in payload, making it possible to transport up to 23,400 pounds at speeds increased 12 miles an hour—from 172 to 184.

One change not affecting employment was absorption of the Boeing Turbine Division into the Commercial Airplane Division, for which it produces gear boxes and other commercial jet airliner parts. The division had worked more than 2 decades in the field of small gas turbine power.

While The Boeing Company was in its 52nd year, the Wichita Division reached the age of 40 in September. Formed on September 27, 1927, as the Stearman Aircraft Company, it became a Boeing division in 1934. The 18,000-plus employees at Boeing-Wichita figure in the Saturn V moon rocket and the Model 747 superjet, as well as a bit of the SST and SRAM. They have a hand in Vertol helicopter production and build the body section for the 737 twinjet. Other Boeing jetliner assemblies are produced in Wichita and it is a certificated modification station for the company's entire Model 700 series. Improvement and maintenance programs for the B-52 bomber and related projects in big-jet research and testing are conducted there.

CESSNA AIRCRAFT COMPANY

The year 1967 was one of continued growth for Cessna Aircraft Company. Aircraft production during the year gave Cessna the lead in total unit production over any other manufacturer, the company's commercial aircraft line expanded and several models were "drafted" for military duties.

Unit production during the year enabled the company to make aviation history by becoming the world's top producer of aircraft. Cessna celebrated the milestone in July with the delivery of its 75,000th aircraft, a Super Skymaster delivered to the Alcoholic Beverage Commission of Tennessee. During each of the past 12 years, Cessna has led the general aviation industry in unit sales and at year-end there were more Cessnas active than any other make.

New models introduced during 1967 brought Cessna's line of commercial aircraft to 30 different models, including 22 single-engine and 8 twins. Growth of the product line has reflected the company's philosophy of offering a wide range of models to meet customer needs in the growing training, personal, utility and business aircraft markets.

Cessna's learn-to-fly program, responsible for generating many new airplane sales and student pilot starts, gained added impetus with the introduction of an Air Age Education program. The program further stimulates learn-to-fly efforts by making classroom material available to introduce aviation courses in schools from the elementary to junior college level.

The Model 150, Cessna's mainstay of learn-to-fly efforts, continued to prove a popular airplane. More than 6,200 have been sold since January 1965. A separate plant was built to handle assembly and delivery of the Model 150. Located 40 miles southeast of Wichita between Winfield and Arkansas City, Kansas, the Cessna Strother field plant was completing 10 Model 150s per day. A European version of the aircraft—the F150—was also being built by Reims Aviation, a Cessna affiliate in France.

Del Roskam, Cessna President, predicted the expected increase in flight training activity and demand for retail sale of the Model 150 in the U.S. would create a demand for more than 3,000 of them during the 1968 model year.

During the first 28 months of the company's extensive learn-to-fly program, more than $60,000,000 in revenue was produced for the company's domestic dealer organization through flight courses and airplane sales and many thousands of people were encouraged to learn to fly. More than 135,000 persons started their flying careers through use of Cessna $5 introductory flight lesson coupons. First used by Cessna in 1965, the coupon promotion is supported by an extensive advertising and promotional campaign.

The company doubled its multi-engine commercial line in the 1967 fiscal year with the introduction of the Turbo-System Super Skymaster, Models 401 and 402 medium twins and the pressurized Model 421 executive twin. The executive 401 and its sister ship for utility use, the 402, were introduced in late 1966. The other two twins were put on the market in 1967.

Cessna entered a new market with the Model 421, the lowest-priced pressurized high-performance twin-engine aircraft marketed in general aviation today. At a base price of $159,950, the Model 421 is in a price category previously filled only by unpressurized twins.

Late in the year, the company introduced its 2 newest aircraft, the Model 177 and its deluxe companion, the Cardinal. These all-new aircraft were designed as luxury models in the low price class of single-engine aircraft. The 177 and Cardinal provide a step-up in luxury and comfort, yet retain an element of economy.

Consolidated sales in Cessna's 1967 fiscal year, ending September 30, totaled $213,000,000, a 5 percent increase over 1966's previous record total of $202,000,000.

Cessna led other general aviation manufacturers in commercial aircraft unit deliveries for the 12th straight year by delivering 6,185 units during the 1967 fiscal year. Commercial unit deliveries during 1967 were the second highest in the company's history.

During the 1967 fiscal year, Cessna military business more than doubled. One boost in military business came when the U.S. Air Force ordered a military version of the popular Super Skymaster tandem twin. Designated the 0-2A and 0-2B, the aircraft were ordered to supplement the older 0-1 Cessna "Bird Dog" in forward air control duties. By year's end, the 0-2 was operational in Vietnam. The 0-2A may be fitted with a variety of wing-mounted armament, while the 0-2B is specially designed for psychological warfare duties. By late 1967, Cessna had received production contracts for 223 of the aircraft.

Cessna delivered the first A-37 attack jet aircraft to the Air Force early in 1967. This marked the first time a general aviation manufacturer had delivered a combat-designated aircraft to the U.S. military. A development from the T-37 trainer, it was originally designated as the AT-37D by the Air Force and later renamed as A-37. Cessna received contracts for 166 of the aircraft during 1967, and a squadron of A-37s was on combat status in Vietnam by fall.

Cessna started production on an order for 39 A-37A attack aircraft and a later order for 127 A-37Bs. The craft are modified versions of the T-37 trainer.

In addition to the A-37, Cessna continued production on the T-37 jet trainer to fill both U.S. and foreign military orders. Orders for more than 200 T-37s were received during the year. Almost 1,000 of the diminutive jets have been produced. They are the first jet aircraft used during flight training in the U.S. Air Force. Other countries operating T-37 aircraft include Germany, Peru, Chile, Brazil, Cambodia, Portugal, Pakistan, Thailand, Turkey and Greece.

The company received several additional contracts for subassembly work on the Bell HU-1D Huey helicopter and the McDonnell Douglas F-4B Phantom jet fighter and production of ordnance dispensers for the military at the company's Military and Twin Division.

Cessna also continued production of the T-41 trainer, a version of the commercial Model 172. Contracts include 255 T-41Bs, which were being used as primary trainers by the U.S. Army, and 45 T-41Cs, delivered to the U.S. Air Force Academy for the first cadet flight training program. An additional 34 T-41As were produced during the year and they joined the USAF fleet.

Cessna's expanded business resulted in a total worldwide employment of over 12,000 people. In addition to aircraft manufacturing, this included Cessna's operations at the Aircraft Radio Corporation, National Aero Finance Corporation, the McCauley Division, the Industrial Products Division, and Cessna Industrial Products, Ltd., in Scotland.

CHANDLER EVANS CONTROL SYSTEMS DIVISION OF COLT INDUSTRIES INC.

Chandler Evans continued during 1967 the expansion in volume and diversification of product which had been evidenced over several previous years. In addition to accelerated production of unitized controls for the Lycoming T53 powerplant utilized in the Bell Iroquois and HueyCobra helicopters, a unit exchange overhaul program was initiated for the Army Aviation Command. This program provided for 48-hour delivery of zero time units on receipt of controls returned from the field.

Production of controls, pumps and other components for all major engine manufacturers placed Chandler Evans products on virtually all American military and commercial aircraft. By year-end, almost 25,000 positive displacement fuel pumps had accumulated more than 35,000,000 service hours on Pratt & Whitney Aircraft and General Electric gas turbine engines for such notable commercial and military aircraft as Boeing 707 commercial transports, B-52 bombers and KC-135 tankers, jet StarLifter commercial cargo jets, and Northrop F-5 Freedom Fighters. Chandler Evans MFP-90 pumps also were on the Pratt & Whitney Aircraft jet engines that power the General Dynamics' Fort Worth Division F-111 variable-sweep wing fighter aircraft.

The Continental J69 turbojet engines on the Ryan Firebee drone aircraft for Air Force, Army and Navy use the division produced MC series fuel controls. A supersonic drone being developed by Ryan also incorporated an advanced version of the MC control.

In the regenerative engine field the division also developed and produced the IC-14 fuel control for a Ford gas turbine truck engine. Like other Chandler Evans fuel controls, it integrates fuel pumping, metering, filtering, pressure regulation and turbine speed governing in a unitized package. Activities of its licensees, Dowty Ltd. of Canada and Dowty Fuel Systems in England are providing Chandler Evans designs for use by engine manufacturers in those countries.

Major developments initiated in 1967 included the main fuel pump for the GE4 engine being developed by General Electric for the Boeing supersonic transport. Of major significance, also, 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.

A substantial commitment in the field of aircraft components and controls resulted in significant new applications for Chandler Evans products in hydraulic, fuel and pneumatic systems. Components were being produced for the Lockheed C-5A, Boeing 747 and Douglas DC-9 in addition to earlier applications on other commercial aircraft.

The greater part of Chandler Evans work in the missile control field was of a classified nature. In addition to the production of actuators and control systems, active development and technology programs were providing marked advancement in hydraulic and high energy stored gas systems.

The Chandler Evans facilities located at West Hartford, Connecticut, consist of a modern industrial plant of uni-level construction, occupying approximately 310,000 square feet and employing, at year-end, more than 1,800 people. Field offices were maintained in Dayton, Ohio; Reseda, California; Seattle, Washington; and Munich, Germany.

CONTINENTAL MOTORS CORPORATION

Continental Motors Corporation continued to maintain its clear dominance in the general aviation marketplace by again delivering well over half of all engines installed in this type aircraft during fiscal 1967.

Continental's major customers in the general aviation field continued to be Cessna Aircraft Company and Beech Aircraft Corporation, with the company also supplying engines for certain models of aircraft built by Aero Commander, Bellanca, Maule Aircraft Corporation, Mooney Aircraft Corporation and others. These aircraft ranged from single-seat agricultural models through a wide variety of aircraft used for personal transportation, air taxi, commuter airlines, cargo, business and corporate travel, patrol and similar activities.

Of major significance during 1967 was introduction by Cessna of its new pressurized twin engine Model 421. Initial deliveries on the Cessna 421, which utilizes 2 375-horsepower turbocharged Continental engines, started during the year. The demand in 1967 for 2 models of the Beechcraft Baron was also noteworthy. Both of these twin-engine Beech aircraft are Continental-powered.

The Bellanca Viking 300 was also announced during the 1967 fiscal year, and it appeared to be enjoying increasing acceptance. This airplane is powered by a Continental engine with take-off rating of 300 horsepower.

Development work by Filper Research on its new Continental-powered helicopter was progressing on schedule, and the aircraft was expected to be certified in the spring of 1968. Continental Motors also had engines in other prototype aircraft expected to be introduced in 1968.

Continental continued to investigate new aircraft engine developments and designs which offer significant advances in the state-of-the-art. These developments, when perfected and implemented, should offer considerable advantages to the airframe industry.

Continental Motors' "Zero Time" remanufactured aircraft engine program was well under way at the company's Mobile, Alabama, facility. Under this program owners of Continental-powered aircraft can exchange their original engine for a like model off-the-shelf factory remanufactured powerplant that has been restored to new engine standards. Each Continental factory remanufactured engine has virtually all new wearing parts.

All Continental Zero Time remanufactured engines are certified by the Federal Aviation Administration and covered by the same comprehensive engine warranty that protects new Continental aircraft engines. In addition, most Zero Time engine exchanges can be completed within 48 hours, as compared to a considerably longer period required for major overhaul.

Continental Motors' licensing agreement with Rolls-Royce Limited of Crewe, England, continued in effect. Under this licensing arrangement, Rolls-Royce manufactures and sells certain Continental aircraft engines for airplane producers in Europe and elsewhere in the free world.

Many Continental engines were delivered during 1967 for military applications of general aviation type aircraft. Typical were the military version of the Cessna Super Skymaster, designated by the military as the 02-A and 02-B, and the T41-C, which is basically a Cessna Model 172. These and other Continental-powered Cessna and Beech aircraft were being used by the military for forward control missions, training, aerial supply, photo reconnaissance and other purposes. All these aircraft are military adaptations of existing, off-the-shelf general aviation aircraft that have been thoroughly tested and proved in civilian applications, thereby extending numerous economic advantages to our nation's defense establishment.

Continental Motors Corporation, together with its subsidiaries, continued as one of the world's foremost independent engine producers, manufacturing, in addition to commercial aircraft powerplants, engines in many different horsepower classes for a wide variety of industrial, automotive, material handling and agricultural equipment, as well as piston and turbine engines for military land and air vehicles. The company and its subsidiaries had manufacturing, engineering, development and product support facilities in Detroit and Muskegon, Michigan; Toledo, Ohio; Milwaukee, Wisconsin; Mobile, Alabama; Chicago, Illinois; Walterboro, South Carolina; and Panama City, Florida, in addition to a network of strategic branch plant locations.

CONTINENTAL AVIATION AND ENGINEERING CORPORATION

Continental continued to develop and produce the J69 series jet engine, which has powered the T-37 Air Force twin jet trainer that has operated successfully for more than 5,000,000 flying hours and the Q-2C target drone with more than 8,000 flights. The J69-T-25 at rated thrust of 1,025 pounds and the J69-T-29 at 1,700 pounds were in production for these respective vehicles. The J69-T-41, at rated thrust of 1,920 pounds, is an uprated version of the T-29; it was approaching volume production for an advanced drone application. In addition, the J69-T-6 rated at 1,840 pounds thrust was under development for a supersonic drone requirement.

CAE Model 356-28A, a modification of the YJ69-T-39, reached the initial production stage for the Air Force.

CAE had under development shaft turbines from 180 to 1,600 shaft horsepower ratings. The TS-120 was being developed under contract with the U.S. Army Mobility Equipment Research and Development Center as a flat rated 120 horsepower (180 horsepower at sea level standard conditions) industrial gas turbine for generator and pump applications. Featured in this simple cycle machine is a specific fuel consumption of 0.70. It is a single shaft turbine with an integral 6,000 revolutions per minute reduction gear with alternate output shaft speeds of 12,000 revolutions per minute available. A single can combustor is designed for quick replacement. An integral air inlet plenum suitable for air cleaner attachment is provided. Exhaust can be directed radially or axially. Integrated automatic start sequencing and safety circuits will be provided. Completion of development and qualification was targeted before 1970 with 60 and 90 horsepower versions projected.

The Model T67-T-1 shaft turbine powerplant (CAE Model 217A-2A), rated at 1,600 horsepower and 0.55 specific fuel consumption, consists of 2 800 horsepower free turbine Model 217-10B gas turbines joined into a single powerplant with a combining gearbox. Each of the 2 engine segments has an annular air inlet, a 2-stage transonic axial compressor, a single-stage centrifugal compressor, an annular combustor and a 2-stage axial flow turbine directly coupled to the compressor. The free turbine power section consists of a single-stage axial turbine connected to the output shaft. The combining gearbox incorporates overrunning clutches, which permits either single or twin operation as desired, or automatic single engine operation should one engine fail for any reason.

Use of the twin turbine concept results in twin engine safety and reliability with no penalty in weight or cost. Economical operation results since at lower cruise power levels, one engine of the powerplant can be used at higher fuel efficiency compared to a larger engine being operated at part power. By alternating the engines used during single operation, time between overhauls for the powerplant can be increased substantially.

The Model 217-10B shaft turbine is the single engine version of the above described Model T67-T-1 twin. Rated at 800 shaft horsepower and 0.55 specific fuel consumption, the Model 217-10B is adaptable for helicopter or turboprop applications.

Available as a fully qualified engine is the Model TS325-1 (military designation T65-T-1), a free turbine, shaft power engine, rated at 310 horsepower and weighing only 135 pounds. The engine completed all military and FAA requirements, and was awarded FAA type certificate No. E6CE. The military rating of the T65-T-1 (TS325-1), built in limited production, is 250 horsepower; the FAA rating is 310 horsepower. Growth of the T65 engine from the latter rating can be readily accomplished. In addition, 2 T65 engines can be joined into a combining gearbox with the Continental power sharing system for use in either shaft or turboprop applications.

The Model 142 is a rugged, low cost, lightweight combination air compressor and shaft horsepower turbine engine. At 60 degrees Fahrenheit and sea level, it provides 150 pounds of compressed air per minute, and 100 shaft horsepower. This engine is based on the Continental Model 141 air compressor, of which over 1,000 have been manufactured. The Model 142 is suitable for ground or airborne applications.

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 divisions include the Curtiss Facility in Caldwell, New Jersey; the Electronics Facility in East Paterson, New Jersey, and Metals Processing Facility in Buffalo, New York.

Subsidiaries include: The Marquette Metal Products Company, of Cleveland, Ohio; the Zarkin Machine Company, Long Island City, New York; Target Rock Corporation, Hempstead, Long Island, New York; and Canadian Curtiss-Wright, Ltd., of Toronto, Canada.

During 1967, the Wood-Ridge Facility continued to manufacture a wide variety of aerospace components for advanced jet engines, including diffuser cases, spacers and carrier assemblies. Also produced at the Wood-Ridge Facility were transmission components for Boeing Vertol CH-47A Chinook helicopters, widely used by the military in Vietnam and throughout the world.

Research and development on advanced technology projects covering gas turbine compressors, combustors, turbines and nozzles and other power generation and conversion systems was also being carried on at the Wood-Ridge Facility.

Development of the Curtiss-Wright Rotating Combustion engine continued. Over 35,000 hours of engine operation had been accumulated by year-end in test and evaluation programs.

Two types of engines were being developed, the RC2-60 and the YRC180-2. The RC2-60 is a 185 horsepower liquid-cooled engine for vehicular, marine, ground support and other military and commercial applications. The air-cooled YRC180-2, being developed under a U.S. Navy contract, weighing 278 pounds, is designed to produce 310 horsepower—more than one horsepower for each pound of weight—at 6000 revolutions per minute.

The RC engine provides more horsepower in a smaller, lightweight unit, which displaces ⅓ less volume and is ⅓ lighter in weight than any standard automotive engine, and is suited to a wide variety of transportation and industrial applications.

By year-end, the engine had already undergone tests in a sports car, U.S. Army truck and a high-speed boat. A prototype of the engine was being used to power Westinghouse portable 60 kilowatt generator sets.

Aerospace components being manufactured at the Curtiss Facility during 1967 included a rotary hydraulic mechanical actuator and power hinge used for the weapons bay door on the USAF F-111 and a rotor fold actuator for Boeing Vertol CH-46A Sea Knight USMC helicopter.

In addition, the Facility was working on a servo actuator for the fin steering control system of the U.S. Navy's Condor air-to-surface missile; a variable exhaust nozzle control unit used on the jet engine of the USAF T-38 and a flap transmission gear box of the type used in the Boeing 737 wing flap drive system.

The Curtiss Facility was also manufacturing sonic analyzers used to determine mechanical operating conditions of turbine engines, accessories and transmissions. These analyzers were in use by the U.S. Army, U.S. Navy and 2 leading commercial airlines.

The Electronics Facility was producing flight simulators, radar maintenance trainers and components for nuclear-powered naval vessels. Having been involved in designing and manufacturing flight simulators for more than 20 years, the facility in 1967 was working on simulators for the USAF C-141 global transport. The C-141 is an Air Force jet cargo aircraft being utilized as a troop and cargo transport, a paratroop carrier and as a medical evacuation plane.

The C-141 simulator has 3 basic parts: an enclosed cockpit section set on a 3-motion circuit—roll, pitch and heave; a computer/power section; and the input/output cabinets which carry data fed into the computer to the cockpit section. Reactions of the pilot to given problems are then carried back through the input/output cabinets to the computer section where they are recorded for future reference.

The facility also produced flight simulators for the Douglas DC-7, C-133 Globemaster, and A-4D Skyhawk; Lockheed's C-130 Hercules, Electra and P-3V Orion; and Boeing's B-52 Stratofortress and 707.

The Electronics Facility was also producing an RMT-100 Radar Maintenance trainer used to train radar operators in troubleshooting. It was making boiler procedure trainers used as a training device for operating nuclear and steam power generating stations.

Instrumentation and rod control equipment required for nuclear power plants used in nuclear-powered ships was also being produced by this facility.

Electronics was manufacturing an 8-bit, up-down counter digital logic card which incorporates a total of 16 integrated circuits in one 6 by 3 inch package with 640 discrete elements.

The Metals Processing Facility continued to specialize in extrusions, forgings, castings and precision engineered products. Extruded titanium (superior in strength to steel at half the weight) integrally-stiffened wing panel sections were being developed in conjunction with the USAF and Lockheed for use in Lockheed's C-5A aircraft.

The facility was also producing extruded pipes and extruded shapes for nuclear, structural and industrial use; forged compressor, stator and turbine blades for jet engine and industrial turbines and a variety of precision engineered products for military, commercial and industrial applications.

Marquette Metal Products Company continued to produce compact precision spring clutches for appliances, marine, office equipment, and a variety of other applications. Marquette, a wholly-owned subsidiary, was also manufacturing textile spindles, governors, aircraft and marine use windshield wipers, automatic speed control devices, swench wrenches, and miscellaneous components for the aerospace and automotive industries.

The Zarkin Machine Company, a new C-W acquisition, is a leader in the production of airframe parts by profile milling. For the F-4 aircraft, Zarkin was producing arresting gear, a hogged out bulkhead assembly, an aileron actuator fitting, a center section wing rib and numerous other parts.

Zarkin was also turning out an inboard flap assembly track for the Boeing 737, an aileron fitting hinge for the F-101, a housing assembly for the Titan II missile and an inboard and outboard track slat for the F-111.

Target Rock Corporation continued to produce specialized valves and fittings for nuclear marine petrochemical and industrial applications.

Canadian Curtiss-Wright, Ltd., continued to produce air compressors and automotive service equipment, generator sets, pumping units and industrial vehicle propulsion engines.

FAIRCHILD HILLER CORPORATION

Continued growth underscored the performance of Fairchild Hiller Corporation in 1967. The company recorded a new high in sales, embarked on several programs of importance to wide segments of the aerospace industry and to the nation, and added to its range of capabilities.

Indications of what the year had in store for the company could be found in several events taking place in 1966 and early 1967. Fairchild Hiller was selected as a major participant in the Boeing 747 and SST programs and as the American company that would work with the Federal Republic of Germany in the development of a revolutionary, V/STOL tactical fighter aircraft. Then the company announced plans to manufacture the Fairchild 228, a jet transport especially designed to serve the needs of the nation's regional airlines.

In other fields, the company won contracts for a wide variety of products, from radars to stores management systems, from automatic variable transmissions for industrial machinery to pressure regulators for space vehicles.

To give it increased dimension, the Company purchased the assets of Burns Aero Seat Company, S. J. Industries, Inc., and Air Carrier Engine Service, Inc. Burns is a leading manufacturer of quality aircraft seats; S. J. Industries produces solar cell arrays; and Air Carrier Engine Service is an overhaul facility specializing in Pratt & Whitney Aircraft engines. All 3 became wholly owned subsidiaries.

AIRCRAFT DIVISION

Home and first facility of the original Fairchild Airplane and Engine Company, the Aircraft Division in 1967 was involved in more programs than ever in its 40-year-old history. Producer of the C-119 Flying Boxcar and the C-123 Provider, both of which were still seeing heavy service around the world, the division was manufacturing the FH-227 and F-27 propjet passenger airliners; the STOL executive and utility Heli-Porter; and the turbine-powered FH-1100 helicopter. It was preparing for an important role in the manufacture of the 747 and the SST airliners. (Its 80,000 square foot bonding facility is unique in the industry.) Production of the Fairchild 228, the first jet transport designed for the stop-and-go flying that is the hallmark of the regional air lines, began in the summer.

During 1967, the division stepped up its modification of some 120 C-123s. The big change to the aircraft, called the C-123K, was the addition of 2 auxiliary GE-J85 jet engines. Placed beside the original pair of piston engines, they give the C-123 exceptional STOL capabilities that enable it to carry out vital troop and cargo missions.

AIRCRAFT SERVICE DIVISION

Fairchild Hiller has in Florida complete maintenance, repair, modification, and redesign centers for aircraft. Capable of handling anything that flies are 3 facilities at St. Augustine, St. Petersburg, and Crestview. Air Carrier Engine Service, Inc., operates at Miami International Airport under the direction of the Aircraft Service Division. The Division offers services ranging from IRAN (Inspect and Repair as Needed) to rehabilitation and modification. Among its capabilities are metal parts manufacture, fuel cell reconditioning, electronics repair, and corrosion control.

Among the 15 types of aircraft worked on by the division during 1967 were the C-119, the C-123, the C-130, the KC-135, the HU-16, the P-5, and the DC-9.

REPUBLIC AVIATION DIVISION

Manufacturer of the P-47 Thunderbolt, the F-84 Thunderjet, and the F-105 Thunderchief, Republic Aviation Division was working on a variety of projects that ranged far afield from military aircraft.

In civil aviation, the division began tooling up in 1967 for the manufacture of wing-control surfaces of the 747 and a large section of the fuselage of the SST. The supersonic transport will be made largely of titanium; Republic, a pioneer in working with this metal, can fabricate it in as large quantities as any U.S. airframe manufacturer.

In space technology, Republic completed a Lunar Module crew station for the Apollo docking trainer; began to develop thermionic energy converters to transform heat from a nuclear reactor into electric power for spacecraft use; and continued studies of extra-vehicular activity, electric propulsion, and experimental structures.

In "down-to-earth" programs, Republic completed the design of a prototype "safety car" for New York State and expanded its programs in the life sciences, including biomedical engineering.

Fairchild Hiller's Republic Aviation Division developed the Safety Car, incorporating many of the safety features found in the cockpits of fighter aircraft, for the State of New York.

Military aircraft retained prominence as a major area of effort. The program for the manufacture of aft sections of the McDonnell Douglas F-4 Phantom fighter completed its third year and was to continue into 1968. Awaiting approval by the Department of

Defense to proceed to the prototype stage was the program concerning the U.S./Federal Republic of Germany V/STOL tactical fighter. The aircraft would combine the lift characteristics of the helicopter with the high performance characteristics of a fighter.

To keep pace with these programs, Republic added more than 200 engineers, increased the amount of working room for its engineering personnel by 18 percent, and refurbished large areas of its 1,500,000 square feet of plant space at Farmingdale, New York.

SPACE AND ELECTRONICS SYSTEMS DIVISION

From its bases at the new Sherman Fairchild Technology Center in Germantown, Maryland, and at Winston-Salem, North Carolina, the Space and Electronics Systems Division won contracts on such disparate projects as the Spacecraft Support Unit of SERT II, seaborne search radar, continuous photograph enlargers, tubular extendible elements, avionics systems (including that for the F-111) and deployable solar arrays.

The Technical Service Division was awarded a third-year option on its support services contract with NASA's Goddard Space Flight Center. The group has been providing scientific and engineering assistance to the Center's Spacecraft Integration and Sounding Rocket Division. Similar services are offered to industry.

The Advanced Optronics Laboratory, a small research organization formed early in 1967, completed a number of projects in the photo-reconnaissance field.

S. J. Industries, manufacturer of solar cell arrays and automatic processing equipment for the food industry, is located in Alexandria, Virginia, and it operates under the direction of the Space and Electronics Systems Division.

STRATOS GROUP

Stratos-Bay Shore

Bay Shore manufactures aerospace compressors, heat exchangers, and high-speed turbo machinery. During 1967, the division won awards for: the design, development and systems integration of mobile shelters for photographic equipment and personnel for the TIPI Total Environmental Facility; ground-support air conditioners for the Air Force; ground air conditioners for the Marine Corps' Semi-Automatic Checkout Equipment for A-6 aircraft; heli-rotor compressors for NATO's Hawk missiles; turbine drives for Lockheed C-130s; air-turbine drives for Boeing 747 hydraulic pumps; ground air conditioners for the Short Airfield Tactical Support System; and the design, development and manufacture of a compact compressor system for field and mobile dental facilities.

Carried over from 1966 were contracts for a family of low-silhouette air conditioners for use in Army mechanized equipment; vapor cycle cooling systems for the Navy's E-2A early warning systems; and air conditioners for Navy A-5A, RF-4B, and RF-4C aircraft, the F-105 fighter-bomber, the F-106 fighter, the F-111 variable wing fighter, Fairchild Hiller's own FH-227 and F-27J propjet transports, and many of the nation's business aircraft.

Stratos-Western

Stratos-Western has prime product lines: (1) space-rated fluid systems and components and (2) airborne launching systems and equipment. They are diverse to the extent that they range in size from switches that can be held in the hand by the dozen to flare launchers that can fit only in the fuselage of a giant C-130 aircraft.

The flare launchers are made in several dimensions tailored to the needs of specific aircraft.

The division, located at Manhattan Beach, California, also produces fire and smoke grenades, and radar, radio, and infra-red markers. The division was the major producer of sonobuoy launch systems and underwater sound source dispensers for the Navy's antisubmarine aircraft.

Western's hardware for spacecraft-pressure regulators, pressure switches, cryogenic valves, disconnect couplings, and subsystems have been associated with the Thor, Atlas, Titan, Saturn, Intelsat, Minuteman, Apollo, and Gemini vehicles.

Stratos Industrial Products

Products for some 2,000 industrial companies were manufactured by Fairchild Hiller's Industrial Products group. Primarily, they were components for speed control transmissions, differential gearing, and precision air and fluid regulation systems. Sold under the trade names of Governaire Pneumatic Controls, Specon Multi-Speed Transmissions and Kendall Pressure Regulators, they are produced for use with machinery used in the mining, tobacco, textile, printing, paper-making, chemical, petroleum, rubber, food, steel, metal-working, glass, and transportation equipment industries.

The division's manufacturing facilities are at Winston-Salem, North Carolina.

Burns Aero Seat Co.

Purchased in December 1966, this wholly owned subsidiary, operating under the direction of the Stratos Group, continued as a major designer and manufacturer of modern airliner seating marketed under the name of Airest.

THE GARRETT CORPORATION

The Garrett Corporation, in 1967, maintained its position as one of the world's leading suppliers of sophisticated systems for the aerospace industry.

Operating through 7 divisions and 2 subsidiaries, the company surpassed its record sales of 1966 and established new levels of production backlog and shipments.

Employment remained stable throughout the year near the 13,000 level.

The outlook for 1968 appeared equally bright. The company's commercial business was expected to equal or surpass its work for the military. Traditionally, Garrett's sales revenue has been approximately 60 percent from the military with the remainder derived from the commercial aviation industry.

Garrett's activities and product areas continued to be widely diversified with more than 4,000 items comprising its 1967 product list. From this broad operating base new non-aerospace programs were actively pursued. High speed ground transportation, on-site power generation, and completely transportable hospitals were a few of the programs in which Garrett was actively applying its aerospace knowledge.

GARRETT-AiRESEARCH LOS ANGELES

A contract award to build the environmental control system for the U.S. supersonic transport culminated a 2-year research program in AiResearch Manufacturing Division, Los Angeles, and further established the company's leadership in the field it has pioneered for nearly 3 decades.

Development of the SST environmental system will continue into 1969 when the first systems will be delivered to The Boeing Company for prototype aircraft.

Other traditional product lines, such as heat transfer equipment, electronics, electromechanical and electrical systems, missile systems and turbomachinery continued at record production levels throughout the year.

AiResearch contributions to the nation's space programs were highlighted in 1967 with the successful launch and recovery of the Apollo/Saturn V in November. The AiResearch environmental control system performed perfectly keeping the spacecraft interior at a comfortable 70 degrees while outside temperatures ranged from 150 degrees below zero in space to 4,500 degrees during reentry. The perfect flight paved the way for manned Apollo missions when AiResearch life support systems will play an even more important role—keeping the astronauts alive and comfortable during earth orbital and lunar flights.

In addition to Apollo, other manned space programs played an important role in AiResearch's developmental work.

The division was under contract to McDonnell to build the life support systems for the Gemini "B," an integral part of the Air Force Manned Orbiting Laboratory, and Airlock, a NASA 3-man space experiment. Early in the year an AiResearch-built helium cryogenic storage system qualified for its role in the lunar landing mission.

Under NASA contract AiResearch continued development of a hypersonic research ramjet engine, termed by many as the aircraft propulsion engine of the future. These engines are designed to propel aircraft at speeds between Mach 3.0 and 8.0 (2,000–5,000 miles per hour). The engine technology developed will be useful for hypersonic transport aircraft, boosters, and for spacecraft flying within the atmosphere.

In other propulsion projects AiResearch began development of a radically different electric motor for the U.S. Department of Transportation's office of high speed ground transportation. This device, called the linear induction motor, is expected to produce speeds up to 250 miles per hour for ground vehicles. When perfected, the new motor could propel tracked air cushion vehicles between cities at speeds competitive to air transportation.

Development of related ground transportation equipment also was significant in other AiResearch product lines. Air conditioning, brakes, actuation systems and electric propulsion for rapid transit trains were being tested during the year.

Military and commercial airframe builders continued to be the major customers for AiResearch. Virtually every aircraft in production relies on AiResearch systems and components.

Commercial transports such as the Douglas DC-8 and DC-9, Boeing 707, 720, 727, 737 and giant 747, Grumman Gulfstream I and II and numerous other airliners incorporate AiResearch systems. The division was also heavily engaged in building systems for military aircraft including the Lockheed C-5A, C-141 and F-104, the McDonnell F-4 series, Northrop F-5 and General Dynamics F-111.

During the year AiResearch was awarded contracts to build the environmental systems and central air data computers for the Ling-Temco-Vought A-7 Corsair. The Canadian-built Northrop CF-5 and the Italian Fiat G 91Y will also be equipped with AiResearch central air data computers.

Another product, the Aircraft Integrated Data System (AIDS) went into full production during 1967. American Airlines announced it would equip its Astrojet fleet of BAC One Elevens with the system. Alitalia also ordered AiResearch AIDS for its fleet of DC-9s, DC-8s and 747s. By year-end these systems were already compiling extensive data on regular commercial flights.

The AIDS concept, which evolved from similar military systems built by AiResearch, automatically monitors and records performance of critical aircraft systems during flight. This data, rapidly analyzed by ground computers, affords airlines with an invaluable maintenance tool for assessing systems performance and physical condition.

Other notable highlights of 1967 for AiResearch Los Angeles included delivery of the first digital central air data computer for the Navy's ILAAS program; the application of AiResearch turbogenerators to offshore oil production platforms; development and introduction of an all electronic cabin pressurization control and development of a new cryogenic refrigeration system for commercial airliners.

GARRETT-AiRESEARCH PHOENIX

The second largest division of The Garrett Corporation, AiResearch Manufacturing Company of Arizona, Phoenix, continued in 1967 to contribute significantly to the corporation's overall success.

Traditional major product lines, small gas turbine engines, air turbine starters and motors, and pneumatic valves and controls, were at record breaking production levels, while the TPE331 turboprop engine family was expanded to 4 to offer customers a horsepower range from 575 to 715 shaft horsepower.

AiResearch space power programs were marked during 1967 by the successful completion of initial testing of a compact, high-speed closed Brayton cycle space power demonstration system operating on gas (argon) lubricated bearings. A Garrett-AiResearch Brayton cycle demonstrator was consigned to NASA's Manned Spacecraft Center, Houston, for evaluation and operational familiarization runs by NASA personnel. The Brayton cycle power system is a strong contender for application to future space missions starting in the mid-70s. The demonstrator system produces 3 kilowatts of AC electrical power.

During 1967, a number of new customers for the TPE331 turboprop aircraft engine was added. At year-end, AiResearch turboprops powered 10 manufacturers' aircraft. These include Aero Commander's Turbo II; the Mooney/Mitsubishi MU-2B; Pilatus (Swiss) and Fairchild Porters, STOL aircraft; Volpar's Beech Super Turbo 18 and Turboliner; Carstedt's Dove Jetline 600; Short Brothers & Harland Ltd.'s Skyvan, produced in Northern Ireland; and North American's OV-10A (Bronco) military aircraft. In August, Swearingen announced that it had selected the TPE331 for the Merlin IIB.

Airborne auxiliary power units continued in 1967 to be a major product line with development and testing of APUs for the Boeing 747 and Lockheed C-5A pointing the way to the future. Early in the year Douglas contracted for an additional $3,000,000 worth of APUs for its twin jet DC-9s, boosting the total number on order to 500 through 1968. Delivery also was made of the first AiResearch APUs for the Army's new AH-56A winged helicopter, marking the first such airborne application for AiResearch APUs.

In the field of aircraft jet engine starters, AiResearch Phoenix was awarded an Air Force contract with a multimillion dollar potential for its newly developed jet fuel starter. The small unit is a compact free turbine engine that mounts directly on and uses the same fuel as the main engine.

To accommodate the continuing growth cycle at AiResearch Phoenix, significant expansion of plant facilities was undertaken in 1967. In February, 60,000 square feet of office space was added to house gas turbine and secondary power systems groups. In August, AiResearch overhaul facilities occupied a new 35,000 square feet addition, which tripled the area of the previous overhaul facility. Areas vacated as a result of these moves were used to expand the company's machining production facilities.

MUST hospital development work continued at AiResearch Phoenix during the year and additional MUST units were deployed to Vietnam, where they served both Army and Marine units. One new Army contract called for converting a MUST hospital ward container into another building of the MUST complex. Similar work was undertaken to develop field kitchen and bakery units, and waste management and disposal systems. A new lightweight MUST utility pack progressed during the year to the hardware stage.

AiRESEARCH AVIATION DIVISION

AiResearch Aviation started the year by opening its new Los Angeles customer service facility, considered to be one of the most comprehensive in business aviation. The new 2-story terminal provides a complete variety of services for the business executive, pilot and crew, and aircraft. Adjoining the West Coast completion center on LAX, the new terminal also houses AiResearch Aviation's business offices.

During the year AiResearch Aviation expanded its national marketing effort to provide more "in depth" coverage of the growing business aircraft market. The expansion program included: a reorganization of the company's marketing staff, with the addition of new personnel; opening a new sales office in Chicago; and moving the Los Angeles and New York sales offices to more complete facilities.

The most important new activity AiResearch Aviation entered in 1967 was the agreement to become the exclusive national distributor of Swearingen's Merlin IIA. AiResearch Aviation has total marketing responsibilities for the entire United States. The Merlin IIA is a fully pressurized, 8-place turboprop that boasts features such as a separate flight deck, a private lavatory and an in-flight dressing room. The addition of the Merlin broadened AiResearch Aviation's line of new aircraft sales. AiResearch Aviation is also a sales and service distributor for the Grumman Gulfstream I and II and the Hawker Siddeley DH125.

Aircraft custom interior completions and avionics installations reached a new high in 1967. With both the Long Island and Los Angeles completion centers working to capacity, AiResearch's completion volume surpassed all previous years. To establish this record year AiResearch Aviation obtained the largest share of the Lockheed JetStar completion business, won unprecedented contracts such as 5 Fan Jet Falcon completions on a single order, plus the normal DH125 and Gulfstream completions.

AiResearch Aviation was awarded a major contract for 89 shipsets of lounge enclosures to outfit the entire American Airline 707 fleet. This 4-person compartment is located in the first class seating area. A number of other programs were completed for other major trunklines during the year.

The division's Bellanca facility was selected to provide a large quantity of ground support enclosures for the Navy. It was also producing all the 737 APU enclosures for Boeing.

GARRETT MANUFACTURING LIMITED

Garrett's Canadian subsidiary, Garrett Manufacturing Limited in Rexdale, Ontario, experienced continued growth in 1967. Sales and backlog continued to increase, and employment exceeded the 500 point early in the year.

By mid year, the building expansion program which was started in late 1966 was completed to provide a total of 90,000 square feet of facility. GML is primarily engaged in development and production of traditional product areas of airborne electronics, aircraft temperature control systems, pneumatic signal generators, static inverters, and radio emergency beacons. Significant advances were made in pneumatic signal generator state-of-the-art, particularly by the development of a computer programmable unit. New development of significance in the temperature control area included a solid state proportional window heat control system. Expansion of radio emergency beacons into downed aircraft locater configurations was also completed in 1967.

The Garrett Manufacturing marine activity continued to expand by design, development and production of new equipment for the Royal Canadian Navy. These included a self-propelled vehicle for between ship provisioning at sea, and a stabilized horizon bar system as an aid to helicopter landing. The program for production of gas turbine-powered main electrical generating systems for the new Canadian destroyer, DDH-280 class, proceeded on schedule.

In addition, Garrett Manufacturing completed the design and initial development for a mesometeorological data collection system. Volume of diversified overhaul activity in most of The Garrett Corporation's manufactured products also increased.

AIR CRUISERS

During 1967, Garrett's Air Cruisers Division experienced a sharp increase in production volume implemented by new facilities, equipment and manufacturing methods. Employment for the same period remained at a stable level.

Sales and backlog surpassed all previous years despite a rapid increase in competition within the industry. Air Cruisers is primarily engaged in design and manufacture of inflatable designs for military and commercial customers. Forecast for 1968 included planning for an additional growth in excess of 30 percent.

Production of inflatable shelters for the MUST (Medical Unit Self-Contained Transportable) Hospital program continued at an accelerated pace. A 100-bed MUST field hospital, deployed in Vietnam, provided care for its first combat casualty 20 minutes after opening. Customer acceptance of the MUST concept was high and it pointed toward increasing production in 1968.

Air Cruisers participated in keen competition on the inflatable survival gear for the new Air Force giant troop carrier, the C-5A. Every contract awarded through 1967 for this type of equipment of the C-5A, including life rafts and inflatable escape slides, was won by the division.

Customized floatation for the F-111 forward capsule, which was designed and developed by Air Cruisers, resulted in production contracts from General Dynamics, the F-111 prime contractor. Production of these units was to extend through 1969.

Air Cruisers' expanded engineering department gave high priority to development of inflatable products for new model aircraft. Some of these included the Boeing 747, the Douglas stretched DC-8 and DC-10, the supersonic transport and other new commercial aircraft.

Another of Air Cruisers traditional product lines, inflatable life preservers, continued in volume production through the year. Contract awards from the military services assured high production during 1968.

AiRESEARCH INDUSTRIAL DIVISION

AiResearch Industrial Division, leading producer of exhaust-driven turbochargers for reciprocating engines continued to maintain its position in the face of stiff competition.

Sales and production for the year showed marked increases particularly in the light aircraft field where turbocharged engines have proved highly successful. Aircraft manufacturers such as Beech, Piper, Cessna and Mooney introduced new models incorporating the performance boosting AiResearch unit. On some models such as the Cessna 421, Mooney Mark 22 Mustang, and Beech Model 60 Duke the turbocharger also provides pressurization for the cabin.

In addition, during the year, a new system of supplying remanufactured components was inaugurated to provide faster more economical service for aircraft users.

As a result of increased business, the division's new test facility and additional manufacturing space completed in 1966 operated at full capacity.

GARRETT SUPPLY

Garrett Supply Division, which has been serving industry in Southern California and Arizona for more than 30 years, continued its expansion program started in 1966.

New industrial customers and expanding markets contributed to growing sales. In Los Angeles, an additional 30,000 feet of warehouse space was added to handle more than 70,000 industrial items stocked by the firm. The Phoenix branch also was physically expanded to better service growing aerospace, industrial, agricultural and mining industries.

The firm continued to stock more than "100 Famous Brands" of industrial tools and supplies ranging from grinding wheels to power transmission equipment and office furniture.

As an added service to customers the division initiated in 1967 a complete Norton Grinding Service Center which makes factory-type service available to customers. Also, added late in the year was the famous Rockwell line of industrial tools to Garrett Supply's inventory.

AIRSUPPLY DIVISION

The company's Airsupply Division, a nationwide sales and engineering agency, is traditionally engaged in representation for suppliers of aircraft and aerospace equipment. However, during 1967 it entered the warehousing and distribution field. It was expected that this new endeavor would contribute substantially to the division's sales objectives during 1968. With headquarters in Santa Monica, California, Airsupply maintained branch offices in 20 major aerospace centers throughout the country.

GENERAL DYNAMICS CORPORATION

A growing General Dynamics Corporation in 1967 marked passage of milestones in several major aerospace programs critical to the defense of the free world. Advances of equal importance were achieved in a variety of technologies from oceanographic research to deep space exploration.

Early in the year, the Department of Defense announced definitization of a $1.8 billion fixed-price incentive contract with General Dynamics for production of 493 F-111 variable-sweep-wing, supersonic jet aircraft for the U.S. Air Force and Navy, the United Kingdom and Australia. (**Editor's Note:** The United Kingdom order was later cancelled.)

By October, the first F-111As were accepted by USAF and placed in combat crew training at Nellis Air Force Base, Nevada.

Another unique aircraft, the tilt-wing, V/STOL Canadair CL-84 was flown extensively in 1967, and was evaluated by the United States, United Kingdom and Canada. The Canadian government announced that it would purchase 3 of the aircraft. Quantity production of the Canadair CF-5 jet fighter got under way for the Canadian Defense Forces, and the Netherlands revealed that it would order more than 100 CF-5s from the General Dynamics subsidiary. Canadair produces the CF-5 under license from the Northrop Corporation.

General Dynamics' older, proven aircraft continued front line service with the U.S. armed forces (F-102, F-106 and B-58) and with commercial carriers (880, 990, 240/340/440 transports and new 600/640 turboprop conversions).

In space, General Dynamics' Atlas Standard Launch Vehicle-3 (SLV-3) continued an outstanding record of successful flights. Coupled with Agena and General Dynamics' Centaur upper stages, Atlas SLV-3s had boosted more than 50 NASA and USAF vehicles from the pad by the fall of 1967. Manufacture of the SLV-3 was concluded in 1967, and the booster was replaced on General Dynamics' production lines by the more powerful SLV-3A and SLV-3C, developed for more demanding future missions.

In missilery, General Dynamics earned a $120,000,000 contract to produce the Navy's new Standard shipboard surface-to-air missile. An adaptation of the Standard missile, the air-launched Standard ARM (anti-radiation missile), also went into production. The company continued to build Terrier and Tartar shipboard air defense missiles for the Navy and Redeye shoulder-launched, antiaircraft missiles for the U.S. Army, Marine Corps, and Royal Swedish Army.

The F-111 production line at General Dynamics' Fort Worth division geared up to turn out 443 variable-sweep tactical and strategic aircraft for the U.S. Air Force, U.S. Navy, and Australia.

For NASA's Project Apollo, General Dynamics completed outfitting the 3 electronic instrumentation ships, *USNS Redstone, Mercury* and *Vanguard.* When Apollo lifts off to the moon, the 3 ships will be on stations in the Indian, Pacific and Atlantic Oceans to track and communicate with the spacecraft. The ships will provide the mid-ocean links in a round-the-world monitoring network.

A pioneer in marine technology and construction, General Dynamics in 1967 led the aerospace industry deeper into the sea. A dozen nuclear-powered attack submarines, 11 large surface vessels and 3 new research submersibles were under construction at General Dynamics' yards during the year. In April, the commissioning of the USS *Will Rogers* brought the Navy's ballistic missile submarine fleet to its authorized strength of 41 ships. The *Will Rogers* was the seventeenth Fleet Ballistic Missile submarine built by the company.

Four General Dynamics-built research submarines were operational and engaged in a wide range of undersea projects. The company also built and put to sea "Monster Buoy" Alpha for the Office of Naval Research. Buoy Alpha is a heavily-instrumented, 50-ton ocean data station designed to gather oceanographic-meteorological information for radio transmission to receivers ashore. A similar buoy, built for the Coast Guard, went on station at the entrance to New York harbor as a replacement for the lightship *Scotland*.

FORT WORTH DIVISION

Development, production, test and delivery of the F-111 aircraft continued as the prime effort of the Fort Worth division in 1967. Employment at the division rose to more than 25,000 by fall, the highest level in 10 years.

On May 10, the Department of Defense announced the production award for 493 F-111 aircraft. The contract authorized production of 331 F-111As for USAF Tactical Air Command, 64 FB-111As for USAF Strategic Air Command, 24 F-111Bs for the U.S. Navy, 24 F-111Cs for Australia and 50F-111Ks for the United Kingdom.

In the award announcement, Secretary of the Air Force Harold Brown stated that "the approval of this contract is an expression of our confidence in the F-111 as a vitally needed addition to an improvement of the operational inventory. The technological advances that have been achieved in the development of this aircraft, with its variable-sweep wing and afterburning turbofan engines, provide a major and far-reaching increase in the combat effectiveness of our tactical forces at any level of combat."

On May 22, 2 F-111As demonstrated their long-range capability by flying from the U.S. to Europe without refueling and without external tanks. The 2 aircraft participated in the 27th Paris Air Show, where they were on display and took part in aerial demonstrations.

In mid-summer, General Dynamics logged in the first flight of the developmental FB-111A strategic bomber. The 45-minute flight included a supersonic run and inaugurated a series of tests to evaluate subsystems incorporated into the FB-111A for long-range, high-payload strategic missions.

By fall, more than 30 F-111As and F-111Bs had flown almost 3,000 test flights totaling more than 5,200 hours. Almost 900 flights were at supersonic speeds, including more than 200 in which Mach 2 and higher speeds were demonstrated. The F-111 was flown and evaluated throughout the largest speed and altitude envelope ever achieved in a tactical fighter.

Within 3 years of its first flight, the F-111 had established an outstanding record of achievements, including flight at Mach 2.5 at altitude, flight at Mach 1.2 "on the deck" for sustained periods, missile firings at supersonic speeds, flight above 60,000 feet, launch of the Navy's air-to-air Phoenix missile, take-offs and landings with rolls of less than 3,000 feet, in-flight refuelings, touchdowns at speeds comparable to a propeller-driven transport, weapons delivery accuracy that USAF has described as "outstandingly amazing," and establishment of a new level of crew safety with a unique, self-contained "shirt-sleeve" environment crew module.

The first F-111As arrived at Nellis AFB in July and were assigned to the 4520th Combat Crew Training Wing. In the first weeks of crew training, F-111As logged as many as 55 flight hours per aircraft per month, a record of utilization unprecedented in a new airplane. F-111s have demonstrated turn-around time of 50 minutes, including post and pre-flight inspections, maintenance and refueling.

In October, the F-111A was formally accepted by USAF Tactical Air Command and turned over to the 4480th Tactical Fighter Wing, the first unit to be equipped with the new aircraft. The first operationally configured production aircraft arrived at Nellis on October 16 after an automatic 1,047-mile flight from Fort Worth that demonstrated the aircraft's low-level penetration capability.

After take-off, the F-111A's terrain-following radar was set for automatic operation, causing climb-dive signals to be fed into the aircraft's autopilot by an on-board analog computer. The autopilot then flew the aircraft at a constant altitude of 1,000 feet following the contour of the terrain.

In 1967, the F-111 also was employed as a test-bed in development of a new family of super-strong, stiff and lightweight structural materials called boron-epoxy composites. The new materials are formed by embedding hair-thin boron fibers in an epoxy-plastic matrix. The resulting composite material is potentially stronger and stiffer than steel and 25 percent lighter than aluminum. During the year, the first air worthiness tests were conducted on F-111 wing panel surfaces and landing gear doors.

More than 100 other research and development contracts in progress at Fort Worth during the year included studies relating to an advanced manned strategic bomber, development of equipment for B-58 supersonic bomber flight controls and a Jupiter fly-by study contract.

Honors also went to F-111 pilots in 1967. Forth Worth division Director of Flight and Quality Assurance Richard L. Johnson earned the coveted Iven C. Kincheloe Award for his F-111 test flights during 1966 and 1967.

The award is presented annually by the Society of Experimental Test Pilots for "outstanding test pilot" performance. Johnson was cited for "consistently flying F-111 aircraft on their most demanding missions, those requiring the highest skills of the professional test pilot."

CONVAIR DIVISION

The Convair division's Centaur 2-burn upper stage proved highly successful during the year. Among its missions were 4 launches of Surveyor spacecraft toward the moon. Early in 1967, NASA chose Atlas/Centaur to launch 1968 missions of Orbiting Astronomical Observatory (OAO) and Applications Technology Satellite (ATS) vehicles.

In addition to boosting Centaur upper stages, Convair division's Atlas vehicles continued to launch other payloads with a high degree of reliability. Through mid-October there were 26 launches, all successful. On October 11, with the Advanced Ballistic Re-Entry System (ABRES) launch of Atlas 69-D from Vandenberg AFB, the division chalked up a full year with a perfect record—34 consecutive successful Atlas and Centaur launches. Atlas 69-D was the 342nd Atlas launched.

In combination with Agena upper stages, Atlas Standard Launch Vehicles-3 (SLV-3) boosted 3 NASA Lunar Orbiters, an ATS, a Mariner Venus fly-by, and a variety of USAF payloads, among them 2 Precision Re-Entry Including Maneuverable Re-Entry (PRIME) missions. In addition, USAF used re-cycled Strategic Air Command (SAC) Atlas missiles as boosters to launch several ABRES and a General Dynamics Orbiting Vehicle 1 (OV-1) scientific satellite.

A major milestone was passed in the Atlas program during the year. In August 1967, General Dynamics delivered its final production model SLV-3. Over the last 3 years, 56 SLV-3 vehicles were delivered for USAF and NASA missions. By early November, 54 SLV-3s had been launched, 52 successfully, for a reliability score of more than 96 percent.

The uprated, more powerful Atlas SLV-3A and 3C replaced the SLV-3 on the Convair division production line in 1967. The SLV-3A can be used with an Agena upper stage and the 3C with a Centaur upper stage. The first SLV-3C assignment was the Atlas/Centaur boost in September of the Surveyor V soft lunar landing spacecraft. The first SLV-3A mission will be the launch of the Orbiting Geophysical Observatory E (OGO-E) scheduled for early 1968.

The SLV-3A is 117 inches longer than its predecessor and can carry an additional 48,000 pounds of propellant. With an Agena upper stage, it can boost 1,450 pounds to escape velocity or a 985-pound payload to Mars. The SLV-3C is 51 inches longer than the SLV-3 and carries an extra 21,000 pounds of propellant. Under a Centaur second stage, it can launch a 2,900-pound payload to escape velocity or a 2,200 pound payload to Venus or Mars.

The first empennage for the USAF C-5A military transport, the world's largest airplane, was delivered by the Convair division to the Lockheed-Georgia Company plant. Delivery was made in 2 giant railroad cars after a 3,000-mile cross country journey from San Diego, California, to Marietta, Georgia.

General Dynamics had a contract in excess of $40,000,000 with Lockheed for production of the vertical and horizontal stabilizers, rudder and elevator which make up the C-5A tail section.

Contracts for production of in-flight refueling modification kits for F-106 jet interceptor aircraft and for improved tactical air navigation (TACAN) system kits for the F-106 were awarded to the Convair division by USAF. The TACAN system is the first to use microelectronic circuitry and provides pilots with range and bearing from ground stations and range between aircraft similarly equipped.

USAF also awarded General Dynamics a contract for preliminary design work on the proposed AX specialized close support aircraft. The 4-month study by the Convair division was part of the aircraft's concept formulation phase of development.

Production of MX-19 aluminum landing mats continued at Convair under contract to Kaiser Aluminum. The mats are made of an aluminum honeycomb core sandwiched between 2 aluminum sheets and framed by aluminum extrusions. The 4-foot-square mats interlock, making it possible to construct landing fields of desired size in a short time.

General Dynamics engineers completed a study for NASA aimed at determining the feasibility of a liquid hydrogen-fueled, air-breathing hypersonic passenger aircraft. The engineers chose a double delta wing as the most promising configuration for a 200-passenger, nickel alloy construction aircraft intended to fly at speeds from Mach 3 to Mach 12 during the 1985–2000 time period.

POMONA DIVISION

Award of a $120,000,000 Standard missile contract to General Dynamics initiated a 6-year production program at the Pomona division to realize the Navy's concept of a standardized shipboard missile system for defense of the Fleet against both surface and aerial threats. Initially, the Standard missile will be used by the Navy for testing and to equip newly-constructed ships. Later, the Navy will equip ships now armed with Terrier and Tartar missiles. The all-electronic, homing Standard missile will eventually protect some 50 destroyers, frigates and escorts.

Two versions of the Standard missile—extended range and medium range—have been developed. Interchangeability of hardware between the 2 models is a key feature of the missile system, with the principal difference in the propulsion systems. The extended range Standard has a separable booster and a sustainer rocket motor. The medium range missile has an integral dual-thrust rocket motor. All missile functions are powered directly by the missile battery, and no hydraulic, pneumatic or hot-gas systems are required.

The Standard ARM, also in production at the Pomona division, is an air-launched, anti-radiation guided missile system. It will be deployed by the U.S. Navy and USAF to locate and destroy hostile ground-based radar installations. The system consists of a modified medium-range Standard missile delivered by existing high-performance aircraft equipped for the detection, identification and acquisition of the radar target. System operation is initiated on receipt by the aircraft of hostile radar transmissions. The received signal is processed to identify threat data, and a missile is launched to home on the source of radar transmission.

General Dynamics also earned a U.S. Army contract for production at Pomona of long lead time items for the Redeye missile system. The world's smallest guided missile, Redeye was developed by General Dynamics to give combat troops protection against attack from low-flying enemy aircraft. During the year, the shoulder-fired missile was supplied to the Army for troop training at Fort Bliss, Texas, and to the Marine Corps for training at Twentynine Palms, California.

The Swedish government also signed an $8,000,000 contract for the purchase of the 4-foot-long, 29-pound air defense system. Sweden announced that it planned to deploy Redeye in its Army antiaircraft units as a replacement for existing 20 millimeter automatic weapons.

Early in 1967, General Dynamics announced receipt of a major award from the U.S. Navy for systems integration, test and training on its Terrier Fleet Modernization Program. The program calls for the installation and test of uprated elements of the shipboard antiaircraft missile system, and the training of operational personnel. Terrier and Tartar antiaircraft missiles at year-end armed 70 ships of the U.S. Navy, in addition to navies of France, Italy, Australia, the Netherlands and Japan. A Tartar repair facility was opened in Australia in the summer of 1967.

In addition to missile systems work, Pomona division announced development of several electronic systems, including an airborne bullet detector unit and a ground-based mortar detector.

Pomona division employment rose to an all-time high of 7,800 in 1967.

ELECTRONICS DIVISION

Prime contractor for the Apollo Instrumentation Ships program, General Dynamics' Electronics division continued work on schedule in 1967 with *USNS Vanguard* completing all final tests. When placed on station, *Vanguard* and her sister ships, *Mercury* and *Redstone*, will be floating electronic platforms equivalent in communications and control capabilities to the Houston Space Center. In addition to its role as prime contractor, the division furnished 8 of the 12 major electronic systems aboard each ship and provided training in operation and maintenance for 22 subsystems.

The U.S. Navy in 1967 awarded the company a contract to cover modifications to Eastern Test Range Instrumentation Ships. Modifications to be made by the Electronics division included increased radar capability for obtaining trajectory and signature data on multiple reentry and orbiting targets. Also included is equipment for control and monitoring, such as closed circuit television, plotting board, control consoles and a computer facility.

A program was under way to extend the operating range of NASA's Space Tracking and Data Acquisition Network to more than 1,000,000 miles and to permit use of the systems on a much broader base. Improvements include provision for 10,000 frequency channels, centralized and automated system control and addition of hybrid ranging codes to resolve ambiguities in transmission and reception in the 1,000,000-mile range.

A new hydroacoustics laboratory was completed by the division in 1967. The new lab complements the 500,000 gallon sonar tank facility in Rochester, New York, and the Seneca Underwater Test and Evaluation Center on nearby Seneca Lake. All 3 facilities were involved in the division's antisubmarine warfare programs.

During 1967, thick-film and thin-film hybrid circuits and thin-film multi-chip circuits were developed and produced by the Electronics division in quantities for inclusion in new communications/electronics equipment. Plans were formulated to expand the division's microelectronics facilities to meet corporate-wide requirements for hybrid microelectronics.

During the year, fundamental work was carried out in the design and fabrication of passive microwave components utilizing ceramic microstrip techniques. Significant gains were made in the use of digital computer techniques for the design of filters, directional couplers and other components in both microstrip and conventional stripline.

New techniques and processes were also under way to produce complete microwave systems in a single, compact assembly. A single assembly would supplant conventional waveguide components currently utilized in radar and tracking systems.

Also in 1967, development of a smaller, lighter and more effective Miniature Sonobuoy Receiver System earned an initial contract from Lockheed for 25 units for its new P-3C aircraft. The new MSRS has 31 fixed-tune channels and maintains the division's place as sole producer of these units.

The U.S. Army signed a contract with the Electronics division for radio-teletypewriters that fit into a shelter mounted on ¾-ton trucks. The division will supply the AN/GRC-106 radio and the MD-522 modulator-demodulator for teletypewriter and voice operation.

Divisional activity in ground surveillance radar was expanded in 1967 by receipt of a contract from the Army for a highly reliable, lightweight microelectronic ground surveillance radar capable of detecting and identifying moving targets on or near the ground under all weather conditions.

A mobile, low-angle tactical radar tracker was also being produced for the Army to provide precision tracking of an airborne target to ground horizon.

STROMBERG-CARLSON

During 1967, the Military Systems Group of Stromberg-Carlson's Data Products Division was active in development on several avionics programs for the U.S. Navy.

Most critical among these was the airborne antisubmarine warfare program designated A-NEW. By late 1967, Stromberg-Carlson had completed the design and fabrication of the A-NEW VSX (MOD 4) display console. This unit will be delivered to the Navy's Avionics Development Laboratory where it will be utilized as a development tool in the service's continuing ASW programs.

Stromberg-Carlson also completed the design, development and fabrication of 4 AEW-C airborne early warning avionics display consoles for use as development tools by the Navy.

During the year, Stromberg-Carlson designed the Navy's A-NEW P-3C displays, and under another contract development of 2 airborne displays for the first VSX avionics flight test (A-NEW MOD 5).

CANADAIR LIMITED

Canadair continued its emphasis on diversification during 1967, with work progressing on production of military and civilian aircraft, aircraft components, a reconnaissance drone, air traffic control and satellite ground station equipment and military vehicles.

The Netherlands announced it will order 105 CF-5 fighter aircraft from Canadair for the Royal Netherlands Air Force. Production of 115 CF-5s for the Canadian Defense Forces was well under way.

The Canadian Government said that it will purchase 3 CL-84 tilt-wing V/STOL aircraft for delivery in 1968 and 1969. By mid-October the CL-84 prototype aircraft had made a total of 305 flights and had been flown by pilots of the Canadian Defense Forces, the Royal Air Force, the U.S. Navy, Army, USAF, Marine Corps and NASA. It had successfully demonstrated vertical and short take-offs and landings, hover, transitions to and from conventional flight and cruising speeds of approximately 300 miles per hour. Simulated land and water rescues also were conducted by the aircraft.

In September, a U.S. tri-service team concluded a 4-month evaluation of the CL-84. The team was preparing an evaluation report, specifically regarding the revolutionary aircraft's potential military role in search and rescue operations.

Twenty Canadair CL-215s in fire-fighting water bomber configuration were sold to the Forestry Department of Canada's Province of Quebec and 10 were sold to the French government. As a water bomber, the CL-215 loads up by opening its hull tanks as it skims the surface of a lake or other body of water. Several other configurations of the amphibian have been developed, enabling it to serve as an air-sea rescue or cargo carrier, crop duster, forest fertilizer or in general agricultural work. The CL-215 was in production and the first aircraft flew its maiden flight in October.

Work continued in 1967 on production of 20 CL-41G tactical-trainer aircraft for the Royal Malaysian Air Force. Fourteen had been delivered by the end of October. This aircraft is a multipurpose jet based on the side-to-side crew seating configuration that is the standard jet trainer of the Royal Canadian Air Force. The Malaysian version can carry up to 3,500 pounds of standard ordnance, including bombs, rockets, air-to-surface missiles and extra fuel tanks.

The company was also producing components for the USAF C-5A heavy logistics transport. Orders in excess of $50,000,000 were received for the manufacture of 58 ship sets of main landing gear fairings and doors, ailerons, aft cargo doors, wing tips and leading edges and slats. Work on these subcontracts will extend through 1970.

During the year, the Federal Republic of Germany became a full partner with Canada and the United Kingdom in the development of the CL-89 short-range reconnaissance drone system. Known officially as the AN/USD-501, the drone completed a series of test flights at the Yuma, Arizona, proving ground of the U.S. Army. Personnel from the armies of Canada, United Kingdom and the Federal Republic of Germany began service engineering flight trials during the year, and planned to follow up with flights under tactical conditions.

The CL-89 is a rocket take-off, jet-powered surveillance vehicle that flies near Mach 1. The 8-foot, 200-pound, missile-shaped drone has twin 70 millimeter cameras mounted in its belly. On completion of a preset flight into enemy territory, the CL-89 returns to a preselected location and lands by parachute. The drone also has the capability for automatically processing its own film in flight.

On the ground in 1967, Canadair completed 41 prefabricated airport traffic control tower cabs for the U.S. Federal Aviation Administration. The company revealed continued interest in both the cabs and its transportable control tower, which can be used as a permanent traffic control center at secondary airfields or as a temporary center at smaller airfields.

In July 1967, Canadair received a $600,000 contract from Northern Electric Company Ltd. for the construction of a satellite ground station antenna.

During the year, Canadair brought in advanced production engineering work from the U.S. Army on the XM-571 CL-91 Dynatrac, an all-purpose, all-terrain articulated tracked vehicle; subassembly work for electronic communications systems, with manufacture of components and modules to follow; and fabrication work on ball valves for U.S. Navy submarines. The company's research and development facility was engaged in such projects as escape systems for flight vehicles, operations research survivability and vulnerability studies and medical research on a venous blood pressure recording system.

GENERAL ELECTRIC COMPANY

Editor's Note: As the 1968 AEROSPACE YEAR BOOK was closing, General Electric announced the formation of 2 new groups in the aerospace industry, effective January 1, 1968, to replace the Aerospace & Defense Group: the Aircraft Engine Group formed from the Flight Propulsion Division; and the Aerospace Group formed from the Missile & Space Division, Defense Electronics Division and Defense Programs Division.

AEROSPACE & DEFENSE GROUP

General Electric's Aerospace and Defense Group consists of 4 divisions which employ a total of more than 55,000. Annual aerospace and defense sales account for about 18 percent of the company's worldwide sales.

Based on Department of Defense awards for the previous fiscal year, General Electric entered 1967 as the nation's second largest defense contractor and the fifth largest NASA prime contractor.

Of the Group's 4 divisions, 3 are operating divisions. They are: the Flight Propulsion Division which has major plant locations in Ohio and Massachusetts, plus satellite plants in Vermont, New Hampshire and New Mexico; the Defense Electronics Division which has 6 product departments and one laboratory operation located in 6 New York State and New England cities; and the Missile and Space Division which has principal research and development facilities at Valley Forge, Pennsylvania, and other installations at Philadelphia, Daytona Beach, Florida, Huntsville, Alabama, Houston, Texas and Bay St. Louis, Mississippi.

The Group's fourth division, the Defense Programs Division, is headquartered in Washington, D.C., and serves primarily as the sales arm for the 3 operating divisions.

The following is a breakdown of the major events during 1967 within each of the 3 operating divisions.

Flight Propulsion Division

A longtime leader in military jet engine technology, General Electric's Flight Propulsion Division demonstrated continued strength in this area during 1967 while showing increased evidence of its determination to become a major supplier in the international commercial aircraft engine market.

One of the company's largest divisions, FPD employed a total of 28,000 at 2 major plant locations (Cincinnati, Ohio and Lynn, Massachusetts) and at satellite plants at Hooksett, New Hampshire; Rutland and Ludlow, Vermont; Albuquerque, New Mexico; and Everett, Massachusetts.

In a move designed to strengthen its commercial aviation business, the division consolidated all of its commercial powerplant programs in September and formed a single commercial engine organization which reports directly to Gerhard Neumann, vice president and division general manager.

Concurrent with the organizational change, the division unveiled plans for a new commercial, subsonic engine, the CF6/34, for "airbus" type aircraft. The 35,000 pound thrust class turbofan is a new generation, high bypass engine designed for low noise, long parts life and a high degree of maintainability. It will be ready for commercial airline service in 1972.

A large measure of the division's commercial jet engine activity during the year focused on the development and testing programs of the more than 60,000 pound thrust GE4 turbojet, a program which gained momentum following the December 31, 1966, announcement that the engine had been selected in the U.S. supersonic transport powerplant design competition.

The division's testing program on Phase III engine hardware began in December. The first group of Phase III GE4 engines was released for manufacture in April. Phase III includes the manufacture of 16 flight test engines, the first of which was programmed for December 1969 with subsequent shipments of 2 GE4 engines each month through July 1970.

Testing and component development work on the GE4 in 1967 included full-scale combustor testing, augmentor testing at GE's remote test sight at Peebles, Ohio, and engine control system and component testing.

A total of 1300 thrust reverser cycles were run, as well as a number of sound suppression tests. The division also installed the Phase III GE4 full-scale compressor in its compressor test tank at its Lynn facility.

As part of its SST program investment, the division began construction of a $12,000,000 advanced Altitude Test Facility in Cincinnati. Expected to be ready for service by mid-1968, it will simulate atmospheric conditions at extremely high altitudes. It will be capable of testing virtually every jet engine in GE's production and development inventory, including the GE4 and TF39.

The Altitude Test Facility is part of the division's 3-year $100,000,000 improvement and plant modernization program.

Other SST-related activities in 1967 included: (1) an intensive engineering coordination program with

Boeing to refine the many interfaces between aircraft and powerplant, (2) establishment of a long-range communications program and working relationship program with U.S. and other airlines having delivery positions for the Boeing 2707 and (3) a program of comprehensive indoctrination for airline personnel on support needs for the SST engine.

On another commercial front, the division counted more than 350 GE-powered business jet aircraft flying in 1967. The total constitutes more than 50 percent of the worldwide turbojet/turbofan business jet aircraft fleet. The GE business jet engine family includes the CJ610 turbojet series (Jet Commander, Lear Jet, and HFB Hansa 320) and the CF700 turbofan series (Fan Jet Falcon).

By year-end, more than 500,000 engine flight hours had been logged by the GE business jets since first entering service in 1964, with more than half of the flight hour total being flown in 1967. Time between overhauls jumped to 1,400 hours in 1967, nearly double the previous TBO of 800 hours.

The year saw 2 growth models added to the company's CJ610/CF700 family. The CJ610-8/-9 and CF700-2D offer 3 to 4 percent improvement in climb and cruise thrusts over preceding models, plus 2 to 4 percent improvement in cruise specific fuel consumptions.

Delivery of CT58 commercial helicopter engines continued in 1967 to Sikorsky for its S-61 and S-62 aircraft and to Boeing/Vertol for its V-107. In March, the FAA certified GE's CT64-820 commercial turboprop engine, latest in the division's commercially certified T64 turboprop/turboshaft engine group. GE engines power all scheduled U.S. commercial helicopter aircraft.

GE commercial airline engines, the CJ805 series, added to the more than 5,000,000 flight hours logged by them through 1966. The series was in service with more than a dozen international and domestic airlines operating Convair 880 and 990 airliners.

Headlining the division's military activities during 1967 was the TF39 program. Designed for the U.S. Air Force's Lockheed-built C-5A "Galaxy" heavy logistics transport, destined to be the world's largest aircraft, the 41,000 pound thrust class TF39 prototype made its first test flight aboard a USAF B-52 at Edwards Air Force Base.

The first TF39 ground test engine was delivered to Lockheed in October. It also underwent climatic tests at Eglin Air Force Base and high altitude testing at Arnold Engineering Development Center, Tullahoma, Tennessee.

During 1967, a large crosswind test facility for the TF39 and other engines was completed and put into operation by the division. Located at Peebles, Ohio, the new facility is the largest of its kind, creating hurricane-like winds of up to 120 knots.

Details of a new TF39 fan were disclosed. Called a "flade" and machined from a titanium forging, it is being used in the second stage of the engine's front fan, providing significant weight reductions and greater strength in this vital section of the engine.

Production continued on the division's small military turbojet, the J85, as Northrop T-38 trainers for the Tactical Air Command and F-5 Freedom Fighters for the U.S., Canada and various Military Assistance Program nations were shipped to many new areas of the world.

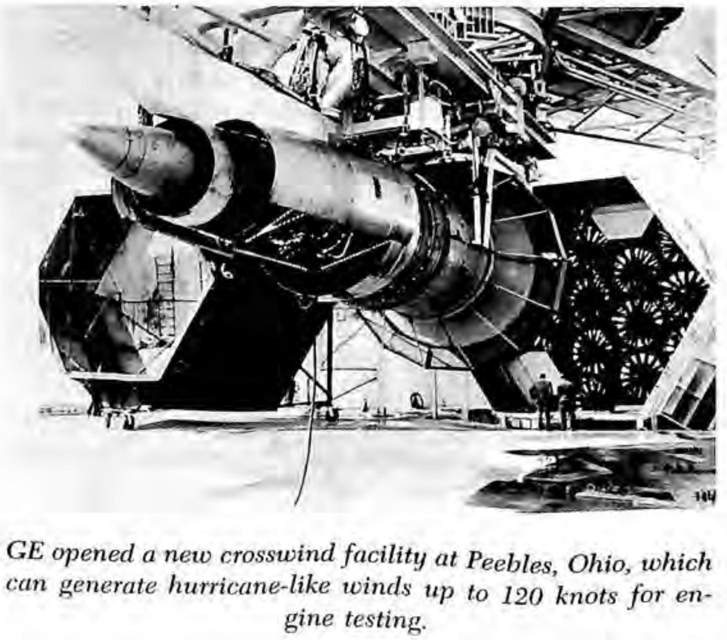
At Cincinnati, an advanced version of the J79 turbojet (the J79-19) was developed for the Italian Air Force's Lockheed F-104S Starfighter. It delivers 17,900 pounds of thrust, resulting in higher speeds and improved take-off and acceleration power. The growth model also provides lower fuel consumption under most flight conditions, including an 11 percent reduction in cruise specific fuel consumption.

The division demonstrated progress on many V/STOL propulsion fronts during the year, including turboshafts, turboprops, lift/cruise fans, direct thrust and deflected thrust engines. For example, development continued on the versatile and highly efficient deflected thrust engine for the U.S./Federal Republic of Germany advanced V/STOL fighter competition.

At the Paris Air Show in May, the division unveiled 2 new members of its GE1 core-engine-concept family—the GE1/10, a 40,000 pound thrust class turbofan with afterburner augmentation proposed for the U.S./Federal Republic of Germany Advanced V/STOL fighter, and, the GE1/J1A1, a 7,000 pound thrust supersonic turbojet with afterburner proposed for new supersonic fighter and intercepter aircraft.

Both jets use a core engine based on the GE1 turbojet, a highly flexible engine which can be transformed into a turbojet, turbofan, turboshaft or turboprop engine for a broad range of propulsion requirements by the addition of components.

The T58 turboshaft engine, powerplant for 11 U.S. military helicopters and 3 commercial versions, passed the 2,000,000 flight hour mark in 1967. In addition



GE opened a new crosswind facility at Peebles, Ohio, which can generate hurricane-like winds up to 120 knots for engine testing.

to Navy, Air Force, Marine Corps and Coast Guard applications, the T58 was powering helicopters used by 6 commercial airline operators.

In May, T58 turboshafts powered the first flight of the X-22A Tri-Service V/STOL research aircraft built by Textron's Bell Aerosystems Company.

The division's T64-12 turboshaft, for the U.S. Marine/Sikorsky CH-53 heavy assault helicopter, successfully completed its preliminary flight rating test in June with its model qualification tests scheduled for completion in December.

In May, the division's first YT64-16 turboshafts were shipped to the U.S. Army for the Lockheed AH-56A helicopter program. They powered the Cheyenne's first flight in October.

GE jet engines modified for land and sea uses included LM100 gas turbines (T58 engines) used as powerplants for hydrofoils, air cushion vehicles and off-highway vehicles.

Operating as the powerplant for a 100-ton ore-hauling vehicle in a New Mexico copper mine, the division's LM100 successfully completed nearly 3,000 hours of rugged testing in February. GE engineers reported the engine met all expectations. The program was designed to demonstrate and evaluate the turbine's ability to reduce overall hauling costs in off-highway vehicles. In addition to the LM100 engine, the ore-hauler's propulsion system included a reduction gear and an electrical motorized wheel system developed by GE.

The LM1500 gas turbine (a derivative of the J79 engine) powers marine craft, such as the high-speed Asheville-class patrol boats (PGM), and is used to drive military aircraft catapult systems and electrical power generation systems.

Research and development progress during 1967 included a new high-strength diffusion bonding process and a new fluidic jet engine control system.

The diffusion bonding process for making hollow bonded titanium compressor blades of considerably lower weight than current production blades was unveiled by the division's Materials Development Laboratory. GE tests revealed that diffusion bonded joints of titanium are as strong or stronger than the parent metal. To be used in the GE4 SST engine, the blades offer savings of up to 50 percent in blade weight, plus weight reductions in the compressor discs which hold the blades.

The practicality of the division's new fluidic engine control system was demonstrated on the J79-15 engine where fluidic controls were used in the engine's start circuit, the acceleration and deceleration circuit, and the speed and overspeed governors.

A milestone of the division's year was October 2, the 25th anniversary of the day in 1942 when 2 revolutionary GE I-A turbojets powered the Bell XP-59 across a California sky on the first U.S. jet aircraft flight. The technology leading to the development of these powerplants was pioneered by Dr. Sanford Moss, a GE scientist, who in 1903 operated the first gas driven turbine wheel in the U.S.

Defense Electronics Division

During 1967 General Electric's Defense Electronics Division reflected continued leadership as a supplier of electronic systems and components to the defense and aerospace market, while strengthening its position as a major research and development organization.

Some of the major programs during the year included guidance and fire control systems for the Polaris and Poseidon fleet ballistic missiles, F-4 and F-111 flight controls, the swiveling gunner's station for the AH-56A Cheyenne attack helicopter, advanced radar and sonar detection equipment, Guidance and Control Group for the Chaparral ground-to-air missile, rapid fire weapons and a variety of advanced computers.

With headquarters in Utica, New York, the division employs approximately 21,000 and includes the Heavy Military Electronics Department, and the Special Information Products Department in Syracuse, New York; the Aerospace Electronics Department in Utica; Armament Department in Burlington, Vermont; the Ordnance Department in Pittsfield, Massachusetts; and the Avionic Controls Department in Binghamton, New York.

In addition there is a satellite facility in Springfield, Massachusetts, which is aligned with the Armament Department and a laboratory operation, the Electronics Laboratory, in Syracuse.

The appointment of Charles W. George as division general manager in January prefaced a number of major organizational changes aimed at improving the division's total military electronics and weapons control competence.

In November, an Advanced Systems and Requirements Operation was established by the division to strengthen its ability to contribute to total system defense contracts. Headquartered in Syracuse, the new operation has international responsibility for the marketing of GE defense electronic systems and equipment, plus the management of the division's expanding engineering effort associated with designing and planning advanced defense electronics systems.

Earlier in the year, a new department (the Armament Department) was added and the Avionic Controls Operation became the Avionic Controls Department. The Armament Department was formerly the Missile and Space Division's Missile and Armament Department.

The year also saw the division's Light Military Electronics Department renamed the Aerospace Electronics Department.

A milestone in microminiaturization was achieved by the division when it delivered the first Microelectronic Indicator for Radar Ground Equipment (MIRAGE) to the U.S. Air Force.

Designated the AN/UPA-56, MIRAGE represents a reduction of nearly 90 percent in power requirements, space and weight over current operational radar indicators. On a per unit basis, it is estimated that MIRAGE will operate 16 times longer between repairs and result in savings of approximately $10,000 per unit per year in operation and maintenance costs alone.

Sonar development maintained a steady pace. Major contracts were received for research and development of advanced submarine detection sonar and for development, fabrication and test of 2 advanced development models of a receiver system for a passive sonar array.

Production continued on the AN/SQQ-14 mine detecting and classifying sonar, as well as on the AN/SQS-26, the U.S. Navy's most advanced surface ship sonar.

The division's AN/MPQ-4A mobile mortar locating radar and AN/TPQ-10 radar course directing central were operating in Vietnam during the year.

The AN/TPQ-10 is used for all-weather guidance and control of aircraft on close air support missions; the AN/MPQ-4A, for pinpointing enemy mortar positions.

Production continued on the mobile high power acquisition radar (HIPAR) for the Nike-Hercules System.

Another major activity was over-the-horizon radar, as the division continued its studies of high-frequency radio propagation.

A contract was received for operation and maintenance of satellite tracking radars developed in conjunction with the Air Force for such SPACETRACK sites as Shemya, Alaska.

A major contributor to the Navy's Polaris and Poseidon Fleet Ballistic Missile programs, the division continued GE's work on the design and development phases of inertial guidance, fire control and support equipment for Poseidon.

The first production award (Phase IIIA) on the Poseidon program was received by the division, which also shipped the first major piece of Poseidon hardware—the Mark 492 Automatic Guidance Test Set which tests and calibrates all Mark 3 Poseidon guidance systems.

Other ordnance programs included (1) solid-state power drives for the single gun aboard the Navy's new PGM Class patrol gunboats, (2) adaptation of the Mark 56 gun fire control system for the Navy's AN/SPA-82 helicopter landing aid program, and (3) attitude reference systems for the Air Force's Re-entry Measurement Program.

Also under development during the year was a sight-line stabilizer for the Swiveling Gunner's Station on the Army's new AH-56A Cheyenne helicopter.

The division Optimum Ratio Stabilization drive, which permits a tank commander to fire accurately while on the move was developed and tested on an M-60 tank at Aberdeen Proving Ground where the system met or exceeded all design objectives.

Work continued on a personnel detector which detects concealed humans by electronically sensing their effluents. Development of electronic propulsion systems for underwater ordnance vehicles also continued.

To meet the demands of the Vietnam conflict, production was stepped up on the 20 millimeter Vulcan cannon and 7.62 Minigun, members of the division's family of high-performance, rapid-fire aircraft and ground vehicle armament systems. These Gatling gun type weapons utilize a cluster of rotating barrels to deliver as many as 6,000 shots per minute.

Production contracts were received for armament systems for Ling-Temco-Vought's new A-7 series of lightweight fighter aircraft. Work on adapting weapons to caseless ammunition was begun as the result of study contracts.

Other weapon research and development activities included new rapid fire gun concepts, single-barrel vehicular cannons, machine guns, flexible helicopter turrets, and antiaircraft vehicular systems and fuses.

A number of 1967 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.

Additional production orders for its F-111 attack radar were received, in addition to new attack radar orders for the FB-111 fighter bomber version. The revolutionary variable-sweep-wing aircraft was being readied for an active role in Southeast Asia.

Designated the AN/APQ-113, the attack radar is the latest in a long line of radars developed and manufactured by the division. It enables the crew of the 2-man aircraft to fire at targets they cannot actually see. The system also updates the information utilized in the aircraft's navigation subsystem.

Microelectronics and solid-state circuitry were used extensively in the new radar which was built to conform to stringent size and weight requirements.

Production began on the Guidance and Control Group for the Army's new Chaparral guided missile which will defend forward areas against attacking enemy aircraft. The division's sophisticated heat-seeking sensor automatically guides the missiles 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 1967. Other high activity programs were satellite command systems, E-2A airborne early warning radar, and data processing systems for antisubmarine warfare.

In conjunction with GE's work on military applications of low light level television, the division built 2 1,000-line resolution TV cameras for NASA's Marshall Space Flight Center. NASA will evaluate them for possible use in the Apollo Telescope Mount (ATM). Designated UVR-700 Focus Projection Scanning vidicon cameras, each weighs only slightly more than 5 pounds and is at least 30 percent smaller than any previous miniature camera with equal high-resolution capability.

With the establishment of the Avionic Controls Department in 1967, General Electric consolidated its technologies, capabilities and facilities for the development, design, and production of commercial and military avionic control systems. The product scope of the new Department included flight controls, engine controls, display weapon control systems, lead computing 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.

The in-house production programs during the year included automatic flight control systems for the F-4 and F-111, weapon controls systems for the F-4, F-105 and F-111, a lead-computing sight for the Vulcan Air Defense System, control moment gyros for spacecraft attitude stabilization, engine nozzle controls, and the swiveling gunner's station for the Army's AH-56A Cheyenne combat rotocraft.

GE's automatic flight control system aboard the F-111 variable-wing aircraft provides triple redundancy with median selection majority logic voting. This triplex system provides a major improvement in reliability and fail—operational control after the first fault occurs. Microelectronic integrated circuits (MIC) are used to provide the optimum in reliability, low cost and ease of maintenance. The experience gained in the technology and design of the F-111 automatic flight control system is being applied to commercial supersonic aircraft.

The swiveling gunner's station provides the AH-56A high-speed compound rigid-rotor helicopter with a dynamically stabilized line of sight to insure accurate weapons delivery. It provides gunners with a 360-degree zone of coverage in train, enabling them to continuously engage and fire upon targets during fly-by without the pilot being required to veer from course. Integrated elements of the gunner's station include: a periscope sight, direct sight, laser rangefinder, missile guidance sensors, controls, displays, and provisions for night vision operation.

The 1967 R&D avionic contracts included a multiweapon fire control system for the next generation of armed helicopters, digital computers for commercial and military flight control applications, and automatic flight control system study for the Army's Advanced helicopters, XV-4B VTOL automatic flight control systems study, liquid metals research study, terrain following displays, solid-state rate sensor and self-optimizing adaptive control systems for spacecraft attitude control and stabilization.

The microelectronic digital computer underwent operational testing with a SST aircraft simulated on an analogue computer. The solid-state rate sensor underwent flight, operational and evaluation testing at Boeing on a B-707 for application on the commercial supersonic transport.

The XV-4B VTOL automatic flight control study produced a triple redundant fly-by-wire system design with instantaneous switching to a mechanical backup system. This design also may be applicable to other VTOL-type aircraft.

The multiweapon fire control system program encompassed design and development of analogue and microelectronic digital computers, manufacture of engineering prototypes and their installation on the UH-1B helicopters.

The Electronics Laboratory in 1967 continued its work in applied research, advanced development and support activities in electronics and related fields for the division, as well as for the General Electric Company at large and its customers.

Investigation during the year at the laboratory included development of advanced, high-speed circuits and memories, control and instrumentation, data recording, and display and signal detection.

Other areas included optoelectronic and microwave devices, solid-state materials, guidance techniques, chemical and biological detection, information processing and optical engineering.

The laboratory continued to advance the state-of-the-art in computer displays. These displays accept speed, attitude and altitude information from vehicle simulators and convert them into a video display of a scene as it would appear through the windshield of an aircraft or spacecraft. The video display is updated 30 times a second so a smooth and continuous picture is displayed.

In late 1967 the laboratory delivered its second computer display to NASA's Manned Spaceflight Center in Houston, Texas. The first was delivered in 1966 for use in pilot information study. NASA will use both displays for engineering evaluation of proposed spacecraft control systems and, to some degree, for astronaut training.

The laboratory also was concerned with techniques for detecting chemical and biological agents. As a follow-up to work in 1966 which resulted in the development of a method that permits bacteria to be detected and identified by their metabolic products by means of a liquid-gas chromatographic process, research continued in 1967 in applying the new techniques to detection and identification of viruses and to the problems of identifying bacteria in mixed cultures.

Adaptive processing techniques developed by the laboratory continued to be applied to detection of malfunctions in jet engines and other mechanical devices. Similar adaptive techniques were being applied to classification of radar and sonar signals to permit accurate and automatic target identification.

Work continued on the laboratory's long-range program to develop automatic techniques for design of advanced computers and other electronic equipment too complex to be accomplished by manual design techniques.

Progress also was registered in the laboratory's continuing investigations in the area of microelectronics, resulting in the development of a broad spectrum of devices and applications ranging from advanced high-speed computer circuits to new solid-state microwave sources.

The division's radio guidance systems were used in previous U.S. space programs including Gemini, Ranger, Mariner and Mercury. Follow-on work in this area during 1967 resulted in programs aimed at the development of more precise radio tracking techniques. Range safety and instrumentation systems were supplied for classified Air Force programs, the Nike and ABRES test launches, and NASA's Orbiting Geophysical Observatory and Applications Technology Satellite.

A new ruggedized computer for mobile and fixed installations, the GE 605, was unveiled by the division. A member of the Compatibles/600 family, the 605 is compatible with the commercial GE 600 series. It is well suited for command and control, message switching and other high-performance, real-time data processing. The GE 605's dual-level processor also permits time-sharing with background batch processing. Development continued on the GE645, a large-scale, time-sharing computer system.

Work also progressed on the development of survivable radio guidance systems, very low frequency land and shipboard communication systems, S-band telemetry transmitters and radiation effects studies.

Missile and Space Division

Research and development remained a major trademark of the Missile and Space Division which marked its 10th anniversary in 1967.

During this first decade, the division's employment rose from 3,500 to 19,000, approximately 30 percent of which are engineers and scientists. The division's facilities were expected to top the 5,000,000 square feet mark with the completion of additional construction in Valley Forge.

Although Valley Forge is division headquarters, development and test activities are conducted at all primary U.S. missile and space operation centers and at some overseas locations.

The Valley Forge Space Technology Center contains the largest concentration of space simulation equipment in the world. Simulators are in use for specialized development work, including a 54-foot vacuum chamber. With wide acceptance of the requirement for pre-launch testing on the ground to achieve long life reliability in space, the chamber's utilization is becoming more critical.

Although most of the division's business originated from the U.S. Air Force in 1957, in 1967 there was nearly an equal split with both the Air Force and NASA; with a small percentage coming from the Atomic Energy Commission and other organizations.

In the field of reentry vehicles, GE has built or is building reentry vehicles for all Air Force ballistic missile weapon systems—Thor, Atlas, Titan and Minuteman. The division was also building target reentry vehicles used in the Nike X anti-ICBM program and a number of advanced reentry vehicle projects.

The division has pioneered the development of satellite control and stabilization systems. The active control system developed for the complex Nimbus weather satellite is one of the most successful ever operated in orbit. While NASA and DOD have ordered 22 passive control systems, 15 have been from MSD. These simple gravity-stabilized control systems have proved highly reliable, long-lived, and ideal for satellites not requiring extremely accurate pointing.

A power plant for operation on the moon's surface was being developed under contract from the AEC. This system, a nuclear powerplant called SNAP-27, consists primarily of a radioisotope, thermoelectric generator with a plutonium heat source. It will provide 64 watts of electrical energy to power the experiments left behind on the moon by the Apollo astronauts when they return to earth. The system will operate continuously, throughout the lunar day and night for years without maintenance.

In the area of scientific satellites, the division is a major contractor for the Biosatellite, which permits basic biological investigation of space; the Geodetic Satellite, which helps scientists learn more about the earth's characteristics, and Orbiting Astronomical Observatory, which will give astronomers their first look at the stars unhindered by pollution of the Earth's atmosphere.

In the field of application satellites, the Missile and Space Division is the prime contractor for the highly successful Nimbus. The division also is a major participant in NASA's Application Technology Satellite program.

As a major contractor in the Apollo program, MSD's work is primarily in the areas of ground support and test, including system reliability assessment and system integration assignments for NASA on the Apollo program.

At NASA's Mississippi Test Facility, the booster stages for the Apollo Saturn V launch vehicle were being tested in 1967. GE/MSD provided technical and test support, facilities management, equipment design, and laboratory design and operation.

The division's Mississippi Test Support Department, a company operation since 1963, reached full stature and maturity during 1967 with the routine testing of giant rocket stages becoming a reality. Formed in 1963 when NASA determined that private industry support would be acquired for the operation of the Mississippi Test Facility (MTF), the department attained full operational status in January 1967 by sending the first flight version of the Saturn V launch vehicle's second stage to the launch pad at Cape Kennedy.

This milestone was a culmination of tasks first assigned to General Electric as an extension of its Apollo support contract. The company moved swiftly in 1963 to form the department which is headquartered at Bay St. Louis. A facility of NASA's Marshall Space Flight Center in Huntsville, MTF is located on a 13,000-acre pine forest and marshland in southwestern Mississippi.

General Electric, as prime contractor to NASA at MTF, has a mission to provide activation and operational support in 2 vital areas: plant and test support operations and technical systems support. The division is principally responsible for services such as transportation, food, medical, security, fire and plant protection, mail, custodial services, insect and vegetation control, as well as test support functions such as data acquisition, handling and storage. It also handles propellants and high pressure gases, and high pressure water facilities among its technical interfaces with state contractors on site.

Major 1967 highlights, in addition to opening the year with the shipment of the first flight rocket stage, included General Electric support to NASA in a Family Appreciation Day for the U.S. Corps of Engineers in January and the arrival in February of the second flight stage of the Apollo/Saturn V (S-II-12) to be tested at the facility.

In March, the department assisted in the debut of the huge new S-1C test stand when a ground test version of the first stage of the Saturn V underwent a successful captive firing. This marked the fully operational status of MTF, since both first and second stage stands were capable of accepting and testing and certifying each for flightworthiness.

Saturn V first stage is lifted into test stand at the Mississippi Test Facility. GE provides NASA with operational support at the facility.

With a growing number of successful rocket firings under its belt, MTSD reduced personnel by some 300. This newest realignment brought the department strength to roughly 1,250 operational personnel by year-end. When compared with department totals as high as 1,800 people in mid-1965, the 1967 cutback reflected the fully activated and operational status of the company operation at MTF.

Meanwhile, test firings continued on a somewhat routine basis. By August, the fifth flight version of the first stage booster of the Apollo/Saturn V space vehicle was successfully static fired. By year-end, full duration, full thrust captive firings of rocket stages were being conducted regularly.

The year also saw the contract between NASA and the General Electric Company for operation, maintenance and support services at MTF extended for an additional 15 months, through September 1969.

The division's Re-entry Systems Department, headquartered in Philadelphia, employs about 6,000 people, of which nearly 2,500 are engineers, scientists or technicians.

The department in 1967 continued to maintain GE's responsibilities for the research, development, and production of vehicles and systems that survive re-entry into the earth's atmosphere or entry into the atmosphere of other planets to perform specialized space missions; support equipment and services for such re-entry systems and the development and application of advanced technologies necessary to produce such systems.

These product categories include such strategic re-entry systems as the Mark 12 for Minuteman III and the Mark 6 for Titan II; re-entry research and test vehicles such as the Re-entry Vehicle Test and Observables Program, the Re-entry F Program, and the family of Nike target vehicles; scientific recoverable satellites such as the Biosatellite; and lifting entry and planetary entry system programs. The department also continued studies of non-defense applications of aerospace technology in areas such as oceanics, water management, and operations research of educational and medical requirements.

The Re-entry Systems Department is headquartered at the Re-entry Systems Center adjacent to the University of Pennsylvania campus. It has other facilities located in Philadelphia as well as at Valley Forge. Total floor space of all the department's facilities grew to over 1,500,000 square feet, and included unique manufacturing areas, testing equipment, research laboratories, and data processing facilities.

Special chambers and test devices are capable of subjecting re-entry vehicles to virtually every condition found in space and on earth.

As General Electric's center for basic research and exploratory development in space-related sciences and technologies, the Space Sciences Laboratory continued work in environmental phenomena and interactions; plasma physics; high-temperature, high-performance materials and structures; and shock wave and superpressure phenomena.

Environmental phenomena and interactions are investigated experimentally and theoretically. Two significant advances made earlier by the staff in the physics of fluids were the first solution of the complete time-dependent equations for macroscopic fluid mechanics, namely the Navier-Stokes equations, and the first solution of the fundamental equation for microscopic fluid physics, the non-linear Boltzmann equation. Further applications were made of the new electron beam technique for flow visualization and diagnostics.

Extensive theoretical and experimental research continued on re-entry observables, with data on vehicle radiation signatures obtained through instrumented re-entry vehicle flights and through observations with ground-based and aircraft-borne instrument systems at the White Sands Missile Range and the Eastern and Western Test Ranges.

Electric propulsion, magnetohydrodynamic power generation, plasma diagnostics, and plasma-microwave interactions were the subject of experimental and theoretical research. Nonequilibrium MHD devices were being developed for operation at temperatures compatible with gas-cooled nuclear energy sources. A late 1967 achievement was the first demonstration of continuous electric power output, at a steady level of several watts, from a nonequilibrium MHD generator.

In space and planetary physics, studies proceeded on the space environment, the measurement of high-energy space radiations, molecule and surface interactions, and the polarization and reflection of light from earth and planetary surfaces and atmospheres.

In advanced materials and structures for aerospace applications, emphasis was placed on the development of fiber-reinforced metal and plastic composite materials, radiation-resistant polymers, dry film lubricants for high vacuum, electronic materials, and structural ceramics.

Mechanics investigations continued on hypervelocity impact; the failure modes of composites; the control and optimization of directional, specific, and bulk properties of composites; and the effect of parametric variations on their performance.

Shock waves in solids and hypervelocity particle impact phenomena were investigated theoretically and experimentally.

One of the high-pressure, high-temperature techniques developed uses a high-explosive blast tube that produces pulses that closely simulate those of maximum interest in missile vulnerability studies. Small high-explosive projectors accelerated metal, plastic, and ceramic particles with masses up to 0.05 gram to velocities of the order of 60,000 feet per second.

Spacecraft Department

The Spacecraft Department continued its work on unmanned satellites with several successful performances of its systems or subsystems in space.

Nimbus II, the meteorological observatory satellite, was launched in 1966, attaining its design goal of 6 months of successful operation in orbit. After more than 18 months in orbit, the spacecraft continued to perform well. Nimbus B, scheduled for launch in early 1968, passed through the design, manufacturing, and assembly stages at the Space Technology Center during 1967.

The flight of the first Orbiting Astronomical Observatory (OAO), launched in April 1966, was terminated after 2 days because of a power failure; however, the GE-supplied stabilization and control system successfully achieved the required pointing accuracy under star-tracker control. The third OAO flight stabilization and control system delivered to the OAO prime contractor met the increased pointing accuracy requirements of the Princeton experiment, 1/10 second of arc.

The Air Force's Gravity Gradient Test Satellite (GGTS), designed and fabricated at the Spacecraft Department and launched in 1966 into a near-synchronous orbit as part of a multiple payload on board a Titan III-C launch vehicle, proved the feasibility of gravity gradient stabilization at synchronous and near-synchronous altitudes. Its pointing accuracy, however, was off 15 degrees in a cross plane, apparently due to magnetic particle viscous dampers failure to lock. In 1967, GE was developing a new version of the magnetically anchored rate damper that is not subject to this failure mode.

The Spacecraft Department continued its development of gravity gradient attitude control and stabilization systems for several of NASA's Applications Technology Satellites.

During 1967, the Apollo Systems Department, headquartered in Daytona Beach, Florida, continued to support NASA on project Apollo chiefly in the areas of engineering services and checkout.

The department's major effort shifted to NASA's Kennedy Space Center where ASD was providing support to the Director of Design Engineering for electrical/electronic design management. The department is responsible for conducting design reviews, providing design changes for compatibility between equipments and acting as the electrical launch support equipment design manager for KSC.

As a direct result of experience in such programs as Automatic Checkout Equipment, Electrical Support Equipment and Electrical Launch Support Equipment, ASD developed major data management services and engineering services for the United States Air Force Computer Integrated Test Equipment (CITE), Airborne Integrated Data Systems (AIDS), and related work for the Apollo Applications Program, Voyager, Minuteman III, and the Atlantic

Undersea Test Evaluation Center (AUTEC). This work included various company developments in pattern recognition, data compression, transmission, storage, retrieval and display, and hardware packaging.

ASD was working with the Atomic Power Equipment Department on the design and development of a reactor-simulator to be used for training operators of a new nuclear power plant station near Chicago, Illinois. This system will electronically simulate the entire operation of a nuclear power plant and represent ASD's first major "spin off" into a growing non-aerospace and defense customer area.

The department also had a contract with the Wright-Patterson Air Force Base's Avionics Laboratory to study the feasibility and design parameters for the development of an electro-magnetic guidance systems evaluator, a new type of flight research simulator.

GENERAL PRECISION SYSTEMS INC.
(formerly General Precision, Inc.)

General Precision Systems Inc. continued during 1967 to establish itself as a major producer of electronic, electromechanical, optical and other precision-made products for the military, government and industry. The company consists of the Kearfott Group in Little Falls, New Jersey; Librascope Group, Glendale, California; Link Group, Binghamton, New York; and Tele-Signal Corporation, Woodbury, New York. General Precision employed at year-end more than 15,000 people in plant space of about 3,000,000 square feet.

General Precision Systems has won worldwide recognition for company achievements in Doppler, stellar and inertial navigation and guidance; analog and digital computation; simulation and training; weapons control and analog and digital communications. Its products range 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 uses a General Precision product.

The wide range of products offered by General Precision Systems Inc. to the overseas markets requires a large degree of flexibility to achieve the most effective means of meeting the various requirements of the many separate and distinct markets and satisfying the national interests of individual countries.

The products and services of General Precision Systems Inc. are 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 General Precision Systems products. This flexible operation allows the company to support the U.S. government overseas sales program.

During 1967, countries in Europe and Asia were providing an expanding market for these products and services, including navigation and simulation equipment for aircraft, and communications, computers and control equipment for a wide range of applications.

KEARFOTT GROUP

The acquisition of several major equipment contracts for navigation, guidance and airborne data processing received by the Kearfott Group in the latter part of 1966 was brought to a climax in 1967 when during the fourth quarter of the year 3 divisions of Kearfott Group received contracts for the A-7 Corsair II program. Kearfott Systems and GPL Divisions were awarded contracts for inertial and Doppler systems respectively by LTV Aerospace and Kearfott Products received an award from IBM Federal Systems for a solid state microelectronic analog-to-digital converter subsystem.

In mid-1967 Kearfott Systems Division was awarded a prime contract by Picatinny Arsenal (Army Munitions Command) for research and fabrication of a super caliber rocket-assisted projectile, including the responsibility for the liquid propellant, rocket engine and associated directional controls. Initially the company will produce 12 complete units for test firing and evaluation.

Prior to the A-7 award, the Kearfott Group had acquired contracts to build Doppler/inertial systems for the Lockheed P-3C. Kearfott Systems Division was also producing inertial equipment for the SRAM (Short Range Attack Missile), for the F-105 and for certain other general aircraft applications. Application of these concepts to the AMSA Program were also under study.

The Doppler radar developments of GPL Division complement the low-cost inertial accomplishments of the Kearfott Systems Division. Elements of the GPL lightweight HELIPATH Doppler set were combined with the HEREFLEX and VEREFLEX heading and vertical reference subsystems to provide the Doppler Heading Attitude Reference System for the AH-56A (Advanced Aerial Fire Support System) advanced helicopter. GPL Division was also producing a modified version of the HELIPATH Doppler radar for use in the huge C-5A transport, and a modified version of the APN-153 Doppler radar for use in the FB-111 variable geometry fighter bomber.

All of these efforts were supported by the development and production of navigation computers, analog-to-digital and digital-to-analog interface devices, servo components, indicators and control/display panels by Kearfott Products Division.

During 1967, Kearfott Products shipped engineering models of its advanced microelectronic analog-to-digital converters to NAR Autonetics for the F-111D, F-111K and FB-111 advanced avionics system. This contract and that for the A-7 Corsair II A to D converters marked Kearfott's emergence as a dominant producer of airborne conversion equipment.

Two very promising digital computers—the GPK-10 and GPK-20 were produced during the year. The GPK-10 low cost, compact general-purpose digital computer is an improved miniaturized version of the AN/ASN-24(V) computer employed in C-141 Star-Lifter aircraft. The GPK-20 computer is a digital, solid-state computer used with Kearfott's inertial system in the P-3C.

Also under contract to the Autonetics Division of North American Rockwell Corporation, Kearfott Products Division designed and was producing control/display panels for the Mark II avionics system used in F-111 and FB-111 aircraft. Unique electroluminescent displays were produced for the Apollo spacecraft.

Another Kearfott Products Division accomplishment for the year was the compact-when-packed and low-silhouette radio communications antennas. Under Army and Marine Corps contracts, Kearfott developed an extremely efficient, tunnel-diode, ferrite-rod antenna for manpack radio use and a variety of inflatable antennas for use in a jungle environment.

On the Lunar Orbiters of 1967, 2 Kearfott thrust-vector-engine control actuators helped provide precision control of the spacecraft, and Kearfott products participated in the series of successful Surveyor missions from launch to lunar landing. Three floated rate integrating gyros helped stabilize the Atlas booster, a digital computer performed the guidance calculations on the Centaur second stage and a strapdown triad of floated rate integrating systems provided precise attitude reference on the Surveyor craft.

LIBRASCOPE GROUP

Librascope Group is composed of the Products Division, Systems Division, and System's subsidiaries: Optics Technology Center and the Advanced Technology Center.

Systems Division designs and manufactures various size disc-memory systems for military, industrial, aerospace, and other computer manufacturers; woven-plated-wire memories for military and aerospace applications; encoders, integrators, flow computers, mechanical computing components, and other products for computing, data processing and communication systems.

Systems Division is the leading manufacturer of computing and data processing systems for shipborne antisubmarine warfare weapon-control systems; makes the largest mass memory systems for data processing used in industry, science, and governmental applications; various types of optical systems for aerospace, military and industrial uses; aircraft pilot sights and the Librascope L-193 head-up display flight-control system for military and transport aircraft.

Optics Technology Center produces sophisticated optical systems and instrumentation for aircraft, space vehicles, laboratory, land and sea applications. The center designed and fabricated the sextant and telescope navigation-simulation assemblies for the Apollo mission simulator, which is being used to train the nation's first moon astronauts.

Other products manufactured during 1967 were pilot sights for jet aircraft, photo-navigational view-finders for reconnaissance aircraft, airborne periscopes that display radar images of the target area, stereo-ranging systems to determine the range of missiles or airborne targets, digital celestial trackers for high-performance aircraft navigation, large screen military intelligence display systems, and automatic 70-millimeter copy camera systems.

The Advanced Technology Center is maintained by Librascope Group to assure that Librascope continues to be a leader in designing and producing computer components and peripheral equipment for land, sea, and aerospace applications. In 1967, the center had research projects on basic material structure, electro-luminescence, woven thin-memory planes, infrared and visible-light detection devices; neuron reactions and biochemistry, and acoustic-processing systems.

LINK GROUP

At the Link Group, the 1967 emphasis was on simulation of military aircraft, commercial aircraft and space missions, and the less glamorous but 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.

At Link's Systems Division, the 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, 707, 727, stretched DC-8 and other aircraft. New orders were received from commercial airlines for additional simulators for these aircraft and for the new 747 jet transport.

A new visual system for flight simulator training of day and night take-offs and landings in all types of weather was also developed. This new system, called VAMP or 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 first VAMP system will be used with a weapon-systems trainer that General Precision/Link is building for the military.

The company also produced a substantial number of simulators for various military aircraft programs including the F-4, F-111 and A-7 programs.

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 and in high schools and colleges.

NASA's astronauts will take their first "flight" to the moon long before their actual blast-off from Cape Kennedy. In fact, the Apollo and Lunar Module Mission Simulators will permit them to take the trip safely, and with remarkable realism, many times without ever leaving the ground.

The Group developed a growing business in information storage and retrieval devices, and is supplying high-accuracy, precision measurement equipment used in mapping operations and determining missile flight characteristics.

Other Link equipment was used by NASA to produce lunar and Mars photographs and by the Weather Bureau to reproduce data acquired by spacecraft for meteorological observation.

A television ground data handling system built by the company was used to produce the television picture and photographs of the moon's surface that were received as electronic signals from Surveyor spacecraft. These pictures disproved the "15-feet-of-lunar-dust" theory which had been claimed as a deterrent to a manned lunar landing.

The Link Ordnance Division attained new prominence in the fields of systems analysis, explosive systems, and the production of sophisticated electro-ordnance components. A number of components are employed in the Saturn, LM and Apollo Command/Service Module and are but a few of the many Link systems used throughout the ordnance, missile and aerospace industries.

The company's new Link Information Sciences Division is a computer applications organization that provides an array of software services to the military and other governmental agencies, as well as educational institutions, industries and businesses. The new division offers skills required for effective problem solution in areas concerning systems research and development, mathematical analysis, computer systems and applications programming, and facility management.

Link was also engaged in the production of industrial products and systems to control material on the move. The Industrial Controls Division is the world's largest supplier of safety-pressure gauges and controls and conservation fittings and gauges for tank farms and fluid blending facilities.

Similarly, there is hardly a blast furnace or steel mill that is not equipped with the company's controls to provide power, speed and accuracy for the steel-making process. Controls are also supplied to the non-metallic material manufacturers including producers of packaging and printing materials, paper, plastic fiber, and textiles.

The Link School Trainer Division sells and services the new Link Driving Simulator widely used in the Allstate Good Driver Trainer Program. The division also produces other educational products such as the computer oriented electronic learning systems.

Link's Transportation Products Division produces a complete line of traffic control devices.

TELE-SIGNAL CORPORATION

Tele-Signal is an engineering oriented, highly skilled electronics development and manufacturing firm capable of applications, original design, development and production engineering, practical design for prototype and long run, large quantity production of component units as well as complete systems for all phases of voice frequency telecommunications transmission including telephone, telegraph, data transmission, timing recovery, and remote supervisory control, monitoring and telemetering. Tele-Signal serves world wide markets, either through company owned and staffed offices or 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. The services offered by this division include planning and erection of plant facilities as well as the 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, private communications systems, and public utilities for transmission over wire lines, radio and satellite relay media. Products that Tele-Signal produced in 1967 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.

Tele-Signal grew during the year to more than 900 engineering production and administrative personnel. It occupied over 100,000 square feet in several plants located in the heart of Long Island, in close proximity to the source of ample production personnel and materials and rapid transportation facilities.

B. F. GOODRICH AEROSPACE AND DEFENSE PRODUCTS

B. F. Goodrich Aerospace and Defense Products, for the second consecutive year, in 1967, expanded capacity of its Troy, Ohio, plant for design, development, testing and manufacture of wheels and brakes.

The new expansion, a large one-story addition, was part of a program to double the company's capacity in this field. In 1966, a 50 percent expansion was completed.

In addition, distribution and service centers for aircraft tires and other aviation products were constructed near airports in Los Angeles, Kansas City and New York.

Work continued on production and testing on tires, wheels and beryllium brakes for the giant C-5A transport plane being built for the U.S. Air Force by Lockheed-Georgia.

In 1967, the company produced inflatable or retractable "seals" (for the Boeing 737 commercial jet airliner) that fill the gaps around retracted tires when the plane is in flight. Use of the seals inside each of the 2 wheel-wells saves about 150 pounds over commonly used wheel-well doors. Development and production of the seals marked the first time any American plane has been so equipped.

The company, working under a subcontract from Sperry Gyroscope, produced the largest rubber product ever molded in one piece—a keel-mounted rubber dome to house and protect advanced sonar equipment in U.S. Navy destroyers.

B. F. Goodrich Aerospace and Defense Products made the largest rubber product ever molded in one piece, a 34-foot sonar dome for the Navy.

The sonar dome—34 feet long, 11 feet wide and 8 feet high—weighs more than 8 tons. It is made of specially developed "sound transparent" rubber which possesses acoustical properties similar to sea water, enabling water-borne sound waves to pass through the dome with minimum distortion for clear pickup by sonar equipment.

"Nofoul" rubber was developed to keep underwater surfaces free of barnacles and other marine organisms and to prevent erosion and damage from cavitation. Tests conducted by B. F. Goodrich, in cooperation with the U.S. Coast Guard, in waters off Key West, Florida, showed that the specially compounded rubber material remains effective four times longer than other types of anti-fouling materials.

Advanced performance testing of "run-flat" aircraft tires was continued in 1967 with simulated high-speed test landings conducted in cooperation with the U.S. Air Force.

Award of contracts to B. F. Goodrich were announced for tires, wheels and brakes for the Lockheed YF-12A, a supersonic, high-altitude interceptor and for the North American OV-10A, an observation and reconnaissance aircraft for use in limited warfare and counterinsurgency operations.

Special lightweight disk brakes and high-flotation, low pressure tires were also developed for use on the OV-10A for landings on remote semi-finished runways in Vietnam and in other jungle and inaccessible areas.

Liquid-cooled brakes (LCB), manufactured and tested in 1966 by B. F. Goodrich, were put into continued testing operations on a United Air Lines jet aircraft used for pilot training. These brakes employ fluid to absorb and transfer heat from the brake lining and wheel assembly, making possible heat reductions up to 1,500 degrees on the brake lining surfaces. The heat exchange apparatus is made by Harrison Radiator Division of General Motors, Lockport, New York.

GOODYEAR AEROSPACE CORPORATION

Significant scientific and technological advances in space, military and commercial activities, plus continuing diversification, were accomplished by Goodyear Aerospace Corporation in 1967.

As the space and defense arm of The Goodyear Tire & Rubber Company, Goodyear Aerospace increased production levels at its headquarters plant in Akron, Ohio, and at its Arizona Division at Litchfield Park. Production got into full swing at its newest facility, a reinforced plastics plant at Jackson, Ohio.

As the war in Southeast Asia intensified, so did the company's contributions to the nation's defense efforts.

Still at the top of the production list was the Subroc antisubmarine missile, for which Goodyear is prime contractor. Now deployed in the U.S. Navy's fleet of nuclear-powered attack submarines, the missile gives the nation a weapon capable of striking hostile submarines with a nuclear punch at long range.

Also in the area of undersea warfare, the company produced tankage systems for the Mark 48, the newest Navy torpedo under development.

Goodyear Aerospace also developed and unveiled a new modular intelligence system which was speeding up the handling of air reconnaissance information on airstrips throughout the world and especially in South Vietnam. Known as WS-430B, the 22 interconnected units provide the primary functions of processing, printing and interpreting the sensor records from reconnaissance aircraft. In addition, the system provides the support functions of chemical mixing, maintenance, film storage, titling, editing and inspection.

The units can be airlifted in a matter of hours to forward airstrips in combat areas anywhere. Each laboratory or shelter, fully equipped, can be transported by a C-130 type aircraft, carried by helicopter, towed over roads or transported by ship.

As America's need to airlift more and more material to Vietnam increased, the production schedule was accelerated during the year for air cargo pallets. These are made of a lightweight aluminum and balsa wood sandwich material called Bondolite. The pallets, weighing 300 pounds each, are capable of handling 5-ton loads and are part of the U.S. Air Force's standardized cargo handling system. They were coming off Goodyear production lines at the rate of 2,000 per month by the end of 1967, double the rate at the beginning of the year.

Also during 1967, Goodyear Aerospace was selected by The Boeing Company for its "prototype build and qualification program" for the 747 lower deck baggage and cargo containers.

The delivery of center wing sections for the Boeing 707 and 720 series jets moved on schedule in the Arizona plant as tooling and facility preparation was completed for assembly of the center wing sections and main landing gear doors for the 747.

Installation of a two-story tall, highly automated vertical stretch machine for producing thin-gauge stretched acrylic plastic sheets at its Akron facility enabled Goodyear Aerospace to strengthen its position as a major supplier of aircraft canopies, windshields and windows.

In Akron, the company produced canopies for the F-4, A-6A, and EA-6B aircraft and windshields or windshield sections for the 747, P-3 and F-228. From Arizona production lines came canopies for the A-7A, F-5A, AT-37D and A-37B aircraft, windshields for the UH-1 helicopter, and windows for the 707, 720, 727 and 737 jet airliners.

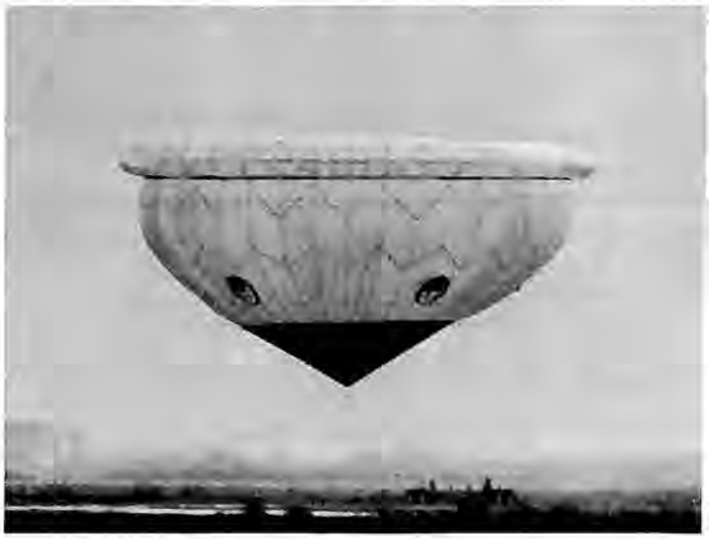
The company continued to produce lightweight, nonmetallic armor plate which has been providing protection for crews of helicopters, reconnaissance aircraft and patrol boats in Vietnam.

Goodyear continued to develop and manufacture sophisticated weapons systems and flight simulators to train military pilots. Most notable of these was an Aircraft Carrier Landing Trainer to teach Navy pilots to land their jets on the rolling decks of an aircraft carrier. Scheduled for delivery to the Navy in March 1968, the trainer has been described as the latest state-of-the-art in visual presentations. Other simulators in production in Akron included an emergency ship handling trainer and a carrier control approach trainer.

Highlights in the field of space included Goodyear's role in the successful mid-air retrieval of the maneuverable reentry PRIME SV-5D lifting body near Kwajalein Island. The company developed a sophisticated recovery system which included a supersonic Ballute (balloon-parachute) for high-speed, high altitude stabilization, which was followed by a specially designed lightweight parachute. The aerial retrieval worked flawlessly, so a backup floatation system proved unnecessary.

More than 30 successful recoveries utilizing the Ballute were made of the ALARR rocket, the high-altitude Air Force system for sampling radioactive debris. Also, ultra-light meteorological Ballutes were used in more than 100 high-altitude probes which recorded wind velocity, wind direction and other data in the upper atmosphere.

A successful test was made at NASA's Wallops Island test facility of a 30-foot Ballute to determine its feasibility as a space brake to decelerate a spacecraft entering the thin atmosphere of Mars.



NASA tested this Goodyear-built 30-foot Ballute, an air-filled fabric bag with potential for slowing a spacecraft.

Goodyear Aerospace began construction of a 30-foot structural model of a space-erectable antenna reflector for the F and G versions of the NASA's Applications Technology Satellite. It was to be available for testing in mid-1968.

The company was building 4 expandable airlocks for evaluation in the Apollo Applications Program. Built for the Air Force, the airlock was designed to eliminate repeated compression and decompression of an orbiting laboratory each time an astronaut enters or leaves the orbital workshop.

At its Arizona Division, the company continued to deliver the country's most advanced side-looking radar system with Air Force improvement programs in process to upgrade the system. Two major radar development programs also were received for highly advanced future systems.

Minuteman II missile transporters, completed in 1966, were returned to the Arizona Division for major modification to carry the heavier and improved *Minuteman III*.

A new plastic laminate entered production in Arizona as crash resistant fuel tank backing board for the F-105 aircraft while other reinforced plastic structures for aircraft and aerospace applications continued in production.

In July, F. Vincent Prus became general manager of the Arizona Division succeeding Morris B. Jobe who advanced to corporate vice president at the Akron headquarters.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION

In 1967, Grumman entered its 38th year with continued growth, record sales, and further expansion of its facilities. Research and development played an increasingly important part in the company's growth and Grumman continued work on several new aircraft programs.

At year-end, Grumman employed 34,000 people in over 30 plants. During 1967, about 5,000 new employees joined the company. The Savannah, Georgia, and Garden City, New York, facilities, for production of the corporate Gulfstream II and the F-111, respectively, added more than 500,000 square feet of workspace. A test facility at West Palm Beach, Florida, was constructed for testing of ocean vehicles.

The corporation produced a variety of military and civilian aircraft, Apollo Lunar Module flight and test spacecraft, an Orbiting Astronomical Observatory, and remained very active in ocean technology. Five model types of aircraft were in production and in service in Southeast Asia.

The A-6A Intruder established a formidable record with units of the Navy and the Marine Corps. This attack bomber was the only all-weather aircraft in service in Vietnam; it features exceptional strike potential due to its large payload capacity and sophisticated electronic capability. By the end of 1967 more than 250 of these planes had been manufactured.

The last of the unique E-2A Hawkeyes was delivered to the Navy in 1967. This early warning aircraft continued to prove its effectiveness in Vietnam, performing a great variety of missions. In the meantime, the research and development effort on the E-2B continued.

The Army's Mohawk surveillance aircraft continued in production and a modification program paralleled the effort. In addition, work on the OV-1D was in progress. All 3 versions of the OV-1 were in service in Vietnam as the "eyes in the skies" of the Army.

The S-2 Tracker, an antisubmarine warfare aircraft, has been in production since 1952 and has undergone 4 modifications, the latest of which is designated the S-2E. A total of 1,500 Trackers has been built, including 38 in 1967. During the year, Grumman also delivered the first S-2E to the Australian Navy; that contract called for a total of 14 aircraft.

The C-2A Greyhound Carrier-Onboard-Delivery aircraft continued to support the ships of the Seventh Fleet with deliveries of vital supplies ranging from typewriter ribbons to jet engines. The aircraft was also seeing service as a medical evacuation aircraft.

With 5 model types no longer in production (the EA-6A Intruder, the HU-16 Albatross, the E-1B Tracer, the C-1A Trader, and the TF-9J Cougar), the company had 10 different types of aircraft operating in 1967 in the South China Seas.

The F-111 program was active in all phases with production of aft fuselages in full swing at the new Garden City facility. Tests of the F-111B and the Phoenix Missile system continued and contract awards for additional procurement of Air Force F-111As and Navy F-111Bs were announced during the year.

The year saw the first flight of the A-6A bombardier/navigator trainer known as the TC-4C. Based on the turboprop Gulfstream I, the TC-4C was produced in record time. A contract for 9 of these aircraft was awarded by the Navy.

Nine Gulfstream Is (including TC-4C) were delivered during 1967, bringing to 185 the total delivered since the late 1950s.

Production of the world's fastest and longest range corporate jet aircraft, the Gulfstream II, continued at both Bethpage, New York, and Savannah, Georgia. FAA certification was received in October 1967, and deliveries began shortly thereafter. By year-end, more than 70 firm orders had been received for this $2,500,000 aircraft.

Grumman's durable Ag-Cat continued to be a high seller in the agricultural crop-dusting market. Over 440 have been produced since 1958, and in 1967 the newly certificated Super Ag-Cat began coming off the assembly lines.

The Apollo Lunar Module (LM) program continued on schedule. Grumman delivered the last of the Lunar Test Articles, LTA-8, to the Manned Space Center in Houston. LM-1, the first unmanned flight vehicle, was delivered to Kennedy Space Center for launch into earth orbit early in 1968. LM-1 was to test the ascent and descent engines of the Lunar Module. LM-2 and LM-3 were nearing completion at the Bethpage facility.

The second Orbiting Astronomical Observatory was delivered to the Goddard Space Flight Center in September 1967. NASA planned to launch this unmanned satellite in 1968. Two more OAO's were scheduled to be delivered.

In the Ocean Systems Department, work on the mesoscaph (PX-15), in cooperation with Dr. Jacques Piccard, continued. The craft's mission will be a 4-to-6-week drift in the Gulf Stream with a crew of 5 from Miami, Florida, to Nova Scotia. The primary objective of the mission is to study underwater phenomena and to conduct scientific experiments.

The military hydrofoil gunboat, the USS *Flagstaff*, was expected to be launched early in 1968. The 88-passenger, 50-knot commercial hydrofoil, *Dolphin*, also built by Grumman, was in active service between Las Palmas and Tenerife in the Canary Islands.

GYRODYNE COMPANY OF AMERICA, INC.

During 1967, Gyrodyne Company of America continued to produce QH-50D pilotless helicopters and supporting equipment for the U.S. Navy's DASH Weapon System. The all-weather fiberglass rotor blade developed by Gyrodyne became standard equipment on this helicopter. This new blade weighs approximately 40 percent less than the wood laminated blade formally used and represents a cost reduction of approximately 30 percent.

During the year further advances were made in the utilization of the drone for military applications other than antisubmarine warfare, for which it had originally been designed. Successful flight demonstrations were made to the U.S. Marine Corps and the U.S. Army. Day and night television surveillance and reconnaissance, night illumination, smoke screening, cargo deliveries and air-sea rescue missions were performed. Additional tests to be conducted in the near future include the installation and use of a minigun and other weaponry to show the complete versatility of this pilotless vehicle. Military jeeps equipped with remote control instrumentation, TV monitor and video tape recorders were utilized to provide a mobile ground station. Similar control equipment installed in piloted helicopters resulted in the availability of a multi-service system whereby these drones can be launched at sea or on land and the remote control of all flight regimes can be transferred from one station to another. Auxiliary fuel tanks were installed to increase the normal flight range of the QH-50D from 1.5 up to 6 hours depending upon the payload trade-off between weapons and fuel.

In April 1967 the initial deliveries of QH-50 helicopters, supporting equipment and training aids was made to the Japanese Defense Agency. Additional production orders were received later in the year and deliveries, in limited quantities, were to be continued through 1968.

Peaceful applications of the QH-50 were successfully tested. The Atomic Energy Commission utilized the drone, equipped with a television camera and sensing devices, to hover over the underground nuclear detonations, "Greeley" and "Mercury" sites, to collect "real-time" scientific data and record the ground zero effects on video tape. Further AEC tests were planned.

The company continued to forge ahead in other important areas. Gyrodyne Petroleum Inc., a wholly owned subsidiary, continued to invest in oil and gas explorations. At year-end the company held varying vested interests in more than 200 producing gas and oil wells.

One program was the Rulison Project in which the company held a 16 percent interest. The Rulison field located in Colorado is estimated to contain one of the world's largest deposits of natural gas. Future plans call for the Atomic Energy Commission and private enterprises to endeavor to economically release this gas via an underground chimney created by means of underground nuclear explosions.

Flowerfield Properties Inc., another wholly owned subsidiary, was continuing participation in the development of a large citrus grove in Florida.

HARVEY ALUMINUM

During 1967 progress at Harvey Aluminum was impressive: a rolling mill in production at Lewisport, Kentucky; start of operations at the alumina plant, U.S. Virgin Islands; commencement of production at Alnor, Karmoy, Norway; advances in the mining operation at the Republic of Guinea, Africa; and the construction of a petroleum coke mill on the Pacific Coast. A location for a new reduction plant in the Northwest was being negotiated.

At the corporate Research and Development Center, Harvey engineers and supporting personnel continued work in the development of various alloys and product applications. The company's research activities in the field of metallic-matrix composites accelerated rapidly during the year. The words "composite metal" promise to become commonplace in the decade of space exploration ahead, since future space age travel by jumbo jet transports and other sophisticated space vehicles will demand superstrength lightweight materials.

The company remained in the forefront in the development of these sophisticated materials and was selected as a principle supplier of metallic-matrix composites for use in both airframe and engine applications. Harvey techniques will allow production of composites in the form of sheet, clad wire and plate. Company processes for producing metallic-matrix composites were well advanced and the metals produced were consistently superior to those made by other means.

Working with the Special Metals and Aluminum Divisions, the company continued its program of developing a method of cold drawing titanium shapes. The result of this effort will be the production of thin titanium shapes hitherto unavailable for commercial use. This program has great application in the supersonic '70s.

The year was highlighted by increased participation in major aerospace programs, notably the C-5A transport and the 747 commercial jet. Each of these represents the largest aircraft of its type ever built, and the company is a substantial supplier to both programs. Working on the development of the C-5A, the company produced considerable tonnage of extremely close tolerance extruded shapes.

HERCULES INCORPORATED

Major milestones in the development of Poseidon took place in 1967 as the first and second stages were successfully static test-fired at Hercules Incorporated's Bacchus Works near Salt Lake City. The Poseidon propulsion development effort was being managed by Hercules; Hercules was working alone on the second stage and with Thiokol Chemical Corporation on the first stage.

A number of successful firings of the launch eject system for Poseidon also were accomplished at Hunter's Point, California. The launch gas generator was developed by the Chemical Propulsion Division of Hercules and Westinghouse Missile Launching and Handling Department, Sunnyvale, California.

During the year, Hercules was selected as one of 2 propulsion contractors to perform development work on the propulsion system for Sparrow, the air-to-air tactical missile used by Air Force, Navy and Marines. Work on the contract began in late 1967 at Allegany Ballistics Laboratory, Cumberland, Maryland, utilizing the new composite solid propellant facility there. The company's highly advanced composite solid propellant, Hercopel, will be used for the project. The development of Hercopel was announced in 1967 after 6 years of work by company scientists.

Hercules continued its research and development activities with caseless ammunition at Kenvil, New Jersey, where a specially-built lab was set up and equipped, and at Bacchus. The company was doing work on one government contract, completed work on a project for one industrial firm and began a development contract with another firm. The company anticipated a good future for caseless ammunition and expected it to make inroads in the ammunition industry. Much of the success in this area depends on the development of suitable weapons to fire the ammunition.

Hercules efforts in filament winding continued strong with good results in the use of boron and other advanced materials for application in a number of new composite items.

During 1967 the company provided propulsion units for Polaris, Honest John, Minuteman, and other defense missiles as well as motors for many and varied space applications. This included precision motors used to place communication satellites into orbit. Hercules-produced motor chambers also were involved in the Athena Program.

Research and Development activities on the propulsion system for the Sprint vehicle continued at Allegany Ballistics Laboratory. Performance requirements of Sprint, part of the Sentinel System, proved one of the most challenging assignments ever undertaken by Hercules scientists.

HONEYWELL INC.

Honeywell's diverse capabilities in research, development and production contributed to the advancement of numerous United States space, missile and aircraft programs in 1967.

Highlights of the year in space included a continuation of the company's broad participation in all manned and most unmanned space projects through leadership in guidance and control systems, or systems integration. Notable among them were Apollo, Centaur, Scanner and Orbital Scanner, Mariner, Apollo Applications and several classified programs.

Key aircraft activities included the development of new concepts in air-delivered weapons, in reconnaissance systems, in automatic flight controls and in satellite navigation techniques. Production of several avionic products, especially air data computers and radar altimeters, rose to meet increased defense and commercial orders.

Honeywell's 2 aerospace-oriented divisions are part of the company's Aerospace and Defense Group, which grew substantially in 1967 to 19,300 persons. Plant space increased as well, by 430,000 square feet, mostly at group headquarters in Minneapolis.

A detailed look at major aerospace activities, by division, follows:

AEROSPACE DIVISION

Minneapolis engineers of the Aerospace Division designed the stabilization and control system that performed successfully on the spectacular flight of the Apollo 4 spacecraft atop the first Saturn V launch vehicle from Cape Kennedy in November.

The plant also built the fuel probes for the Douglas S-IVB rocket that makes up the third stage of the giant Saturn V, and the second stage of the Saturn I. The Minneapolis facility furnishes a large proportion of the cockpit instruments, switches and meters for the Apollo Lunar Module, which was scheduled for its first test flight in early 1968. At mid-year, more than $1,000,000 in new orders was received from the National Aeronautics and Space Administration's Marshall Space Flight Center for meters and switches to be used in the Apollo Telescope Mount, a scientific experiment to be conducted on Apollo missions after the lunar landing.

Development continued throughout the year on the attitude control and experiment platform scan control subsystems for 2 Mariner spacecraft to be launched in 1969 towards Mars. The work is being done under a $6,000,000 contract with Jet Propulsion Laboratory, Pasadena, California.

Inertial guidance systems built at St. Petersburg, Florida, for the Atlas-Centaur launch vehicle continued to perform virtually flawlessly on the 4 Surveyor flights during 1967. On each launch, the Honeywell system aimed the Centaur's soft-landing payload so accurately that no mid-course correction would have been necessary for any of the spacecraft to hit the moon. NASA hailed the guidance accuracy of one of the flights as "the best ever achieved" by an inertial system (one that requires no ground aids to tell it where it is in space).

Contracts exceeding $9,000,000 were booked for additional Centaur guidance systems during the year as NASA assigned the hydrogen-powered second-stage rocket to launch one Orbiting Astronomical Observatory (OAO), 2 Applications Technology Satellites (ATS) and the next 2 Mariners.

Meanwhile, Florida space engineers developed and delivered an advanced inertial guidance system for laboratory evaluation by NASA's Manned Spacecraft Center, Houston, Texas, under a $550,000 award. The system consisted of a special sensor block employing gyroscopes strapped-down rather than gimballed to the body, and a Honeywell SIGN-III digital computer.

Under another award, from the Applied Physics Laboratory at Johns Hopkins University, an airborne system was developed to enable accurate position information to be derived from Navy navigation satellites. The new navigation aid, suited for shipboard as well as aircraft use, consists of a Doppler signal receiver, lightweight computer and control-display unit.

In the commercial aircraft field, Honeywell booked record orders for air data computers, mostly from

Honeywell's Aerospace Division started volume production of air data computers, such as the one displayed by field service engineer, designed for the Boeing 700 series transports.

Boeing for use on 707s, 727s, and for the first time, 737s. The instrument helps reduce the pilot's workload by automatically converting air temperature and pressure data into form used by many other cockpit systems.

The Aerospace Division won a contract to produce fuel measurement systems for the Boeing 747. An agreement was signed with Smiths Industries of London to jointly pursue the marketing and production of automatic flight controls for future commercial jets, such as the Lockheed 1011, McDonnell Douglas DC-10 and British Aircraft Corporation BAC Two-Eleven.

In the military aircraft business, the company continued development of the automatic pilot, fuel gauges and engine pressure ratio instruments for the giant Air Force C-5A Galaxy being built by Lockheed-Georgia. The 5-axis autopilot and pilot's helmet sight for the Army AH-56A Cheyenne helicopter moved into limited production. Radar altimeters were sold for the first time for the Navy SH-3D antisubmarine helicopter and the Air Force B-58 Hustler.

It was disclosed during the year that many key avionic systems of the Air Force's Mach 3 high-altitude SR-71 and YF-12A aircraft were provided by Honeywell, including autopilot, air data computer, fuel gauges and the inertial navigator (for the YF-12). Overseas, the Swedish SAAB J37 Viggen fighter, equipped with a Honeywell-designed autopilot, entered the flight-test stage. Preliminary design began on the F104S autopilot for the Italian Air Force.

The Air Force successfully flight tested a highly accurate prototype inertial navigator using electrically suspended gyros aboard a C-124 at Wright-Patterson Air Force Base, and began testing a new concept in in-flight maintenance of reconnaissance equipment aboard an RF-4C at Shaw Air Force Base.

Company engineers undertook a study of direct lift control for the Air Force, looking into the possibility of changing the attitude of an aircraft in flight without changing the pitch. The concept is considered applicable to many future commercial and military flight controls.

Technology was advanced in several other aerospace areas during the year, including communications devices, plated-wire computer memories and microminiaturized electronic circuits, for the immediate needs of government and commercial customers.

SYSTEMS AND RESEARCH DIVISION

Longer-range requirements of the military and space agencies were studied for solutions—and eventually new products—by the Systems and Research Center in Minneapolis and the Honeywell Radiation Center in Boston.

During 1967, the Minneapolis technical center completed an intensive study of the earth's horizon and recommended to NASA the implementation of a new satellite program to define globally a potentially more reliable space reference. The Orbital Scanner project calls for the launching of 2 precision-instrumented satellites in the early 1970s to map an infrared layer of the horizon for up to one year. Six companies were named to Honeywell's team for the prime award competition.

Several significant projects in the expanding aerial and ground reconnaissance field were begun or completed by Honeywell scientists and engineers, while research continued in infrared detection materials and arrays.

Among programs won were an airborne visual target acquisition and reporting system employing the Honeywell helmet sight, an advanced mapping subsystem, a helicopter real-time display and a tank-mounted infrared night vision system. Work was completed on a 2 year experiment for the Air Force that investigated the effects of weather on the resolution of obliquely-aimed aerial reconnaissance camera photographs.

Initial success of the laser gyroscope in 1966 was exploited in 1967 with the receipt of contracts for navigator-type laser gyros. Laboratory testing began on small laser rate sensors for advanced missile autopilots. A technique for stabilizing 2 carbon dioxide lasers was evolved in the laboratory as a step toward deep-space communications devices.

Research and development of fluidic (no-moving-part) devices and systems moved forward on a number of fronts. As one example, a fluidic temperature probe was successfully flown aboard the X-15 that set a world speed record of 4,534 miles an hour in October, measuring temperatures of up to 3,000 degrees Fahrenheit.

Contracts were received from the Navy for a pneumatic helicopter autopilot and from the Army for a hydraulic-fluidic helicopter yaw damper. Both systems, first of their kind, were to be flight-tested in 1968. Other work for jet engine control and natural gas pipeline control applications progressed well.

Electro-optical research and development performed in Boston continued to expand. A $1,200,000 contract was received from NASA for fine sun sensors for the Apollo telescope mount. Magnetometers for the Apollo lunar surface experiment package (ALSEP) were delivered to NASA's Ames Research Center.

A new laboratory of 85,000 square feet was begun in Lexington, Massachusetts, to bring together all of the Radiation Center's radar, laser, infrared and ultraviolet research work under one roof late in 1968.

HUGHES AIRCRAFT COMPANY

To the employees of Hughes Aircraft Company, 1967 was the Year of Surveyor. At least in the glamour part of Hughes activities—space—Surveyor dominated the scene with 3 successful soft-landings out of 4 attempts.

As in 1966 when Surveyor 1 electrified the world by making a perfect soft-landing on the moon on the first attempt of the U.S. space program and made 11,500 photographs of the lunar surface, 1967 also became a "Surveyor year" when Surveyor 3 landed in April, Surveyor 5 in September and Surveyor 6 in November.

As remarkable as the soft-landings themselves were the performances of the scientific experiments carried by the 1967 Surveyor spacecraft.

Surveyor 3 carried aboard a "lunar back-scratcher" —a claw-like scoop that scratched, furrowed and dug into the moon's crust to increase man's knowledge of the lunar soil. The scoop, called a surface sampler, reached out 5 feet from the spacecraft and dug as deep as 18 inches into the moon over a 24-square-foot area, gathering samples of the soil for Surveyor's TV camera to scrutinize.

In July, Surveyor 4 suddenly lost contact only 2½ minutes from touchdown.

Surveyor 5 made a hair-raising landing September 10 against 1,000-to-1 odds after a team of Hughes and Jet Propulsion Laboratory engineers abandoned computers and whipped out pencils for a 40-hour skull session of calculation to save the spacecraft from impending disaster due to a helium leak. The difference between catastrophe and success at one point was only 2/10 of a second, but they reprogrammed the mission to bring off an unorthodox landing that was a complete success.

No. 5 carried a miniature analytical laboratory, a gold-plated box the size of a jewel case called an alpha scattering device. Its 6 Curium-242 radioactive sources bombarded 4 square inches of the moon with streams of alpha particles to analyze moon soil elements. The device proved to scientists that the moon contains basalt, similar to the composition of many areas of Earth, indicating a formation caused by volcanic eruption.

Hughes technician checks alpha-scattering device carried aboard the successful Surveyors 5 and 6, built by the company for NASA.

This feat was termed by NASA as the most important contribution of the Surveyor program with the possible exception of the soft-landings themselves.

Surveyor 6 made a perfect mission to soft-land November 9, also carrying the alpha scattering instrument and the magnet, and began almost immediately to transmit quality photos from its landing spot in the Central Bay region. Only a few hours after this success, a NASA official said that "it can truly be said that the Surveyors have served as the unmanned pathfinders that have built a bridge to the moon for man."

Hughes built 7 Surveyors for NASA under direction of JPL to explore the moon as a forerunner to the Apollo manned landings. The seventh and last Surveyor was scheduled for launch early in 1968.

But dramatic as the Surveyors were, they were far from being the only major achievements of 1967 for the Hughes Aerospace Group.

The Space Systems Division provided 3 more Intelsat 2 synchronous-orbiting communications satellites to the Communications Satellite Corporation (COMSAT), serving as manager for a 56-nation consortium. Two were launched to positions over the Pacific in January and September, and one over the Atlantic in March. The new "space switchboards" went to work to provide communications between the U.S. mainland and Hawaii, Japan and Australia, and between the U.S. and Europe. They also will support the NASA Apollo astronaut program and provide communications between the U.S. and Southeast Asia for the Department of Defense.

In May Hughes was awarded a $300,000 feasibility study contract for the design of a multipurpose communications satellite that would be used in 1969 for intercontinental and regional service by the International Telecommunications Satellite (INTELSAT) Consortium. The Intelsat 4 multipurpose satellite would have about 10 times the capacity of the Intelsat 3 generation planned for 1968 launch.

Within the Hughes space labs, possibly the most exciting satellite project to come along since the birth of the space age is the ATS—Applications Technology Satellite. The first ATS of 5 which Hughes was building for NASA was launched in December 1966, but 1967 saw 2 more put up, one in April and another in November.

During the April ATS launch, the satellite was unable to achieve a synchronous orbit, because the second stage rocket failed to restart. However, the ATS spacecraft are virtual "smorgasbords" of science, carrying a payload of many different experiments, so this ATS still was able to complete many parts of its mission and return valuable data to Earth.

In November, the third ATS in the series enjoyed a perfect launch and quickly went into its synchronous orbit over the mouth of the Amazon river above Brazil. It carried 18 experiments including means to warn man of storms, flood and drought, to find downed astronauts, and even to track migrating game through forest or jungle.

The ATS orbiters are designed to improve man's ability to cope with his environment. Someday, Hughes scientists predict, they will result in better communications, better air navigation methods, more accurate long-range weather forecasting, and avoidance of crop losses and flood damage.

Hughes also was building the biggest communications satellite ever to be constructed. The giant experimental tactical communications spacecraft, being built under direction of the U.S. Air Force, will contain a 5-element antenna array consisting of UHF antennas, each nearly 8 feet long.

Another development in the satellite field—one which may affect many future satellites—was revealed in October at the annual AIAA meeting, when a Hughes engineer demonstrated a new working Gyrostat concept that presages giant satellites never before considered possible.

Because Anthony J. Iorillo said "it ain't necessarily so" to a long-held theory of satellite design, he began studies that apparently rendered the old theory obsolete, paving the way for future satellites to spin about their minor axes with never a wobble while some parts spin and others remain stationary.

Major performance advantages cited are:

- Satellites can be made much larger, more powerful, longer lasting and efficient.
- While a portion is spinning for stabilization, important payloads, such as antennas, lasers or telescopes, can remain stationary or be moved to point them precisely in any direction.
- Pointing accuracy could be so great that one antenna could be pointed at New York and another at Los Angeles, for example, to provide point-to-point satellite communications for the first time.
- Such satellites could continuously track and relay signals from other satellites or manned space capsules.
- The new satellites can be of elongated configuration, virtually unlimited in size. Because they no longer must be of squat shape, they can use the full volume of the booster shroud for the first time.

In the company's work on the Phoenix missile program for the U.S. Navy, a major milestone was reached in March when the first launch of a guided Phoenix missile from an F-111B interceptor scored a hit. In the test conducted off the California coast near the Naval Missile Center at Point Mugu, the Phoenix system located a small jet target drone on radar, locked-on at long range and scored the hit. The significance lay in the fact that the hit demonstrated the successful integration of the Phoenix with the F-111B aircraft into a complete working weapon system. In previous firings the Phoenix missile had been launched from an A-3A Skywarrior equipped as a Phoenix test-bed.

Another Hughes missile, TOW (for Tube-launched, Optically-tracked, Wire-guided missile) was successfully fired from a UH-1B Army helicopter, scoring hits on moving and stationary targets more than a mile away during tests at the Army Missile Command, Redstone Arsenal, Alabama. The accuracy was partly the result of a Hughes-developed stabilized gun-sight which permits the gunner to hold a bead on a target even while the pilot is taking evasive maneuvers to avoid ground fire.

In another 1967 development, Hughes and ASAF scientists reported that space "blow-outs" would no longer be a problem because of a new self-sealent that could plug the punctures caused by micro-meteoroids colliding with spacecraft during lunar or interplanetary journeys. The sealant consists of fast-reacting chemical materials that could be used in multi-walled honeycomb structures mounted in the walls of spacecraft. Hughes scientists said the sealant shows great promise for possible use in space-suits and expandable space structures, such as lunar shelters and escape capsules, as an important life-saving device.

At Hughes Aircraft's Ground Systems Group in Fullerton, California, the group's new "Missile Mentor" electronic air defense system made news in 1967 when it was unveiled in January by the U.S. Army. The system coordinates the firing of surface-to-air missiles in the defense of American cities faster, more reliably and less expensively than the Army's older missile master systems, which the new complexes replaced. The new Missile Mentors were placed in 24-hour operation during the early part of 1967 at strategic U.S. sites to protect the major population centers of New York–Philadelphia, Detroit–Cleveland, Washington–Baltimore, Chicago–Milwaukee, Pittsburgh, San Francisco, Los Angeles, Boston and Miami.

In May, 10 250,000-watt radio transmitter units were shipped to a site in the Philippines, where they were being readied to start beaming Voice of America broadcasts for the first time through the bamboo curtain of Communist Asia in January 1969. The transmitters were built at Hughes-Fullerton under a 3-year, $2,400,000 U.S. Information Agency contract.

Hughes-Fullerton achieved 2 significant milestones during 1967 in the production of its Manpack Combat Radio. In March the company delivered the first of its new 16,000-channel models to the armed services; they were improved models of the earlier 10,000-channel versions. In October, the firm's 2,000th Manpack was turned over to the U.S. Army. The manportable radios were being used throughout Vietnam and elsewhere.

Another of the company's Mark 1B satellite communications ground link terminals—the ninth—was dedicated in Okinawa in October ceremonies. The latest ground station was built for the Army's Satellite Communications Agency (SATCOM) for sending and receiving voice and teletype messages through any of the 19 Orbiting Department of Defense satellite relays that circle the earth above the equator.

In September, Hughes-Fullerton disclosed design and performance details for a "big eye" the company was building for the Navy—the only air-searching, automatically-tracking radar-computer system to be used in what has been described as the most sophisticated antisubmarine warfare training station in the world. The system will locate and track automatically surface and airborne targets within part of the Navy's Pacific Missile Range Facility, called Barking Sands Tactical Underwater Range (BARSTUR). The station was being built on the island of Kauai in Hawaii and was expected to become fully operational early in 1968.

In March, Hughes-Fullerton launched an intensive recruitment drive to hire 330 additional engineers and scientists and more than 1,500 technical and administrative personnel to meet the largest backlog of new and follow-on business in its history. The new personnel were for current programs and to help the company meet long-term commitments under the $300,000,000 NATO Air Defense Ground Environment (NADGE) program and a $70,000,000 Air Force contract for production of transportable tactical air operations centers designated 407-L.

In June, Hughes Aircraft's wholly-owned electrical contracting subsidiary, Meva Corporation, acquired the Forster Design Agency of Long Beach, California, to strengthen marine shipboard custom design activities of Meva's Marine Division, based at Wilmington, California. The acquisition particularly will complement and reinforce the division's activities in shipboard electrical and electronic systems and equipment.

In what was described as "the largest collection of operating military laser hardware ever assembled," in March, Hughes aerospace laser experts demonstrated 5 tank and airborne laser ranging systems and a laser illuminator to representatives of military and industry. The display was designed to show how the laser had risen from the status of a laboratory novelty to the ranks of hardened military equipment in the 7 years since its discovery at Hughes Research Laboratories.

Hughes has built tank rangefinders under contracts with the U.S., Japan, Germany, Switzerland and Sweden.

One of the airborne rangefinders displayed was a helicopter laser-ranging subsystem for VATLS (Visual Airborne Target Location System), a completely militarized rangefinder that is the first "Mil-Spec" laser equipment produced by American industry.

In November the U.S. Navy awarded Hughes a $16,000,000 contract for production of the Walleye missile at the firm's Tucson, Arizona, plant. The initial contract was to cover work beginning in 1968 and carry the production into early 1969.

The company's Microwave Tube Division changed its name to the Electron Dynamics Division to reflect its expanding product lines and in the spring moved to new expanded quarters in Torrance, California. The division is one of the nation's major research and development organizations in the area of microwave tubes, supplying traveling-wave tubes for major U.S. space programs. Among the missions on which Hughes tubes are playing a key role are Pioneer, Mariner, Lunar Orbiter, Apollo, Syncom, Early Bird, ATS and Surveyor.

The Santa Barbara Research Center, a Hughes subsidiary, was awarded a $500,000 contract by Jet Propulsion Laboratory for the design, development and fabrication of a prototype 2-channel infrared radiometer to measure the surface temperature of Mars on future Mariner fly-by spacecraft. SBRC also received a contract from the Department of Commerce to build major components of an improved infrared spectrometer for use aboard the 1969 Nimbus D satellite for weather forecasting.

Twelve air-transportable "mini labs" were built by the company's field service and support division under a $1,500,000 contract with the U.S. Army Electronic Command at Fort Monmouth, N.J. The unique shelters, no bigger than a vacation camper, are designed for on-the-spot maintenance of military communication support equipment. Weighing 4,000 pounds each, they can be airlifted by the Huey helicopter now in use in Vietnam.

Lawrence A. Hyland, vice president and general manager of Hughes Aircraft Company, was presented with the "Industrialist of the Year" award in January by the Southern California Industry-Education Council for outstanding service to education. The firm was a pioneer in bringing industry and education leaders together for mutual benefit.

In August, Hyland was honored by the Western Electronics Manufacturers Association (WEMA) which presented him with its annual Medal of Achievement "for significant contributions to the advancement of electronics in the West."

The year began with the appointment of Dr. Nicholas A. Begovich, a company vice president, as group executive of the Hughes Ground Systems Group at Fullerton, California. At the same time Edwin H. Meier, a vice president, was named assistant group executive to Dr. Begovich, and Dr. Malcolm R. Currie, vice president, was named to succeed Meier as manager of the Hughes Aerospace Group's Research and Development Division at Culver City, California.

Other important appointments during the year included elevation to vice presidencies of Dr. Leonard Gross, manager of the Aeronautical Systems Division, and Dr. William H. Christoffers, executive of the Industrial Electronics Group.

John D. Couturie, Hughes vice president and treasurer, was elected to the board of directors of TelePrompTer Corporation. TelePrompTer and Hughes are partners in Theta Communications for the development and commercial distribution of electronic communications products and systems and in cable TV systems in New York and Los Angeles.

The company's gross income, which had exceeded $400,000,000 for the 9 years through 1965 and topped $500,000,000 in 1966, rose to more than $550,000,000 in 1967.

Total employment increased slightly to about 31,500 at the 11 Hughes facilities in Culver City, Fullerton, Malibu, El Segundo, Canoga Park, Santa Barbara, Los Angeles, Torrance, Oceanside and Newport Beach in California, and Tucson, Arizona.

HUGHES TOOL COMPANY

AIRCRAFT DIVISION

Hughes Tool Company continued to manufacture helicopters for commercial and military programs as well as military gun ordnance systems.

Activities at the company's main plant in Culver City, California, was dominated by the production of the Army's OH-6A Cayuse light observation helicopter, of which a substantial number were in service in Vietnam.

A total of 1071 of the turbine-powered helicopters were to be delivered to the Army through December 1968, reaching a peak production of 90 ships per month.

Hughes was competing for a follow-on contract to build 2,680 helicopters with options to bring production to a total of 3,870 over a period of 5 years with delivery beginning in spring of 1969.

Hughes received 2 awards at the annual meeting of the American Helicopter Society in May.

For developing the high-performance OH-6A light observation helicopter, which was described as "10 years ahead of its time," the company was honored with the Igor I. Sikorsky International Trophy. Specifically, the award cited the ship's record-shattering flight 2,213 miles, nonstop from Culver City, California, to Ormond Beach, Florida.

Robert Ferry, Hughes chief engineering test pilot, won the Frederick L. Feinberg Award for piloting the craft on its 15 hour, 18 minute flight.

In July, Rea E. Hopper, the firm's vice president and general manager, announced the promotion of Thomas R. Stuelpnagel to the newly created post of vice president and assistant to the general manager. Mr. Stuelpnagel was formerly director of ordnance engineering.

Hughes announced completion of negotiations with 2 foreign firms, licensing Nardi S. A. Construzioni per Aeronautiche of Milano, Italy and Kawasaki Aircraft Company of Japan to manufacture and market versions of Hughes OH-6A military and Model 500 commercial helicopters.

Under the marketing terms of the agreement with Nardi, the Italian firm will sell the helicopters in the European Common Market and in some North African countries pending State Department approval.

A similar pact with Kawasaki, approved by the State Department in mid-October, authorized the Japanese manufacturer to build and market the turbine-powered helicopter in southeast Asia.

Hughes Tool Company at year-end employed more than 4,200 workers, as compared to fewer than 650 in 1965.

Structural facilities for the engineering, administrative and manufacturing functions now occupy more than 1,000,000 square feet.

At Palomar County Airport near San Diego, where all production flight testing of military and commercial helicopters was being done, work was completed on a 33,000-square-foot hangar and administrative building. The need for this flight test center away from the Culver City plant was perceived when the sale of helicopters and production projections made it evident that more than 100 aircraft per month would have to be given a final checkout before customer delivery. The facility is on a 10-acre site adjacent to the airport.

Assembly of the Hughes 300 and TH-55A helicopters, and fabrication of major subassemblies for the OH-6A was expanded at Rose Canyon near San Diego. The entire 100,000 square feet of available space was committed to helicopter fabrication, an increase of 40 percent over 1966.

More than 700 persons are employed at the 2 San Diego facilities.

Production of 396 TH-55A 2-place primary trainer helicopters was begun at Rose Canyon in response to an Army contract received in June. On December 1, Hughes was able to deliver 10 of the craft 8 months ahead of the required schedule.

The contract for the primary trainer carried an option clause for 198 additional ships which would raise the Hughes trainer fleet to 990 at the Army's Primary Helicopter School, Ft. Wolters, Texas.

Interest in Project Sky Knight, the first day-night patrol of a city by helicopter, attracted the attention of law enforcement officials all over the world.

Hughes supplied 3 of its Model 300 Helicopters at cost to the Los Angeles County Sheriff's Department to patrol Lakewood, California. Financial aid came from the President's Office of Law Enforcement Assistance.

Two major developments in the experimental program were the expansion of the helicopter patrol to cover 5 additional cities adjacent to Lakewood, and a 6-month extension of the project running through December 31, 1967.

Although final evaluation of the Sky Knight program will not be completed until after the test period has expired, officials noted that the crime rate in Lakewood dropped a startling 17.5 percent from November 1966, to April 1967, while it was still rising in other Southern California cities with comparable socio-economic characteristics.

Los Angeles County Sheriff Peter J. Pitchess called the helicopter "the first significant new dimension for police patrol work since the patrol car replaced officers on foot and horseback 40 years ago."

INTERNATIONAL BUSINESS MACHINES CORPORATION

FEDERAL SYSTEMS DIVISION

IBM people and advanced information systems were actively involved in the nation's space and defense efforts during 1967.

IBM System/4 Pi, a new family of computers introduced a year earlier, was selected in 1967 for a number of advanced military aircraft. It will handle such critical tasks as navigation, target identification and weapons delivery. Among the airplanes in which System/4 Pi will fly are the Air Force version of the swing-wing F-111 and the Navy's A-6, A-7 and EA-6B tactical aircraft.

Though it fits in a suitcase, System/4 Pi is powerful and rugged enough to meet the rigorous demands of aircraft, space and ground-combat applications. For example, it can withstand 50 g's of shock while operating at temperatures ranging from 65 degrees below zero to 185 degrees above.

In Huntsville, Alabama, near the Marshall Space Flight Center, IBM continued building the 3-foot-high instrument stages for the National Aeronautics and Space Administration's Saturn V moon rockets. More than 60 electrical and electronic units integrated into each Instrument Unit stage provide the vehicle guidance, control and data handling systems.

At the Cape Kennedy, Florida, launch site, IBM specialists checked out the Instrument Unit for the Saturn V's first qualification flight, and assisted in operating the launch support complex. IBM will handle the critical assignment for every Apollo/Saturn mission.

At NASA's Manned Spacecraft Center in Houston, Texas, control tower for all manned space flights, IBM installed its System/360 Model 75 data processors. The powerful computers, which replaced the IBM 7094s used during Project Gemini and early Apollo flights, can perform up to 80 billion calculations a day during an Apollo/Saturn mission.

Installation of System/360s also began at NASA's Goddard Space Flight Center in Greenbelt, Maryland. The new computers will test tracking and communications equipment in the Manned Space Flight Network, and will support the flights of unmanned scientific satellites.

During 1967, IBM computers at Goddard and at the Jet Propulsion Laboratory in Pasadena, California, supported a series of successful unmanned scientific space probes. They included the Surveyor series of soft lunar landings; Biosatellite II, which was recovered after orbiting the earth with living plant and animal samples; and Orbiters IV and V. IBM's role included using computers to enhance moon pictures transmitted from space.

While IBM people prepare for man's journey to the moon, others focused on travel closer to earth. At the Federal Aviation Administration's experimental facility near Atlantic City, New Jersey, IBM programmers neared completion of the 165,000 computer instructions required for a semi-automatic air traffic control system.

The programs, and a network of special computing systems developed by IBM for the FAA, will help air traffic controllers manage en route flights through the nation's air space. The first system was scheduled to become operational in 1968 at the Jacksonville, Florida, air route traffic control center.

In 1967, IBM won a U.S. Army contract to develop a data processing and communications system on wheels for armies in the field. Called the Combat Service Support System, it will store logistic and personnel records in mobile System/360s to keep track of everything from manpower to menus to munitions. Each system will be installed in 4 35-foot trailers built for rough terrain. The Army planned to make the Combat Service Support System operational in 1968.

Solving special systems problems of the government is the business of IBM's Federal Systems Division, headquartered at Gaithersburg, Maryland. Employing 12,500 people, the division has 4 operating centers, including its Center for Exploratory Studies established in 1966 to help meet the advanced technology needs of the federal government.

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, Paramus, New Jersey; ITT Industrial Laboratories and ITT Federal Laboratories, both of Fort Wayne, Indiana, and San Fernando, California; ITT Gilfillan, Van Nuys, California; ITT Industrial Products Division, San Fernando, California; ITT Electron Tube Division, Easton, Pennsylvania, and Roanoke, Virginia; and ITT Electro-Physics Laboratories, Hyattsville, Maryland.

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 was engaged during 1967, as in previous years, in engineering and manufacturing of products and systems including Tacan and other point-source navigation, hyperbolic navigation, electronic defense and antisubmarine warfare.

Tacan systems included airborne and ground antenna systems, indicators, data links and test equipment. Hyperbolic systems included Loran ground stations, Omega and Loran C/D shipboard and airborne receivers, and support equipment to provide navigation capability to aircraft and ships for long-range, worldwide coverage. Electronic defense and ASW systems included reconnaissance, electronic countermeasures, direction finders, radar trainer systems, underwater instrumentation and sonar training devices.

ITT Avionics Division has the distinction of having designed every Tacan antenna that has ever become operational. Some 2,000 of these antennas had been installed at sites around the world by the end of 1967.

During 1967 the Avionics Division's Hydro-Acoustic Laboratory became operational. The facility, a research and development laboratory constructed above a 200,000-gallon above-ground water tank, was being used to test and evaluate advanced designs of underwater instruments.

The division was prime contractor for the U.S. Navy's Barking Sands Tactical Underwater Range, an underwater tracking facility installed off the coast of Kauai in the Hawaiian Islands. This facility, completed in 1967, will provide the Navy with the capability of evaluating the tactical performance, under actual sea conditions, of antisubmarine warfare weapon systems and operations.

ITT Defense Communications Division

ITT Defense Communications Division continued to design, develop and produce message- and circuit-switching systems, satellite communication relays and terminals, and tropospheric-scatter and line-of-sight radio communication systems.

The division was building communication, telemetry and command subsystems for the Intelsat III series commercial communication satellites scheduled to be launched by Comsat, the Communications Satellite Corporation, in 1968. (TRW Systems, Inc., is program manager for the Intelsat III satellites.) In mid-1967 an 85-foot-diameter commercial satellite communication earth terminal built for Spain by ITT Defense Communications Division neared completion 40 miles north of Madrid. Also in 1967 a dual satellite communication earth terminal built by the division began operating at its site in the Canary Islands, relaying spacecraft tracking network communications across the Atlantic to NASA's Manned Spacecraft Center in Houston, Texas. Indonesia ordered a satellite communication earth terminal from the division so it too will be able to participate in the global satellite communication network.

Under contract to the U.S. Air Force, ITT Defense Communications Division was building a major computer-based message-switching system (497L) to be integrated into military communications networks in the United States and abroad. Under the contract the division will design and furnish store-and-forward automatic digital switches and integrate them into switching centers and communication links which are part of the United States' worldwide government communications network.

In 1967 a message switching communication center built by the division for the Department of State completed acceptance testing. Called the Automated Terminal Station, the new communication center is located on the fifth floor of the new State Department building in Washington, D.C.

In mid-1967 the division was awarded contracts by the U.S. Army Electronics Command for tactical tropospheric scatter radio sets and antennas. The 12/

24-channel pulse code modulation AN/GRC-143 sets will be packaged in mobile shelters.

And in 1967 the U.S. Air Force conducted preliminary field tests of an ITT Defense Communications-designed manpack microwave radio system at Eglin Air Force Base, Florida. Developed for Rome Air Development Center, Griffiss Air Force Base, Rome, New York, the terminal is a miniaturized FM microwave radio system which provides quick-reaction line-of-sight communication under varied field conditions. It is completely solid-state and makes extensive use of microelectronic integrated circuits, thick film and monolithic techniques.

Federal Electric Corporation

During 1967 Federal Electric Corporation, world-wide service subsidiary of International Telephone and Telegraph Corporation and one of the largest and most active members of ITT's Defense-Space Group, continued to devote a major share of its activities to aerospace.

Federal Electric was particularly active in 5 major project areas: (1) systems implementation; (2) missile range services; (3) NASA space programs; (4) operation and maintenance services and (5) base support services.

Federal Electric's systems implementation engineers provide systems design and planning as well as procurement, installation, test and checkout of communications and radar systems. These systems cover tropospheric scatter, microwave link, digital data transmission and display, and submarine cable systems. All systems feature high volume of traffic, high speed transmission and high reliability of operation in communications. FEC also operates a vast radar network with full radar capability for search, acquisition and tracking.

In 1967, Federal Electric's outstanding systems implementation achievement was the completion of a 7,600-mile submarine cable communications system linking Cape Kennedy and Grand Turk Island in the Bahamas.

Employing the latest technological advances in submerged repeater and lightweight armorless cable to permit transmission of high-speed broad-band data, the system provides real-time information from down-range tracking and telemetry stations for all Cape Kennedy-launched space and missile flights.

Another systems implementation accomplishment in 1967 by Federal Electric Corporation was Project Fast Race. This involved the installation for the United States of a tropo communications system between the United Kingdom and Germany. Federal Electric completed the project within the required time schedule.

Federal Electric continued as prime contractor for the Air Force Western Test Range which extends from California across the Pacific to the Indian Ocean. More than 1,800 Federal Electric engineers and technicians performed operational maintenance and support services both ashore and afloat in 1967. They were involved in such services as missile tracking and instrumentation, communications, timing control, data storage and retrieval, logistics supply and quality control.

Federal Electric personnel also operated and maintained instrumentation and communications facilities at Vandenberg Air Force Base and Pillar Point, California, as well as at Hawaii and Eniwetok in the Marshall Islands. Federal Electric specialists also manned radar, optical and telemetry equipment aboard 10 ocean-going range ships operating out of Hawaii and Port Hueneme, California.

Besides providing range safety and instrumentation data in the launch area, Federal Electric also handled in-flight and trajectory information and provided impact scoring, recovery data, and data reduction on all missile and space shots launched during the year from Vandenberg.

At the Kennedy Space Center, Federal Electric was the prime contractor for communications and instrumentation support services. Nearly 1,700 Federal Electric engineers and technicians maintained, calibrated, repaired and operated a wide range of communications and instrumentation equipment. Timing continued to be a vital function of Federal Electric's activities at the Kennedy Space Center. From one central source time references were being sent to more than one hundred local stations to guarantee split-second synchronization for operations throughout the Kennedy Space Center.

In addition, ITT's service associate also provided computer programming and data reduction services for NASA at the center. Federal Electric also functioned in the fields of administrative and operational intercom, public address and paging, fire reporting, point-to-point telephone, mobile radio and television, countdown, timing and data transmission, test and switching centers, communications centers and cable systems.

Throughout 1967, Federal Electric Corporation continued to serve the Marshall Space Flight Center as prime contractor for reliability support services. The company performed reliability research and development, analysis and documentation for NASA in support of the Saturn/Apollo lunar program. Federal Electric specialists also monitored other NASA contractors to assure the highest levels of reliability in the manufacture and assembly of the Saturn launch vehicle and associated systems.

Federal Electric's third major area of 1967 NASA support services was the Manned Spacecraft Center, Houston, Texas, where the company served as prime contractor for technical information and logistics support services. Federal Electric engineering and technical specialists aided NASA scientists in documenting the results of a vast research and development program to expand the fund of knowledge on space technology. The ITT company provided technical writing, editing, report preparation and reproduction, test procedure documentation, data storage and retrieval, microfilming, graphic arts and logistics support.

Since 1956, Federal Electric Corporation has operated and maintained the Distant Early Warning Line (DEWLine) across Alaska, Canada and Greenland. The 3,600-mile DEWLine is the world's largest radar surveillance communications network.

For the fourth straight year, Federal Electric Corporation, through its subsidiary ITT Technical Services, Inc., performed a wide variety of base support services for the United States Air Force in its Flight Test Installation in Palmdale, California. Its responsibilities covered runway maintenance, service and repair; crash and rescue operations on the ground augmented by helicopter search and rescue operation in the air; operation and maintenance of all communications systems, not only ground telephone and teleprinter units but also ground-to-air high frequency radio communications; and ground control operations in the control tower, directing and controlling all aircraft on the ground, both prior to take-off and after landing. The company also handled the procurement of all needed supplies and materials, and furnishing of all utilities such as electricity, gas, potable water and a variety of standard and special fuels for aircraft and ground vehicles.

ITT's Federal Electric Corporation was one of a score of aerospace companies running Job Corps Centers for the Office of Economic Opportunity. The systems management approach developed by the aerospace industry was being applied to the solution of complex social problems.

Federal Electric employed such an approach in developing a total program for the Kilmer Job Corps Center which the company has operated and maintained since February 1965.

Under the ITT service organization's banner, a multi-discipline team consisting of sociologists, psychologists, educators, operations analysts and civil, mechanical and electrical engineers researched the problem from every angle, analyzed it into relevant factors and integrated thousands of operations into the organized pursuit of definite results. The end-product was a program custom-designed to meet the educational, occupational and citizenship needs of the Kilmer corpsmen.

ITT Industrial Laboratories Division

ITT Industrial Laboratories Division activities during the year embraced applied research, design, development and fabrication of electro-optical sensor devices and equipment, aerospace instrumentation for missiles and space vehicles, and related apparatus in the physical sciences. Special emphasis was placed on components and equipment that operate in the infrared, visible and ultraviolet portions of the electromagnetic spectrum, and on specialized television, including associated major components.

The unique combination of sensor and equipment capabilities in one organization has led to significant contributions by ITT Industrial Laboratories to the aerospace field, both directly through accomplishments in satellite instrumentation design and indirectly through the exclusive line of phototubes which are incorporated in stabilization, mapping, and other electro-optical subsystems needed for almost every important U.S. space experiment or mission.

Scientists and meteorologists around the world were utilizing information gathered by the ITT ILD-developed infrared nighttime camera aboard NASA's Nimbus I and II weather satellites, and presented as strip maps extending from pole to pole. Previous picture transmission from satellites had been limited to daytime patch photography of sunlit portions of the earth requiring considerable work to construct a photographic mosaic to study a significant earth area. On the basis of nighttime photos taken by the ITT ILD-built camera without the interference of reflected sunlight, the U.S. Geological Survey has repositioned Mt. Siple, a 10,000-foot high mountain in Antarctica, used by pilots as a navigational aid. Its location, based on earlier charting expeditions, was found to be 45 miles too far east. Future relief maps will show the corrected location.

The Nimbus-B also will include a daytime camera to be designed and developed by ITT ILD. Another daytime space camera was developed for NASA's Applications Technology Satellite (ATS) scheduled for launch in early 1968.

It is significant that both the Nimbus B satellite and ATS daytime cameras will utilize a unique camera tube also developed by ITT ILD. This tube, called a Vidissector, the modern version of Dr. Philo T. Farnsworth's original television camera tube, will receive optical images and translate them into electronic information for transmission to ground stations and reproduction as pictures.

ITT ILD also contributed to NASA's Orbiting Geophysical Observatory (OGO) satellite project. In an effort to aid scientists trying to learn the source and nature of a mysterious light reflection in space, ITT ILD developed a photoelectric camera to photograph this mysterious phenomenon in 3 colors. This equipment was a pioneering effort in transmitting color photographs from a space satellite.

ITT ILD-developed electro-optical sensors, including photodiodes, multiplier phototubes, but fixed and scannable, and image converters, continued to make important contributions to the U.S. space effort both in orbit and on the ground. Many of these applications are described in the text of ITT Aerospace Division activities. For example, the moon-traveling Lunar Orbiters I, II, III, IV, and V were guided on their trans-lunar path from their earth parking orbit to the moon with the aid of "eyes in space" developed by ITT ILD, highly sensitive photomultiplier tubes which sought out the star Canopus and used it as a fixed reference point for orientation and accurate guidance of the space vehicles.

Direct-view storage tubes, originated by ITT Industrial Laboratories, also found broad application in aircraft and space vehicle cockpit displays as well as in the myriad of ground equipments necessary to assure flight crew safety. Typical of such applications was the Weather Bureau's new weather radar remoting system (WB/RATTS-66) being installed at major commercial airfields throughout the country and FAA's tower cab bright display.

In addition, ITT ILD started work late in the year on an infrared filter wedge spectrometer for the Nimbus D program. This device is intended to determine the moisture content in the earth's cloud cover by analyzing its spectral radiation.

Scientists and engineers at ITT Industrial Laboratories continued to build on their pioneering efforts in the research and development field, particularly in the area of special purpose tubes, image handling equipment, and in the new and growing field of space technology.

ITT Federal Laboratories
ITT Aerospace Division

ITT Federal Laboratories' ITT Aerospace Division continued to be one of the world's foremost laboratories engaged in the development of advanced space products and systems.

In 1967, key technical contributions were made in the areas of rendezvous and docking; missile guidance and fuzing; reconnaissance, surveillance and detection; space guidance, navigation and communications; position location equipment; low light-level TV and night vision; small scientific satellites; and undersea technology.

ITT Aerospace continued development of its laser space rendezvous and docking system for use in post-Apollo missions. Prototype equipment was successfully demonstrated in 1967 and contracts were under way with NASA to define flight hardware and also study advanced versions of this electro-optical equipment. Tests proved its superiority over RF systems designed for the same mission.

Also under development and preliminary production at ITT Aerospace was the Navy's satellite navigation receiving system, AN/SRN-9. Equipment provides position location accuracies for ships to 50 feet on a worldwide coverage basis with all-weather capability. Applications engineering for commercial uses is also under way, including land and airborne environments. In addition to the SRN-9 equipment, ITT Aerospace provided several tracking receivers for use in comsat stations located around the world.

Electro-optical developments were continued in both optical communications and night vision. A laboratory version of a deep space optical communications link was developed for NASA with current emphasis on acquisitions and tracking techniques. A breadboard low-light-level TV camera system was also developed in response to urgent Southeast Asia requirements.

Exploratory and advanced development work was carried out for a unique tactical missile guidance system employing pseudo-noise technology. Preliminary tests demonstrated wide improvements possible in present-day tactical surface-to-air missile systems.

Multi-altitude transponder (MATS) development was continuing for use aboard advanced Army SECOR satellites at 2,400 nautical mile altitudes versus previous orbits under 1,000 miles. Extensive microminiature development was applied to this program. Applications of an ITT small scientific satellite were also being pursued.

ITT Aerospace was a principal supplier of electro-optical sensors on a key USAF satellite program, details of which are classified. Reconnaissance cameras capable of nighttime surveillance were being developed for the Navy. Work in this area was also applicable to undersea inspection and other underwater requirements. ITT Aerospace was finding solutions to undersea requirements in secure communications, telemetry, tracking and surveillance.

ITT Gilfillan

Early in 1967, ITT Gilfillan was selected by the U.S. Army to develop an advanced mortar locating radar system. In this equipment, modern radar and computer technologies are integrated to provide instantaneous information regarding location of enemy weapons.

With this development, ITT Gilfillan entered its 25th year of design, development, production and support of major radar equipments for U.S. and foreign government agencies. Long a leading producer of ground-based radars for air traffic control, ITT Gilfillan also was heavily engaged in development and production of modern radar equipments for surface weapon systems.

Under a multi-year procurement of the U.S. Navy, production continued of AN/SPS-48 long-range shipboard radar for missile and aircraft guidance and control.

In mid-year, development of the AN/TPS-32 radar was completed for the U.S. Marine Corps. This helicopter transportable, 3-dimensional search-and-height-finding radar was selected for use with the Marine Tactical Data System.

Deliveries of lightweight ground controlled approach radars to U.S. and foreign military agencies continued throughout 1967. Equipment types included the AN/TPN-8 for the U.S. Army and Marine Corps; AN/FPN-36 Quadradar for U.S. and foreign government agencies; and AN/SPN-35 for aircraft carriers of the U.S., United Kingdom, Canada and Australia. Modernization and logistic support was provided for the AN/MPN-11 through 16 series of ground-controlled approach radars used by the military forces of the U.S. and more than 15 foreign countries.

Corporate- and government-sponsored research and development in advanced radar techniques and systems increased substantially over prior years. Among future products toward which this activity was directed are air traffic control radars of greatly improved performance and reliability. Development of an advanced model of a precision approach radar which was demonstrated to Department of Defense officials in 1966 progressed in 1967.

At year-end the majority of ITT Gilfillan's manufacturing and test activities were being consolidated in new facilities in Van Nuys, California, to provide for increased efficiency and anticipated growth.

ITT Electron Tube Division

ITT Electron Tube Division is responsible for managing ITT's special-purpose electron tube business in the United States. The division is a completely integrated organization which develops, manufactures and markets a broad line of products—high-vacuum tubes, hydrogen thyratrons, traveling wave tubes, klystrons, spark gaps, noise sources, direct view storage tubes and light sensing and emitting devices.

The division's 1967 activities were carried on at 2 modern plants in Easton, Pennsylvania and Roanoke, Virginia. These unique facilities were specially designed and built for the sole purpose of engineering and manufacturing special-purpose quality tube products. Both plants have complete machine shop installations, glass working shops, chemical cleaning operations, specialized metal heat-treating equipment, clean room assembly areas, exhaust-process stations, and a full range of allied equipment utilized in the specialized testing of a variety of tubes.

The Communications, Industrial, and Microwave Operations—power tubes, traveling wave tubes, gas discharge devices—were centered at the Easton plant. For a broad range of applications in communications systems, navigational gear, pulse modulation, and industrial heating equipment, the power tube line offers a variety of high vacuum tubes—water, air, or vapor cooled diodes, triodes, and tetrodes. Output power of these tubes ranges from 1 to 600 kilowatts. Research was being carried on to develop power tubes having increased reliability and higher output, along with maximum efficiency. Typically, 1967 achievements in the power tube area included the development of type F1086, a switch tube in which current reversal has been completely eliminated from the operating range. This tube is the heart of many of the world's primary navigational aids.

In the gas discharge tube line, the world's largest glass and ceramic hydrogen thyratrons were being manufactured at Easton. More than 60 different types of tubes were being produced, ranging in operating voltage from 300 to 100,000 volts and in peak power capability from .05 to 100 megawatts. These tubes are used in pulse modulators for radar and linear accelerator systems.

The gas tube operations continued to expand, with development aimed at producing a device which holds off 80 kilovolts and passes 30 amperes of average current. This followed the development of the world's first multigrid hydrogen thyratron capable of holding off 100 kilovolts. New devices added to the line are triggered and two element spark gaps used to protect expensive components in high power equipment. The Electron Tube Division has long been an important source for microwave tubes used in such applications as point-to-point voice and TV communications, radar, electronic countermeasures, and radar augmentors. The line includes medium power CW, TWTs, and 1 kilowatt to 4 kilowatt pulse tubes, a line of backward-wave oscillator tubes, millimeter wave reflex klystrons, noise sources and gas discharge tubes having a precise level of white-noise output to measure receiver sensitivity or tune crystal detectors.

The Roanoke facility continued as a leader in the development and manufacture of Electro Optic Tubes, such as direct view storage tubes, image converter tubes, and image intensifiers. These tubes were being manufactured for use in airborne weather radar systems, high brightness cockpit displays for military terrain-following and fire control radar, star trackers, laser detectors, TV pickups for terminal guidance missile systems, and weather satellites.

Development and production activities were being carried forward in the area of passive "night vision" image tubes, requiring only ambient light as a source of illumination. The Iatron storage tubes developed at the plant have a storage time of a few seconds to several minutes. The fast erase capability of some recently developed tubes allow display of TV images at standard frame rates without dunking of the storage mesh during the fly-back period. This is unique in the industry.

In addition to display tubes, Roanoke was also making a line of recording storage tubes which accept CRT deflection scanning patterns, store them for up to 6 hours, and read them out as often as required. These devices may be used for pattern and frequency conversion, data storage, or to activate a number of different monitors.

KAISER AEROSPACE & ELECTRONICS CORPORATION

The business of Kaiser Aerospace & Electronics Corporation continued during 1967 to consist primarily of the production of solid fuel rocket motor nozzles, machined aircraft structural components, aircraft precision gears and gear assemblies, and the design and production of the airborne Kaiser Flite-Path (registered) navigational aid and community antenna television (CATV) equipment.

The corporation had a backlog of orders totaling $44,431,000 as of September 30, 1967, compared with $40,277,000 as of September 30, 1966, and the volume of sales during 1967 substantially increased.

At San Leandro, California, Kaiser was operating one of the most modern numerically controlled machining facilities in the United States, performing work on the Grumman F-111 program and the Boeing commercial 747, 727 and 707/320 aircraft. The San Leandro Plant, winner of the USAF Zero Defects Achievement Award, was one of the nation's leading producers of nozzles for major military missile programs, such as Poseidon, Polaris, Minuteman and others.

At Palo Alto, California, continued 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 proceeded at high rate. In addition, there was limited production of new integrated display systems for use in both military and civilian light aircraft.

The Embe Gear Plant at Glendale, California, acquired in 1966, continued the manufacture of precision gears and hydraulic and electro-mechanical systems for the aircraft and aerospace industry.

In Phoenix, Arizona, the company was designing and manufacturing military electronics support equipment. Kaiser CATV Corporation, a wholly-owned subsidiary of Kaiser Aerospace & Electronics Corporation, and also located at Phoenix, continued production of CATV equipment for sale throughout the United States. Kaiser Aerospace & Electronics is a wholly-owned subsidiary of Kaiser Industries Corporation.

KAMAN CORPORATION

Developments in Kaman's growth/diversification program continued to extend the company's activities in new fields of endeavor and carry Kaman's business and backlog to new highs.

During 1967 the company shortened its name from Kaman Aircraft Corporation to Kaman Corporation and reorganized its 9 divisions into 4 market-oriented business groups: Aerospace, Science and Technology, Special Products, and Fixed Base Operations.

Kaman's growth in its first score of years was substantially through internal development, but in 1967 the company broadened its financial structure to be ready to take advantage of growth by acquisition opportunities.

In the aerospace field Kaman's Aircraft Division continued major airframe component production contracts for tactical, strategic and commercial aircraft. These included flaps and spoilers for the Lockheed C-5A; thrust reversers for the C-5A's GE TF39 engines; cargo door shrouds, trailing edge panels and control surfaces for the McDonnell Douglas DC-8 and DC-9; wings and tail empennage for the Grumman OV-1A Mohawk; and rudders, doors and access panels for the Grumman A-6A.

Kaman also entered the production of aircraft equipment, principally with a contract for galleys from Eastern Airlines, and announced plans for expansion of its sales in the field.

In addition to these major programs, the company had important work for GE (Cincinnati and Philadelphia), Perkin-Elmer, Avco, Itek, DeHavilland Canada, Fleet, Raytheon, Boeing, Beech, and Lockheed-California.

In the helicopter field the most significant development was the start of retrofit and modification of Navy SeaSprite rescue helicopters from single to twin T58 turbine configuration. The change will improve the engine reliability, hot day and altitude performance of the Navy rescue/utility helicopter, enabling the SeaSprite to continue critical missions even with one engine out. First deliveries of the twin turbine UH-2C joined the fleet in the China Sea in November.

Kaman HH-43 Huskie helicopters continued to be the rescue workhorse of the Air Force in Vietnam, being credited with nearly two-thirds of the saves by Aerospace Rescue and Recovery Service in Southeast Asia. The company also received a small production contract for additional Huskies.

Research work in the Aircraft Division of Kaman Corporation concentrated on means of improving the performance and reliability of helicopters and periodic reviews of the potential for new types and designs of VTOL aircraft, including rotorcraft. Kaman engineers had specialized mechanical components and vibration control devices and had a study contract for a new concept called "controllable twist" rotor, one which would vary its pitch or angle of attack over its length, offering potential for increased lift and speed in pure helicopters and compound aircraft.

During the year Kaman announced formation of a new division—KAcarb Products—to produce and market a new type of self-lubricating bearing developed by Kaman engineers. It was in use on the UH-2 series of helicopter at year-end and was expected to be made standard in other models of Army and Navy helicopters in 1968.

Kaman's Instruments Division in Austin, Texas, has among its programs work on the Apollo biomedical instrumentation. Their cardiac output computer and cardiac tachometer, developed for NASA, are used in test work and as "on board" equipment.

Kaman's Nuclear Division in Colorado Springs, Colorado, emphasizes studies on weapons effectiveness on vulnerability and countermeasures for the Department of Defense. In addition to work in commercial application of activation analysis, Kaman is active in investigation of application of nuclear energy to recovery of natural resources and power plants.

KOLLSMAN INSTRUMENT CORPORATION

Products of the Kollsman Instrument Corporation received wide-spread customer acceptance during 1967. All divisions exhibited continuing growth.

AVIONICS DIVISION

The demand for aircraft instrumentation by the commercial airlines, operators of business aircraft and by the armed forces, continued to grow in 1967 and the production volume of the Avionics Division expanded accordingly.

Orders from Boeing, McDonnell Douglas and British Aircraft Corporation exceeded those placed in previous years. Important new orders were received for instrumentation to be incorporated on the new Boeing 747 jumbo jet. Kollsman's integrated flight instrument system was selected for the new stretched version of the Douglas DC-8 aircraft. Many of the major commercial airlines throughout the free world also placed initial orders for Kollsman altitude reporting equipment to be incorporated in their jet fleet. The Kollsman KS-200 air data computer was certificated for the Douglas DC-8 aircraft and began certification flights on the Boeing 737 twin jet. Orders for these new air data computers greatly exceeded previous levels, reaffirming the company's position in the air data systems market for commercial aircraft.

In the military avionics area, first contracts were received for servo pneumatic altimeters, type AAU-19. These instruments, which have become the standard altimeters to be used by all branches of the service, represent a future business opportunity the volume of which was expected to exceed that for all instrument types previously manufactured. Also associated with the altitude reporting program instituted by the Department of Defense, contracts were received for the TTU-229 test set, which will be used extensively by the services for the test and checkout of altimeters and air data computers.

The company support of military aircraft in almost all areas continued at levels above the previous year. Important efforts involved the depot overhaul and repair of sextants, C2A computers, and astro tracker systems for B-52 and B-58 aircraft. Very large production commenced on the vertical velocity indicators used on practically all Navy and Air Force aircraft. Contracts were also received for Toris Combiner Lenses which are incorporated in the Mark II Avionics system Heads Up Display.

ELECTRO-OPTICS DIVISION

While still maintaining a position as a developer of state-of-the-art techniques and processes, the Electro-Optics Division, in 1967, began to realize significant return on the research and development investments initiated in prior years. Production of an infrared receiver and an integrated sighting telescope was initiated for a mobile weapons system. The division's lightweight, reliable, high-accuracy star tracking system was utilized for an Air Force manned space system.

Continued acceptance of space qualified flyable systems associated with the Apollo program, the Goddard Experiment package and star trackers for the Orbiting Astronomical Observatory reflected the success of a long and well planned effort to develop capabilities in this technology. In addition, the division's hand-held space navigation instrument produced for NASA was selected for the Apollo mission.

Extensive investigation into the figuring and polishing of optics led to the technique of ION Beam Erosion. Through the use of controlled erosion of surfaces by ION beams, a practical solution to the problem of manufacturing aspheric lenses has been obtained. Continued development of the technique will also provide a solution to the precise machining of turbine blades and ball bearings.

Development continued in the Advanced Optical technology field. Under NASA sponsorship, the division provided a visual flight reference system to be used as a research tool for evaluation of visual presentations in color TV, black and white TV, fiber optics and direct viewing. This device will be used to determine the astronauts' visual reference system for Apollo.

Participation in NASA's Orbiting Astronomical Support Facility (OASF) and the Optical Technology Apollo Extension System (OTAES) programs provided for the development of a sophisticated capability in the field of large optics. This technology was being developed for utilization in the fields of scientific experimentation, earth resources identification and scientific exploration.

Through a Navy-sponsored development, the division diversified into the data retrieval and viewing field with a compact system that can be used wherever "instant access" is desired for pictorial or printed data.

SYSTEMS DIVISION

The principal program in Kollsman's System Division in 1967 continued to be the USQ-28 Aerial Mapping System for the Air Force. Category II flight testing and preparation for operational deployment of the USQ-28 received accelerated emphasis in 1967 when the RC-135A aircraft which serve as the USQ-28 aerial platforms were transferred from Wright-Patterson Air Force Base to the headquarters of the using command, the 1370th Mapping Wing at Forbes Air Force Base, Kansas. Concomitant with the transfer, Kollsman's Systems Division was given added major responsibilities for engineering and management support of the intensified flight test program. Test mapping missions were flown throughout the continental United States, preparatory to deployment of the RC-

135As overseas in 1968 to map other friendly countries of the world.

Embodied in the USQ-28 System are some of the most advanced equipments in the western world. Some of these equipments were built by Kollsman, others by carefully selected subcontractors who are foremost in their product lines and technological disciplines. Characteristic of the USQ-28 subsystems are its inertial platform, the most precise inertial navigator flown to date; its computer, the largest airborne digital computer extant; its Geocon IV lens, the world's most advanced mapping lens.

Closely paralleling the Systems Division's work in developing the USQ-28, the nation's fastest and most accurate means of acquiring data for mapping, was a contract with the U.S. Army Engineering Topographical Laboratory for automated reduction of data for incorporation in the maps.

CORPORATE TECHNOLOGY CENTER

The Corporate Technology Center was actively engaged during 1967 in areas of rapidly changing technologies, preparing the ground work for future Kollsman programs.

The center was engaged in the exploration of new laser concepts involving meteorology, simulation, communications, and oceanography. The successful optical laser system for underwater use led to several Navy contracts on underwater TV systems. The Underwater TV system was successfully tested at the David Taylor Model Basin, and it produced high-resolution pictures over a significantly greater range than heretofore possible. Kollsman's patented laser weapon fire simulator, an aid in the training of tank gunners, was produced in quantity, and additional production orders for Kollsman's Ordnance Division were anticipated. The company also developed a laser optical alignment system which has an extremely accurate long-range, all-weather laser theodolite with an unprecedented capability in precision meteorology. A Navy contract was initiated to develop a lightweight laser range estimator for use in weapons training activities. New developments of a solid-state air data computer and solid-state pressure transducer will permit Kollsman to provide high-performance reliable equipment that will be required in new generations of military and commercial aircraft, including the supersonic transport. Under contract from the National Institutes of Health, Kollsman was studying the possibility of transmitting power through the intact skin for powering electronic devices implanted in the human body.

The Delphic II data display system, previously used by Columbia Broadcasting System in a unique presentation for telecasts of the entire Gemini series, was being evaluated for even wider use in the Apollo telecasts. This display equipment was demonstrated to professional educational groups, and shows considerable promise for use as a teaching aid. In diversification beyond the electromechanical display, Kollsman developed a solid-state display device under government contract.

CORPORATE ORDNANCE

The backlog of Corporate Ordnance Operations increased 60 percent during 1967. The organization was engaged in the production of anti-personnel mines, test sets and firing devices at Bridgeport, Connecticut; mechanical artillery fuzes and sophisticated electronic/infrared influence fuzes at Melrose Park, Illinois; complex influence fuzes and Kollsman-developed Laser Weapon Fire Simulators at Syosset, New York. Ordnance Group headquarters at Elmhurst, New York, was engaged in design and product improvement programs on a variety of mechanical, electro-mechanical and opto-mechanical fuzes and fire control devices.

Corporate Ordnance Operations continued expansion of activities during 1967 and were established formally on a divisional basis. The Ordnance Group experienced considerable success in obtaining design development and production contracts from the Army and Navy which substantially broadened the Ordnance scope of operations and technical capabilities. The Corporate Ordnance Operations operational conception of utilization of total group resources rather than divisional or substantial relationships, resulted in establishing an Ordnance Department at the Casco subsidiary at Bridgeport, Connecticut; at Melrose Park, Illinois; at Syosset, Long Island; and Elmhurst, New York.

The Casco facility was actively engaged in producing anti-personnel devices, test sets and firing devices. Melrose Park facility was producing complex influence fuzes and the Kollsman developed Laser Weapons Fire Simulator. The Elmhurst facility, headquarters for the Corporate Ordnance Operations group, was actively engaged in design and development programs and product improvement programs on a variety of mechanical, electromechanical and optomechanical fuzes and fire control devices.

LEAR JET CORPORATION

Acquisition of controlling interest in Lear Jet Industries, Inc., by the Gates Rubber Company, Denver, Colorado, in April, added financial stability as well as management depth to the 5-year-old company in 1967.

Charles C. Gates, Jr., Gates Rubber president who subsequently became president of Lear Jet, said the acquisition was a step in Gates' long-range plan to materially serve the general aviation industry. Previously, a substantial portion of Gates Rubber's activities had been directed toward surface transportation. The 55-year-old firm grossed approximately $260,000,000 in sales in 1966.

William P. Lear, Sr., remained as board chairman, concentrating on advanced engineering programs and new product development.

Corporate offices, which in 1966 were temporarily located in Los Angeles, were returned to Wichita, Kansas, site of the Lear Jet Aircraft Division and Brantly Helicopter activities. The company's Avionics Division in Grand Rapids, and Stereo Division in Detroit, conducted expanding activities in 1967. Additionally, a research and development center was established in Santa Ana, California.

AIRCRAFT DIVISION

Building from its position as a world leader in manufacture of business jet aircraft in 1965 and 1966, the Lear Jet Aircraft Division by end of 1967 had maintained its lead in total deliveries of corporate jet aircraft, with some 160 having entered service.

Collectively, the Lear Jet fleet had accumulated well over 150,000 flight hours, equivalent to 75,000,000 miles of travel.

A survey of Lear Jet owners indicated more than half transitioned to turbojet operations by replacing light twin piston-powered models, confirming the broad market appeal of the aircraft.

Enhancing interest in the entire business jet industry was a unique jet flight familiarization course inaugurated in 1967 by Lear Jet. The concentrated 2-day program is open to all pilots, and includes 10 hours of ground school, plus one hour "left seat" pilot time in a Lear Jet. It is designed to assist in ultimately supplying jet-rated pilots required to crew the growing number of non-military aircraft forecast for the next decade.

In addition to numerous deliveries to United States and foreign-based corporate owners during 1967 for routine business operations, 2 Lear Jet deliveries during the year established "firsts" within the industry.

Buker Airways, Inc., of North Springfield, Vermont, began operating a Lear Jet Model 24 on a 5-night-per-week mail run between New York City, Cincinnati, and Pittsburgh. This marked the first time a business jet had been utilized in continued regular air mail service.

Later in the year, Sun Airlines, of St. Louis, inaugurated Lear Jet service as the world's first third-level air carrier using pure jet equipment on scheduled flights.

In October, the Lear Jet Model 25 received FAA Type Certification under FAR 25 regulations governing the air transport category. The Model 25 is 4 feet 4 inches longer than the Model 24 and carries a total of 10 persons. It claims the same basic performance qualifications, utilizing higher thrust General Electric CJ610-6 engines.

In September, Malcolm S. Harned was elected Lear Jet executive vice president and Aircraft Division general manager. Harned has 20 years management experience in aircraft engineering and marketing, most recently as senior vice president of the Hughes Tool Company Aircraft Division.

At mid-year, Gates Aviation Corporation, a subsidiary of The Gates Rubber Company, was appointed distributor for Lear Jet aircraft. During a 3-month startup organizational period, during which regional and area sales offices were established, the Denver-based marketing organization announced sale of 11 Lear Jets valued in excess of $7,000,000.

AVIONICS DIVISION

Further diversification into military and commercial fields keynoted 1967 activities for the Lear Jet Avionics Division.

Well over $1,000,000 in work was assigned by the U.S. Navy, in production of standby attitude gyro indicators for light attack aircraft of a type operating in Southeast Asia.

The U.S. Air Force awarded the Avionics Division 2 contracts relating to electronics equipment installed in more than a half-dozen varied types of aircraft.

Lear Jet's Model 24 became the first business jet to be used in regular air mail service when Buker Airways started operating a 5-night-a-week run.

Late in the year, King Radio Corporation commissioned Lear Jet to supply a quantity of directional gyros for a new heading system the firm developed for the 1968 business aircraft market. This represented the Avionics Division's first commercial production contract.

By mid-1968 it was anticipated some 80 percent of the division's production will be "outside company" work, with the balance representing deliveries of instrumentation to the Lear Jet Aircraft Division.

BRANTLY HELICOPTER

Relocation of all Brantly B2B and Model 305 manufacturing from Frederick, Oklahoma, to Wichita was completed early in 1967. In October the company was awarded a production certificate for both aircraft, permitting company personnel, rather than FAA staff, to conduct production inspections. A production certificate attests to a company's high standards of workmanship and effective quality assurance program.

RESEARCH AND DEVELOPMENT FACILITY

Always having been a research and development oriented company, Lear Jet in 1967 organized a research and development facility on Orange County Airport, near Santa Ana, California. There a staff of technical specialists was concentrating on new product research and development of advanced features for Lear Jet products.

LEAR SIEGLER, INC.

Lear Siegler continued to demonstrate superiority in progressive technical and scientific innovations during 1967 while increasing its output of aerospace systems and components under a broad range of production contracts. Not only was the product spectrum broadened and market penetration deepened, but in new-order bookings a healthy balance was maintained between advanced new-product development work and follow-on contracts.

In addition, LSI further expanded its activities via acquisition of aerospace and related operations. Shortly before the close of calendar 1966, LSI purchased the assets of the Telemetrics Division of Technical Measurements Corporation to complement the technical capabilities of LSI's Electronic Instrumentation Division. During the same period, Astek Instrument Corporation, a manufacturer of pneumatic and electro-pneumatic air data-instruments that was partially owned by Lear Siegler, became a full division of the company.

LSI AVIONICS GROUP

Astek Division

To provide a more effective environment for the new division's expanding operations, Astek occupied a new facility in Armonk, New York, during the first quarter of 1967. The new building, designed specifically for the manufacture of precision products, will allow for considerable growth before further expansion is required.

During the year, the division introduced a new pneumatic digital altimeter (counter drum altimeter) and completed development of a self-contained encoder altimeter. The counter drum altimeter, which provides improved presentation of altitude, was to be placed on the commercial aircraft instrument market in 1968. The self-contained encoder altimeter is an advancement to the state-of-the-art in altimetry. Providing automatic reporting of aircraft altitude to a ground station, the Astek instrument, which was developed in conjunction with the U.S. Navy, combines an optical encoder with a standard altimeter to provide an instrument with minimum potential radio frequency interference problems and very little or no changes to existing aircraft configuration.

Astronics Division

LSI's leadership in the field of aircraft automatic flight controls was enhanced with the development and delivery of an integrated VTOL (vertical take-off and landing) flight control system under a contract from the Air Force Flight Dynamics Laboratory at Wright Patterson Air Force Base. The system, which includes a VTOL integrated control-display system, was installed in a Sikorsky CH-3C helicopter and was in flight test as an in-flight simulator for investigation of low visibility operations.

Paralleling Astronics' work in the VTOL flight control area was a 5-axis, miniaturized control system for helicopters. This system, demonstrated to Air Force, Army and Navy personnel, is the prototype of a new family of helicopter controls that will provide stabilization in any axis.

In June, the Astronics Division's AWLS (All-Weather Landing System) became the first such system in the world to be certified for operations under Category III weather conditions in which the ceiling is zero and the slant runway visibility is as little as 200 meters. The certification was granted by French authorities for the AWLS-equipped Caravelle jet transports. Earlier in the year the division completed fabrication, installation and company flight test of a dual flight control/all-weather landing system in a Federal Aviation Administration owned Convair 880. This system, which also includes newly developed dual servos, was being test flown by the FAA as part of a program to determine Category III landing requirements for commercial aviation.

In the area of the division's major production items, significant contracts were received for continuing production of dual flight control systems for the A-7A and A-7D Corsair II aircraft used by the Navy and Air Force and for flight control systems for the BQM-34A Firebee target drone.

Contracts were also received for work in connection with the division's North Seeking Gyroscope. Providing indications of true north within accuracies of 20 arc seconds, this instrument's primary applications include artillery, missile, radar and geographic survey alignment.

Instrument Division

To keep pace with increasing production volume, construction of a 92,000-square-foot addition to the

Instrument Division's more than 458,000-square-foot, 3-building complex was started in mid-September and was scheduled for completion in April 1968.

A development of major significance during the year was an award to the Instrument Division for production of the DIVIC (Digital Variable Increment Computer), an airborne computer which culminated 6 years of research and development jointly funded by the company and various government contracts. Employing the most advanced microcircuitry, DIVIC forms the heart of an airborne navigation system that has demonstrated that the circular error probability of such systems was a mere 0.4 nautical mile, or in terms of relative position, 100 feet or less.

Increased gyro performance and life, smaller size, lighter, and better reliability and maintainability were achieved through the division's development of the Series 9000 gyro. The new gyro, which incorporates the best features of two other gyros produced for more than 40 different military aircraft, can be adapted for use in missiles, drones, tanks and many other applications in addition to aircraft stabilization requirements.

Also introduced during the year was "Mini Par," a new addition to the Instrument Division's precision aircraft reference system line. Basically, the new system is a miniaturized 2-gyro reference, weighing just 20 pounds and occupying only 556 cubic inches of space. The Mini Par can be used as primary reference or as a backup for a more sophisticated system such as other members of LSI's precision aircraft reference family.

The division's attitude director indicator and dual flight director computer, key units in the new C-141 all-weather landing system, contributed to the certification of the StarLifter for Category II operations. This was the first certification of a military aircraft to make fully automatic landings.

Major continuing production programs at the Instrument Division involved the AN/AJB-3 and 7 bombing systems and ASN-50 and 70 reference systems.

LSI POWER EQUIPMENT GROUP

Power Equipment Division

The already broad range of Power Equipment Division's products which produce or harness power and include motors, generators, starters, clutch/brakes, and servo actuators, was expanded during the year through technological development in many related areas.

Among the significant products introduced by the division were the world's fastest industrial clutch and brake and a DC electric motor designed specifically for deep submergence applications. Designated "Fastep," this clutch/brake is a highly versatile motion-control module that was judged one of the most significant new products of the year by a national publication. The electric motor, developed for deep submergence propulsion equipment, is an oil filled or "wet" motor which has a projected brush life of 20,000 hours and efficiency of 70-75 percent.

Product development and continuing programs, primarily for aerospace applications, covered a wide range of power and power control requirements. Electrical systems and components for all models of the DC-8 Series 10 through 60 were in production, as was similar equipment for numerous other makes and types of aircraft. In addition, a new generator and static voltage regulator package was developed for use on a military helicopter employing a "night vision" concept, and development was started on a new type of generating system to provide AC and DC power from the same generator.

In the area of power control, the division developed throttle control actuators for 2 important, classified applications and yaw damper control servo actuators for the new OV-10A light-armed reconnaissance aircraft.

Romec Division

Romec Division, a leader in the field of aerospace hydraulic and pneumatic systems and components, recorded impressive achievements over the past year. Major programs in-work at the division included a jet pump for the AAFSS (Advanced Aerial Fire Support System) fuel transfer system and the hydraulic pump for the Walleye air-to-surface missile. Fluid handling components for the Agena space booster, J85 and J79 jet engines, Apollo program, and a variety of fixed and rotary winged, private, commercial and military aircraft were also in production at the division. In addition to lube and scavenge pumps and fuel booster pumps, these products included pneumatic units, pressurization sets, cooling equipment units, check valves couplings, and hydraulic power packages.

Among the division's major research and development programs was the development of the lubrication and scavenge pump for the supersonic transport engine, the largest known unit of its type.

Transport Dynamics, Inc., A Wholly-Owned Subsidiary of LSI

Assigned to LSI's Power Equipment Group following the merger of American Metal Products Company into Lear Siegler, Transport Dynamics is a leader in the field of self-lubricated bearings. The company had produced or was in production on bearings for the F-111 multi-service fighter, the SST, the Mark 46 torpedo, the Saturn booster, and the unmanned Mariner and Surveyor spacecraft.

In addition, during the year, the company supplied bearings to Boeing for the commercial 707, 720, 727, and 737 and will also supply bearings for the huge 747. On the 727, for example, LSI provided bearings for the landing gear, wing attach points, horizontal stabilizers, nose gear, and flap system. Similar LSI bearings are being used in the Douglas DC-8 and DC-9, in other civil aircraft, and in commercial and government helicopters.

The company was selected to provide all bearings for the nose and main landing gears of the C-5A military cargo transport and it continued as a supplier to other major government aircraft, including the Boeing B-52, Lockheed C-141, McDonnell F-4 Phantom, Ling-Temco-Vought A-7, and North American XB-70.

Overseas, LSI became the largest supplier of bearings for the new Anglo-French Concorde supersonic transport.

SYSTEMS AND SERVICE GROUPS

Cimron Division

During the past year, the Cimron Division enlarged its product line into a broad spectrum of test instrumentation and data systems related to a variety of aerospace programs. Primarily a manufacturer of digital voltmeters and instrumentation products, the division introduced new lines of 3- and 4-digit instruments to augment its 5-digit unit. Cimron instruments were being used on the Grumman EA-6B and A-6A and the General Dynamics F-111.

Development of 2 new models of the Hydro-Squeegee solder leveling machine, developed by Cimron and used by a large number of circuit-board manufacturers, was completed and production on both units was scheduled to begin near the end of the year. One of the new machines, the Model 1000, incorporates functional improvements with completely automated operation.

Component Services Division

LSI's Component Services Division with facilities in Harrisburg, Pennsylvania; Oklahoma City, Oklahoma; and Los Angeles, California, performs instrument and equipment overhaul and repair on a wide variety of government, commercial and private aircraft systems and components.

To complement and further diversify its product repair and overhaul capabilities, the division acquired facilities and personnel to provide service for a variety of communications and photographic equipment.

Data And Controls Division

In addition to being recognized as the leading U.S. manufacturer of weather radar, the Data and Controls Division of LSI achieved prominence in other areas of ground-based and avionic equipment through its product capability. The division contributed to the success of the Lunar Orbiter mission by providing 2 precision voltage units for the spacecraft. Both the precision voltage unit for the "line scan tube" and the programmable precision voltage supply for the "photo multiplier" were integral components of the photo transmission system.

To meet the need for power supplies that are compatible in size, weight and ratings with miniaturized airborne electronic equipment utilizing integrated circuitry, the division developed a group of miniaturized multiple power processors. These devices are used with the advanced Loran-D and IHAS (Integrated Helicopter Avionics System) systems.

Electronic Instrumentation Division

The Electronic Instrumentation Division successfully entered an entirely new market during the year with the receipt of more than $10,000,000 in contracts for the manufacture of fuzes and fuze booster assemblies for the U.S. Army. The division was also developing prototypes of a new optical proximity fuze under a contract from the U.S. Air Force, which was awarded on the basis of results of a company funded development program.

Shortly before the start of 1967, LSI acquired the business and assets of the Telemetrics Division of Technical Measurements Corporation, a leader in the field of telemetry equipment. This operation was phased into the complementary technical capabilities of the LSI division.

With the delivery of systems to the Naval Ordnance Test Station, White Sands Missile Range, and Vandenberg Air Force Base, the Electronics Instrumentation Division completed its initial entry into the digital data systems field. All 3 systems contained advanced, newly developed equipment.

In the field of airborne video systems, the division achieved success with the television system supplied for the Advanced Technology Satellite which was used to provide visual information on the behavior of the extendable booms during a gravity gradient experiment.

C. G. Hokanson Division

While extending its leadership as a manufacturer of ground support air conditioning equipment for commercial and military aircraft, missiles, and spacecraft, the C. G. Hokanson Division entered another area of specialization within the aircraft industry during the year. Applying new construction techniques which utilize honeycomb material, epoxies and special extrusions, Hokanson entered the aircraft galley and interior furnishings field. Manufacturing facilities were established and production on galleys for leading air carriers of 3 continents was started during the first half of 1967. Later in the year, the division also received an award to provide this type of equipment for the passenger compartment of aeromedical evacuation transport aircraft of the U.S. Air Force.

For the vital role that a Hokanson mobile air conditioner played in the success of the Surveyor moon landing, the division received its second commendation from the program's prime contractor. The LSI unit keeps the temperature of the spacecraft's electronic equipment at optimum levels during the long hours of checkout prior to lift-off.

During the year, 2 model H-65 mobile air-conditioning units were ordered by Sud Aviation and British Aircraft Corporation for testing prototypes of the Concorde supersonic transport. At year-end 47 airlines in 53 countries utilized the division's equipment to maintain cabin comfort for passengers during airport stopovers. This line of ground support air conditioning equipment was expanded during the year with 2 new models of aircraft heating carts utilizing the waste-heat principle which eliminates noxious fumes and the explosive hazard of current combustion-type heaters.

LSI Services Division

Significant growth was achieved during the year in the area of services, where the roster of technical personnel approximately doubled. Among the major service contracts received by the Services Division was a 3-year "call contract" with an estimated value of $30, 000,000 to provide aircraft and aerospace systems maintenance for the Air Force. This was the third such 3-year contract consecutively won by LSI. A similar 3-year contract with an estimated annual value of $7,000,000 was received from the Army.

The LSI Services Division was also selected to provide on-site support for modification of the McDonnell Douglas F-4C Phantom, a program which involves the installation of AIMS equipment. This program, recently developed in a joint venture by the DOD and the FAA, is to improve the identification and orientation of aircraft operating in congested areas.

LING-TEMCO-VOUGHT, INC.

Ling-Temco-Vought, Inc., expanded during 1967 to 7 diversified and highly successful subsidiaries employing a total of more than 60,000 persons and expected sales of more than $1.8 billion.

The company, headquartered in Dallas, Texas, began the year with only the parent company and 4 subsidiaries: LTV Aerospace Corporation, LTV Electrosystems, Inc., The Okonite Company and LTV Ling Altec, Inc. Acquisition of Wilson & Co., Inc., home-based in Chicago, Illinois, was finalized in June.

Employing much the same solid business techniques as that used in forming the parent corporation, LTV redeployed Wilson & Co. into 3 subsidiaries—Wilson & Co., Inc., processed and fresh meat, poultry, shortening, institutional foods and freeze-dried foods; Wilson Sporting Goods Co., sports and athletic equipment, athletic clothing and plastic products; and Wilson Pharmaceutical & Chemical Corporation, gelatin, pharmaceuticals, polyester resins, organic chemical derivatives and sulfuric acid.

Ling-Temco-Vought securities are listed on the New York Stock Exchange; the securities of each of the subsidiaries are listed on the American Stock Exchange.

In addition, LTV proposed a tender offer for any and all stock of Greatamerica Corporation, a Dallas-based holding company with an 80 percent interest in Braniff Airlines and extensive holdings in the banking and insurance industries. In November the Civil Aeronautics Board put its stamp of approval on the acquisition; CAB approval was mandatory because one segment of LTV was involved in aircraft manufacture.

With CAB approval granted, acquisition of Greatamerica Corporation was scheduled to be finalized "as soon as practical."

Also in the year's picture, in addition to the parent company's acquisition of Wilson & Co., Inc., were 5 other acquisitions by subsidiaries.

Memcor, headquartered in Huntington, Indiana, and a quality manufacturer of tactical radio equipment and guidance components, was acquired by LTV Electrosystems, Inc., as a division; Pye-Ling, Ltd., English manufacturer and European distributor of electronic vibration environmental test equipment, microwave power supply units and other product lines, became a wholly-owned subsidiary of LTV Ling Altec, Inc.; Ling Altec also acquired Allied Radio Corporation of Chicago; the Jefferson Wire and Cable Corporation of Worcester, Massachusetts, was merged into The Okonite Company, and Goldschmidt Chemical Corporation of New York City was acquired by Wilson Pharmaceutical and Chemical Corporation.

In the aerospace field, it was an outstanding year of advancement for LTV Aerospace Corporation, headquartered along with the parent company in Dallas, Texas.

With its A-7A Corsair II light attack Navy aircraft operating from carriers positioned off the coast of Vietnam, the subsidiary's Vought Aeronautics Division turned its attention to follow-on versions of the versatile aircraft. The A-7B, also built for the Navy and equipped with a more powerful engine, went into

LTV Tower, Dallas headquarters of Ling-Temco-Vought, Inc.

production during the closing months of 1967.

Meanwhile, Vought Aeronautics geared for production of 2 more advanced versions of the aircraft, the A-7E for the Navy and the A-7D for the Air Force. Both aircraft will incorporate much improved avionics systems, providing more accurate navigation and weapons delivery systems in all weather conditions, and more powerful engines.

In all, the subsidiary expected to produce more than 1,600 of the aircraft during the life of the contract.

A continuing program for the modification and remanufacture of the F-8 Crusader series gained new momentum during 1967. A total of 395 of the supersonic fighters were programmed for modification and remanufacture, extending the aircraft's service life into the mid-1970s and increasing its combat capabilities.

Test work continued on the subsidiary's XC-142A triservice transport aircraft, the world's largest vertical short take-off and landing aircraft and, in the commercial field, the company teamed with The Boeing Company as a major subcontractor on the 490-passenger 747 transport and the SST (supersonic transport). LTV Aerospace was to produce the complete tail section of the 747 and was also named body structure subcontractor on the SST.

In the field of research, work was started on a new $2,500,000, 97,000-square-foot Corporate Research Center near Grand Prairie, Texas, midway between Dallas and Fort Worth, with completion scheduled for early 1968. The Research Center also had divisions in Anaheim, California, and Honolulu, Hawaii, as well as in Dallas.

Along with construction of the new research center, LTV Aerospace embarked on a program of enlargement of facilities to accommodate its expanding business. Heading a list of construction projects was a new $15,000,000, 1,000,000-square-foot manufacturing, office and laboratory complex for the company's Missiles & Space Division. Additional construction at the main Dallas plant occupied by the Vought Aeronautics Division included a new $3,000,000 machine shop and special projects building, a $1,200,000 engineering building and new warehouse facilities. A $4,000,000 satellite machine shop also is being constructed at the Gregg County Airport near Longview, Texas.

In the space field, the Missiles & Space Division's 4-stage Scout continued a busy launch schedule for NASA, the Department of Defense and a number of foreign nations, including the United Kingdom, Italy, West Germany, France and members of the 10-nation European Space Research Organization (ESRO).

As part of Italy's San Marco program, the vehicle participated in the first orbital launch along the equator and the first launch from a sea-based mobile launch platform, anchored to the sea bottom off the east coast of Africa.

Studies continued toward possible use in the Apollo program of the division's Astronaut Maneuvering Unit, the self-propelled, stabilized back pack unit designed to permit an astronaut in a pressure suit to operate like a one-man space vehicle for assembling and servicing spacecraft in orbit. The division also performed engineering design work on larger extravehicular units, including an open Maneuvering Work Platform described as a space-going toolshop and an enclosed version equipped with remotely-controlled manipulators for space tasks.

The Missiles & Space Division received new orders for the huge fuel and oxidizer containers used in the first stage of the uprated Saturn I launch vehicle. Nine of these containers, each more than 62 feet long, are clustered in each rocket to provide 850,000 pounds of fuel for the first stage motors.

In missile activities, the Missiles & Space Division's Michigan facility near Detroit, prime contractor for the Army's Lance battlefield missile, received an $11,000,000 contract calling for the first industrial buy. The contract calls for supplying Lance ground support equipment and training missiles to support engineering service tests and troop training and to equip initially the first Lance troop battalion.

LTV Aerospace Corporation and Kaiser Jeep Corporation entered a joint bid in the U.S. Army competition for quantity production of the M-561 1¼-ton truck, also known as the Gama Goat, developed by the company's Missiles and Space Division.

Development of an Extended Range Lance (XRL) also was approved by the Army. In addition, an exploratory development contract was awarded by the Navy for a ship-launched Landing Force Support Weapon version called Sea Lance.

Two other segments of LTV Aerospace—Range Systems Division and Kentron Hawaii, Ltd., made extensive business gains.

Range Systems Division, winner of a NASA contract in September to provide facilities support services to the Houston Manned Spacecraft Center, moved into an exceedingly strong position to compete in nearly all services required by NASA.

Range Systems, a service organization holding contracts for services at White Sands Missile Range and Kennedy Space Center as well as at the Houston facility, was furnishing a broad spectrum of electronic engineering and technical support services for key space and defense projects. Also, the division was prime contractor for 2 range instrumentation ship conversions for the Navy and, under another contract, holds prime electronics systems responsibility and performs in the same capacity on one of the Navy's two major communications relay vessels.

In the Pacific, Kentron Hawaii, Ltd., provided extended services to the area from Honolulu, including range operations and maintenance, electronic equipment repair and calibration, telecommunications, engineering, installation and operations, and oceanology.

Earlier in the year Kentron Hawaii won an Army Materiel Command contract for maintenance, operation and development of the Nike-X test site range technical facilities at Kwajalein Atoll, Marshall Islands.

It also was a year of advancement for LTV Electrosystems, Inc., a major electronics corporation producing a great variety of components, products, systems and services for government and industrial markets. With 12 major facilities in 5 states, the subsidiary is composed of 4 operating units—Greenville Division, Garland Division, Memcor Division and Continental Electronics subsidiaries.

Greenville Division, the largest operating segment, began work on an Air Force contract to produce one of the most advanced airborne weapons control systems to date during 1967. Although unable in many instances to announce specific contracts due to security restrictions, the division received numerous contracts for both classified electronics systems and aircraft modifications.

In a relatively new field, airborne illumination of large ground areas, the division developed a small, 3-light illumination system similar to the 28-light system developed last year. Called AGIL II (airborne general illumination light), the new system can be mounted in helicopters or light aircraft.

The unit is capable of providing a surface circle of light 3,500 feet in diameter—6 times brighter than full moon light—with the aircraft at an altitude of 3,000 feet. In comparison, the AGIL I 28-light system prototype, mounted in a C-123 transport, provides a circle of light one mile in diameter—5 times brighter than full moon light—with the aircraft at 5,000 feet.

An advanced version of the 28-light system was developed under an Air Force contract for installation in C-130 cargo aircraft.

The Greenville Division moved its computer sciences and contract administration operations into a new 65,000-square-foot building, part of a $2,000,000 expansion program, during the year. Also completed was a 380-foot extension to the main production area, providing a free-span production area more than 1,600 feet long and 175 feet wide, with a 52-foot vertical clearance.

The Garland Division began production of the advanced AN/AYA-7 Digital Communications System, developed by the division, in 1967. Significant contract for digital core storage units further increased the division's digital systems activity. The division's leadership position in automatic controls continued to grow with a contract for the Boeing 737.

Another significant contract for Boeing 747 controls and a technical assistance contract on the supersonic transport added further impetus to the automatic controls line. The division's work included large precision parabolic antennas for satellite communications, electronic warfare system developments and programs, guidance systems, displays and other electronic activities vital to the nation's defense and space programs. Programs in which the Garland Division participated during 1967 included the A-7A, F-8, 727, 737, 747, Minuteman, Titan, Apollo and others.

The Garland Division's work force increased by 500 employees during the first 10 months of 1967 with the expansion continuing.

Memcor Division, Electrosystems' newest operating unit, was acquired in March 1967. Headquarters and Midwest Operation and Components Operation were located at Huntington, Indiana. Courter Operation was located in Boyne City, Michigan, and the Montek Operation in Salt Lake City, Utah.

The division's major product line included systems, replacement components and accessories for a number of tactical communications requirements. Memcor-built radios were being utilized by both combat and front-line service branches of the Army and the armies of many friendly and foreign nations.

Shortly after Electrosystems' acquisition of Memcor, the new division-to-be received the largest award ever won by Memcor, an Army contract to produce the 3 major components of the AN/VRC-12 series of vehicular-mounted communications systems. This lightweight, modular system is installed in trucks, tanks and armored vehicles and is much smaller and less complex than preceding systems.

Memcor's production of the AN/PRC-25, the latest version of the Army's famous "walkie-talkie," reached peak production during the year of more than 4,000 units per month. The transistorized, self-contained PRC-25 is both portable or vehicular-mounted and is used for short-range, line-of-sight communications.

The Montek Operation received an Air Force contract for TMC-212 TACAN test monitor and control units with multi-year options and potential follow-on business.

In 1967 Memcor completed construction of new facilities at its Courter Operation, including a "clean room" production area of highest industry standards and double the size of previous accommodations. The Walleye and Bullpup gyro production was in the new facility and space was available for additional product lines.

Continental Electronics, a subsidiary of LTV Electrosystems, continued to lead the company in the fields of super-power radar and radio transmission systems.

In 1967 Continental began deliveries of the first super-power transmitters to come "off the line" in its new high-volume transmitter production facility, establishing an industry "first" for volume production of such equipment.

The new facility is located in a 76,000-square-foot building; the facility and test areas are, in reality, transmitter "production lines" capable of delivering a variety of high-power transmitter designs in quantity to a predetermined schedule.

Continental received contracts for a multi-year purchase of high frequency 40 and 200 kilowatt ISB transmitters for the Naval Electronics System Command (NESC), a continuing operation and maintenance contract for RAM/STALLION radar systems at the White Sands Missile Range, a contract from the Research and Development Command (RADC) for VHF radar, a contract for the OTH (over the horizon) radar transmitter, and a contract from the Navy Research Laboratory (NRL) for a VHF radar.

In addition, a contract was received for a one-megawatt broadcast transmitter for the Broadcast Corporation of China. Still in progress was a contract for construction of a VLF radio station in Norway for NATO, and a contract from the U.S. Information Agency for 10 350,000-watt high frequency transmitters.

Continental previously produced the Ballistic Missile Early Warning System transmitters, the world's most powerful radio installation, and the Voice of America's systems penetrating Eastern European Asia.

LTV Ling Altec, Inc., formed an Ordnance Division at its Anaheim, California, headquarters to manufacture and market certain proprietary equipment and the subsidiary's Ling Electronics Division opened a new manufacturing facility at Wilmington, Massachusetts, where the company's shakers, electropneumatic transducers and micro-gee oscillating and linear rate tables were being manufactured.

In addition, Du Mont Mobile Communications Division broadened its line of mobile radio transmitters and radio-telephone equipment and added a new hand-held 5-channel FM receiver.

Product development and evaluation programs continued at an accelerated pace at The Okonite Company, headquartered at Passaic, New Jersey. In addition, the merger of Jefferson Wire and Cable Company with The Okonite Company became effective in October of 1967.

LOCKHEED AIRCRAFT CORPORATION

Strengthening its position among the most broadly based of top U.S. aerospace firms, Lockheed Aircraft Corporation during 1967 carried on a wide range of research, development, and manufacturing programs in 7 major fields for military and commercial customers.

Principal areas of activity ranged from Lockheed's traditional market, air vehicles and support, to aerospace trajectory (missile and propulsion) systems, orbital and planetary vehicles and missions, ocean surface and undersea research and vehicles, land and underground programs, electronics including communications and information systems, and overseas operations and investments.

In air vehicles, 1967 milestones included:

• Announcement in the fall that Lockheed was offering world airlines an advanced technology tri-jet transport, the L-1011. The new, flexible range, jumbo jetliner was designed to carry from 227 to over 300 passengers in greater comfort than earlier jets to meet mushrooming air travel requirements of the 1970s.

• Decision to offer to cargo carriers a larger, growth version of the Lockheed 100 Hercules commercial airfreighter, in service with 6 airlines at year-end. A cargo compartment stretched 100 inches can carry an extra 640 cubic foot cargo pallet, increasing productivity 30 percent.

• On-schedule manufacturing progress on the first C-5A Galaxy heavy logistics transport, world's largest airplane, under a $1.4 billion Air Force contract for the Military Airlift Command. The 728,000 pound giant was scheduled to roll out in February 1968 and have its first flight in June.

• By year-end, MAC's entire 14 squadrons of C-141 StarLifters had become operational. Playing key roles in cargo carrying and medical evacuation missions between the U.S. mainland and Southeast Asia, the C-141s had a total capacity of 595,000,000 ton miles a month.

• Deliveries of military C-130s neared the 1,000 mark. These rugged turboprop airlifters were in service with the U.S. and 14 foreign nations.

• Lockheed's 2,000 mile-an-hour titanium SR-71 strategic reconnaissance aircraft, flown by the Strategic Air Command, carried on supersonic training flights over much of the U.S. at altitudes up to 15 miles. Early development studies of its sister ship, the F-12 interceptor, continued.

• P-3 Orion antisubmarine patrol plane production for the Navy moved at a steady pace, with more than 250 in Atlantic and Pacific fleet service. The advanced P-3C was scheduled for fleet introduction in 1969. Both Australia and New Zealand added P-3Bs to their patrol forces.

• A test program demonstrated in-flight performance of the prototype F-104S Starfighter armed with radar guided Sparrow missiles. Italian firms were to build 165 under license, equipped with new, higher thrust engines.

• A day ahead of schedule, Lockheed's first AH-56A Cheyenne winged helicopter for the Army had its successful first flight in September, beginning flight tests and proving stability of its rigid rotor design concept. Among other vertical lift activities, the XV-4B Hummingbird direct lift, diverted thrust experimental craft for the Air Force was scheduled for June 1968 first flight.

• The new Dash 8 version of the JetStar executive jet transport with more powerful engines and other improvements received Federal Aviation Administration certification in May. Lockheed delivered 18 JetStars during 1967's first 10 months.

In aerospace trajectory, Lockheed was managing 2 Navy fleet ballistic missile programs. An improved Polaris A3 incorporated developments from the Polaris-Antelope project. Poseidon, eventual successor to Polaris, with double the payload and twice the accuracy of the A3, was in development stages and nearing first test firing. In related rocket propulsion work, important programs included development of a family of very small solid rocket motors under subcontract to Avco Corporation, a follow-on contract from North American Rockwell Corporation, for Apollo launch escape motors, and a subcontract from The Boeing Company to develop and produce the propulsion system for the Air Force's new air-to-ground short range attack missile (SRAM).

Lockheed's military and civilian space efforts centered around its Agena satellite and second stage booster. Agena's military work was classified. For NASA, Agenas during 1967 participated in 3 Lunar Orbiter launches, put Mariner V in the long trajectory that carried it within 2,400 miles of Venus in October, teamed with a Thor first stage booster to launch the fourth Orbiting Geophysical Observatory (OGO), and played a booster role in the third Applications Technology Satellite launch. Vice President Humphrey described Agena as "in a very real sense the power behind our unmanned space efforts. . . . the work horse of the space program."

Lockheed also was studying an advanced orbiting communications spacecraft for Communications Satellite Corporation and held a range of NASA study contracts in fields related to manned space travel, orbital refueling techniques, cargo delivery systems, and biomedical research.

Significant progress was recorded in ocean work. Lockheed's research submarine *Deep Quest*, built with company funds, made its successful first dive in September and continued a test series that will carry it ultimately to 8,000 feet below the surface. Experience gained with *Deep Quest* helped Lockheed win Navy contracts to design, develop, and build 2 full scale deep submergence rescue vehicles. Lockheed and another contractor also were selected to develop competitive preliminary designs for a deep submergence search vehicle capable of operating at depths to 20,000 feet.

Operations at Lockheed's Seattle shipyards were hampered in 1967's early months by a strike of electrical workers against 12 West Coast yards. A settlement was reached in July. During the year Lockheed completed and delivered the 21,700 ton *Sea Lift* vehicular transport ship, largest it has yet constructed, and the guided missile destroyer escort *USS Ramsey*. It launched the fifth of 7 16,500 ton Navy landing platform docks, began sea trials of the *Plainview*, world's largest hydrofoil vessel, and had 11 ships in various construction stages as 1967 ended.

Anti-corrosion protection was another phase of Lockheed's marine work. Its patented lead platinum Cathanode systems protect navy and commercial vessels, docks, canal locks, offshore oil rigs, undersea craft, and underwater sections of San Francisco's new Bay Area Rapid Transit. Under field test was a new anti-corrosion coating applied through a heat flash process.

Among Lockheed's land-oriented interests were special purpose ground vehicles, low cost housing, and heavy construction including dams and tunnels. Its prototype TerraStar amphibious vehicle, employing a unique multi-wheel drive system, passed all phases of rigorous tests and was accepted by the Army late in 1967. Also under development was Twister, an advanced off-road ground vehicle applicable to military use.

Lockheed was making significant progress with its patented Panel Lock low cost housing system, using wall and roof panels that can be quickly formed and erected by low skill labor at building sites. Homes using this system were built in Guam, Puerto Rico, California, and Australia, and Lockheed held a substantial equity interest in a firm formed in the Philippines that planned to build up to 1,500 houses a year. Under construction were dams in Colorado and Oregon, and Lockheed was participating in a joint venture to build a tunnel near Los Angeles as part of a system to carry water from northern to southern California.

Cargo pallets and containers compatible with air, rail, maritime, and truck shipping requirements were among Lockheed's product areas, as was a family of custom designed shipboard and industrial cranes and other materials-handling equipment.

Electronics continued to be a major field of Lockheed activity. Centered in one of its 9 operating companies was a wide range of electronic products and services, including Army and Navy gunfire control systems, a Navy ship-to-shore "moon bounce" communications system, computer memory systems and circuit boards, a family of recorders, and development of a helicopter radar system. Another Lockheed operating company is a leading producer of airborne flight and maintenance recorders and a specialist in aircraft electronic modifications and installations.

Lockheed's information system work, involving systems and applications for computer and communications technology, was taking on national scope. Late in 1967 it received a U.S. Public Health Service award to study reporting requirements of representative hospitals. The states of California, Alaska, Massachusetts, and West Virginia all contracted for development of statewide information systems, and Lockheed carried on similar work for medical, educational, and government agencies.

Lockheed had customer service and marketing representatives in many parts of the world. International activities included joint venture developments and licensed manufacturing programs.

Principal management changes during 1967 included election of Daniel J. Haughton as chairman, succeeding Courtlandt S. Gross, and A. Carl Kotchian as president, succeeding Haughton. Gross remained as a director and chairman of the finance committee. Group Vice President M. Carl Haddon was elected executive vice president, succeeding Kotchian. Taking over Haddon's post was W. A. Pulver, succeeded as Lockheed-Georgia Company president by T. R. May, also elected a corporate vice president. Haddon also became a member of the board, succeeding Robert Proctor, who did not stand for re-election. Proctor died some months later. Others named as corporate vice presidents were Robert I. Mitchell, with responsibility for commercial aircraft programs, and T. F. Morrow, assistant to Kotchian.

In 1967's first 9 months, Lockheed reported sales of $1.55 billion, net earnings of $38,200,000 and a record high backlog of $2.6 billion, compared respectively with $1.6 billion, $41,000,000 and $2.3 billion for the same 1966 9-month period. Employment at the end of September totaled 94,600, compared with 89,500 a year earlier.

THE MARQUARDT CORPORATION

The Marquardt Corporation established significant milestones in precision rocket technology during 1967 as the result of its rocket performance on the highly successful NASA Lunar Orbiter program.

Marquardt's R4-D 100 pound thrust rocket served as the velocity control engine on each of the 5 Lunar Orbiter missions. Produced by Marquardt's Rocket Systems Division under contract to The Boeing Company, the rockets executed a total of 28 command firings (as of October 20, 1967) for midcourse corrections, orbit adjustments, photo orbit injections, and planned crash landing maneuvers. Each of the critical maneuvers was accomplished with precision accuracy and 100 percent reliability.

R-4D rockets were also used for attitude control on NASA's Project Apollo Service and Lunar Modules, each module being equipped with shipsets of 16 engines. Marquardt was also supplying rocket engines for a classified Air Force program. Since the development of the R-4D engine, the Rocket Systems Division has developed a broad line of bipropellant and monopropellant rockets, with thrusts ranging from 0.1 to 2,000 pounds.

Marquardt's activities during 1967 were further characterized by a broadening of product lines and manufacturing services, particularly in the ordnance field. At its Ogden, Utah, manufacturing facility, Marquardt continued production of fin-and-nozzle assemblies for the 2.75-inch rocket. Other Ogden production programs include engine stator blades for the Air Force C-5A program, fuse adapters for the Army T-46 bomb, and ram air turbines for emergency and auxiliary electrical and hydraulic power for various military and commercial aircraft.

Also during 1967, following transfer of ram air turbine production from Van Nuys to its Ogden manufacturing facilities, Marquardt established a Systems Engineering Division (SED) at Van Nuys. The new division is actively engaged in development and production of controls and accessories, and tactical warfare, ordnance, and munitions systems.

Marquardt's airbreathing technology activity continued to progress in the area of advanced composite propulsion systems development. Significant technical achievements were being made in Ejector Ramjet development (a rocket-ramjet composite engine) and in supersonic combustion ramjets (Scramjet).

At year-end 1967, Marquardt employed approximately 2,500 personnel. The company maintained operations at Van Nuys and Pomona, California; Ogden, Utah; and Westbury, New York; and district offices in Washington, D.C.; Dayton, Ohio; and at Van Nuys, California.

MARTIN MARIETTA CORPORATION
BALTIMORE DIVISION

In 1967, the Baltimore Division continued to move ahead in areas of advanced manufacturing technology, production of a variety of aerospace products and components and in aircraft modification. The year also saw the conclusion of Baltimore's PRIME lifting body spacecraft program which successfully demonstrated a maneuvering reentry at orbital speed. A larger, manned lifting body research vehicle, the X-24A, also was delivered to the Air Force.

The PRIME vehicles were developed for the Air Force Systems Command's Space and Missiles Systems Organization as part of its Spacecraft Technology and Advanced Reentry Test Program (START). All mission objectives were met on just 3 flights within a 4-month period. The last vehicle was flown April 19, one day from the contract date scheduled 28 months earlier. A fourth flight vehicle, awaiting launch at Vandenberg Air Force Base, was cancelled as unnecessary.

PRIME claimed several "firsts." It was the first lifting body spacecraft to maneuver hundreds of miles in crossrange, the first flight of a strapdown guidance system, and it demonstrated the integrity of a new Martin Marietta-developed elastomeric silicone heat shield which was wrapped completely around the flight vehicle.

The X-24A, also a project of the START Program, was designed and built for the Air Force Aeronautical Systems Command. At rollout ceremonies July 11 in Baltimore, when the wingless rocket vehicle was turned over to the Air Force, Lt. Gen. Charles H. Terhune, vice commander, Air Force Systems Command, called the X-24 "a vital link between the fields of aeronautics and astronautics (which) will help to develop the technology needed for a possible future requirement for a manned, lifting body reentry vehicle capable of returning from space and landing at a designated site of the pilot's choice, much as conventional aircraft land today."

The X-24, a larger, piloted version of the PRIME configuration, was delivered to Edwards Air Force Base in August. After a ground test program, including wind tunnel tests at NASA's Ames Research Center, the X-24 will be carried aloft by a B-52, dropped at about 45,000 feet, then rocket under its own power to supersonic speeds of about Mach 2 at 100,000 feet. From this altitude—where the PRIME vehicle ended its flight profile—the X-24 will maneuver like an airplane to a landing at conventional aircraft speeds. On completion of the X-24 flight program, scheduled to begin in 1968, data will have been obtained on the same lifting body configuration throughout the speed regime—from hypersonic orbital speeds down through supersonic, transonic, and subsonic—to a tangential landing.

The corporation's maneuverable, lifting body spacecraft technology, growing out of the PRIME and X-24 projects, was to be concentrated with other space activities in the Denver division which also has responsibility for advanced design and future requirements in this area.

Under contract to NASA, a sprayable version of the elastomeric silicone ablator used on PRIME was developed at Baltimore as an ablator for the X-15-2. The ablator-coated rocket plane made its first flight in October, reaching a speed of 4,534 miles per hour. During the flight, temperatures on leading edges reached 3,000 degrees Fahrenheit. This was 1,000 degrees over the pre-flight estimation. A second flight was scheduled for 1968 in an attempt to reach Mach 8 speeds.

Also for NASA, the Baltimore division delivered the first Apollo Lunar Service Drill (ALSD) test unit. It performed flawlessly during field testing in Death Valley. The lunar drill is designed for obtaining core samples of the lunar surface. Thermal sensors for measuring lunar heat flow will be implanted in the holes. The drill is a rotary-percussion type using a tungsten carbide bit, thus eliminating the need for water as a coolant and flushing agent.

Martin Marietta's Modification Center at Baltimore was busily engaged in preparing a number of aircraft for new missions. Electronic modifications were performed on such aircraft as the B-57, EC-121, RC-135 and the Navy's P-2.

One of the more technologically significant programs in the Modification Center was the conversion of 2 F-106B jet fighters into Variable Stability Trainers (VST) for use by the Aerospace Research Pilot School at Edwards Air Force Base. The VST will be able to duplicate the flight characteristics of the F-105, F-111, X-15 and X-24A. The F-106/VST marks the first time a variable stability aircraft has been developed for routine training operation. Prior craft of this type have been used exclusively for research. Martin Marietta was investigating a variety of applications of its VST concept. One of these was the use of VSTs by commercial airlines for pilot training. Its versatility would permit airlines to use the same trainer for a number of different aircraft, eliminating the need for diverting revenue-earning planes from normal operations.

Aircraft manufacturing work included continuing production of major assemblies of the Bell UH-1 Huey helicopter, Boeing Vertol CH-47A Chinook helicopter, and horizontal stabilizers for McDonnell Douglas DC-8 jet transports.

Major tooling work was being performed under a number of contracts. Expendable plaster/plastic tools were being made for the F-111 for both the USAF and Navy versions. The largest plaster stretch blocks ever produced by the Baltimore division were made in 1967 for Lockheed's C-5A.

DENVER DIVISION

The scope of operations at the Denver division broadened considerably during 1967 with concentration of much of the corporation's space-related activities there and receipt of several new space contracts.

In July, the division was selected by the National Aeronautics and Space Administration (NASA) to negotiate a major contract for payload integration of experiments and experiments support equipment in space vehicles for the manned Apollo Applications Program (AAP). The assignment also included missions analysis and systems engineering associated with AAP flights.

Tasks under AAP will be performed by Martin Marietta for 3 NASA manned space flight centers: Marshall Space Flight Center, Huntsville, Alabama, for work on the orbital workshop and Apollo telescope mount; Manned Spacecraft Center, Houston, Texas, work on meteorological and earth resources payloads; and Kennedy Space Center, Florida, for post-integration planning and support for launch operations.

In June, the division was selected by NASA's Jet Propulsion Laboratory, Pasadena, California, as one of 2 major contractors to conduct parallel, competitive studies for feasibility and preliminary design of a planetary entry capsule weighing 5,000 to 7,000 pounds for the Voyager mission to Mars.

Mission design parameters include launch aboard a Saturn V rocket, separation from a Mars-orbiting bus, and a soft landing on the planet's surface. The entry capsule design includes an unmanned, automated surface laboratory. The lander capsule would operate with the orbiting bus as a spacecraft team, providing reconnaissance from orbit as well as simultaneous surface measurements.

On October 17, the last in a series of 13 test flights for the Planetary Entry Parachute Program (PEPP) was conducted 30 miles above White Sands Missile Range, New Mexico. The last 9 tests in this series were conducted during 1967 under the direction of the Denver division, for NASA's Langley Research Center, Hampton, Virginia. Four other program flights during 1966 were conducted by NASA. Two additional flights were cancelled because sufficient data was acquired from other scheduled flights during 1967.

PEPP's objective was to choose a parachute design that would be suitable as an aerodynamic braking device to help decelerate unmanned, instrumented spacecraft as they approach soft landings on planets surrounded by low-density atmospheres. The atmospheric density of earth in the test region of about 30 statute miles (about 130,000 feet) altitude, combined with the velocities at which the parachutes were deployed, resemble the conditions which scientists expect to encounter during entry through the target planets' atmospheres.

The division also completed for Langley Research Center during 1967 a contractual study investigating the feasibility of using buoyant stations for missions up to 100 days and longer about the Venusian atmosphere. Instruments aboard the stations, weighing from 200 to 2,000 pounds, would take readings of the planet's atmospheric and surface conditions, then relay this information back to earth.

Another spacecraft-related activity at the division was Meteoroid Penetration Detector Development, an 18-month program begun in 1967 under contract with Langley Research Center.

Work under this contract includes 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 data is critical to the design of manned and unmanned spacecraft, particularly those that would travel into deep space.

All of the corporation's maneuverable spacecraft technology, growing out of its experience with the U.S. Air Force's PRIME lifting body and X-24 supersonic manned research vehicle, was concentrated during the year in Denver along with responsibility for advanced design and future requirements. Entry materials research functions also were centered at Denver.

Other advanced technological studies under way at Denver during the year included:

• Investigation and demonstration of non-contaminating insertion techniques for launch-pad repair of sterilized planetary vehicles, analysis of contaminating factors in the manufacturing cycle of sterilized spacecraft, effects of sterilization on spacecraft batteries, and construction and test firing of a sterilizable prototype propulsion module for planetary vehicles;

• Studying effects of in-space contamination on the accuracy and operation of optical experimental equipment such as the Apollo telescope mount;

• A variety of live simulation studies into the effects of zero-gravity conditions on extra- and intra-vehicular activity, special maneuvering units such as backpacks and jet shoes, crew activity as affecting the attitude control of in-space hardware and problems in attitude control while conducting orbital tracking operations.

Activity increased during 1967 on construction of about $10,000,000 worth of scheduled new facilities for assembly, test and checkout of spacecraft and their systems.

Acceptance testing was completed at mid-year for a new $5,000,000 Space Simulation Laboratory, outfitted with a 24 by 36 foot thermal vacuum chamber that accommodates completely-assembled spacecraft. Construction of a new 80,000-square-foot electronics manufacturing facility, for manufacture, assembly and test of electronic components used in aerospace vehicles and spacecraft systems, was nearly complete.

The year opened with orders for 30 Air Force Titan III launch vehicles on hand. By year's end, orders had increased the count to more than 50 vehicles, involving all 4 versions available: Titan III-B, C, D, and M.

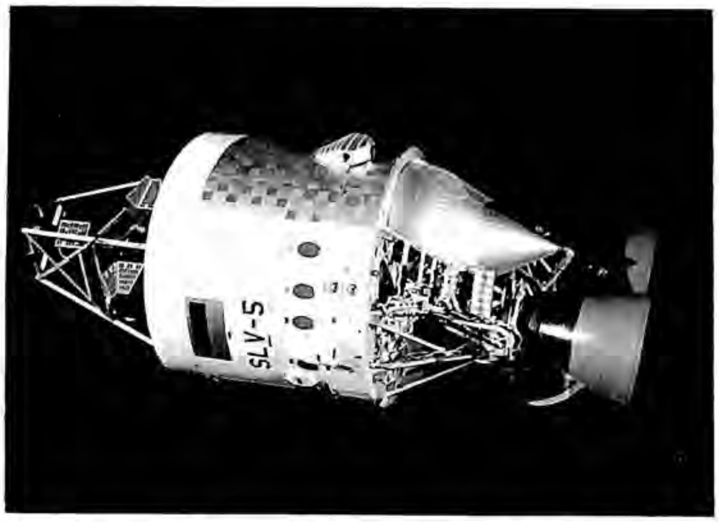
Titan III growth also was under vigorous study, encompassing enlarged versions, with increased performance, reliability and cost effectiveness receiving particular attention.

As part of the continuing support for NASA's interest in Titan III, the corporation studied for Lewis Research Center the feasibility of combining a Titan III with a high-energy Centaur upper stage. Emphasis was on the vehicle's utility for planetary missions and deep space probes.

Improvements during the year, providing greater reliability at reduced cost, as well as increased performance, included: a monopropellant attitude control system; conversion to digital flight controls; and adoption of a digital remote multiplex instrumentation system.

Studies, designed to examine options for other major performance increases, included: extension of on-orbit operating lifetime; conversion to high efficiency, pump-fed flight engines; increased propellant capacity for use on larger boosters; and lightweight, higher-efficiency batteries and fuel cells.

Multiple payloads continued as the hallmark of Titan III in the nation's space program. At the beginning of the year, Titan III-C during its early research and development test flights had lofted 41.8 percent of the total weight placed in synchronous or near-synchronous orbit and 61.5 percent of the total number of satellites.



Martin Marietta-Denver had a year-end backlog of more than 50 orders for Titan III vehicles. Titan III-C and its Transtage (shown) lofted multiple payloads twice in 1967.

The Titan III-C at the end of 1967 had placed 61.8 percent of all satellites in the synchronous corridor and 73.3 percent, or 2,748 pounds, of the total weight in orbit at that altitude.

By the end of the year, Titan III flights included 3 by Titan III-C from Cape Kennedy. The 3 flights were:

• On January 18, 8 Department of Defense communication satellites were carried by Titan III-C into a near-synchronous, equatorial orbit 21,000 miles above the earth as part of the Initial Defense Communication Satellite Program (IDCSP).

• On April 28, tandem Vela nuclear detection satellites were stationed in a 70,000 by 5,370-mile orbit along with 3 small Octahedral Research Satellites (ORS).

• On July 1, a 6-satellite payload, consisting of 3 IDCSP satellites, a Department of Defense gravity experiment (DODGE), Despun Antenna Test Satellite (DATS), and Lincoln Experimental Satellite (LES-5) was stationed precisely in near-synchronous orbit of 21,000 miles.

ORLANDO DIVISION

In 1967, Martin Marietta's Orlando division continued work on its 4 major tactical missile systems—the Army's Pershing, Shillelagh, and the Sprint missiles, and the Navy's Walleye glide bomb, and entered a new phase of the development program on the RADA communications system for the Army. Three significant developments affecting the division's future workload occurred during the year. These were: the winning of the competition for the SAM-D development program, in which Martin Marietta teamed with Raytheon Company; the winning of 3 important studies for the Army's Mallard communications system; and the Department of Defense decision to deploy an ABM defense system, which will mean a production go-ahead for the Sprint antimissile missile.

The Orlando division also continued to supply system components and logistic field support for the Navy's air-to-surface Bullpup missile system, and the Army's BIRDiE electronic fire control system.

Improved ground support equipment for the Pershing system was in full development during 1967, and a production go-ahead was anticipated for the new concept. Under the Pershing 1-A system, as the program is known, several changes were being made to the ground support equipment used in counting down and launching the missile. The biggest outward change was the switch from tracked to wheeled vehicles for transporting the firing unit. Increased mobility and reliability, less vibration, and lower maintenance costs are expected to result from this change. Other major Pershing 1-A system improvements centered in a new programmer test station and a new erector-launcher.

A series of annual practice test firings from off-range sites in southeastern Utah into White Sands Missile Range, New Mexico, continued during 1967. These exercises, designed to maintain troop proficiency in handling the 400-mile-range Pershing missile, included firings by American and German units stationed in Europe as well as those U.S. units headquartered here, since there are no suitable range facilities in Europe.

Development work on the Sprint antimissile missile, slated to be one of the major components of the Anti-Ballistic Missile Defense System, continued during the year under a contract with the Bell Telephone Laboratories. After 4 years of the development effort, the Orlando division had received a total of $302,352,000 for research and development activities, and $3,514,171 for production planning activities under its incentive contracts with BTL and the Western Electric Company. Flight tests of the missile continued during the year at the White Sands Missile Range; and the transporter/loader, developed for handling all loading and maintenance operations on the missile at the launch site, successfully passed its incentive tests. The huge vehicle, a 53-foot-long tractor-trailer rig with a 25 foot vertical tower, was developed for Martin Marietta by the Westinghouse Electric Corporation.

Further test firings of the missile were conducted at White Sands during the year, and later tests were scheduled for Kwajalein Atoll in the Pacific, where the Sprint missile will be integrated with other elements of the ABM system.

Work accelerated during 1967 on the Shillelagh antitank missile project with successful firings of the first Martin Marietta-produced missile in June and the award of a $5,800,000 production contract. Martin Marietta is a second production source for the missile.

In September, the project moved into a facility devoted exclusively to Shillelagh production at Herndon Airport. Work under the original educational contract, which has grown to nearly $2,000,000 since its award in March 1966, was completed there and the facility was ready for mass production of Shillelagh missiles by mid-December. Deliveries of missiles under the production contract were expected to begin early in 1968.

Shillelagh is a lightweight, surface-to-surface guided missile system which is designed as main armament for armored combat vehicles. A direct fire missile which is launched from a combination gun-launcher, Shillelagh will be effective against tanks, troops and field fortification. Its 152 millimeter gun-launcher can fire either missiles or conventional ammunition, and it provides high accuracy against moving or stationary targets.

Production of the Walleye glide bomb continued for the second year at the Orlando division, along with transmitting and launching equipment for the Bullpup air-to-surface missile. Bullpup was operational with both Navy and Air Force fighter aircraft as well as aircraft of the NATO nations. Walleye, a highly accurate weapon with no propulsion, is television-guided to the target. Developed by the Navy, it was slated to become operational with both Navy and Air Force fighter units.

In mid-1967 the Orlando division took on responsibility for its fifth tactical missile when it was selected as principal subcontractor to Raytheon for the advanced development phase of the Army's SAM-D air defense missile system. Under this contract, Orlando will have responsibility for the missile and its shipping-launching container.

In the communications field the division continued its progress toward development of the radically-new RADA communications system for the Army. A go-ahead on Phase III, the prototype-building and field-testing phase of the development effort, was expected by early 1968. This will be a 12 month program.

In October, Martin Marietta was selected by the Army to perform 3 extensive studies in support of the Mallard communication system development program. These studies will be conducted at Orlando. RADA is expected to be a part of the Mallard system. Mallard is an automatically switched digital information handling system, with security provisions, being developed for ultimate tactical use by the armies of the United States, Australia, Canada, and the United Kingdom. Project Mallard is part of the U.S. Army's complete program to study, develop, and produce modern tactical communications for the 1975–1977 time period.

With more than $8,000,000 invested in advanced research facilities during the past 4 years, the Orlando division continued to push a strong research program aimed at increasing its over-all capability in tactical missile systems and communications. Newest facility in the division's growing research center was the $2,000,000 Guidance Development Center dedicated in 1966, which is the most advanced facility in the country for the development testing of both optical and RF guidance systems.

Areas of major research interest at Orlando during 1967 included guidance and control, ablative and protective coatings, structures, and new materials. Extensive research continued in lasers and their applications, inertial reference systems, millimeter and submillimeter wave investigations, and advanced warhead fabrication. During the year, Orlando made major strides in the practical application of fluidics, ranging from industrial machine controls to a spacecraft attitude control system. Quantity production of commercial fluidic devices, the completion of a feasibility model for a solar probe attitude control, work on a digital fluidic readout for a manned spacecraft, and extensive research into the characteristics of fluid flow are among the highlights of current accomplishment.

In the millimeter wave area, an engineering prototype of an earth-space communications link was built for the NASA Applications Technology Satellite. This equipment was to be used in propagation experiments with the synchronous satellite scheduled for flight in 1968.

In addition, considerable work was being done in improved versions of the Bullpup missile, with advanced guidance and control equipment and new types of payloads.

RESEARCH INSTITUTE FOR ADVANCED STUDIES (RIAS)

Martin Marietta's Research Institute for Advanced Studies (RIAS) is the corporation's basic research division. Situated among the farmlands west of Baltimore, Maryland, the Institute's professional staff conducts fundamental studies in biosciences, materials science, physics and fluid sciences. Kenneth Jarmalow is Director.

Although RIAS discoveries could result in marketable new products, the Institute is not oriented primarily in that direction. Research programs are chosen by the scientists themselves, expressing both their own intellectual interests and a relevance to current technological problems affecting defense, space exploration and other major areas of national importance.

As a result, many of the Institute's investigations are sponsored by the Air Force, Army, Navy, Advanced Research Projects Agency, Atomic Energy Commission, Department of the Interior, Charles F. Kettering Foundation, National Aeronautics and Space Administration, and U.S. Public Health Service. The product-oriented divisions of Martin Marietta, other industrial firms, and academic institutions consult RIAS for advice on experiments or research problems.

During 1967, RIAS had 90 professional staff members, about half of whom held doctorate degrees. This staff included prominent scientists from many foreign countries as well as the United States and was augmented by visitors from universities and other basic research centers who present seminars or participate in regular RIAS programs for periods of a few months to a year. Results of RIAS research are published freely in the leading science journals and in symposia papers.

The fluid sciences group, the newest department at RIAS, was formed in March 1967 and was headed by Associate Director Stephen H. Maslen. This group was performing basic studies in aerodynamics and structural dynamics affecting aerospace vehicles, high performance aircraft and boosters. Its specific areas of interest included viscous interaction in rarefied gas flow, interaction of jet flows with solid surfaces, 3-dimensional laminar boundary layers, and control surface instability in lifting bodies during hypersonic and transonic flight.

Maslen's staff also was engaged in developing new techniques for calculating non-equilibrium flow and was examining the aeroelastic behavior of long slender vehicles, vibrations of toroidal rocket propellant tanks, nonlinear damping effects, and the propagation of impacting shock waves.

The RIAS biosciences group, directed by Dr. Bessel Kok, continued experiments in photosynthesis, chemosynthesis and exobiology. In photosynthesis, RIAS scientists sought a better understanding of the light conversion mechanism and related biochemical transformations in living plants.

Studies also were investigating the role played by manganese in the evolution of oxygen in green plants. Chemosynthesis efforts focused on the biochemical processes of hydrogen bacteria. These microbes use hydrogen instead of sunlight as their energy source and may be useful in spacecraft life support systems.

Dr. Kok was pursuing a new experimental technique for detecting life in space. His exobiology experiment employs a relatively simple technique that uses a lightweight mass spectrometer to trace the "life induced" transfer of an isotope of oxygen from common chemical compounds to water.

The RIAS materials science group expanded its science staff during 1967 to pursue a broadening scope of ceramics studies. Titanium carbide, vanadium carbide and their alloys were being investigated in a combined theoretical and experimental program that encompasses electron microscopy, mechanical behavior, band structure and bonding studies. This program, started by Associate Director A.R.C. Westwood in 1965, was intended to provide structural materials with improved ductility and high temperature strength surpassing any materials used today.

Meanwhile, the materials group was continuing original work dealing with surface-sensitive environmental effects on material structure. This area examines many structurally important metals, such as titanium, aluminum, copper and their alloys, which may embrittle and fracture under relatively low stresses in salt or methanol environments. Objectives included both elucidation of the mechanism of this type of failure as well as the means for preventing embrittlement.

Studies of the chemical and metallurgical factors involved when solid metals (e.g., beryllium, zinc, aluminum and copper) are embrittled by liquid metals (e.g., mercury and gallium) have revealed problems that may be encountered in advanced nuclear reactors using liquid metals as coolants. RIAS materials specialists were seeking to prevent this type of failure by formulating appropriate alloying additions to the solid metal or its liquid metal environment.

Dr. Louis Witten's physics group was performing promising research in metastable compounds, charge transport in semiconductors, quantum chemistry and ion transport. Research dealing with the physical mechanisms involved in the decomposition of high-energy crystals resulted in techniques for modifying and controlling the burning rate of these compounds, which are used as explosives and solid rocket oxidizers.

Quantum chemistry studies of high-energy compounds were centered on techniques for predicting chemical and physical properties, such as bonding, reactive behavior and stability, before such compounds are synthesized in the laboratory. Research on ion transport was aimed at understanding how electrically charged particles flow through membranes, promising fundamental information that may contribute to new water desalting processes.

NUCLEAR DIVISION

Martin Marietta's nuclear operation, housed in the Baltimore plant, was given divisional status in 1967.

The largest power source delivered by the Nuclear Division in 1967 was the S.S. *Sturgis,* also known as the MH-1A, a floating nuclear power station capable of producing 10,000 kilowatts of power, and housed in a jumboized World War II Liberty ship. Built for the Corps of Engineers, it can be towed anyplace in the world for use as an auxiliary power source in disaster or combat areas.

Two Snap-19 generators were fueled and readied for shipment. The pair of generators will provide 70 watts of power for NASA's Nimbus B weather satellite, scheduled for launch in 1968.

Design and development efforts continued, under contract to AEC, on Snap-29, a modular fueled generator capable of delivering electrical power in 200 watt units. It is the most powerful nuclear generator yet designed. Depending on mission requirements, it can produce 200, 400, 600 or 800 watts of electrical power for use on manned and unmanned missions, meeting both NASA and DOD requirements for long duration missions.

The Nuclear Division also added to its inventory of commercial generators in 1967. It was producing the MW-3000 and LCG 50 along with the LCG-25. The line of generators offered users a choice of power in 3, 25, and 50 watt units for a wide variety of uses, terrestrial or undersea.

Two MW-3000 generators are the sole power source for an undersea wellhead control system. The system was designed for off shore oil wells. Implanted on the ocean floor, it allows topside operators to control oil flow through acoustics. The compact wellhead control system supplies power at the source, eliminating the need for interconnecting electrical cables and the associated maintenance problems.

An LCG-25 was adapted for underwater use for the Naval Facilities Research Laboratories as part of NASA's Nimbus B Interrogation, Recovery, Location System (IRLS). The generator, attached to a buoy floating about 200 feet beneath the ocean surface, will supply power to an experiments package floating on the surface. As the weather satellite passes overhead it will receive scientific data such as wind velocity and water temperature transmitted by the experiments package.

During 1967 the Nuclear Division continued to examine the potential of applying nuclear electrical power to a variety of other uses where remote location or rough environment make conventional power difficult to maintain or nearly impossible to obtain.

McDONNELL DOUGLAS CORPORATION

McDonnell Douglas Corporation made many notable advances in both its commercial and military aircraft programs during 1967. In fact, the merger of McDonnell Company and Douglas Aircraft Company, consummated on April 28, was itself one of the year's biggest business stories in the aerospace industry. The merger brought together 2 pioneering companies with long traditions of success in the fields of aeronautics and astronautics.

Donald W. Douglas (second from right), chairman of Douglas Aircraft Company, accepts check for $68,700,000 from James S. McDonnell, chairman of McDonnell Company, while McDonnell president David S. Lewis (left) and Douglas president Donald W. Douglas, Jr. (right) look on. The stock transaction was part of the merger of the 2 firms into McDonnell Douglas Corporation.

The record of the several models of the McDonnell Phantom used in Vietnam by the Air Force, Navy and Marines was outstanding. F-4C Phantoms clearly demonstrated their superiority over the best operational communist fighters by shooting down 9 Mig-21s over North Vietnam the first week in January. By year's end the total of Mig fighters downed by the F-4 in Southeast Asia had risen to more than 50.

The F-4M Phantom for the Royal Air Force was flown for the first time on February 24, and the F-4E, latest Air Force model of the Phantom with added air-to-air superiority provided by a multi-barrel cannon in its nose, made its first flight on June 30. The first F-4E delivery to an operational squadron was made on October 3.

The 2,000th Phantom, an F-4D model, was delivered by McDonnell to the Air Force on March 12, and this total had climbed to over 2,500 by year's end.

Douglas, likewise, reached several program milestones in the famed Skyhawk family of A-4 attack bombers for the U.S. Navy and Marine Corps and TA-4 trainers for the Navy.

On June 30, Douglas delivered the first A-4F, newest member of the versatile attack bomber series, to an operational Navy squadron. Sixth version of the Skyhawk to be developed by Douglas, the A-4F has a more powerful jet engine than its predecessors. Other advances include nose wheel steering, wing-lift spoilers and a zero speed—zero altitude ejection system.

Other Skyhawk highlights during the year included the delivery of the 2,000th Skyhawk, a 2-place TA-4F advanced jet trainer, and the delivery of the first 2 of 10 Skyhawks to the Royal Australian Navy.

Initial deliveries of 4 new models of DC-8 and DC-9 jetliners by Douglas Aircraft Company were achieved during the year. Three versions of the DC-8 Super Sixty Series were introduced into airline service, signaling the beginning of the era of the giant jetliner in commercial aviation. The fourth Douglas transport to make its debut was the DC-9 Series 30, an extended fuselage version of the popular short-to-medium range twinjet.

The Super Sixty Series, consisting of the Super 61, Super 62 and Super 63 DC-8s, provides air carriers with the expanded seating capacity and greater range required to meet the growing demand for jet speed and comfort.

The world's largest commercial jetliners in operation, the Super 61 and Super 63 each carry a maximum of 259 passengers in 187-foot-long fuselages.

The Super 61, first of the 4-engine Super Sixty Series DC-8s to enter commercial service, was delivered January 26. Designed for transcontinental service on high density routes, the Super 61 by year-end had been ordered by 10 airlines in both passenger and convertible passenger-cargo versions.

On May 3 Douglas delivered the first of its DC-8 Super 62s, longest range commercial jet transport flying. Capable of carrying up to 189 passengers and their baggage 6,000 statute miles nonstop, the Super 62 had been ordered by 8 airlines for service on transoceanic routes.

Range increase of Super 62 over the standard Series 50 DC-8 resulted from aerodynamic improvements to pods and pylons, larger fuel capacity and greater wingspan.

The Super 63, third of the DC-8 Super Sixty Series to be introduced on commercial air routes, was delivered July 15. Combining the range advances of the Super 62 with the extended fuselage of the Super 61, the Super 63 was designed to transport up to 259 passengers over intercontinental distances.

Fourteen United States and overseas airlines placed orders for the Super 63. The big transport, available in a convertible passenger-cargo version, as well as the all-passenger model, will haul a maximum of 115,400 pounds of bulk freight when converted to an all-cargo configuration.

First delivery of the Series 30 DC-9, on January 27, was a major milestone in the company's twinjet transport program. The Series 30, which will carry up to 115 passengers compared to a maximum of 90 for the earlier Series 10 DC-9, had been ordered by 25 domestic and overseas airlines and the Series 10 by 19 carriers through the end of 1967.

Another milestone in the DC-9 program in 1967 was the rollout of the Series 40, largest version of the twinjet. The Series 40, with a maximum capacity of 125 passengers in its 125-foot-long fuselage, was scheduled for initial airline delivery in 1968.

A fourth version of the DC-9, the Series 20, combines the fuselage of the Series 10 and the wing of the Series 30. Scheduled for first delivery in 1969, the Series 20 was designed for take-off from very short runways.

In addition, Douglas announced its first sale of the DC-9 as a business jet. The order, for a Series 30 version which will serve as an airborne office for a corporation with international interests, was expected to be followed by several others.

Orders from airlines for the various versions of the DC-8 and DC-9 continued at a steady pace during the year. As of October 31, Douglas had received orders from 34 airlines for a total of 489 DC-8s, including 194 Super Sixty Series jetliners. Thirty-five carriers and the Air Force had purchased 492 DC-9s.

The Air Force orders were for the production of 8 C-9A aeromedical evacuation transports for a domestic airlift of sick and injured United States servicemen. The $28,700,000 contract was announced in August.

Designed to transport 30 litter patients or 40 ambulatory patients, or a combination of both, the C-9A, essentially an adaption of the DC-9 Series 30 commercial twinjet, will cruise at 520 miles per hour over a range of up to 2,000 miles.

Major government projects of McDonnell Douglas Corporation involved the development of spacecraft and launch vehicles for use in the nation's program for exploring and investigating space.

In May the Air Force announced the signing of contracts with McDonnell Douglas totaling $855,172,000 for work on the Manned Orbiting Laboratory (MOL). Douglas, contractor for the MOL vehicle, received $674,703,744 for engineering development work. McDonnell, contractor for the Gemini B spacecraft, was awarded a $180,469,000 definitized fixed price incentive contract.

McDonnell Astronautics Company also received a $500,000 study contract during May from the National Aeronautics and Space Administration for a Mars landing capsule study.

In 1965, McDonnell initiated its own study program designed to provide the technical background required for design specifications for a Mars landing vehicle. The company's Space System Laboratories have been studying the atmosphere on Mars, and in particular, the sand and dust storms believed to exist on the planet's surface. To investigate this and other areas of the Mars environment, a Martian Environmental Simulation Facility, capable of simulating that planet's surface characteristics of pressure, temperature, atmospheric composition, wind velocity, sand and dust storms, was developed.

Techniques of fabricating sterile components for interplanetary spacecraft were also under development at McDonnell. Laboratory engineers and technicians were working under a study contract with NASA to develop a sterile assembly challenge concept. This system was prompted by the existence of technological gaps which prevent terminal heat sterilization of spacecraft components. The McDonnell concept can be utilized with a high level of confidence in the sterility of spacecraft components.

James S. McDonnell, board chairman of McDonnell Douglas Corporation was recipient of the Robert J. Collier trophy for significant achievement in aeronautics and astronautics for 1966. The trophy was presented to McDonnell on May 24, 1967, by Vice President Hubert H. Humphrey at the National Air and Space Museum of the Smithsonian Institution in Washington, D.C.

Development work continued throughout the year on the McDonnell Company collision avoidance system known as EROS (Eliminate Range Zero System). McDonnell Douglas was cited as developer of the first collision avoidance system by the Air Transport Association of America on July 12. By year's end, more than 6,000 operational flights of the EROS system had been achieved on the F-4 Phantom flight test program.

Engineering development work on the Dragon antitank missile which McDonnell Astronautics Company is developing for the U.S. Army Missile Command continued at a steady pace. Several test milestones were achieved and the program progressed steadily toward production status.

Douglas continued production of the giant S-IVB rocket stage, with the seventh of the liquid hydrogen, liquid oxygen-powered vehicles delivered to NASA and the eighth and ninth scheduled for delivery by the end of the year.

The S-IVB is the uppermost stage of both the Uprated Saturn I, which will place manned Apollo spacecraft into orbit about the earth, and of the powerful Saturn V, the rocket which will propel the astronauts to the moon. In 3 launches through 1967, the S-IVB performed flawlessly for NASA.

Newest assignment for the S-IVB was to serve as an orbital workshop as part of the Apollo Applications Program. Launched into orbit as part of an Uprated Saturn I, the S-IVB will provide shelter and working space for 3 astronauts inside its empty liquid hydrogen tank. Astronauts in an Apollo will rendezvous and dock with the S-IVB and enter it through an airlock built by the McDonnell Astronautics Company. The airlock provides a "shirtsleeve" environment inside the huge tank, and makes docking between the Apollo and S-IVB possible.

Modifications necessary to permit conversion of the S-IVB to the orbital workshop are performed by Douglas for NASA. These include the installation of floors and partitions of metal grating to serve as "rooms" when the fuel is depleted.

In October NASA announced the signing of a follow-on contract for $146,500,000 for 9 S-IVBs for Saturn V vehicles, increasing to 27 the number of S-IVBs for which the company has received contracts.

Production of 2 other launch vehicles, the Air Force Thor and the NASA Delta, continued at Douglas, prime contractor for both rockets.

Newest version of the Thor in production is the Long Tank Thor. It provides additional propellant tankage, substantially increasing the vehicle's payload capability.

The dependable Thor, which recorded its 100th consecutive successful launch on March 29, serves as the first stage of several United States launch vehicles, including NASA's reliable 3-stage Delta.

Through October 1 the Delta had placed 9 spacecraft into orbit about the earth during 1967, increasing its record of successful orbits in a row to 19 and its overall performance as America's prime booster of research satellites to 49 successes in 52 launches.

Payloads placed in orbit by the Delta in 1967 included 3 Intelsat communications satellites, 2 ESSA weather satellites, Orbiting Solar Observatory III, BIOS II and 2 IMP satellites, designated Explorers XXXIV and XXXV.

Another Douglas space program was the development and manufacture of payload fairings for the Air Force and for NASA. Newest contract was for production of a 3-part fairing for use on a Titan III rocket.

Douglas' chief missile program was the development of the Spartan missile of the Army's anti-ballistic missile system. The Spartan is designed for long-range interception of attacking ballistic missiles. As airframe developer of the Spartan, Douglas is a major subcontractor to Bell Telephone Laboratories and to the Western Electric Company.

The company was also producing the Genie air-to-air rocket for use by the Air Force as a defense against invading aircraft. Other major missile and space programs included investigations in such fields as lifting bodies, reentry, biotechnology, solar physics and astronomy from space platforms.

Scientists at the Douglas Advanced Research Laboratories concentrated on mathematical sciences, life sciences, material sciences and environmental sciences, areas which supply the basic foundation for the company's aircraft, space and missile programs.

Emphasis at the Donald W. Douglas Laboratories was placed on research in the fields of nuclear and energy conversion technology for space and terrestrial applications. Dedicated March 29, the facility houses 36 separate laboratories on a 117-acre site in Richland, Washington.

Projects under way there included study of a conceptual design for a radioisotope power source which could be implanted in the human body to power a heart assist device and development of improved radioisotope heat sources containing promethium-tungsten metal ceramic combinations.

Douglas activities in the nuclear field also included its participation in Douglas United Nuclear, a joint subsidiary of Douglas and United Nuclear Corporation. The firm operates reactor and nuclear fuel fabrication facilities under contract to the Atomic Energy Commission at the AEC's Hanford, Washington, plant.

At Astropower, Douglas engineers and scientists were producing long-life, heat-resistant batteries for space applications and were conducting investigations in desalination of sea water, artificial intelligence systems and materials.

Employment on a consolidated basis on September 30, 1967, was 137,000.

MENASCO MANUFACTURING COMPANY

Menasco continued during 1967 to capture an ever-increasing share of the U.S. aircraft landing gear market, including an award in late October of a $10,000,000 contract from the Lockheed-Georgia Company for production of welded steel axles for the C-5A Galaxy transport. As the Lockheed-Georgia contract was received, Menasco announced a total of $20,000,000 in new business which included, along with the C-5A, follow-on orders for landing gear on other programs which brought the company's backlog to a record $73,000,000.

Lockheed officials, in announcing the award, said the Menasco welded axles for the plane's 4 sets of 6-wheel main landing gear will save approximately 600 pounds per airplane over a mechanical joint design.

Menasco has been a leader for 25 years in producing welded assemblies by its unique "Uniwelding" process.

The company's Texas Division was recipient of a major award in April when The Boeing Company gave a contract for production of main landing gear for the new 737 transport. Potential involvement extends into the 1970s, with initial deliveries to begin in April 1968.

Menasco was participating in the Bell UH-1B helicopter program; Boeing Minuteman Shock Isolation program; Boeing 707-120, 707-320, 720, 727 aircraft and CH-46A helicopter programs; General Electric reentry program; General Dynamics-Grumman F-111A, F-111B and B-111 programs; General Dynamics F-102, F-106, B-58 and Atlas programs; LTV F-8 and A-7 programs; Lockheed C-141, P-3 and JetStar programs; McDonnell Douglas F-4K and Saturn programs; Lockheed-Georgia and U.S. Air Force C-130 transport; U.S. Air Force Boeing KC-135 jet tanker and Convair F-106 interceptor.

All-time records were achieved by Menasco in its 1967 fiscal year which ended June 30. Shipments were $37,799,337 compared with $27,273,538 a year earlier.

A $1,000,000 building program for the company's California Division in Burbank was scheduled to begin in late 1967 and be completed in October 1968. The first phase, costing in excess of $700,000, was to add a 57,000 square foot building and represented the largest addition to the division since 1941.

Plans were being developed for a 68,000 square foot expansion of the Texas Division in Fort Worth, which would increase the size of the division by 30 percent and cost in excess of $1,000,000. An additional 5 acres of land was added to the site of the division, bringing it to a total of 46 acres.

During fiscal 1967, Menasco invested or committed $2,500,000 in new plant and equipment. During the same time, the government provided or committed to provide Menasco with new and used equipment of approximately the same value.

Plans to acquire $1,000,000 in new equipment for the California Division during 1968 were announced in October. This will be primarily 6-spindle profiling and large deep-hole boring machinery for C-5A production.

During 1967, Menasco was cited by The Boeing Company for successful on-schedule completion of liquid springs for the Minuteman shock isolation program. This production, from 1963 through 1967, provided 196 shock isolators for the Minuteman base hardening system.

Menasco received a "Project Sterling" Supplier-Of-The-Month award from Grumman Aircraft Engineering Corporation for designing and producing the main and nose landing gear for the FB-111, bomber version of the F-111. Menasco designed, manufactured and delivered the first gear in only 14 months.

Relationships with organized labor were excellent during 1967 in both divisions. An extensive training program under the Manpower Development and Training Act, plus on-the-job training for employees, helped to meet the need for an addition of 25 percent in skilled personnel over 1966. Employee turnover was the lowest since 1964.

While Menasco continued its leadership in the field of aircraft landing gear, becoming during 1967 the largest manufacturer by volume in the United States, new related products in its acknowledged area of competence were being given intensive study. An accelerated research and development program was instituted during 1967 to apply Menasco's specialized technological competence to new areas of shock mitigation. Research into application for marine and automotive use continued to be a major effort of Menasco's engineering force. A Special Products section to study needs of the aerospace industry was established.

NORTH AMERICAN ROCKWELL CORPORATION

In 1967 2 large industrial firms were merged to form North American Rockwell Corporation. The new corporation combined the complementary strengths of North American Aviation, Inc., and Rockwell-Standard Corporation. Its product line includes aircraft, atomic energy, missiles, electronics, space vehicles, rocket propulsion, automotive products, agricultural and industrial equipment, textile machinery, and fiberglass yachts. A dynamic force in the nation's industrial community, it ranked in the top 20, with $2.4 billion in total sales, for the fiscal year ending September 1, 1967.

Net earnings totaled $68,261,000 for the year, which ended with a backlog of unfilled orders totalling $3.6 billion. The large backlog represented an increase of 38.3 percent over the previous year.

To meet predicted demands for company products in the years ahead, a continuing program of capital expenditures for new plants and equipment was carried out during the year and it was continued at an even higher rate in 1968.

In the electronics complex at Anaheim, California, a new company-owned building was completed in 1967 and 2 others were to be finished in 1968. One of these is a $5,000,000 engineering and laboratory facility for advanced work on the Minuteman program, while the other is for production of second- and third-generation microelectronic elements. In addition, 1,300 acres of choice property were purchased or optioned in Orange County, California, for the company's electronic production in the fields of data systems and information systems. Construction of a manufacturing complex covering 1,000,000 square feet was to begin in the summer of 1968.

In rounding out its extensive capabilities in the engineering and production of space systems, the company completed a $16,000,000 launch vehicle complex at Seal Beach, California, in 1967.

The company's aircraft and missile facilities were also expanded in 1967. At Homestead, Florida, the first unit of what will ultimately be a $6,000,000 aircraft sales and service complex was under construction. At the Los Angeles International Airport, the company's capabilities in large air transport subcontracting were being furthered by additions to the structural machining center scheduled for completion in 1968. Also scheduled for 1968 completions were 2 buildings in Tulsa totaling 240,000 square feet to manufacture sections for large air transports.

Through these and other facilities being constructed or planned, North American Rockwell can meet expanded demands for company products.

Throughout the year, the Minuteman I intercontinental ballistic missiles were being replaced as planned by second-generation Minuteman IIs. The company provided the guidance and control systems and the automatic checkout equipment for both these Air Force missiles.

Employing microelectronics for the first time in the operational system, the Minuteman II's guidance unit can steer to a preselected point a quarter of the way around the world. Improvement in the reliability of this highly sophisticated and effective guidance system continued throughout the year.

The company also began delivering test versions of the advanced guidance system for Minuteman III, which incorporates further innovations and capabilities.

The company was also developing a family of microelectronic computers for the aircraft that will carry the Air Force's SRAM (Short Range Attack Missile) and the Navy's Condor air-to-surface missile, as well as for the guidance systems of the F-111D and FB-111 aircraft.

Work progressed on the avionics system, believed to be the nation's most advanced, for the F-111D tactical fighter and the FB-111 strategic bomber.

North American Rockwell developed a new family of airborne radars using microelectronic circuits, in which off-the-shelf modules can be combined to produce low-cost systems for all types of aircraft.

The company, which had built the guidance system for the Polaris submarines, continued fabrication of the prototype guidance system for the Navy's nuclear submarines to be armed with the Poseidon ballistic missile. This is an advanced version of the Polaris ballistic missile that can rise from underwater and find its way to far-distant targets. The Navy requested a proposal on additional Ships Inertial Navigation Systems to be delivered in 1969.

North American Rockwell was producing microminiaturized electronic systems that check automatically and rapidly on the operational readiness of various aircraft, missiles, and space systems. During the year, a contract was received for manufacture of microelectronic BACE (basic automatic checkout equipment) units to be used with the A-6A Navy aircraft.

In addition to the use of microelectronic circuits on Minuteman guidance, computers, and F-111 avionics, the company was pioneering in the design and production of much more advanced microelectronic circuits called MOS (metal oxide semiconductor) and SOS (silicon-on-sapphire) devices. These have from 10 to 500 times as many circuit elements on a single device as the circuits used in Minuteman guidance, F-111 avionics, and production computers. They are also more reliable and less expensive.

During 1967 North American Rockwell received important new orders for military aircraft, expanded its line of commercial aircraft, won new subcontracts for large aircraft assemblies, and furthered its competitive position in tactical missiles.

Go-ahead was authorized for long-leadtime items on additional RA-5C tactical reconnaissance aircraft, the Navy's largest operational jet airplanes. Capable of flying at twice the speed of sound, these twin-jet aircraft operate at altitudes from treetop level up to more than 8 miles high. They carry a variety of advanced sensing equipment, including unique cameras that photograph territory distant from their flight path in any weather, day or night. Data gathered by an RA-5C can be processed by computerized intelligence systems (also developed by the company) and placed quickly in the hands of strike pilots. These operations have proven so effective that RA-5C deliveries were scheduled into the 1970s.

Production continued on Navy orders for the T-2B twin-jet trainer. Navy and Marine pilots were using this aircraft for more than half of all annual training flights. Deliveries were scheduled through December 1968, and the Department of Defense approved Navy plans for additional procurement which would extend deliveries into 1971.

The T-39 Sabreliner, described in Air Force documents as "the most efficient non-combatant vehicle in the USAF inventory," was in use at more than 50 bases throughout the world. Because its controls and cockpit are like those of big jet aircraft, even though it is smaller, it is used in training multi-engine pilots, instrument pilot instructors, radar operators, and navigators—thus cutting training costs. The Navy was also using it for training pilots to use weapon-control equipment. In addition, the T-39s were serving the Air Force as a mission support vehicle, airlifting high-priority materials and key personnel. In fiscal 1967, the company began modifying Air Force T-39s from a 6-place to a 9-place configuration.

North American Rockwell's Los Angeles Division placed in production 2 new models of the Sabreliner: the Series 60, left, with a 25 percent increase in cabin space, and the Series 40, with somewhat less capacity.

The company began deliveries of the OV-10A Bronco, a light-armed reconnaissance aircraft and the first specifically designed for a combination of ground-support missions in limited warfare. It burns a wide variety of fuels, including standard gasolines used in ground vehicles, so it can refuel from supply lines of ground forces. Besides the initial order of 185 units for the Air Force and Marine Corps, an additional 38 were fully funded in the 1967 fiscal year and long-leadtime items have been authorized for 48 more. Several proposals were made for growth versions, including a close-support attack aircraft.

The X-15 aerospacecraft entered the ninth year of its flight research program. It set speed and altitude records in nearly 200 flights for the Air Force and the National Aeronautics and Space Administration. Modified for higher speeds, the X-15A-2 set a new unofficial world speed record of Mach 6.72 (4,534 miles per hour). Continued high-speed flights were planned up to about 5,000 miles per hour.

Other experiments continued with the XB-70, whose size and performance characteristics make it invaluable for supersonic transport research. The Air Force flight test program, which included a series of flights to gather sonic boom data for the SST program, was completed during the year, and a new 15-month flight research program was begun by NASA to support the SST and other large aircraft developments.

In the program to develop the Condor air-to-surface missile, aerodynamic models were delivered to the Navy for drop tests. The Condor will be guided by a company-designed-and-built guidance system which brings a new dimension in missile accuracy.

In addition to several existing contracts to maintain and modify AGM-28 Hound Dog missiles, which are associated with the Strategic Air Command's B-52 bomber force, the company won a new contract to inspect and overhaul the missiles where necessary to insure their operational reliability. This was an example of continuing sales emanating from a relatively old (first deliveries in 1957) product line.

North American Rockwell at year-end was producing 12 aircraft types for the general aviation market. The Aero Commander Divisions were building 10 executive, business, training, and agricultural aircraft. In addition, the company's Sabreliner offered the longest warranty of any business jet and represented experience gained in a total of more than 20,000,000 flight miles. In 1967 the Federal Aviation Administration certified a higher-thrust engine and approved the new 10-passenger Series 60 model.

During fiscal 1967, the Aero Commander Division delivered 330 airplanes, an increase of 50 percent over fiscal 1966. In order for North American Aviation and Rockwell-Standard to merge without any objection from the Department of Justice, the Jet Commander program was sold to Israel Aircraft Industries, Ltd. Facilities at Bethany, Oklahoma, continued to produce twin engine models of the Aero Commander line, including the new Turbo II Commander introduced in August of 1967.

Designed to operate from short runways, the pressurized Turbo II Commander cruises at 280 miles an hour. With its versatile electronics equipment, pressurized comfort at high altitudes, and relatively low cost and high speed, it is finding wide acceptance for corporate use.

Due to its extensive facilities for manufacturing large structural sections and its advanced capabilities in tooling and machining, the company continued to add major subcontract work to its regular aircraft production. Aircraft programs in which the company was subcontractor for key assemblies, components, or tooling during 1967 included the Douglas DC-9 and the Boeing 727, 737, and 747 commercial transports, the Lockheed C-5A military transport, the Bell Huey-Cobra helicopter, the Boeing CH-47A Chinook helicopter, the Pratt & Whitney Aircraft turbofan engine afterburners for the F-111 series aircraft and several others.

North American Rockwell was making assemblies or entire aircraft systems in the fields of trainers, various combat types, research aircraft, military and commercial transports, and both jet and propeller-driven private aircraft.

On November 9, 1967, the world acclaimed the spectacular success of the complex 3-stage space mission that tested the whole U.S. concept for sending men to the moon: the first launch of the colossal Saturn V launch vehicle, carrying an unmanned Apollo spacecraft.

North American Rockwell's role in this event was considerably larger than that of any other company. It included design, development, construction, and test of the spacecraft itself, consisting of the Command Module and the Service Module; the launch escape system; the adapter (sheath) for a 2-man vehicle that will later descend to the moon from an Apollo in lunar orbit; the hydrogen-powered second or middle stage of the Saturn V launch vehicle; the rocket engines propelling all 3 stages; and a number of smaller engines for maneuvering and other purposes located in various parts of the Saturn V/Apollo stack.

In what must rank with the outstanding technological achievements of modern times, the 8-hour mission began by lifting the heaviest weight ever to leave the earth. It continued by sending around the earth the greatest tonnage ever in orbit. After the planned 2 orbits, the third-stage engine was ignited again for the first demonstration of the critical restart that will be essential in moon trips, shooting Apollo to a peak altitude of 11,232 miles for a fiery return through the earth's air blanket at faster speeds than a spacecraft intended for human crews had ever flown before. The successful mission ended by parachuting Apollo to a bull's-eye landing within sight of its prime recovery ship, and within the precise time schedule.

One key objective of the flight was to test the Apollo Command Module's ablative heat shield under the actual conditions of returning from the lunar mission and reentering the earth's atmosphere at nearly 25,000 miles per hour. Previous spacecraft had reentered the atmosphere at the normal earth-orbiting speed of more than 17,000 miles per hour. Although the Command Module had to survive temperatures twice as hot as molten lava, its heat shield was only 2¼ inches at the thickest point. Another "first" was the separation of the Launch Escape System from the spacecraft under actual lunar-mission flight conditions.

The test also marked the first launch of the Saturn S-II, second stage of the Saturn V vehicle. In all, Apollo 4 accomplished about 200 firsts in man's exploration and use of space. As NASA reported, Apollo 4 had to perform about 12 times better than Mercury or Gemini just to get off the launching pad.

Although the November 9 flight was the most difficult space mission ever attempted, the huge combination of superpower engines and new rocket stages performed precisely as planned, signaling the fact that the moon is only 60 hours away.

As the nation's principal designer and builder of large liquid rocket engines, the company supplied propulsion for several of the nation's large ballistic missiles and for 800 U.S. military and civilian space launches, comprising about 80 percent of all American space vehicles launched.

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 passed all qualification tests and at year-end was in regular production for current and future flights of 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 five J-2 engines. Each generating up to 225,000 pounds of thrust, they achieve high efficiency by using liquid hydrogen as fuel. A single J-2 powering the Saturn V's third stage must be turned off and on during the mission—a complex technical feat demonstrated successfully in the first Saturn V flight. The J-2 engines are the nation's largest operational liquid hydrogen engines and were also in continuing production at year-end.

Eight H-1 engines, each generating 200,000 pounds of thrust, provided the first-stage power for the Uprated Saturn I 2-stage vehicles used in space flights preceding the Saturn V missions. The H-1 clusters powered successful missions in all 13 Saturn I flights. During 1967 NASA contracted with the company for additional H-1s.

The small reaction control engines for reentry maneuvering of the Apollo spacecraft worked well on initial test flights and contracts were received for production of 36 more units. The company also successfully test-fired a new injector for the ascent engine of the Lunar Module that will lift 2 astronauts from the moon to start their return to earth. NASA ordered 20 liquid propellant ullage motors (to aid the flow of fuel in the absence of gravity) for the S-IVB third stage of the Saturn V vehicle.

The company was to build the propellant tanks for the Air Force's Manned Orbiting Laboratory which will test various human capabilities in space.

During the year the company's plant at McGregor, Texas, delivered solid propellant rocket motors under accelerated schedules for the Navy's air-to-air Sparrow and air-to-ground Shrike missiles, while gas generators were provided for the Navy's Tartar and Terrier surface-to-air missiles. A new contract was received for production of gas generators for the Army's Shillelagh missile. The solid propellant motor for the Phoenix air-to-air missile, which will be used on the Navy's new F-111B fleet defense fighter, was nearing its qualification tests. Production began on the ullage motors for the S-II second stage of the Saturn V vehicle.

Also approaching completion was the development of the storable liquid rocket engine for the Army's Lance surface-to-surface missile.

A pioneer in the first rocket engines that powered the nation's large ballistic missiles, North American Rockwell Corporation has since extended its leadership into most areas of rocket propulsion.

North American Rockwell approached the markets of the future along 3 principal avenues aimed at growth and increased profitability. First, it intended to enhance its position in its regular markets by continuing to make better products at a competitive cost and to explore new product lines that satisfy commercial or Government needs. Second, it planned to continue entering additional markets through further diversification. Third, by wider application of both its technical and marketing capabilities, it expected to help create new markets that did not exist before.

In fulfilling these objectives, the company's principal instruments are its extensive and often unique facilities, its versatile and seasoned management, its financial strength, and the diversified skills—running into hundreds of technical specialties—of the 115,000 people of North American Rockwell.

NORTHROP CORPORATION

For the second consecutive year Northrop Corporation posted new records in sales, earnings, and backlog. Total employment of the company rose to nearly 24,000 in 1967, and a long-range recruiting program called for the hiring of approximately 5,000 more employees by 1970. The company remained active in more than 50 countries in addition to major facilities at home in 9 states and the District of Columbia. Nearly 6,000,000 square feet of administration, engineering and manufacturing space was in use at year-end.

The year 1967 was one of growth and a year in which the company strengthened its position in its 5 major product areas: aircraft, communications, electronics, advanced weaponry, and space.

Northrop was a major participant in 3 of the most important projects in air transportation: the Boeing 747, the USAF/Lockheed C-5A and the supersonic transport. Deliveries of fuselage sections for the 747 were to begin early in 1968. Most of 1967 was spent in designing and fabricating the largest assembly fixtures in the history of aircraft. The company also completed and occupied in 1967 one of the largest and most advanced facilities in the aerospace industry for handling, processing and assembling large aircraft structural components.

Northrop was selected by The Boeing Company to manufacture a 40-foot titanium fuselage section of the supersonic transport. Northrop has been engaged continuously over a 10-year period in the production of complex titanium alloy assemblies and has conducted an extensive independent research and development program to advance capability in all aspects of fabricating newer alloys. A number of titanium test sections were built and delivered to Boeing.

Northrop Corporation started fabrication of 153-foot passenger sections of the Boeing 747 jetliner.

The bulk of the company's aircraft activities, however, continued to center around the F-5 Freedom Fighter and the T-38 supersonic trainer. The F-5 was serving in the armed forces of more than a dozen nations and additionally was being produced under license agreements in Canada and Spain. The company expected F-5 production at its Hawthorne, California, facility to continue through 1971 and perhaps beyond. Of significance among F-5 activities in 1967 was the conclusion, amid commendations from the Defense Department, of a combat evaluation program for the F-5 in Vietnam and the subsequent turnover of a squadron of Freedom Fighters to the South Vietnam Air Force.

The T-38 Talon, the world's only supersonic, twin-engined jet designed specifically for pilot training, passed a historic milestone in 1967 when it flew its 1,000,000th hour of pilot training. This record was compiled by the U.S. Air Force Air Training Command while maintaining the lowest accident rate of any aircraft in the Air Force jet inventory. Before the end of 1967 the 1,000th T-38 was to roll off the assembly line at Hawthorne, California. In addition to the USAF, the T-38 was being used by the Federal Republic of Germany Air Force for pilot training at Sheppard AFB, Texas, and by the National Aeronautics and Space Administration for maintaining astronaut flight proficiency.

Also in 1967 the company was one of 4 contractors selected by the U.S. Air Force from 17 participating companies to conduct funded studies of a new tactical aircraft (AX) specifically designed for close support of troops in limited warfare operations.

Development work continued in 1967 on a new jet target drone, the NV-105. It was announced in April that the U.S. Navy awarded the company a contract for development and initial production of 200 of the targets, designated MQM-74A.

Fiscal 1967 saw Northrop's communications business surpass the $100,000,000 level, with indications that communications will match the growth of air transportation in the 1970s. The bulk of Northrop's communications business was at Page Communications Engineers, Inc., a wholly-owned subsidiary based in Washington, D.C. In addition to beginning work on a major program to engineer, install and operate an integrated wideband communications system (IWCS) in Southeast Asia, Page continued to expand its involvement in the satellite communications area.

The IWCS includes 250,000 miles of communications links connecting more than 50 key U.S. Army and allied military stations in Southeast Asia. Working with U.S. Underseas Cable Corporation, a Northrop affiliate, Page completed also the laying of 1,567 miles of underwater cable linking 6 coastal cities in South Vietnam and Thailand.

In the field of satellite communications, Northrop Page received a contract in 1967 to install a company-developed transportable earth station in Panama, the first equipment of this type to be planned for Latin America. Previous earth stations, which feature large receiving antennas for detecting and relaying signals from satellites, have been installed in the continental United States, Hawaii, The Philippines, Australia, and Thailand. Other types of Page activities included extensive civil communications projects, such as a complete telecommunications system completed for the government of the Bahamas.

To enlarge its activity in the communications field and acquire a manufacturing capability, Northrop acquired in late 1966 The Hallicrafters Company, Chicago, Illinois. Hallicrafters makes a variety of consumer, industrial and military communications products.

Northrop's activities in its third major product area, electronics, was highlighted in 1967 by the first disclosure that the company had developed and built an astroinertial navigation and guidance system for the U.S. Air Force SR-71 long-range reconnaissance plane. The system enables the Lockheed-built aircraft to navigate with high standards of accuracy at speeds of more than 2,000 miles per hour at altitudes of 80,000 feet. Northrop's navigation and guidance activities are headquartered at the company's Nortronics Division which operates a number of facilities in Southern California and Massachusetts.

In 1967 the company delivered its first components developed for the U.S. Air Force/Lockheed C-5A inertial-Doppler navigation system. The navigation system for this huge jet transport being built by Lockheed-Georgia Company will be completely self contained and will have an accuracy better than one nautical mile per hour. The system includes a Northrop-developed Floated Lightweight Inertial Platform (FLIP) and a Northrop-developed computational system including a primary and an auxiliary digital computer. Northrop Nortronics' Precision Products Department, Norwood, Massachusetts, was producing gyroscopes for the inertial measurement unit. Small enough to fit into an average coffee cup, the gyros use ceramic gas bearings to replace the more conventional bearings. As one of the nation's leading producers of inertial sensing equipment, Nortronics PPD has provided gyros and accelerometers for scores of military and space programs.

Northrop Nortronics received an additional contract from Lockheed in 1967 to develop and produce computers to be used in a malfunction analysis detection and recording (MADAR) system that will monitor all major aircraft systems on the Lockheed C-5A.

Another major product line in the electronics category was automatic checkout equipment. One of the first major Northrop developments in this area was for the Polaris missile. When the U.S. Navy decided to supplement its Polaris fleet with a more advanced missile system, the Poseidon, Northrop was awarded the contract to develop checkout equipment. Delivery of these first systems began in 1967. Another automatic checkout system is TEAMS (Tactical Evaluation and Monitoring System), which will be installed aboard a new fleet of antisubmarine warfare destroyer escorts.

Northrop was also engaged in production of large screen display systems, ultra-precision test laboratories for testing advanced inertial components, electronic centers for rapid identification of undersea objects, electro-optical systems, and electronic countermeasures.

Northrop's advanced weaponry business was mostly of the long-range development type and was expected to continue at its level of the past few years regardless of any significant changes in world conditions. Work continued during 1967 on the first fully controllable, solid propellant rocket motor at Northrop Carolina, a wholly-owned subsidiary near Asheville, North Carolina, under contract to the U.S. Air Force. Development continued also on television-aided target seekers, electro-optical systems originally developed under the direction of the U.S. Army Missile Command. Other work in weaponry included advanced pyrotechnic devices, underwater demolition kits, battlefield flares, warheads, bomb and rocket dispenser pods for aircraft, and loaders, launchers and airframe components for Hawk surface-to-air missiles.

In the nation's space program, Northrop is probably best known for spacecraft recovery and landing systems. The three-parachute Apollo system was redesigned during the year to accommodate a heavier payload, the result of additional safety requirements instituted by NASA. For post-Apollo programs, NASA selected Northrop's Ventura Division to perform research flight tests of an all-flexible parawing. Northrop also built the first 2 lifting body vehicles, the M2-F2 and HL-10, which completed 17 manned experimental flights.

Northrop's Nortronics Division was designing and building the spacecraft structure and several mechanical subsystems for the Mariner-Mars 1969 flight. A Northrop-built instrument package, called Flare Activated Radiological Observatory (FARO), was orbited in July from Vandenberg Air Force Base. An earlier radiation detection satellite (FESS), launched under the same OV1 series, was still sending data to earth after 2 years in space. Another satellite, the OV2-5, was completed and awaiting a 1968 launch date. All of the OV (Orbiting Vehicle) satellites were built under contract to the U.S. Air Force Office of Aerospace Research. Numerous space research programs were in progress, ranging from studies of man's physical capabilities on the moon to self-sealing techniques for spacecraft structures subjected to meteoroid penetration.

While Northrop classified its programs and products into 5 major categories, there were other 1967 activities which had the potential of significant growth. In the field of marine science, Northrop continued to work with the Navy as prime support contractor for engineering and management phases of the Deep Submergence Systems Project. In April, it was announced that Northrop had received a pioneering U.S. Navy contract to develop and produce unmanned underwater target vehicles for ASW proficiency training.

The company developed an important new capability in the manufacture of stringers, long metal bars that give strength and rigidity to the skins of large aircraft structures. About 800 153-foot aluminum stringers were to be produced for each Boeing 747 fuselage.

Northrop Architectural Systems, a wholly-owned subsidiary in Los Angeles, made significant gains in 1967 despite a declining construction market. A producer of sliding doors, windows, curtainwalls, store entrances, and so forth, the subsidiary opened a new facility near Chicago during 1967 to enable additional penetration of eastern markets.

Northrop Corporate Laboratories was formed in 1967 to conduct applied research in areas expected to affect the company's product spread several years in the future. Initial activities included funded studies of the effects of nuclear radiation on electronic equipment and research in basic electromagnetics.

PACIFIC AIRMOTIVE CORPORATION

On August 4, 1967, the final approval required to complete the transaction by which Pacific Airmotive Corporation was acquired by Purex Corporation, Ltd., was granted by PAC stockholders at a special meeting held in Burbank. Purex, headquartered in Lakewood, California, is the fourth largest producer of household cleaning products. It also manufactures industrial and institutional cleaning products and machinery, drugs and toiletries, plastic products and machinery for thermoforming plastics.

The merger of the 2 companies followed Pacific Airmotive's 6-month report of sales and profits that established another record high for any similar period in the company's 39-year history. Pacific Airmotive was being operated as a wholly-owned subsidiary of Purex with no change in management.

During the year, an agreement was signed with International Jetstream Corporation, St. Louis, under which Pacific Airmotive will act as sales agent for the new Handley Page Jetstream turboprop manufactured in Britain. Type certification of the 300 mile per hour, 18-passenger aircraft was expected in February 1968, with first customer deliveries soon after. PAC will perform post-factory installations of interiors and electronics and provide Jetstream maintenance and spares support in this country.

Pacific Airmotive Corporation signed a 1967 agreement whereby the company will act as sales agent for the Handley Page Jetstream turboprop (shown) manufactured in England.

PAC's Allison-Convair program, one of the company's major efforts, was accelerated at the beginning of the year to accomplish the completion of 3 Convair 580s per month instead of the 2 aircraft completed formerly. PAC, under exclusive contract to the Allison Division of General Motors Corporation, converts Convair 340/440 aircraft to Allison turboprop power for domestic and foreign airlines, and corporate and government customers.

The company's Fan Jet Falcon program continued at a high level and was moved to larger quarters at Long Beach (California) Municipal Airport where all post-factory installations on the Falcon were performed. Servicing and spares support for the Falcon, as well as for other business/executive type aircraft, were available at the Burbank, Long Beach and Westchester County Airport (White Plains, New York) facilities.

A new agreement was signed with the Business Jets Division of Pan American World Airways for a continuation of the contract whereby PAC functions as sales agent for the Fan Jet Falcon in the United States. The agreement, specifying sales, lease, repair and maintenance, is effective through December 1969.

Other major overhaul, interior and conversion work was being handled at PAC's Santa Monica (California) Branch, including the conversion of DC-6 type aircraft to cargo-passenger configuration under license to Douglas Aircraft Company.

The PAC-designed Rainboe Rain Repellent system was installed on the North Central Airlines and Air Canada fleets. Additional aircraft for which the windshield rain repellent system received FAA certification during 1967 included the F-27, Vanguard and Caravelle, totalling 18 aircraft types certificated through 1967.

Manufacturers signing contracts in 1967 with Pacific Airmotive for the distribution of their products to airlines and general aviation customers included Aircraft Radio Corporation, manufacturers of a new line of flight instruments; General Electric Company's Instrument Division, which produces a variety of indicators, amplifiers, transmitters, etc.; the Weston-Garwin Carruth Division of Weston Instrument Company whose instruments are widely used on general aviation aircraft; and Aero Products Research, Inc., producers of a major line of pilot supplies.

In October, the headquarters of the Aviation Products Division was moved to a larger facility in North Hollywood, California. The division's North Hollywood and Pacair Branches shared the new 20,000 square foot building.

Western and United Airlines ordered initial provisioning of spare parts for their fleets of Boeing 737s and Pacific Southwest Airways ordered provisioning for its 7 Boeing 727s. A purchasing contract was signed with Pakistan Airlines providing for the purchase of products by PAC for the carrier.

PAC developed a kit for the conversion of the Hughes 269-A helicopter carburetion system to fuel injection and received FAA certification in May. The conversion replaces the PS pressure carburetor with the Bendix RS fuel injection system.

North Central Airlines awarded an exclusive long-term engine service contract to PAC in April, one of 8 carriers to sign exclusive JT8D contracts with the company in a period of 12 months. The contract included complete overhaul and repair of engines and accessories; parts and accessory exchange; engine leasing for emergency transitional periods; and a line and base maintenance plan providing for parts, repair kits and necessary technical support. Other exclusive JT8D service contracts were signed with Alaska Airlines and Allegheny Airlines during 1967. Braniff International, Overseas National Airways and Trans Texas Airways signed standby agreements with PAC for engine service.

In addition to the new JT8 program, the company continued overhaul and service of many other jet and piston engine types.

An in-flight monitoring program was implemented by Pacific Airmotive which provides airline customers with daily performance information on each engine, denoting deviations from the normal engine characteristics with probable causes and suggested corrections. The program offers documentary evidence of each engine's past and present performance, and identifies problem areas in engines and instrumentation, resulting in a reduction of unscheduled shut-downs.

PAC's Light Aircraft Division, distributor of Cessna aircraft in California, Arizona and western Nevada, expanded its facilities during 1967. Business Aircraft Distributors, the Cessna wholesaler for northern California and Nevada moved to a new and larger building on Oakland International Airport. A parts warehouse was added to the Long Beach facility occupied by Airflite, Inc., the distributor for southern California and Baja California. Pacific Airmotive-Palm Springs, one of 4 company operated dealerships, enlarged its capabilities with the addition of an engine overhaul shop providing complete overhaul and maintenance service for light aircraft at this location.

PHILCO-FORD CORPORATION
AERONUTRONIC DIVISION

Personnel growth, facilities expansion, and record sales marked the year 1967 at Philco-Ford Corporation's Aeronutronic Division.

At 7 locations in southern California, Aeronutronic was actively engaged in research, development, test and production of tactical missiles, missile weapon systems, automatic weapons, stabilized fire control systems, air defense systems, advanced radars, reconnaissance and intelligence systems, propulsion products, high-strength armor, and missile and bomb fuzes.

During 1967 employment climbed to a peak of more than 6,200, a new high for the nearly 12-year-old aerospace/defense firm.

Aeronutronic continued to maintain its headquarters at Newport Beach, California, on a 200 acre site, including more than 750,000 square feet of floor space.

In addition, major facilities were located at Lawndale, California, where the Shillelagh guided missile system was being manufactured for the Army in a 200,000 square foot plant.

At Anaheim, California, the division had more than 300,000 square feet of manufacturing and engineering buildings. The Anaheim Air Defense Manufacturing Plant, occupying 130,000 square feet, was the site of production of the Chaparral air defense system.

Also, opened during 1967, was a new 130,000 square foot plant—the Anaheim Ordnance Manufacturing Plant—where automatic weapons such as the XM129 grenade launcher and XM140 automatic cannon, as well as other ordnance and electromechanical devices were under development and in production. Engineering buildings totalling 73,000 square feet were located nearby in Anaheim in support of the Anaheim production programs.

Aeronutronic's Radar and Intelligence Operation was housed in separate facilities in Santa Ana, California. During 1967, Dr. Samuel J. Rabinowitz, former Department of Defense official, joined Aeronutronic to head the Radar and Intelligence Operation.

During 1967, the division also opened a new facility in Anniston, Alabama, and a new field office in Bettendorf, Iowa. The Anniston Repair Depot, located at the U.S. Army's Anniston Army Depot, was opened to support the division's Shillelagh guided missile program, and the new office opened at Bettendorf, Iowa, will have jurisdiction over contractual commitments Aeronutronic has with the U.S. Army Weapons Command at the Rock Island Arsenal, Rock Island, Illinois.

Shillelagh continued as Aeronutronic's largest program, and during the year the weapon system entered active service with the U.S. Army. First deployment of the system was with a tank battalion at Fort Riley, Kansas. Also, during 1967, Shillelagh got its first foreign assignment, when missiles were shipped, with the General Sheridan armored reconnaissance airborne assault vehicle, to the Australian government for operational evaluation. The Australian assignment was part of the American, British, Canadian, Australian (ABCA) Standardization Loan Program. Two Sheridan vehicles and 20 Shillelagh guided missiles were assigned to the Australian Army for evaluation.

In October, the Chaparral Air Defense System, for which Aeronutronic is prime contractor, was put on public display for the first time at the annual meeting of the Association of the United States Army (AUSA) in Washington, D.C.

In early 1967, Chaparral concluded a highly successful guided flight program at White Sands Missile Range, New Mexico, as part of the development flight test program. During the tests, Chaparral successfully attacked several aerial targets. Chaparral is one of two systems selected by the U.S. Army to provide field commanders with low altitude air defense as part of newly-organized Air Defense Battalions.

In addition to the Chaparral system, the U.S. Army introduced publicly for the first time at the October AUSA meeting the new Main Battle Tank (MBT-70) being jointly developed by the United States and the Federal Republic of Germany. The main armament for the MBT-70 is the Aeronutronic-developed Shillelagh guided missile system. In addition to the General Sheridan armored reconnaissance airborne assault vehicle and the MBT-70, Shillelagh was also being adapted to the M60 A1E1 battle tank.

Late in the year, with the first public flight of the U.S. Army/Lockheed Cheyenne AH-56A Advanced

Aerial Fire Support System, it was disclosed that the Cheyenne would carry the Aeronutronic XM129 grenade launcher and the Aeronutronic XM140 automatic cannon. Aeronutronic is a prime producer of automatic weapons designed to fire 30 millimeter and 40 millimeter ammunition, and is heavily involved in research and development of advanced weapons in the 20 to 60 millimeter class for advanced military applications.

Aeronutronic continued to be an organization with diversified, but related business interests, and maintained a prime role as a producer of systems and subsystems for the Department of Defense.

PIPER AIRCRAFT CORPORATION

Piper Aircraft's gross sales in the fiscal year ending September 30, 1967, amounted to $80,400,000, a slight reduction from the record high of $81,300,000 in 1966.

While the results for 1967 were not up to expectations, in either sales or profits, in several other ways the year proved to be a highly satisfactory one during which much was accomplished.

Start-up costs of the Navajo production were largely behind the company as it started 1968, and the new retractable geared Cherokee Arrow was in production at Vero Beach at the rate of 4 daily. Efficiency in the manufacturing operation at Vero Beach was markedly improved and several of the company's organizations, principally Sales and Service, Engineering and Production Management were materially strengthened.

The reduced demand for the smaller general aviation type airplanes in 1967 was experienced by the entire industry, which delivered an estimated 13,000 airplanes, totaling approximately $270,000,000 as compared to 14,667 airplanes in 1966 valued at $305,000,000. By comparison Piper's unit sales increased a few units and its dollar volume decreased by only one percent. As a result, Piper's percentage of the industry's unit sales for aircraft selling under $200,000 increased from an estimated 29 percent to 33 percent, and its share of the dollar market went up from 26.7 percent to 29.8 percent.

Export deliveries were the best in the history of the company, with the dollar volume to all parts of the world outside of continental United States increasing from $19,000,000 to nearly $23,000,000. This represented 28 percent of the company's 1967 business, and the sale of aircraft to foreign countries gives every indication of becoming a larger percentage of the company's overall sales in future years.

During 1967 Piper sold $5,600,000 in spare parts and accessories throughout the world, an increase of 16 percent over 1966. The sale of these products to domestic outlets increased slightly from $3,300,000 in 1966 to $3,500,000 in 1967, while international sales rose 37 percent, from $1,600,000 to $2,200,000.

The continued growth of Piper's exports was attributed in part to an intensified demand for business and private aircraft that surmounts restrictive financial and political conditions in international markets.

Increased pilot training programs built around the Cherokee 140 were a significant factor in Piper's increased share of the domestic market. Also contributing to Piper's industry position were new programs in the marketing and sales organizations.

Corporate sales teams were being employed successfully in the Navajo program in cooperation with the Piper distributor and dealer organization. These sales teams proved to be an effective means of concentration upon specific markets for the Navajo. During the year market studies were completed on the commuter airline business to determine the course Piper Aircraft should take in this expanding field.

International Sales continued a program to strengthen its distribution organization through the development of financially strong and independent businessmen to provide outlets for Piper products. At year-end, Piper had 417 domestic dealers and 176 foreign distribution outlets.

Leading all Piper models in unit sales was the Cherokee 140 which enjoyed an increasing demand as a trainer and builder of new pilots. Highest in dollar volume was the popular Aztec series, long a favorite with the air taxi and cargo business. The new Navajo, Cherokee Arrow and Cherokee D series, all in volume production, were expected to make new sales gains for Piper. The Cherokee Six, offered in 260 and 300 horsepower versions, continued to enjoy a strong market.

Piper announced plans to occupy production facilities at 2 new locations in central Pennsylvania, thus providing nearly 300,000 square feet of additional floor space for expansion. The larger of the 2 sites is located at Quehanna, 58 miles northwest of Lock Haven, and formerly occupied by Curtiss-Wright Corporation. The other manufacturing facility is in South Renovo, 25 miles up the Susquehanna River from Lock Haven.

The company's decision to acquire the new property was based on a desire to expand in the Lock Haven area for the present time rather than establish new production facilities in another state. Initially Piper's new plants will employ a relatively small number of people, but should be expected to increase as production is stepped up.

The Quehanna plant, which consists of 2 large factory buildings and 3 small buildings, will eventually be equipped to fabricate aircraft components. Piper Aircraft planned to manufacture plastic and fiberglass parts at the Renovo facility when remodeling work is completed. With the greatly increased use of fiberglass aircraft parts, the Lock Haven plant was pressed for adequate space and the 36,000 square foot Renovo facility will accommodate this growing operation.

At its main location in Lock Haven, Piper had over 750,000 square feet under roof and more than 2,150 employees. At Vero Beach, where Piper was producing its popular Cherokee series, facilities totaled nearly

525,000 square feet and employment was 2,250. Piper has produced well over 75,000 aircraft since the first Piper Cub was flown in 1930.

Piper had more than 520,000 square feet of plant area and 2,200 people at its Vero Beach, Florida, facility.

Piper's new Cherokee Arrow, introduced last summer, was named Plane of the Year for 1968 by Plane and Pilot Magazine. It is a 4-place aircraft with retractable landing gear that lowers itself if the pilot forgets. The automatic extension feature of the Arrow's landing gear has been hailed as a major safety feature device to prevent inadvertent wheels-up landings.

Piper expected to fly its new 18-place commuter airliner, the PA-35, early in 1968. The first prototype was under construction at the Research and Development Center in Vero Beach.

This new aircraft is a significant addition to Piper's large and diversified lineup of models now serving the commuter airline, air taxi and air freight business around the world. The plane measures 39.25 feet in length and has a wing span of 51 feet.

Piper's completely new design concept incorporates numerous ideas and design features developed through years of manufacturing experience for the general aviation industry. During the PA-35's development, special emphasis was placed on the particular needs of various air transport groups, and the ruggedizing of the complete airplane to insure economical operations.

Powered by 2 470 horsepower turbocharged TIO-720 Lycoming engines, the PA-35's general performance characteristics will be similar to the Aztec C, widely known for its handling ease, short field capabilities and lower maintenance costs. Cruise speed will range from 200 miles per hour at sea level to 230 miles per hour at 17,000 feet.

The 10,000th Cherokee was built in 1967 and a Cherokee Six was the 10,000th Piper airplane to be delivered overseas when it reached Kenya, Africa. According to industry figures, this represents the largest aggregate of aircraft shipped overseas by any U.S. aircraft manufacturer.

The Peruvian Air Ministry bought 30 Cherokees. The contract was negotiated following a series of flight evaluations by Peruvian pilots. The planes were ferried to Peru for civilian flight training and pleasure flying by 10 aero clubs.

Sheila Scott, winner of 1967 Harmon Award, was named outstanding Aviatrix for her round-the-world flight in a Piper Comanche in which she established a new speed record on her 28,633 mile global trip.

West Coast Airlines picked Piper in serving the Pacific Northwest, by initiating a "Mini Liner" air service with 4 new turbocharged Navajo twins on daily scheduled routes.

Nearly 20,000 persons toured Piper Aircraft facilities throughout the year. Vacationers comprised a large portion of the visitors during the summer months.

PNEUMO DYNAMICS CORPORATION

Pneumo Dynamics' 2 aerospace facilities, Cleveland Pneumatic Tool Company (CPT) and the National Water Lift (NWL) division, continued in 1967 the production increases and facilities expansion which had characterized the previous year.

Aircraft landing gears at CPT and flight control mechanisms at NWL accounted for the major share of Pneumo's aircraft business. Systems and components for space vehicles and missile programs contributed a small but technologically significant portion of production.

CLEVELAND PNEUMATIC TOOL

Highlights of the year at Cleveland Pneumatic were the start of production on the Boeing 747 landing gear program and the on-schedule progress of the $14,000,000 expansion of CPT's production, assembly, and engineering test facilities.

Heart of the expansion project was the new 160,000 square foot "big gear" manufacturing plant adjoining the existing assembly buildings and the Engineering Test Center. Building construction was virtually complete at year-end. The plant's 30- and 40-foot heights, with complete overhead crane coverage, will efficiently accommodate the largest landing gear parts likely to be required in the foreseeable future. Facility use was to be inaugurated in 1968 with the transfer of 747 landing gear production from the main plant.

The expansion project, including additional engineering, warehouse, and office facilities, was to increase total floor space by nearly 50 percent, permitting rearrangement of the 500,000 square foot main manufacturing plant, increasing its capacity and efficiency for the whole range of more conventional size landing gears and other Cleveland Pneumatic products.

The first few of approximately 100 large machine tools which will equip the new plant were on the floor in November. Of the 33 very large new machine tools to be installed in the "big gear" plant, most were being specially designed. An additional 63 large machine tools located in the main plant were to be moved to the new production area.

The adjacent Engineering Test Center features an 85-foot high drop test tower, providing the greatest capacity of any such test rig in the free world. The tower is designed to accommodate landing gears up to 32 feet extended length, with a 6 foot allowance for fixturing and free drop. It will have capacity for gears for aircraft twice as heavy as any on the drawing boards today. In addition, the Test Center houses three smaller drop test rigs, a 107-ton static test frame, and a full range of instrumented hydraulic and mechanical test equipment.

Production in 1967, on the commercial side of CPT's aircraft business, included landing gears and components for the McDonnell Douglas DC-8 and DC-9, maintaining Cleveland Pneumatic's record of supplying landing gear for every model of the Douglas transport series since the DC-4. A large quantity of landing gears was produced for nearly all versions of the Boeing 707 transport series, and for the Boeing 737. Production continued on spares for the Convair 880 and 990, and landing gears for the twin-engine Grumman Gulfstream II.

In military aircraft, CPT was supplying landing gear and other aircraft components, or complete landing gears, for more than 30 separate programs. Included were the Boeing B-52 and KC-135; Boeing-Vertol's CH-46A and H-21A; Grumman's A-6A, C-2A and TC-4C; the Lockheed C-141; McDonnell-Douglas F-4; North American's XB-70, F-100, OV-10A and T-2B; and Kaman's H-43B and HU2K-1.

Work performed on missile and space programs included nozzles for Minuteman II and safety ventilation valves for that system's underground launch control centers, and components for the Saturn V, Scout and Poseidon programs.

NATIONAL WATER LIFT

Production of aerospace systems and components was up substantially at National Water Lift's plants in Kalamazoo and Grand Rapids, Michigan; El Segundo, California; and Palm Beach Gardens, Florida.

Production of aileron flight control servo actuators for the Boeing 727, 737 and DC-9 continued throughout 1967. NWL was also producing the elevator flight control servo actuator for the 737. Deliveries of the rudder flight control servo actuator for the Boeing 747 were scheduled to begin. In addition, NWL was designing the aileron flight control servo actuators for the Boeing supersonic transport. Flight controls were being supplied for the Lockheed C-130 aircraft. All McDonnell Douglas F-4 aircraft were to be retrofitted with NWL's aileron flight control servo actuator. Production continued on high temperature engine components for various models of General Electric's J79, J85/15, TF39 and Pratt and Whitney Aircraft's TF30.

Other commercial jet engines for which NWL furnished components included the GE-1/4 SST engine.

Quantity production of Pneumo's aircraft weight and balance system (STOW) was continued at NWL's Instrumentation and Control Operation in Grand Rapids. STOW, which was being installed on all TAC C-130 aircraft, measures the aircraft's gross weight and center of gravity. NWL was also producing a roll gyro for the Walleye missile, and pursuing future weight and balance systems for commercial aircraft, helicopters and shipboard weighing systems (SAWSS) for aircraft carriers.

NWL was participating in the Apollo, Surveyor, and Lunar Orbiter programs, the Apollo program utilizing over 35 NWL components. Landing gear shock absorbers for the Surveyor moon probe were designed and manufactured by NWL, and systems and components were supplied for AIM-47A, AQM-37A, Gemini-Titan, Transtage and Polaris.

RADIO CORPORATION OF AMERICA

DEFENSE ELECTRONIC PRODUCTS

The Radio Corporation of America in 1967 maintained its position as one of the world's largest and most broadly based enterprises devoted primarily to electronics. RCA continued to pioneer in many areas of electronics, communications, and space sciences, from microminiaturized electronic components to enormous space surveillance systems. The Defense Electronic Products organization of RCA during 1967 embodied 5 semi-autonomous operating divisions, a structure chosen on the basis of providing the government with the most efficient combination of skills, facilities and resources.

Defense Engineering

The position of Chief Defense Engineer was established to assure the government that the total engineering resources of RCA Defense Electronic Products would be brought to bear where required.

Four highly skilled operating activities reporting directly to the Chief Defense Engineer provided the various DEP Divisions with additional required resources. The 4 activities, described in some detail below, were Advanced Technology, Central Engineering, Defense Microelectronics, and Systems Engineering, Evaluation and Research. These organizations work closely with the RCA David Sarnoff Research Center, perform tasks for the various Defense Electronic Product divisions and, in highly selected areas, perform on techniques contracts for the Government. These 3 areas of established contact help assure awareness of the latest available results from basic research, realistic understanding of the Government's needs and effective communication with the Defense Electronic Product divisions.

Advanced Technology

Advanced Technology is the central organization in RCA Defense Electronic Products responsible for the development of advanced techniques critical to the new product needs of the Government and the DEP Divisions. It works closely with the David Sarnoff Research Center in identifying new physical phenomena and devices with potential for the Divisions. In addition, Advanced Technology works with each of the DEP Divisions to understand the pressing needs of the Government and to marry new technical approaches to both new and old problems.

Advanced Technology successfully advanced the state of art in many basic fields, such as: (a) neural network voice recognition, (b) laser communication devices, (c) masers, (d) thermoelectric air conditioners and infrared coolers, (e) wide-band magnetic recorders, and (f) electro-optical and solid-state displays.

Central Engineering

Central Engineering plays a vital role in practically applying the capabilities of newly evolving technology to manufacturing processes invoked in producing reliable defense and aerospace products. Its objectives are: to contribute to reduced cost and better products by promoting a more common usage of known materials, parts, design techniques, and processes; to provide specialty skills and costly facilities that are uneconomical to duplicate in each division; and to develop new or to improve existing techniques and processes to meet current and future manufacturing needs.

Defense Microelectronics

With a clear understanding of the impact of microelectronics on electronic equipment, the Defense Microelectronics Activity was established to spearhead microelectronics developments within DEP. In addition, DME both actively participates in and provides technical guidance to microelectronics programs undertaken by each product division of DEP. DME specializes in the design and development of the critical high performance circuits and circuit arrays required to more fully integrate RCA's key electronic equipments.

Systems Engineering, Evaluation, and Research

SEER (Systems Engineering, Evaluation, and Research) is the Defense Electronic Products staff systems engineering organization that provides a focal point within DEP for the synthesis, development and technical direction of new system concepts, proposals and programs. SEER personnel represent some of the most competent and imaginative specialists within RCA. These creative, highly qualified engineers, scientists and managers are individually selected for their demonstrated competence in the concept initiation, planning and evolution of major systems efforts undertaken by RCA.

Aerospace Systems Division

The Aerospace Systems Division at Burlington, Massachusetts, through its diversified talents and comprehensive systems engineering capabilities, has contributed significantly to the state of the art by means of government- and company-sponsored studies and field support of major aerospace systems and reliable products. Its major accomplishments have been in electronics for manned space systems, automated test equipment and tactical products and systems employing electro-optical and radio frequency technology.

ASD provided assistance on overall systems and hardware engineering for the electronic subsystems to support Grumman's successful proposal for the Lunar Module portion of the Apollo Program. ASD in 1967 was under contract to supply to Grumman the Rendezvous Radar, Transponder, and Landing Radar for the Lunar Module vehicle. ASD was also building under contract to Grumman the 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 turn signals for the gimballed descent engine. DECA will control the descent engine of LM throughout the power descent to the moon, turning the engine on and off and controlling the intensity and direction of its thrust. Its mission complete with the touchdown on the moon, the DECA will be left behind with the remainder of the LM descent stage.

ASD was under contract to the U.S. Army Missile Command for the Land Combat Support System (LCSS) program. This includes all studies, investigations, design, engineering fabrication, and modifications of test equipment which will provide complete field maintenance capability for the TOW, Lance, and Shillelagh Missile Systems. Depot Installation Maintenance Automatic Test Equipment (DIMATE), developed by RCA for the Army Electronics Command, and installed at Tobyhanna, Pennsylvania, and Sacramento, California, has proven the capability of automatic test systems to troubleshoot assemblies of Army electronic systems. It has reduced conventional electronic testing time by as much as 75 percent.

ASD built and delivered the AN/TSQ-47 system for the U.S. Air Force. The AN/TSQ-47 is an Air Traffic Control/Communications System designed for use by the Air Force Communications Service Mobile Squadrons to support advanced air bases in a tactical employment, newly acquired air bases under combat conditions, temporary replacement or supplement to a fixed facility, and training and mobility exercises.

The AN/APN-155 Low Level Altimeter was developed under contract for McDonnell Douglas Corporation and qualified for use in the F-4 high-performance jet aircraft. It has been a highly successful solid-state equipment which was put into production in 1965, and its excellent acceptance resulted in 1967 follow-on orders for additional units.

The Aerospace Systems Division was conducting research programs and was delivering products using laser devices. ASD performed a Laser Design Concept Study for the U.S. Navy. In this study, a high-energy, short-pulse laser system employing frustrated total internal reflection isolators was investigated. This resulted in a high-power missile-tracking laser system. ASD was awarded a contract by the U.S. Army for the design, fabrication, and testing of a quantity of Laser Rangefinder systems. Under contract to the Naval Air Development Center, ASD developed a Blue-Green Laser Transceiver Unit for use under water.

ASD was doing additional development work for the Air Force on the AN/FSR-2 Optical Tracking System to further refine this space tracker, part of the SPADATS system.

With partial support by the Air Force Avionics Laboratory, ASD developed a highly sophisticated, general purpose aerospace computer, the VIC.

In the field of electronic warfare systems, ASD was engaged in exploiting recent technological advances in integrated micro-circuits by applying them to the design of such systems, under certain Air Force Avionics Laboratory contracts.

Astro-Electronics Division

The Astro-Electronics Division, also known as the RCA Space Center, has achieved an unexcelled reputation for the design and fabrication of long-life unmanned spacecraft and spacecraft systems. Located near Princeton, New Jersey, this division is a leader in the development of weather satellites, communications satellites, scientific satellites, lunar and interplanetary space systems and subsystems. AED has set outstanding records for spacecraft performance in orbit. The actual lives of more than 30 AED-built spacecraft all exceeded mission requirements. Spacecraft built by AED include TIROS weather satellites, a SERT (Space Electric Rocket Test) space platform, ESSA operational weather satellites, Relay communications satellites, Navy Navigation Satellites, and a number of classified spacecraft.

For the Lunar Orbiter Program, AED built the communications and power supply systems, under contract to The Boeing Company. These systems were 100 percent successful on board all 5 Lunar Orbiters launched in 1966 and 1967. AED also assisted Boeing in spacecraft design, systems engineering, environmental testing, and onsite technical support.

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 the second-generation of experimental weather satellites. AED is responsible for a major part of the Nimbus hardware, providing 2 different television subsystems, video and infrared tape recorders, solar cell power supplies, and video ground station equipment. All of the Nimbus spacecraft subsystems built by AED operated successfully on the first 2 satellites.

Two Relay communications satellites, built at the RCA Space Center, were operational for more than 5 years. The division in 1967 was engaged in several studies for both the Communications Satellite Corporation and NASA. These include advanced communications satellites, voice broadcast satellites, and deep space communications satellites.

Development activities of the division during the year covered a wide variety of spacecraft and spacecraft systems. These included unmanned earth natural resources satellites, ultra-high resolution television sensors, infrared 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 a world weather watch.

AED has made contributions to the manned spaceflight program. A miniature, lightweight television camera was designed and built for use in the Apollo Command Module. The 4½ pound camera was the first to make extensive use of integrated circuits. The division also built a TV scan-converter for use with its Apollo camera and performed studies and subsystem testing for RCA's portion of the Lunar Module. In addition, AED undertook studies for the manned spaceflight program in the areas of color television and 2 types of power supplies.

Five ESSA operational weather satellites, built by AED for NASA and the Environmental Science Services Administration, were successfully placed in orbit on February 3 and 28, 1966, October 2, 1966, and January 26 and April 20 in 1967. The ESSA 1 and 2 operational weather satellites represented the world's first global operational satellite system. The ESSA 1 satellite carried 2 half-inch vidicon cameras. Automatic Picture Transmission cameras aboard ESSA 2, as well as ESSA 4, transmitted on a real-time basis cloud cover pictures to APT ground stations around the world. ESSA 3 carries a pair of RCA Advanced Vidicon Cameras used for an operational mission for the first time. ESSA 5 carries the AVCS equipment which has been sending pictures to Command and Data Acquisition Stations in the United States.

Five Lunar Orbiter spacecraft were launched and successfully placed in orbit around the moon, providing high-resolution pictures of potential lunar landing sites. Each spacecraft carried RCA communications and power supply subsystems. Lunar Orbiters 1 through 5 were launched on August 10 and November 6, 1966, and February 4, May 4 and August 1 in 1967.

The Astro-Electronics Division planned to pay increased attention to developing those spacecraft and space systems which return practical benefits to the nation. Continued development and improvement in weather, natural resources, and communications satellites were planned along with new technology that will lead to greater scientific knowledge of the earth, planets, and stars.

Communications Systems Division

The principal facilities of the Communications Systems Division (CSD) are located in Camden, New Jersey; New York City, and Tucson, Arizona. These comprehensive facilities house a complete engineering organization capable of effective project management and comprehensive systems and product engineering through all phases of design, development, and manufacturing.

The headquarters facilities of CSD in Camden, employing over 7,700 engineers, scientists, technicians, 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. Located on the Delaware River in the Port of Philadelphia, it is immediately accessible to trucks, rail, or sea transportation. Housed in several buildings with a combined floor space of 1,350,000 square feet, these facilities contain the engineering, manufacturing, support and administrative activities of the Division. Specialized engineering laboratories of CSD in Camden include: Light Communications Equipment, Heavy Communications Equipment, Digital Communications Equipment, Recording and Television Equipment, Command and Control, Advanced Communications Technology and Communications Systems.

CSD's Camden Manufacturing Plant has several unique production facilities for space age electronics. Among the most important of these is the CSD "White Room" which is utilized for the production of ultra-reliable electronic equipment for such programs as Minuteman. This facility consists of a 20,000 square foot area where temperature and humidity are rigidly controlled and where the dust content is kept at an extremely low level. Another unique Camden manufacturing capability is the Multilayer Printed Circuit facility which is one of the most advanced in the industry. The Camden Plant was being further advanced in 1967 through the increasing use of the tape control fabrication equipment.

The Communications Systems Laboratory located at 75 Varick Street in New York City employed in 1967 125 scientists, engineers and technicians. Total floor space was 50,000 square feet. Charged with the responsibility of devising new concepts in communication techniques and systems, the laboratory's function was to provide additional technical strength supporting the general operations of CSD.

The Tucson Plant facility is located on a 100 acre site in Vail, Arizona, near Tucson. At year-end, over 17,500 square feet of floor space was devoted to manufacturing and engineering support operations.

CSD is responsible for numerous large-scale military programs involving diverse skills and capabilities. Management competence has been proved both in their planning and scheduling and in the judicious combination of engineering and specialized facilities to produce, implement and maintain fully integrated communications systems. A salient example of production competence has been demonstrated by the delivery of over 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.

CSD had under way programs for the design, development, and production of communications for government applications including communications techniques investigation and conceptual studies. This large and diversified area encompasses the development and production of communications transmission and terminal equipment and systems for submarine, shipboard, manpack, vehicular, fixed plant, aircraft, missile, space-ground, and space vehicle applications.

RCA has long been a leader in advanced tactical military communications. CSD was carrying on this tradition in 1967 with a number of very significant development and production programs, including:

AN/PRC-25, AN/PRC-77. The AN/PRC-25 radio set is a prime operational equipment in Vietnam, well-known to the military for its performance and dependability. This FM manpack set weighs 24 pounds including receiver-transmitter unit with rechargeable battery, antenna and headset, and provides 2-way voice communications up to 10 miles. More than 25,000 sets had been delivered through 1967. The AN/PRC-77 is an improved version with several added capabilities.

Ultra-Reliable UHF Radio Set. These microelectronic radio sets, under development for the Air Force to replace the widely-used ARC-34 and similar equipments, will provide significant improvements in size, weight, and performance along with a 5-fold increase in reliability.

P-3C UHF and HF Transceivers. Being developed for application to the Lockheed P-3C antisubmarine warfare aircraft, these radio sets have potential application in a number of advanced aircraft. Principal features include high power, high performance, low size and weight, advanced self-test capabilities, and 1,200 hours guaranteed mean time between failures.

AN/PRC-62. This advanced microelectronic radio set is a single sideband high frequency unit designed for use by combat and combat support units. It is capable of being transported and operated by a single man, and consists of a receiver-transmitter unit with a lightweight rechargeable battery power source, antenna and headset.

AN/ARC-104. This microelectronics high frequency single sideband radio set is a long-range communications set developed under contract to the U.S. Navy. The design of this advanced integrated electronics set features maximum use of the most advanced microcircuits and techniques.

CSD was also very active in supplying heavy communications equipment for the military. Some of the important 1967 programs were:

AN/TRC-97/97A. This operational equipment is being supplied to both the U.S. Marine Corps and the Air Force. It is a complete tactical communications facility suitable for multichannel voice, teletype or data traffic with high reliability and performance. This is designed for unattended operation, and utilizes solid-state circuitry throughout for high reliability and easy maintenance. The system can be set up for operation in one hour by 2 men. Over 100 AN/TRC-97s were in use in Vietnam.

AN/GRC-50. A tactical microwave radio relay set designed and produced for the U.S. Army to provide line-of-sight communications in intermediate or forward area military operations.

Digital communications and switching systems and equipment were an important part of the CSD product; 3 programs of interest were:

Ship's Interior Communications System (ICS). This will be a centralized circuit switching system for the control of interior shipboard communications. Two switching centers will serve up to 2,500 subscribers. The ICS represents the first attempt at modernizing and completely overhauling shipboard communications. It will be a stored program system with sufficient redundancy for high reliability and survivability under battle conditions.

Minuteman Sensitive Command Network (SCN). CSD, under subcontract to The Boeing Company, designed, developed, and produced the SCN which interconnects the various Minuteman unmanned launch and manned launch control facilities in a complex cable network to provide command-control status reporting. The command system's Digital Data Processing Equipment (DDPE), developed by CSD, handles secure launch or inhibit launch command messages, and processes digital messages for automatic system and network checkout. The operational equipment has far surpassed the ultra-high reliability goals. CSD continued to provide engineering services and equipment modification on the Minuteman Force Modernization Program.

Automatic Digital Network (AUTODIN). A vital link in the Air Force world-wide logistics-data communications network, this is the world's largest and most advanced operational data communications system. Under contract to Western Union, CSD designed, developed, produced, programmed, and installed these equipments. The initial network included 5 large automatic switching centers capable of terminating 550 lines. Completed in 1967, the AUTODIN Expansion Program increased to 9 centers capable of terminating 2,700 lines.

CSD was also responsible for major space communications programs:

SHF TACSATCOM Terminals. The SHF Tactical Satellite Communication Terminals will provide extremely reliable tactical communications together with high mobility for battlefield and airborne use. Five configurations are to be supplied: airborne, 1-¼ ton truck shelter, jeep-mounted, teampack, and manpack terminals. Delivery was scheduled to begin in mid-1968. The tactical stations will be tested with an experimental satellite by all 3 branches of the military.

Apollo Communications. CSD was responsible for the design, development and manufacture of the VHF AM Transceivers for the Apollo Command Module (CM) and Lunar Module (LM). These equipments will provide voice and data communications link between the LM, the CM, and the astronaut on the lunar surface.

Lunar Module Communications Subsystem. CSD, under contract to Grumman Aircraft Engineering Corporation, is responsible for the complete Lunar Module Communications Subsystem consisting of S-band transceivers, S-band power amplifiers, VHF transceivers, a signal processor, and the S-band steerable antenna. Major effort was being devoted to interface definition and control and to detailed testing and performance evaluation of the communications equipments when operated as an integrated subsystem.

Space Suit Communications (SSC). CSD was developing for NASA a space suit radio set that will permit 2 astronauts on the lunar surface to communicate with each other and with mission controllers on earth through the Lunar Module. Each SSC will have full duplex transmit-receive capability, will weigh about 5.5 pounds, and will be no larger than a cigar box.

Miniature Spacecraft Video Recorder. A miniature battery operated television recorder designed specifically for space applications has been developed for NASA's Manned Spacecraft Center at Houston. This recorder, occupying 850 cubic inches and weighing only 30 pounds, has record and playback capability for a full 4 megacycle video bandwidth.

Gemini Telemetry Transmitter and Recorder. CSD provided the telemetry transmitters and recorders used in the Gemini missions.

Missile and Surface Radar Division

The Missile and Surface Radar Division (M&SRD) is located at Moorestown, New Jersey. Here is where the highly advanced radar net, BMEWS, was designed, developed and manufactured for installation at 3 widely separated sites in the Western Hemisphere. Also, in 1966, M&SRD built and installed for the Air Force a large tracking radar at the Clear, Alaska, site.

From the installation of the first precision monopulse tracking radar, the XN-1 at Patrick Air Force Base in 1957, M&SRD has designed and produced a family of 71 such radars of ever-increasing sophistication and capability. At year-end they were installed at locations around the globe, both on land and at sea. The standard RCA AN/FPS-16 and its transportable version, the AN/MPS-25, are precision C-band instrumentation radars standardized for the Air Force, Army, Navy and NASA, and are ideally suited for assuring range safety and for tracking rockets, missiles, nosecones, boosters, tankage assemblies, instrument packages, debris, earth orbiting satellites, and space vehicles. The AN/FPQ-6 instrumentation radar and its air transportable version, the AN/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, from 1958 through 1967, has observed test launchings of all U.S. missiles, and analyzed data obtained from many thousands of observations of bodies reentering the atmosphere. This installation has also been a leader in space object identification since the day it made the first such measurements on Sputnik II, using an FPS-16 at Patrick Air Force Base, Florida.

RCA also developed a high performance tactical radar, UPS-1, for use by the Marine Corps, Air Force, Army and Navy. It is packaged in lightweight units, suitable for transportation and operation in the assault phases of amphibious operations.

Under the Apollo Re-Entry Ship Program, M&SRD developed the first precision tracking radar to use integrated circuits for all essential electronic functions—CAPRI. This instrument will have the general capability of the AN/FPS-16 radar, except that the user will have 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.

M&SRD's newest major effort in the radar field was to design, engineer and build the AN/FPS-95 for the Air Force. The division in 1967 was awarded the contract to develop this advanced instrument.

The first major real-time ground support system for space missions to use integrated circuits was installed on the Eastern Test Range by M&SRD. It consists of 4 ground stations at Antigua Island, Ascension Island, Grand Bahama Island and Pretoria, South Africa, and a control station at Merritt Island Launch Annex near Cape Kennedy. Ship-borne stations will also be deployed. The system will enable flight scientists to select and call up various telemetry data from space vehicles while they are in flight down the Eastern Test Range.

M&SRD developed the first truly lightweight hand held radar for use by combat infantrymen in detecting moving targets and directing small arms fire in all weather and visibility conditions. It weighs as little as 2 pounds in its lightest version. It 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.

A 2-part program for advancing the effectiveness of air defense cover for tactical naval units was under way at M&SRD. In one of these, a far-reaching evaluation of existing equipment was made and a significant program of improvements including new systems integration concepts and hardware was put into effect. The other, a long-range study, recommends state-of-the-art improvements in both components and system integration to provide increased effectiveness for ASMS, (Advanced Surface Missile Systems) the naval air defense system of the future.

To enable astronauts on the moon to communicate with earth, a 10-foot parabolic antenna was needed. It could weigh only a few pounds. To meet this specification, a completely collapsible self-erecting structure of metallized cloth was developed. It packs into a cylinder only 3 feet long and 10 inches in diameter and erects automatically with no assistance from the operator, yet its contours are within the very fine tolerances needed to direct a beam of energy efficiently from the moon to the earth.

West Coast Division

The West Coast Division maintained two facilities during 1967, one in Van Nuys, the other, the Aviation Equipment Department, in West Los Angeles, California.

The Van Nuys facility of WCD has been a leader in the development of special purpose computers, random access memories, displays, electronic countermeasure equipment, and secure communication systems since 1960.

One of the major products of the Van Nuys facility is the Saturn Ground Computer System for NASA's Marshall Space Flight Center. This system provides real-time control, checkout, and monitoring of digital and analog data from the Saturn systems. Major equipments in the data processing system are the Saturn computer and the Saturn IODC display, which provides a visual presentation of alphanumeric and symbolic data in tabular and graphic formats.

Other major special purpose data processing programs at WCD have included automatic checkout and launch control equipments for the first operational Intercontinental Ballistic Missile and data processors and displays for the Ballistic Missile Early Warning System.

The division was engaged during 1967 in 2 other data processing fields: message switching systems and radar data processing. United Airline's Electronic Switching System, installed in 1965, accommodates the airline's total teletype message traffic. It automatically processes and distributes all received teletype message traffic, including "interline" messages exchanged with other airlines. It distributes flight plan messages and forwards output traffic of the reservation system.

A similar system, AIRCON, is installed at RCA Communications, Inc., facility in New York City.

The 4100 Series computers, key equipments in the message switching system, were also used for processing radar data on the Atlantic and other missile ranges.

Other major developments in the Information Systems field were displays and random access memories. The Model 3488 and Model 70/568 Mass Memories store approximately 5 billion bits of data. These mass memories are the largest and most economical on the market, in terms of cost-per-bit. Design and development of third generation random access memories are in progress. These third generation systems will provide faster access time and greater capacity at lower cost-per-bit.

WCD was the major supplier of displays to RCA's Electronic Data Processing Division. The displays, used for communicating with computer systems, utilize standard 110V-60 cps power and can be connected to the computers by standard telephone lines. Therefore, they can be situated at any convenient location. The latest displays employ integrated circuits.

Paralleling the division's work in information storage, retrieval, and processing have been its outstanding efforts in Electronic Countermeasures. The division has been a major developer and supplier of deception-jamming equipments to the Navy. The Electronic Warfare group was engaged during 1967 in engineering and manufacturing programs for Radio Frequency Oscillators and Amplifiers.

In addition, the Electronic Warfare and Advanced Systems group was having considerable success in study programs on high density power supplies, the utilization of integrated circuits in ECM programmers and new electronic warfare concepts. The division was merging its capabilities in ECM and Information Systems to provide full electronic warfare system capability.

The division was also active in design and development of ordnance systems and such avionics equipments as navigation control panels and distance measuring equipment.

The Aviation Equipment Department of WCD is devoted exclusively to the design, development and manufacture of airborne electronic equipment for civil aircraft. It is the world's leading supplier of weather radar, having produced almost 6,000 of these vital instruments for aircraft ranging from the largest jet airliners to the smallest twin-engine private airplanes. At year-end, RCA Aviation Equipment Department electronic systems, including Distance Measuring Equipment (DME) and Air Traffic Control Transponders as well as radar, were installed in aircraft of more than 90 of the world's air carriers. The department counted among its customers some 20 airframe manufacturers, and its equipment was being sold and serviced by more than 90 domestic and foreign dealers.

ROHR CORPORATION

For Rohr Corporation 1967 was a year of record growth in several respects. During the fiscal year ended on July 31 the company increased its manufacturing floor area by 402,933 square feet, or 17 percent, to accommodate rapidly increasing business volume. Sales for the same period were 26 percent above those for the previous year.

In addition to plant expansion to provide space for new aircraft programs, Rohr developed and put into service automated handling, storage and parts control systems to speed operations on the increasing volume of production. Computer control of parts flow was expected to improve both schedule and cost performance.

To facilitate research efforts on thrust reversal systems, jet engine acoustics and associated studies, a test range was established in a remote area near the Chula Vista plant. This facility includes engine test stands, supporting equipment and instrumentation for sound studies, thrust reversal tests and other "hot end" study programs. The test range operates in support of in-plant research laboratory facilities that also were expanded during the year to meet requirements generated by anticipated advanced aircraft programs.

One of the earliest test programs conducted at this new facility involved design substantiation studies on the thrust reverser for North American Rockwell Corporation's Sabreliner executive jet. Rohr received a contract in April for design and production of thrust reversers for the very successful North American business jet.

One of the major milestones for the company during the year was the announcement by The Boeing Company that Rohr had been selected to build the propulsion pods for the United States supersonic transport. The initial contract called for production of pods for the 2 prototype aircraft.

Another milestone later in the year was delivery of the first strut and nacelle assemblies for the C-5A to the Lockheed-Georgia Company. These assemblies were delivered to Lockheed for use in engine ground tests.

Meanwhile, fabrication of tooling for the pods and struts for Boeing's 747 got under way at the Chula Vista plant. Rohr engineers worked with Boeing through the year on design of the pods, pylons and thrust reversers for the giant airliner.

These and other new aircraft programs led to the major plant expansion effort conducted during the year. Hot forming and sizing facilities for titanium were expanded substantially to accommodate the supersonic transport and other new aircraft with greater titanium structure requirements. Similarly, the company's adhesive bonding facility at the Riverside plant was increased by 70,000 square feet as a result of increased demand for bonded structures on new aircraft.

New refinements in adhesive bonding techniques resulted in additional applications for bonded structures, such as in the sharply contoured bonded ducts for the high-bypass ratio turbofan engines on the Douglas DC-8 Super 62 and 63.

Other new programs contributing to the company's increased sales volume and facilities requirements were the pods and thrust reversers for Boeing's 737 short-range jetliner and the pods, pylons and thrust reversers for Grumman's Gulfstream II business jet.

During the year the Rohr Antenna Division started overseas field erection on 3 more communications satellite ground station antennas in the 85 to 97-foot diameter range and continued volume production of microwave relay antennas for civilian communications in the United States and Canada.

The division also started construction on a series of aluminum hulls for Navy workboats and on rudders for destroyer escorts, marking an increased effort in the marine products field.

One of the major accomplishments of the company's Space Products Division was fabrication of a highly advanced ablative nozzle for the largest solid fuel rocket motor developed in the Air Force's solid rocket motor feasibility program. Delivered to Aerojet-General Corporation, this nozzle performed according to specifications in a test firing that developed 5,700,000 pounds of thrust.

RYAN AERONAUTICAL COMPANY

Production of landing radar systems for the actual flight hardware Lunar Module that will carry the first Apollo astronauts to the moon was well under way at Ryan Aeronautical Company at year's end while engineers envisioned new applications of the firm's long-established airframe projects.

From among 13 radar units scheduled for delivery by mid-1968, systems were to be selected for installation on the vehicles which will make the actual moon landings. The Ryan landing radar, spectacularly proved during 1966 and 1967 in the Surveyor unmanned lunar exploration program, makes possible a soft touchdown by feeding altitude and velocity measurements into a guidance computer and into the astronauts' cockpit displays. As the pivotal element in the automatic "closed loop" landing control system, the Ryan radar will help brake the Lunar Module to a near zero velocity hover above the landing site before settling the vehicle gently on the lunar surface.

Proof of Ryan landing radar's reliability was afforded in 1966 when Surveyor 1 made the first lunar soft landing of an unmanned spacecraft, and in 1967 by similar performances of Surveyor 3, Surveyor 5, and Surveyor 6. Trouble-plagued Surveyor 5 was "rescued" in a remarkable operation during which the Ryan radar demonstrated its ability to adjust to an unexpected situation arising from a leaky pressure valve designed to force fuel to the 3 rocket engines that brake the descent in the final stage. The Ryan radar had to take control of the spacecraft only 4,400 feet above the lunar surface, rather than the normal 35,000 to 40,000 feet. In a landing sequence condensed from the usual 2 minutes to less than 60 seconds, the radar functioned perfectly.

The military services were offered, during 1967, innovations in the V/STOL and jet target drone fields. To meet the vital need for a fast plane to retrieve downed pilots in the jungle and mountainous terrain of Vietnam, Ryan proposed a Combat Aircrew Recovery Aircraft (CARA), a larger growth version of its high performance, high speed XV-5A Vertifan fan-in-wing V/STOL.

Designated Ryan Model 230, CARA is a jet-powered, high subsonic (Mach .8), extremely maneuverable plane (ultimate load factor 11.0) which combines the performance and survivability of a jet fighter-bomber with a vertical take-off and landing aircraft. It would be capable of accompanying strike forces from land bases or aircraft carriers to strike zones, loiter at safe altitudes during a strike and provide instant response to a rescue mission as it develops.

The Ryan XV-5A Vertifan, which during 2½ years of flight test experience demonstrated its complete flight profile including an ability to land on and take off from any surface that would support the aircraft's weight, including unprepared desert, was transferred during 1967 to NASA. After modifications are completed, an extensive additional flight research program at Ames Research Center near San Francisco was to begin in 1968.

In the drone field, Ryan proposed a smaller version if its famed jet-powered Firebee, the free world's most widely used remote-controlled aerial target. Tailor-made for U.S. Army missile and automatic weapons training requirements, the new target, code-named the Army Training Target Systems (ATTS), would perform in the 175–600 knot speed range and at altitudes of 400 to 40,000 feet.

Meanwhile, the newest Ryan target, the supersonic Firebee II, began flight tests at Point Mugu Naval Missile Center after successfully completing an intensive series of functional checks of engine, airframe, flight control and electronics systems, and tests of the recovery parachute system. Fourteen prototype Firebee IIs, the first high performance jet targets to be produced which exceed the speed of sound, were being built for the Navy flight test program to extend through 1968.

New production and performance records continued to be set by the subsonic Firebee, a standard target of the Air Force, Army and Navy for nearly 20 years. The 2,000th such Firebee was delivered, and one of the numerous bases utilizing these targets, Roosevelt Roads Naval Air Station, Puerto Rico, celebrated its 1,000th operational mission in 1967. During one stretch, a record 87 consecutive flights without a loss were completed. At Tyndall Air Force Base, Florida, a Ryan field service crew took over complete Firebee target flight, control and maintenance from the Air Force while achieving 100 percent flight reliability over a

3-month period, a record for a new contractor service facility.

Ryan solar panels harnessed the sun's energy for the electric power requirements of Mariner V as it flew by Venus in mid-October. The rugged structures were also aboard Mariner I Venus and Mariner IV Mars space probes, and showed their rugged characteristics by continuing to provide power to Mariner IV after 3 years in space.

It was revealed during 1967 that Ryan solar panels have also been carried by the Navy earth-orbiting Transit navigational satellites, as well as by DODGE (Department of Defense Gravity Experiment) high-flying satellite, first to photograph the entire circle of the earth.

A new generation of solar panel structures was developed and was being tested at Ryan. The panels are lighter and larger, to meet the needs of deep space probes of the future, and unlike the rigid Mariner panels, the new arrays roll out and away from the spacecraft, exposing more panel area to generate more electric power than ever before.

Ryan Aeronautical Company developed a deployable solar array for Jet Propulsion Laboratory's 1969 Mars probe.

Evaluated during the year were a Ryan aircraft "sink rate" Doppler radar system that can detect structural damage resulting from hard landings on aircraft carrier decks; a small, 8-pound short pulse radar sensor capable of extremely accurate altitude measurements while in low-level, high speed flight at times of restricted visibility; and a velocity sensor designed for use aboard air cushion vehicles, the first radar navigation system to demonstrate measurement of forward and drift velocity for such surface craft.

To meet its production commitments, Ryan completed a $1,700,000 government-funded machine tool expansion program and brought the work force at its 3 San Diego plants up to 4,700 during the year, compared with less than 1,600 two years earlier and 4,100 at the end of 1966.

SOLAR DIVISION OF INTERNATIONAL HARVESTER COMPANY

Critical high-temperature jet-engine components, flight hardware for every stage of the Saturn/Apollo vehicle, ducting for jet fighters, and gas turbine auxiliary power units for helicopters and business jets were the main elements of Solar's aerospace work in 1967.

Largest single aerospace production items were vane-and-shroud assemblies for the Pratt & Whitney Aircraft TF30 engine to be used on the F-111 and other aircraft. Other engines for which Solar was manufacturing similar parts included the J52, JT11, JT8D, JT3D, and the GE4 supersonic transport engine.

Solar contributions to the Saturn/Apollo program included, for the first stage, ducting for fuel, pressurization, and hydraulic systems, plus heat exchangers; for the second stage, propellant feed, pressurization and vent lines, plus flexible metal hose and bimetallic, joints for engine controls; for the third stage, further bimetallic joints; for the instrument unit, coolant manifolds, accumulators, and heat exchangers; for the lunar module, main communication antenna structures and the SNAP-27 lunar nuclear power plant structures; and, for the Apollo spacecraft, main communication antenna structures.

The IH Division continued to fabricate the stabilator slotted leading edge and boundary-layer-control ducting for the McDonnell Douglas F-4 Phantom jet fighter.

The other side of Solar's business, the development and manufacture of gas turbine engines, continued in 1967 to make contributions to the aerospace industry.

Solar's Titan gas turbine auxiliary power units were being used in every major U.S. military cargo helicopter program. Helicopters in Vietnam were relying on the 80- to 150-horsepower Titan engines to restart main engines and operate all hydraulic and electrical systems. This enabled the troop and equipment carriers to operate wholly independent of ground-support installations when necessary. Titan APUs also were on board the F-27, FH-227, Fan Jet Falcon, and JetStar aircraft. The commercial Solar auxiliary system provides self-contained electrical power in addition to ground air-conditioning, again freeing the aircraft from reliance on ground-support facilities.

In addition to these programs, the Titan gas turbine found further applications as a source for electrical power in a variety of special military airborne programs, including air-to-ground illumination systems.

Solar in 1967 stepped up its capability for working with the unusual new metals of the space age with the construction and outfitting of a surgery-clean advanced development fabrication center at its plant on the San Diego harbor-front. The new facility was established in order to provide Solar with full capability to make prototype, development, and limited-production quantities of newly developed components and subsystems, usually requiring an advance of the fabrication art. A variety of advanced machine tools and forming equipment was operating in a dust-free controlled atmosphere, enabling Solar to handle such metals as beryllium, titanium, the refractory metals, dispersion-strengthened metals, and the family of stainless steels and super-alloys.

Solar Division of International Harvester constructed and outfitted a new surgery-clean advanced development fabrication center at its main San Diego plant.

A new brazing furnace, described as "the biggest all-metallic cold-wall vacuum furnace west of the Mississippi," was installed by Solar for work on aerospace contracts. The working compartment is 48 inches in diameter and 54 inches high and is capable of a 10^{-6} Torr vacuum. The high-temperature brazing operation is controlled by a digital computer.

Solar announced the design and development of a blast valve whose purpose is to protect hardened structures from nuclear explosions and contamination. A 24-inch valve was thoroughly tested under conditions simulating nuclear explosions and other sizes were expected to complete qualification in 1968.

Solar completed development of several composite-material systems for electromagnetic shielding, successfully tested in actual nuclear explosions.

In Solar research laboratories, new advanced work was pushed in the fields of composite materials, high-temperature sensors, titanium joining methods and high-temperature plastics, in addition to fundamental investigations into materials both metallic and non-metallic. Diagnostic equipment and techniques were expanded to include electron microprobe, electron microscopy, infrared analysis, and gas chromotography.

Solar's employment continued to climb in 1967 at its 2 San Diego-area plants, passing 3,900 by year's end. An extensive professional recruiting drive remained under way as production volume continued to expand in both aerospace and turbomachinery.

SPERRY RAND CORPORATION

SPACE SUPPORT DIVISION

The Space Support Division continued in 1967 to provide technical and engineering support to the Marshall Space Flight Center's astrionics laboratory and to be responsible for development and integration of missile system guidance and control equipment, instrumentation, communication and tracking equipment associated with the Saturn/Apollo Program. The division's $12,695,727 cost-plus-incentive-award-fee contract was renewed in April.

An expanded effort was being undertaken to gain greater participation in the area of advanced study programs and the development of a series of aerospace product lines. A Marketing Department was added to the division with the Marketing Manager directing all marketing functions within the division and responsible for the national and international marketing of telemetry and communications system and subsystem design and development, as well as engineering support.

Continued growth of the division necessitated an expansion of 3,000 square feet in March with an option on a second area of the same size. Facilities at year-end comprised 3 separate buildings containing a total of 43,000 square feet of floor space.

Work force increased during the year from 800 in January to 900 at year-end, with 40 percent of the work force comprised of engineers.

SPERRY FLIGHT SYSTEMS DIVISION

In continuing production at Sperry Flight Systems Division were automatic flight controls and instrument systems for the Boeing 727 and 737, Douglas DC-8, and DC-9, Grumman A6-A Intruder, Lockheed JetStar and Grumman Gulfstream II.

Among the division's major new programs was the SPZ-1 combined autopilot-flight director system for the Boeing 747. The initial $14,000,000 award was made to Sperry on April 4. Value of the contract could exceed $40,000,000 over the course of the 747 program. Under an additional Boeing contract, received in August, Sperry was also to produce magnetic compass systems for the 747. Total value of this contract was about $2,000,000.

Slated for initial deliveries to Boeing in mid-1968, the SPZ-1 will have triple computer channels for "fail operational" automatic landings. Some control panel elements and computer channels are common to both the autopilot and the flight director, simplifying the pilot's job by making it possible for him to set autopilot and flight director controls simultaneously. This configuration also makes the electronic design more efficient by eliminating duplication of circuits that may be used by both the autopilot and flight director.

Sperry's dual-channel SP-50 autopilot was used to make the first fully automatic landing of a U.S. airliner in routine passenger service. The aircraft, a Boeing 727 flown by Pan American, touched down at New York's John F. Kennedy International Airport on February 27, 1967, controlled all the way to the ground by the Sperry system.

In another program, McDonnell Douglas Corporation was using a Sperry SP-50AL autopilot in developing a fully automatic landing system for the DC-9 twin-jet. Planned for eventual Category III operation, the system was used in more than 200 automatic landings during a flight-test program conducted by Douglas in mid-1967.

During 1967, Flight Systems Division expanded its facilities from 375,000 to 400,000 square feet and increased the work force from 2,900 to 3,200. The breakdown of the business mix was maintained at about the previous year's level of 70 percent commercial and 30 percent military customers.

SPERRY GYROSCOPE DIVISION

During 1967, Sperry Gyroscope Division highlights included the successful completion of Inertial Reference Unit (IRU) production for the Lunar Orbiter project, the start of work on the fleet modernization of the Terrier missile fire control system, a new contract for development of a new submarine sonar system, and continued testing on Sperry's Loran-D tactical radio navigation system for ground and air units.

The Navy, under a $17,200,000 contract, authorized the modernization of the Mark 76 fire control system for the Terrier surface-to-air missile system during 1967. Sperry, serving as systems manager for the project, was improving some 14 systems for 4 Navy DLG-class ships. The program, designed for rapid ship turnaround, involves improving the system to provide "increased performance, serviceability and reliability," and adapting the system to accommodate the new Standard missile system under development for the Navy.

To carry out full systems tests on land of the improved Mark 76 system, a new 42,000 square foot facility was opened by Sperry at its MacArthur Field, Long Island, site. At MacArthur, final assembly and tests were being conducted prior to shipment to the shipyards for installation aboard ship.

While Sperry completed work on the inertial reference system for the highly-successful Lunar Orbiter spacecraft program, development work on the Attitude Reference Unit (ARU) for the Spartan missile progressed. The Spartan moved a step forward with the Department of Defense announcement late in 1967 that it would be deployed as part of the Sentinel anti-ICBM system.

The Sperry design consists of a 4-gimballed stable platform which uses 2 fluid sphere gyroscopes for sensing changes in the missile's attitude. The unit was designed to withstand extremely high g forces during launch and acceleration and to operate in a nuclear environment. The Sperry ARUs will be used in the flight test program of the Spartan. Production contracts have yet to be awarded.

Early in the year, Sperry Gyroscope received additional funds from the Navy's Ships Systems Command to continue work on a new advanced submarine sonar system. The system was expected to be deployed with the Navy's nuclear submarine fleet.

Sperry's work under this contract calls for design analysis and covers system integration, transducer and array designs, self-noise and baffling materials, signal processing, reliability, fault monitoring and repair, human factors and interface studies.

The company was also at work on a surface ship sonar system, called PAIR, which can detect, track and classify undersea targets simultaneously and continuously. The PAIR system can automatically supply the necessary fire control data for launching weapons against enemy targets. Microcircuitry is used extensively throughout PAIR system components, providing lighter weight, more compact equipment, with the added features of higher reliability and ease of maintenance.

The division was also producing precision Ship's Inertial Navigation Systems (SINS) for Navy attack submarines and surface ships, including 6 major carriers. And work was continuing on a fixed-site, mobile and shipboard electronically-scanned radar system in which a computer-controlled radar beam provides extremely rapid scanning rather than using a mechanically-driven radar "dish" to direct microwave energy.

Earlier work on this new radar technology is embodied in Sperry Gyroscope's HAPDAR (Hard Point Defense Array Radar), in operation at White Sands Missile Range, New Mexico.

Winding up the year, Sperry Gyroscope delivered the first transportable Loran-D radio navigation transmitter complex to the U.S. Air Force. The entire system was undergoing test at Eglin AFB, Florida.

The transmitter complex is part of a tactical navigation system that will enable combat forces—both ground and air elements—to operate under all-weather conditions from the same precise position information.

The airborne portion of the system is an outgrowth of Sperry's development of the first microcircuit loran receiver system, and can be carried in a wide variety of aircraft, from transports to fighters to helicopters. Installations can also be made in jeeps and light trucks for use by ground units. Sperry also developed a lightweight, man-carried unit as well.

SPERRY MICROWAVE ELECTRONICS DIVISION

Major aerospace production at the Sperry Microwave Electronics Division included semi-automatic checkout equipment for flight-line and depot maintenance programs of A-7A, F-111A, B-52 and B-58 radars. The equipments are designed to meet the maintainability and turnaround-time standards necessary for maximum aircraft utilization.

Production of card, module and component testers for the Navy SINS program and development of automatic testers for ILAAS circuit cards represented a major step toward the improvement of maintenance programming. This type of checkout equipment was expected to become even more significant as prime equipments become more complex and are further miniaturized with LSI techniques. A majority of Sperry's development effort on checkout equipment was being devoted to this activity.

Various standard radar test sets, such as the AN/UPM-29 and AN/UPM-32, were also being produced.

For the Navy's Versatile Avionics Shop Testers (VAST), the division developed and produced a series of computer-programmable microwave signal generators. These units are capable of synthesizing the RF signals needed for trouble shooting 85 percent of the Navy's carrier-based avionic systems now operating or projected for the future.

In the microwave component area, the division continued development and production of discrete ferrite isolators, circulators, and phase shifters for prime microwave systems. New projects were begun to miniaturize components and integrate them in printed microwave circuits. During 1968, this work was expected to result in a capability to produce complete microwave circuit functions on chips similar to those available at low frequencies.

SPERRY SYSTEMS MANAGEMENT DIVISION

The Sperry Systems Management Division, brought to full divisional status by the Sperry Rand Corporation in June 1967, reflects the evolution taking place in the aerospace industry in the conception and development of electronic systems of ever increasing complexity and sophistication. The division in 1967 was active in systems development and management for advanced military aircraft, control and instrumentation for deep submergence vehicles, and the Poseidon fleet ballistic missile submarine program.

The division, which grew out of a group formed to develop the revolutionary Polaris navigation subsystem, was upgrading the subsystem for the new Poseidon missile submarines to achieve accuracy goals 4 times higher than those of the Polaris A-3 missile weapons system. ILAAS, the Integrated Light Attack Avionics System for an advanced Navy aircraft, was ready to be flight tested. A study also was under way for the Navy on advanced avionics requirements for aircraft of the 1980s.

The Sperry Systems Management Division was involved in projects for another environment, the ocean's depths. The instrumentation and control system for an advanced deep submergence research vehicle was completed and was ready for installation in the vessel. The division developed 2 trainer simulators for the Navy's Deep Submergence Systems Program, and these were being used in the training of hydronauts to operate the deep-diving vehicles. Surface vessels, too, were an object of systems management interest. The Sperry Systems Management Division was teamed with Todd Shipyards Corporation in the competition for developing and building the DX-class destroyers for the Navy.

UNIVAC DIVISION

The unusually successful activity of the Sperry Rand UNIVAC Division attracted national attention during 1967. Deliveries began of the new 9000 series of low-cost computers which substantially reduce data processing time for general business functions. The divisions real-time systems were revolutionizing the handling of airline reservations, contributing vitally to the nation's defense and space programs, and finding significant new applications in industry and science.

Systems being delivered in the 9000 series were the UNIVAC 9200, for use with punched card equipment, and the 9300, used with either cards or magnetic tape. Featuring an exclusive plated-wire memory and integrated circuits, the new computers were in worldwide demand for such applications as inventory control and payroll processing. Customers included the U.S. Junior Chamber of Commerce (which was employing a 9300 at its national headquarters for handling data on its 250,000 members), hospitals, insurance firms, and businesses ranging from a molasses manufacturer to a sporting goods company.

During 1967, the division installed a major portion of a computerized information system for United Air Lines. To be operating in 1968, the system includes passenger reservations and aircraft scheduling. It employs 3 UNIVAC 1108 Multi-Processor Systems and over 2,800 cathode ray readout screens for use by agents. The $56,000,000 system was to link 116 cities served by the airline.

Northwest Airlines ordered a UNIVAC 494 for handling data from 29 cities. The Air France computerized reservation system, which uses 2 1108s to link Paris and 5 countries, neared its 1968 operation. Both Scandinavian Airlines and Eastern Airlines improved their existing systems with 494s.

Sperry Rand was a major supplier of computer equipment for the initial anti-ballistic missile system under development. This work was taking place at the UNIVAC Federal Systems Division.

UNIVAC continued to make important contributions to the nation's space effort. It delivered its first Titan III aerospace computer in May. The 80-pound

UNIVAC 1824s were to be used to assist in pre-launch checkout and to compute steering commands during flight.

Installation of 2 dual 1108 systems was completed at the National Aeronautics and Space Administration's Manned Spacecraft Center in Houston. They are being used for advanced research and engineering projects and as a scientific computing backup to the center's Real-Time Computing Complex.

NASA's advanced computing capability for manned space missions was beefed up during 1967 with the completion of a UNIVAC 1108 real-time computer complex at the Manned Spacecraft Center in Houston.

At the NASA Marshall Space Flight Center, UNIVAC began replacing existing computers with a totally integrated 1108 system linking all buildings requiring computing capability.

During 1967, the division completed delivery, installation, and network checkout of new UNIVAC 1230 systems in NASA's Manned Space Flight Tracking Network. The 1230s, used at 14 ground sites and on 3 tracking ships, will process and relay telemetry and command information between the Mission Control Center and the Apollo spacecraft.

A UNIVAC 418 began operating during the year at NASA's Electronics Research Center in Cambridge, Massachusetts. It was being used in conjunction with the 1108 complex in Houston for remote batch processing.

The market for UNIVAC products continued to grow rapidly. The Louisiana State Police headquarters began operating a 418 system whose memory includes a list of all stolen cars in the nation. Police throughout the state can query it to receive vital information. The computer also switches messages between police regions. Banks in the U.S. and abroad continued to install real-time systems for processing accounts. The National Bureau of Standards ordered an 1108 for processing data from over 200 Federal agencies, including the Bureau of the Budget. Kinki Nippon Railway Co., Ltd., Japan's largest railroad, installed a second 418 system for handling seat reservations for express trains and tourist buses.

In 1967 the division unveiled a visual communication terminal, the UNISCOPE 300, for instantaneous viewing of computer-stored information. Applications include faster customer service at tellers' windows in banks.

The accent was on expansion. UNIVAC at year-end was employing about 23,500 people. The former Sperry-Utah Division in Salt Lake City was realigned in 1967 to become UNIVAC Salt Lake City. Including about 2,000 employees and 2 plants totalling 369,000 square feet, it will be used for producing computer hardware. Also transferred to UNIVAC was the former Sperry Farragut Division in Bristol, Tennessee. The Federal Systems Division began operating a new 280,000-square foot plant in Eagan Township near the Twin Cities. UNIVAC's World Headquarters in suburban Philadelphia completed occupancy of a 47,000-square foot addition to its administration wing.

UNIVAC's dynamic growth during 1967 was expected to continue as the computer market expands. New systems in the 9000 series were to be introduced and large real-time computers will meet ever more diverse needs, often being operated as a service for many people on a time shared basis. Data will frequently be displayed visually as man learns to work more smoothly with computers. The division planned to continue its aggressive research and development program concentrated on new computer systems, improvement of peripheral equipment and research into advanced electronic circuitry and memory storage components.

VICKERS INCORPORATED DIVISION

Major production for 1967 at the Vickers Incorporated Division included Minuteman Flight Control System components for both stages; hydraulic systems and components for the Douglas DC-9 and the 60 Series DC-8 and Boeing 700 series. In addition, the Division produced hydraulic engine starters and substantial amounts of other hydraulic equipment for the Bell UH-1 and Sikorsky CH-46, CH-47, and CH-53 helicopters. Due to escalation of the Vietnam conflict, these particular planes brought about a considerable increase in Vickers production during the year. A major program continued for the A-7A.

Programs in prototype production stages included: a major part of the hydraulic components for the Lockheed C-5A, the largest military transport to be built, which may use more hydraulic horsepower than any plane except the XB-70; Vickers hydraulics for elevation and azimuth control on the launcher to aim the Chaparral heat-seeking missile to protect front battle areas from aircraft; a contract to supply the hydraulic engine starter and hydraulic power packages for Lockheed's combat helicopter, the Cheyenne AH-56A.

SUNDSTRAND AVIATION DIVISION OF SUNDSTRAND CORPORATION

The Sundstrand Corporation experienced unprecedented growth in 1967, nearly doubling its number of employees. Sundstrand Aviation contributed substantially to this growth with the opening of its new headquarters and Research and Development Center in Rockford, Illinois. Another facility, the Turbine Systems Research Laboratory, is a 20,000 square-foot facility equipped for the research, development and production testing of advanced hot-gas, turbo-machinery systems. This building was completed earlier in the year and dedicated in November.

Several business acquisitions were made by the Sundstrand Corporation during the year. Howard Foundry of Chicago, Illinois, and United Control of Redmond, Washington, were 2 to be allied with the Aviation Division. Howard Foundry is the largest foundry of its kind in the U.S. and has casting production capabilities ranging from grey iron through the exotic metals. United Control designs and manufactures electronic components, systems, and instrumentation for the aerospace industry.

Continuing as a leader in aircraft secondary power systems, Sundstrand Aviation introduced several new product lines designed to serve in military and commercial applications.

A natural extension of technological and manufacturing capabilities, mechanical actuation systems were added to the family of aviation products. By year-end, Sundstrand had been selected by Boeing to participate in the design of the supersonic transport wing-sweep actuation system. In addition, several proposals for secondary control actuation systems were made to other airframe manufacturers.

The Integrated Drive Generator (IDG), an advanced electrical generating system, was well advanced in Phase I testing when it was publicly introduced during the summer. By the end of the year, Phase II development of a production prototype was under way with the cooperative efforts of 4 of the country's largest generator manufacturers. Because the IDG combines the reliability-proven Axial Gear Differential (AGD) constant-speed drive with a constant frequency AC generator in a single package, it shows a weight reduction of 20 to 30 percent, a similar decrease in size, and an increase in reliability over the separately-housed AGD/generator combination.

Development of the production prototype Mark 48 torpedo engine was completed during the year and several units were delivered. The Mark 48 torpedo is an advanced ASW weapon.

Production continued on accessory drive gearboxes. Formal proposals for additional units were presented to several airframe manufacturers including Boeing for the SST.

Sundstrand continued to make progress in the development of missile power units (MPU) during the year. MPU's are small turbine driven, electrical, hydraulic, or combined electro/hydraulic power sources providing energy for missile-borne equipment. Outstanding in this area was the award of a contract for hydraulic power units to provide the Poseidon missile with thrust vector control.

In other space and missile activity, Sundstrand research teams continued work on organic rankine cycle technology under contract from the Atomic Energy Commission and the U.S. Air Force. Included in this area is a 150 kilowatt organic power study program.

Development of the lightweight, high-speed, half head hydraulic pumps and motors, continued under contracts for evaluation units for the SST, Mystere 20 TS, and the Mystere 20 PD.

Constant Speed Drives (CSD) continued as a major product area in 1967. The Axial Gear Differential (AGD) CSD continued to establish remarkably high reliability records on various aircraft applications. New contract awards included the Boeing 747, Grumman EA-6B, Fairchild Hiller F-228, and the German VFW 614. Proposals outstanding at year-end offered equipment for high-density, short field, commercial jets, business aircraft, and an assortment of military aircraft.

THIOKOL CHEMICAL CORPORATION

Thiokol Chemical Corporation moved ahead in several areas of rocket propulsion technology in 1967.

Its Wasatch Division successfully test-fired, in late May, a 156-inch diameter, monolithic rocket. The test incorporated a full-sized submerged, omniaxial flexible seal nozzle. In August, a 120-inch diameter motor with hot gas thrust vector control, was static tested as part of another program to develop large space boosters. Both motors were developed under contract to the Air Force Rocket Propulsion Laboratory.

Wasatch continued work on the first stage of the Poseidon fleet ballistic missile in its joint venture with Hercules Incorporated. Under the arrangement, Thiokol lines the motor chambers, casts, cures and X-rays the propellant, and returns loaded motors to Hercules for final assembly. A contract with Lockheed Missile and Space Company was signed during the year by executives of Thiokol and Hercules.

In other solid propellant rocket motor developments, Wasatch successfully static-tested 3 full-scale pulse motors, also under contract to the Air Force Rocket Propulsion Laboratory. Purpose of the program was to demonstrate the technology applicable to future air launch missiles, including the capability of the grain retention system to withstand severe environmental conditions. The motors contained 2 formulations of a composite propellant with different burning rates.

Wasatch also successfully static tested a single-chamber controllable solid propellant rocket motor in a program conducted with the Aeronutronic Division of Philco-Ford. The motor was tested through 4 operating cycles; the unique propellant developed by

Thiokol was successfully extinguished 3 times at ambient conditions. This was the second test for the motor.

Beginning in mid-1966, rocket propulsion systems from 2 Thiokol divisions successfully soft-landed Surveyor spacecraft numbers 1, 3, 5 and 6 to assist in the study of the lunar surface for the planned Apollo manned landing. The main braking retro rocket was provided by the Elkton Division of Thiokol, the 3 attitude and velocity control liquid vernier engines by the Reaction Motors Division.

In other space motor activities, the Reaction Motors Division formally completed qualification of the C-1 Radiamic engine under a development program sponsored by NASA's George C. Marshall Space Flight Center. Rated at 100 pounds nominal thrust, the C-1 engine was developed to meet the space vehicle maneuvering and velocity control requirements of typical NASA missions.

An earlier RMD engine, the LRX-11, used in the 1947 flights of the X-1 aircraft, and 10 years later as the interim propulsion for the early X-15 aircraft, found renewed application possibilities during 1967. NASA planned to use the LRX-11 in powered flights of the M-2 and HL-10 manned lifting bodies.

Reaction Motors also received a contract by the Naval Systems Command for the investigation of liquid air-augmented rocket primary combustors. The engine in this concept utilizes the principle of 2-stage combustion, the primary or gas generator stage-yielding fuel-rich products that are burned with air in the secondary stage to produce thrust. Use of atmospheric oxygen results in substantially higher specific impulse or performance.

Reaction Motors produced its 50,000th packaged liquid motor for the Bullpup air-to-surface missile. In another area of technology, the division developed a new nitroso rubber material combining various desirable properties, including non-flammability in a 100 percent pure oxygen atmosphere.

In other space motor applications, Thiokol's Elkton Division provided 13 solid propellant motors for the Apollo/Saturn 4 vehicle. Eight were used to separate the first and second stages; 4 to separate the second and third. The 13th motor was used to jettison the escape tower immediately after launch.

Elkton also provided the decelerating rocket power for the AIMP mission, which placed a satellite in orbit around the moon. A modified version of its successful Surveyor main retro rocket was employed in the Burner II mission, conducted under contract to Boeing for the Air Force. The motor was qualified as the third stage for a version of the improved Delta vehicle.

In propellant technology Elkton applied its "Q" series of advanced propellants to power gas generators.

The Poseidon missile under development will carry auxiliary power units using these propellants. They were also being used in the Mark 46, Mod 1 torpedo. They ignite smoothly, operate at low flame temperatures and produce relatively clean exhaust gases.

Thiokol's Huntsville Division continued its program work on the Nike X research and development program. It also was announced that Huntsville was selected to develop rocket motors for the U.S. Army's SAM-D missile.

Castor motors produced by Huntsville found increasing application, including international areas. The orbiting of a San Marco payload for Italy and the UK-3 satellite for Great Britain utilized Castor rocket motors. Some better known satellites launched by augmented Thor and Delta vehicles included 3 comsats, the IMP-F and IMP-E Interplanetary Monitoring platforms, the OGO III Orbiting Geographical Observatory, and the ESSA-4 and ESSA-5 Weather Satellites. Castors also contributed to advanced knowledge by boosting the first Scramjet vehicle and 28 Athena vehicles.

Huntsville was also the first defense contractor to receive the Department of Defense Zero Defects Participation Award from the Army.

Thiokol's Longhorn Division continued to produce pyrotechnic devices for the Army. During the year it celebrated the 25th Anniversary of the Longhorn Army Ammunition Plant, and observed its own 15th anniversary of the establishment of the Longhorn Division. It also received funding for the Nike Hercules program, and the U.S. Army Materiel Commands Participation Award for its outstanding Zero Defects Program.

During the year, Thiokol acquired the property and assets of Hy-Tel, Incorporated. Thiokol's Astro-Met Division, developer and producer of sounding rocket systems, was assigned responsibility for the manufacture of Hy-Tel's electronic equipment, which is used primarily to monitor water and snow conditions in remote watershed areas.

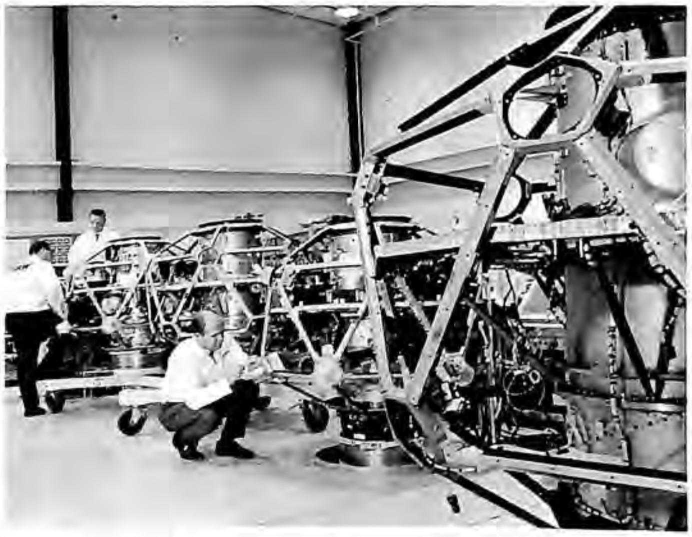
In the sounding rocket area, Astro-Met continued to provide systems for the exploration of the earth's atmosphere. One spectacular in the sky was the launching of barium clouds 200 miles over Wallops Island in a NASA experiment to help measure winds and electric fields. The resulting glow was visible for hundreds of miles along the Eastern seaboard.

The year completed Thiokol's 26th year of progress in rocketry. It continued to provide the opportunities to develop and build the technology required for the propulsion needs of the future.

TRW INC.

In 1967, Cleveland-headquartered TRW Inc. broadened its support of the nation's scientific, military and commercial space programs; expanded its systems engineering efforts in missile and other major defense activities; accelerated its use of advanced technology in non-space, non-defense projects; made deeper inroads in the European space programs; and further penetrated the U.S. jet aircraft engine market with new orders for parts for the new generation of "jumbo jets."

Highlighting the company's space activities in 1967 was the first successful launch of a pair of USAF advanced Vela nuclear detection satellites with 3 piggybacking Environmental Research Satellites on a single booster. Each Vela weighed 510 pounds and was put



TRW was working on an advanced series of Vela nuclear detection satellites.

in a 60,000 mile circular orbit on opposite sides of the globe. Each carried instrumentation designed to detect nuclear events near the earth's surface or deep in space. The 20-pound ERS spacecraft that rode piggyback on the Titan III-C were injected into elliptical orbits. Two of them were on radiation missions, while the third investigated the effects of space environment on metals.

A second long-term TRW spacecraft program, NASA's Orbiting Geophysical Observatory, produced another successful launch in July—OGO IV. The 1,240-pound OGO carried 20 experiments for the study of the relationship between the environments of the sun and the earth.

TRW participated in USAF's Initial Defense Communication Satellite Program, which was completed in 1967 with 2 launches that provided the final link in the global system. Each of the 18 communication satellites in the network contain 6 major subsystems built by TRW.

Work continued throughout the year on Comsat Corporation's initial system of Intelsat III commercial communication satellites. First delivery of the TRW designed and built satellites was to be made in 1968. Each of the 250-pound satellites will provide 1,200 2-way voice channels or 4 television channels. Following production of the first 4 of these satellites, TRW's contract called for increasing participation in the program by 9 subcontractors in Europe and Japan.

In propulsion subsystem work, the company continued to progress in its development of the variable-thrust Apollo Lunar Module descent engine that will be used to soft-land 2 U.S. astronauts on the moon. In addition, TRW was awarded a contract during the year to build the midcourse correction engine for JPL's pair of Mariner probes to be launched toward Mars in 1969.

Long-term endurance testing continued throughout 1967 on an advanced Mercury Rankine Power Conversion unit, formerly a part of AEC's SNAP-2 program. The units are the most fully developed dynamic power conversion devices for extended manned or unmanned space missions in the nation. Completion of 2 10,000 hour endurance tests was scheduled for mid-1968. Upon completion of these tests, the 4-kilowatt turbo-alternator units will have demonstrated an operational life of considerably more than one year.

In the electronics area, TRW produced the central computer and sequencer, and thermal louvers for JPL's successful Venus probe, Mariner V; work continued on an abort guidance section for the Apollo Lunar Module; additional flight tests of USAF's Space Ground Link Subsystem were conducted; a portable alignment gyrocompass was delivered to NASA; and a study of guidance and navigation requirements for an advanced SST was completed for the same agency.

TRW's systems engineering support of major defense and space programs, initiated in 1954 with the Atlas ICBM program, continued and expanded in 1967. Programs included USAF's Minuteman ICBM, the Navy's ASW program, NASA's Apollo program, and the Army's Cheyenne helicopter and Sparta reentry test programs. In addition, hardware for a Reentry Measurement Instrumentation Program was produced for the Army under a Bell Telephone Laboratories subcontract.

The application of advanced technologies to socio-economic problems—a new field called "civil systems" by TRW—accelerated in 1967. Under a Department of Transportation contract, TRW was evaluating high speed ground transportation systems for the Northeast Corridor. For the Province of Alberta, Canada, the company was helping design a $100,000,000 health sciences center in Edmonton. Other civil systems projects ranged from the study of an automated automobile inspection system to flood plain control techniques.

In the commercial sector, TRW's long-term laser research program not only produced new advances in laser holography during 1967 but also brought a pulsed ion laser to market.

In an effort to expand its commercial activities, TRW announced plans to acquire Mission Manufacturing (and its subsidiary, International Controls Corporation), a Houston oil field equipment and services firm, and Hazleton Laboratories, a Falls Church, Virginia, commercial research laboratory specializing in biosciences.

The company also expanded its international space activities during the year. With Engins Matra of France, TRW established a new firm in Paris, Matrel, to provide systems analysis services for European space programs. Working agreements were also signed with Sweden's SAAB and Germany's ERNO. In addition, extensive support was provided the ESRO 2 satellite project under an agreement with Britain's Hawker Siddeley Dynamics.

In Japan, a joint venture with Mitsubishi Electric produced a new firm, MTRW, to design and build ground stations. The company's first contract was awarded for the antenna portion of the first Mexican ground station, which will be used to transmit television coverage of the 1968 Olympic Games throughout the world via Intelsat III satellites.

Business growth during 1967 resulted in an increase in employment to 17,000 at the company's Systems Group and required an expanded facilities construction program. Three buildings—a research building, a manufacturing building, and an 11-story administration building—were completed at the Group's Redondo Beach, California, headquarters. The 13th and final building for the Redondo Beach site was nearing completion at the end of 1967. To provide space for additional expansion, adjacent property was acquired in Manhattan Beach. Ground was broken in October for the first buildings on the new site.

In aircraft and related industries, TRW continued to play a leadership role in 1967. New components were shipped for the giant C-5A aircraft, the largest plane yet developed. Capability in this area was expected to lead to major contributions in the supersonic transport program.

In addition, significant manufacturing programs got under way at TRW for components to be used in the JT8 gas turbine for the 727, 737, and DC-9 airliners; the JT3 engine in the "extended" versions of the 707 and DC-8; and the TF30 engine used in the F-111. Volume production also continued on parts for the Lycoming T53 engine and for the United Aircraft PT6 which has applications ranging from the Beech King Air executive aircraft to the gas turbine racing car entry in the 1967 Indianapolis 500 race.

TRW forged ahead during the year on development of manufacturing processes for prototype gas turbine engine components for the large aircraft production programs for the late '60s, including work on shafts and discs for the new GE T64 gas turbine engine for the Advanced Aerial Fire Support System to be used in the Army's new, revolutionary helicopter. Research and development also advanced in 1967 on state-of-the-art sophisticated turbine blades which maximize air cooling for high performance engines. This work was to be applied to production for the JT9 engine which will power the big Boeing 747, and to other advanced designs for the next generation of aircraft engines.

TRW static inverters were being manufactured for Pratt & Whitney Aircraft's TARGET program, which involves the development of a natural gas fuel cell power plant for on-site total energy systems. The TRW static inverter will convert direct current power of the fuel cell to the alternating current required for the total power applications planned. TRW was increasing its overseas market for industrial static power conversion equipment as well. In 1967, more than 100 static converters were delivered or placed on order for international customers. This equipment will provide standby power to computers and instruments controlling the operation of power plants, oil refineries, chemical plants and highway tunnel lighting systems.

The company's ordnance program proceeded during the year as TRW's new 25 millimeter multipurpose automatic cannon was purchased for field evaluation tests by a number of European governments. The lightweight dual-feed weapon was primarily designed by TRW ordnance consultant Eugene Stoner to give U.S. vehicles "standoff ability" against 23 millimeter weapons carried by Soviet vehicles. The TRW weapon was considered a prime candidate for use in the Army's Vehicle Rapid Fire Weapon System.

TWIN INDUSTRIES CORPORATION (DIVISION OF THE WHEELABRATOR CORPORATION)

The year 1967 was one of the most active in the 22-year history of Twin Industries Corporation. New business raised the company's backlog to the highest it had been in a decade. Employment increased substantially, and an expansion program was implemented to provide additional manufacturing area, modern facilities and new equipment for present growth.

During 1967 significant changes were made in the management and capabilities of Twin Industries. A new generation moved into management as J. J. Lee retired from the position of president after 50 years in the aircraft industry. R. F. Hurt, formerly president of Lockheed Propulsion Company and vice president of Lockheed Aircraft Corporation, assumed the presidency of Twin Industries. Other management changes were made and new executives added to Twin's capable staff.

An extensive modernization and expansion program was inaugurated. Under this program new construction for additional manufacturing space was completed by year-end. An environmentally controlled building of over 24,000 square feet augmented the modern bonding facilities. Within this building the temperature, humidity, dust, pressure, etc., are carefully controlled to meet, or exceed, requirements of latest bonding specifications. A new adhesive spray room increased capacity by 50 percent and an additional chemical processing tank line, with tanks 10 feet deep and 30 feet long, expanded Twin's capabilities for handling large panels. New equipment, which included a 225-ton stretch press capable of forming sheets and extruded shapes up to 36 feet long and a 24-foot roll, were installed in another new addition.

A large heat treat bottom quench furnace, numerically controlled machine tools, and other equipment were also added under the expansion program.

Production continued on the vertical fin, rudder, and spoilers which Twin manufactures for the Boeing 707/720 commercial transport. Also continued was the production of the ground spoilers and flight spoilers for the Boeing 727.

Wing leading edges and trailing edge panels produced for the Lockheed C-141 Starlifter continued during 1967 and phased out during the fourth quarter to complete a very successful program. Twin was manufacturing the complete empennage for the Grumman Gulfstream II, and delivery schedules gradually increased during the year as this new airplane received certification from the FAA and deliveries to customers commenced. Also in production for Grumman were the outer wings, flaps, ailerons, and spoilers for the S-2 Tracker and major bonded assemblies for the E-2A Hawkeye and Gulfstream I business aircraft.

Initial deliveries were made to the General Electric Company of splitter assemblies used on the C-5A engine thrust reverser. Deliveries continued to be made to the Raytheon Company for electronic equipment consoles used on the Hawk missile system.

Highlights of 1967 included the receipt of 2 major subcontracts on the Boeing 747. These contracts covered the tooling and manufacture of window panel assemblies, fuselage frames, and floor panels. Twin also received a new contract from Cornell Aeronautical Laboratory for the manufacture of the cabin, cockpit structure, nose section, flaps, and vanes which will be installed on a Convair 240 in order to simulate SST flight and landing problems.

Initial deliveries were made to Northrop Norair for bonded honeycomb door assemblies used on the F-5 Freedom Fighter.

During the year employment increased by 18 percent, reflecting the growth of activities at Twin Industries. The receipt of new orders and follow-on orders increased the backlog from $30,369,000 as of January 1, 1967, to approximately $47,000,000 at year-end.

UNITED AIRCRAFT CORPORATION

United Aircraft continued to expand its manufacturing capability in 1967 to meet accelerated customer requirements in the military and commercial fields.

The company strengthened its position as a leading supplier of jet engines, helicopters, propellers, environmental control systems, advanced airborne radar, and other tools of flight.

United Aircraft's solid propellant boosters and liquid propellant rocket engines operated successfully in such programs as Titan III-C and Centaur/Surveyor.

During the year, the company continued to deliver equipment for Project Apollo. It also further directed its aerospace capability to non-aerospace areas, including electrical power generation, high-speed rail transportation, marine technology, and biomedics.

At the same time, its program of research and development was intensified in such areas as power conversion, metallurgy, lasers, advanced helicopters, and communications.

United Aircraft increased its office and manufacturing space by about 1,000,000 square feet during 1967, including a large, new office building at Pratt & Whitney Aircraft and a new electronics plant at Hamilton Standard. Employment was about 80,000 persons.

United Aircraft realigned its divisional structure in a move designed to improve overall operating efficiency and to strengthen the corporation's total effectiveness.

Sikorsky Aircraft was reorganized into 2 main subdivisions: Air Transportation Systems and Surface Transportation Systems.

United Aircraft Corporate Systems Center was discontinued as a division of the corporation, effective December 31, 1967.

Corporate Systems Center's high-speed train program was assigned to Sikorsky's new Surface Transportation Systems. The electronics, guidance, and information systems work carried out at Corporate Systems Center was transferred to Hamilton Standard division, which also took over management of the CSC facilities in Farmington, Connecticut.

To accelerate United Aircraft's participation in microelectronics, Electronic Components division was formed in Trevose, Pennsylvania, and the Vector division there was discontinued.

Electronic Components took over all microelectronics activities performed by the Hamilton Standard, Norden, and Vector divisions. The telemetering and communications programs of the Vector division were transferred to the Norden division and Vector's medical telemetry operations were shifted to Hamilton Standard.

To broaden and strengthen the corporate management structure and give it flexibility in directing the increased growth of United Aircraft, the company created 2 group vice president positions. One group vice president is responsible for all propulsion activities as carried out by Pratt & Whitney Aircraft and United Technology Center divisions. The other is responsible for the activities of Hamilton Standard, Norden, and Electronic Components divisions.

United Aircraft Research Laboratories, the company's central research organization, concentrated on a series of basic and applied programs in 1967.

The laboratories continued production and delivery of 2,000 pounds of continuous boron filament to the Air Force under the largest single boron contract ever awarded. Its scientists also developed a silicon carbide-coated boron filament called BORSIC (trademark). Unlike uncoated boron filament, BORSIC retains its strength at high temperatures when embedded in light metals such as aluminum or titanium.

Research scientists continued fluid mechanics and materials studies related to gaseous core nuclear rockets suitable for flight in and beyond the earth's atmosphere.

Engines of this type offer the possibility of single stage-to-orbit or near-planet capability. Pursuing its interest in rocketry and hypersonic air-breathing propulsion, the laboratories continued work in the supersonic combustion ramjet concept for the Air Force.

Research Laboratories intensified major programs in laser research in an effort to advance technology and discover possible new applications. In one program, scientists generated and measured laser pulses 4 trillionths of a second in length with peak powers of 100 billion watts. As a result, it will now be possible to measure reaction rates and the structure of matter to a degree never before possible.

United Aircraft continued to carry out product development and manufacturing through 6 autonomous divisions. Because each has its own product lines and technical interests, detailed activities of the corporation are reported separately in the following columns under the names of the divisions. They are: Pratt & Whitney Aircraft, jet and rocket engines, marine and industrial gas turbines, fuel cells; Hamilton Standard, propellers, accessories for spacecraft and aircraft, controls, electronics; Sikorsky Aircraft, helicopters and other advanced vertical-lift aircraft, high-speed, turbine-powered trains; Norden, guidance, navigation, radar, telemetry, and other electronic systems; Electronic Components, microelectronics, high power transistors, semi-conductor devices; United Technology Center, solid-propellant boosters and advanced space propulsion systems.

PRATT & WHITNEY AIRCRAFT DIVISION OF UNITED AIRCRAFT CORPORATION

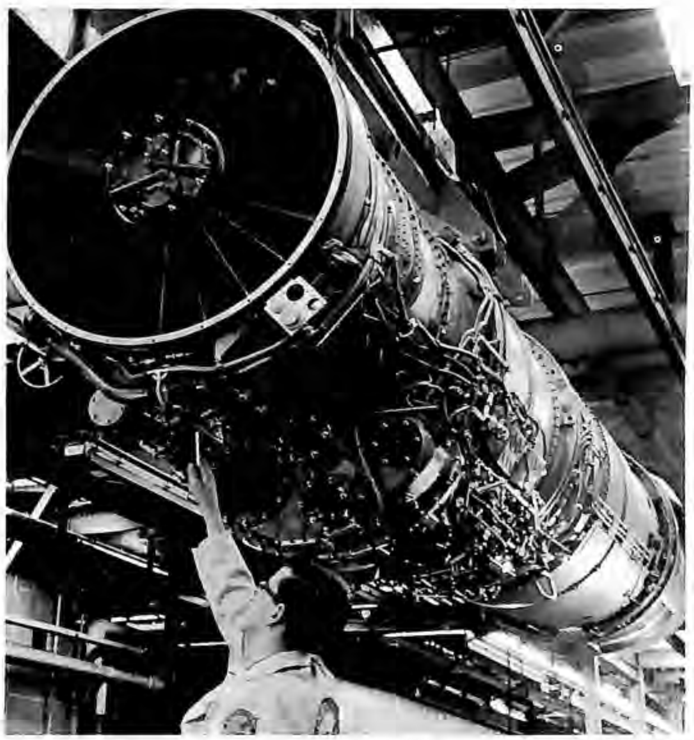
Pratt & Whitney Aircraft revised the development schedule of its JT9D turbofan for the Boeing 747 in 1967, a year that also saw the division's TF30 military engine enter service with Air Force and Navy units, an expansion of industrial and marine uses of its gas turbines and additional applications of its fuel cell powerplants.

The JT9D's initial thrust rating was increased from 42,000 pounds to 43,500 pounds. The more powerful JT9D-3 engine model will be available for initial 747 airplane deliveries. The JT9D-3 has the same external configuration as the 42,000-pound-thrust JT9D-1. It has an 8-foot inlet—almost twice that of the 18,000-pound-thrust JT3D turbofan, workhorse of the long-range Boeing 707 and Douglas DC-8 commercial jet fleets—yet it is only 125 inches long, 9 inches shorter than the JT3D.

By early October, testing of the JT9D had passed the 400-hour mark. Four engines were being tested, with a fifth scheduled to join the program before month's end. Deliveries of ground-test JT9Ds were set to begin in the spring of 1968 with pre-production engine deliveries to commence during the summer. Societe Nationale d'Etude et de Construction de Moteurs d'Aviation (SNECMA), France's largest aircraft engine manufacturer, announced that it intended to exercise the option it held since June 1966 for the European JT9D manufacture under license.

Both versions of Pratt & Whitney Aircraft's TF30 engine entered service with the military. Navy squadrons on both the East and West Coasts began operations with LTV Aerospace Corporation's A-7A Corsair II, a subsonic, multipurpose attack plane powered by the non-afterburning TF30 in the 10,000-pound-thrust class. By October 15, over 25,000 flight hours had been accumulated on the more than 120 A-7As accepted by the Navy. In late summer, the plane passed a maintenance and reliability evaluation, the first of its type ever written into a production contract by the Navy. Qualification tests of the TF30-P-8, latest model of the powerplant for the A-7A, were completed and deliveries to the Navy were started in July.

The afterburning TF30, the first afterburning turbofan in the world, is the powerplant for General Dynamics' Air Force F-111A, FB-111 and Navy F-111B. Air Force pilots of the Tactical Air Command began training in the F-111A at Nellis AFB in Nevada. The TF30 with afterburner is in the 20,000-pound-thrust class.



A Pratt & Whitney Aircraft TF30 afterburning turbofan, powerplant for the USAF and Navy F-111 and FB-111 and the first of its type, is readied for delivery.

A basic version of the afterburning TF30, the TF306, was being developed by SNECMA for use in 2 models of the French Dassault Mirage, the F2 and the G. The F2 made over 100 flights. The G, a variable geometry aircraft, was scheduled for its first flight late in 1967.

Development of the J58 turbojet for the Air Force's Mach 3 YF-12A and SR-71 aircraft built by Lockheed continued at the Florida Research and Development Center. The YF-12A, powered by 2 J58s, each in the 30,000-pound-thrust class, is the holder of 9 speed records.

The Lockheed C-141 StarLifter, a jet transport powered by 4 TF33 (JT3D) engines, each developing 21,000 pounds of thrust, continued to set records, including those for speed and daily operational flying time, in logistics flights to Vietnam and other parts of the world.

Other TF33 models, delivering slightly less thrust, were powering the Boeing C-135B and B-52H, 2 of a wide variety of aircraft powered by Pratt & Whitney Aircraft engines. The J57 was powering the B-52 bomber, the KC-135 tanker-transport and the C-135 transport, all produced by Boeing, the North American F-100, the McDonnell F-101, the Convair F-102, LTV Aerospace Corporation's F-8 and the Douglas A-3. The larger J75 was the powerplant for the Republic F-105 and Convair F-106. The J52 served to power versions of the Douglas A-4 and Grumman's highly sophisticated A-6.

The J60 (JT12) was powering the North American T-39, known commercially as the Sabreliner, the North American T-2B and the Lockheed C-140, commercially known as the JetStar. A free turbine version of this engine, the JFTD12, was power plant for the Sikorsky S-64 Skycrane helicopter. The JT12 develops up to 3,300 pounds of thrust; the free turbine version up to 4,500 shaft horsepower.

In the field of commercial aviation, Pratt & Whitney Aircraft engines continued to see extensive service throughout the free world. As of October 1, 114 airlines either had ordered or were operating aircraft with Pratt & Whitney Aircraft engines. Between January 1 and October 1, 369 P&WA-powered planes were ordered, including 70 by United Air Lines, the largest single airline order in dollar value ever made.

Orders for Pratt & Whitney Aircraft-powered transports in the first 9 months of 1967 included 48 Boeing 747s with JT9D engines, 54 Douglas Super Sixty Series DC-8s, powered by 4 JT3Ds, and 51 Boeing 707 Intercontinentals, also JT3D powered. Four of the 707s were ordered by the Federal Republic of Germany for use by the West German Air Force.

A total of 235 Boeing 727s, 737s (flown for the first time in April), Douglas DC-9s and Sud Aviation of France Super Caravelles, all powered by the JT8D turbofan developing up to 14,500 pounds of thrust, were purchased in the 9-month period. Included among the orders was an Air Force contract for 8 DC-9s for use in transporting the sick and wounded and the first announced sale of a business version of the plane. An afterburning model of the JT8D, built under license by Svenska Flygmotor of Sweden, was power plant for the SAAB 37 or Viggen. This multipurpose, combat aircraft, capable of speeds in the Mach 2.5 range, was in test status prior to delivery to the Royal Swedish Air Force.

Pratt & Whitney Aircraft commercial engines had accumulated over 57,000,000 operating hours by October 1. In July, 4 JT3Ds were removed from a Trans World Airlines' Boeing 707 for a routine inspection after flying 2,500,000 miles, a distance equivalent to 100 trips around the world. In what was believed to be a record, these engines had remained in the plane for 16 months, since it was built, tested and delivered to TWA. The JT3D enjoys the longest time between overhaul (TBO) ever given an aircraft engine —12,000 hours. TBO for the JT4, commercial version of the J75 turbojet used in some longrange versions of the Boeing 707 and Douglas DC-8, is 10,500 hours; for the JT8D, it is 7,800 hours.

Production of fuel cell powerplants for the Apollo program continued, as did development of those for the Manned Orbiting Laboratory. The PC3A-2 fuel cell powerplant, designated Powercel as a registered trademark, will provide on-board electrical power and drinking water for the Apollo astronauts. At the end of October, PC3A-2 fuel cell powerplants stood ready for their second flight test, an unmanned launch of the Apollo system. These units produce between 563 and 1,420 watts of electricity.

In February, a team of 26 companies in the gas industry selected Pratt & Whitney Aircraft to carry out a large-scale, 3-year research program to develop a fuel cell powerplant, operating on natural gas.

A month later, it was announced that a portable fuel cell powerplant had been successfully operated in the field in tests conducted by the U.S. Army's Electronics Command. The powerplant, designed as an improved means of providing electricity for field use, proved up to six times more efficient than a conventional, small engine-driven generator.

Development under a 2-year Army contract was begun at the Florida Research and Development Center on a small, 1,500-horsepower turboshaft engine suitable for vertical and short take-off and landing aircraft and helicopters. Designated the ST9, the engine combines improved performance characteristics with rugged simplicity. Testing of a lightweight water jet propulsion system capable of powering a 55-foot marine craft at speeds of more than 50 knots, without propeller or rudder, was begun for the Navy. The water jet, powered by a modified P&WA engine, takes water from inlet ducts in the hull of a vessel and pumps it at high velocity out the rear to provide thrust.

Work on the 15,000 pound thrust RL10 liquid hydrogen rocket engine and other advanced rocket engines continued at the West Palm Beach, Florida, facility. The RL10 maintained its perfect flight record during the year in the launch of 3 Surveyor spacecraft to the moon. On 2 of the missions, the engines were shut down and restarted in space. As of October 31, 58 RL10s had operated in space without a failure.

More non-aviation applications for jet engines were developed by the division's Turbo-Power and Marine Department.

A 694-foot, "roll-on, roll-off" cargo ship, the first of its type in the free world to be powered by large aircraft-type gas turbine engines, was launched by its builder, the Sun Shipbuilding and Dry Dock Company. Powered by 2 FT4s, marine versions of the JT4 turbojet, the vessel has a top speed of 25 knots, making it one of the fastest cargo vessels on the high seas. It can carry up to 7,000 tons of cargo—tanks, trucks and other vehicles that can be driven on board—over a range of 6,000 miles.

These same engines, rated at 20,000 horsepower, were supplying boost power for a new class of Coast Guard cutters, 2,800-ton high-speed vessels built by the Avondale Shipyards. The first of these, the *Alexander Hamilton*, was scheduled for speed trials in late October. The second, the *Dallas*, was commissioned and a third completed preliminary sea trials. Four others were launched and a seventh was set for launching by year's end. Another version of the powerplant, the GG4, was being used to boost the speed of a pair of Royal Danish Navy frigates, the *Pedar Skram* and the *Herluf Trolle*. These engines were equipped with free turbines manufactured by Stal-Laval, of Sweden. Both vessels were in naval service.

Pratt & Whitney Aircraft marine powerplants also were being used to power a pair of Royal Canadian Navy helicopter-destroyers under construction, the first of their type to use all gas turbine power, and a hydrofoil built for the Royal Canadian Navy by deHavilland of Canada.

In the industrial field, Pratt & Whitney Aircraft gas turbines were serving the electrical, gas transmission and petro-chemical industries. They were in use throughout the United States and in Europe, Latin America and the Far East.

In June, The Philadelphia Electric Company purchased 13 FT4-powered electrical generating units, the largest sale to a single power company. Earlier, Northeast Utilities, a holding company with subsidiaries in Connecticut and Western Massachusetts, ordered 7 units, each powered by a single FT4. The Florida Power Corporation purchased 5 units from the Worthington Corporation, each with 2 FT4s. A GG4 was sold to Mitsubishi Heavy Industries, of Japan, for use by the Kansai Electric Power Company.

Pratt & Whitney Aircraft-powered generating units played a key role in limiting the summer's electrical power failure in New Jersey, Delaware, Pennsylvania and Maryland. Six of 8 FT4-powered units owned by utilities in these states went into operation when the blackout began. The other 2 were held in reserve and placed into full operation later, as restoration of electrical service began. At year's end field service operating experience on the installed industrial and marine units had passed 600,000 hours.

In January, construction was completed on 2 new office buildings at the division's East Hartford, Connecticut, main plant, giving Pratt & Whitney Aircraft a total of 283,000 square feet more office space. One month later, a 220,000-square-foot manufacturing facility was acquired in Rocky Hill, Connecticut. In May, plans were announced for a 800,000-square-foot addition to the division's Middletown, Connecticut, plant. The building, scheduled for completion in 1968, was to house machinery for the manufacture and assembly of jet engines, including the JT9D.

HAMILTON STANDARD
DIVISION OF UNITED AIRCRAFT CORPORATION

Increased production of jet aircraft equipment and continued growth of its newer product lines highlighted Hamilton Standard's activities in 1967.

Fuel controls in quantity were supplied for General Electric, Lycoming and Pratt & Whitney Aircraft gas turbines which power more than 20 commercial and military aircraft. These jets include all Boeing and Douglas airline models, military planes like the Lockheed C-141 transport, Douglas A-4E and Grumman A-6A attack craft, McDonnell F-4 fighter as well as military and civilian versions of Sikorsky and Vertol helicopters.

Experimental models of the new fuel control for the Boeing 747 giant transport were built and delivered for engine test. This control, although the same in size and weight as those built for the 707 and DC8, automatically meters twice the fuel flows, up to 3,500 gallons an hour. It also performs additional functions like enriching fuel flow during cold weather startup and regulating reverse thrust.

Air inlet controls, hydraulic computers like the engine devices, were manufactured for the U.S. Air Force and Navy versions of the F-111 sweep-wing supersonic fighter.

Development work progressed on the cabin air conditioning, temperature and pressure regulating systems for the 747 aircraft. Contracts were received to supply air conditioning packages for the U.S. Army's Beech U-21A utility aircraft and to continue making preproduction heat exchangers for the Anglo-French Concorde supersonic transport.

The Boeing 737 became the first airliner to be equipped with a fully automatic cabin pressure control. The system was built by Hamilton Standard. In production was environmental control equipment for the Northrop F-5, Douglas A-4E and their trainer versions, Ling-Temco-Vought A-7 carrier-based jet and Lockheed JetStar executive plane.

A shoe-box sized gas management assembly controlled the atmosphere aboard the National Aeronautics and Space Administration's Biosatellite during its 48-hour earth orbit in September. Flight hardware of the Apollo lunar module's environmental control system was shipped. Development of the life-support backpack designed to be worn by the moon-exploring Apollo astronauts moved closer toward flight qualification.

Significant advances were made in the development of a highly mobile pressure suit for future manned space missions. In addition, the Air Force selected the division to design an extravehicular space suit with a self-contained life-support system, hard-shell torso and fabric arms and legs.

Hydrazine-fueled rocket engines, representing another new Hamilton Standard space product, were built for several programs, including the Interim Defense Communications and Application Technology (ATS-C) satellites. The division pressed forward with development of regenerative life-support systems for long-duration space flights. A laboratory model of an oxygen-producing molten salt cell was delivered to NASA for evaluation, and a prototype atmosphere regeneration unit was built for the Air Force.

Space and life systems operations were reorganized into 2 autonomous departments—space systems and biomedical systems. The move allowed the division to strengthen its growing activities in the medical and health field while maintaining its leadership in space life-support.

Circulatory-assist pumps designed for treating heart patients were sold to clinics, hospitals and medical schools. The Telamedic transmitter-receiver set, which relays by telephone a patient's electrocardiogram to the physician's office from the home or hospital, was introduced. Advanced circulatory-assist and kidney dialysis devices were among the projects initiated as a result of several contracts received from the National Institutes of Health.

The Lockheed AH-56A armed helicopter and Bell Aerosystems X-22A research transport, both equipped with advanced propellers, successfully made their first flights. These lightweight propellers have fiberglass blades and integral gear boxes. Propellers were manufactured for the Handley Page Jetstream executive aircraft, North American OV-10A counter-insurgency aircraft, Lockheed C-130 transport, P-3 antisubmarine patrol plane, Grumman OV-1 reconnaissance craft, and deHavilland CV-7 Buffalo cargo carrier. Modified aircraft propellers also were supplied for the Bell Aerosystems SK-5 air cushion vehicle.

In electronics, a flight path control that guides a helicopter through complete submarine-search missions, including sonar dunks, successfully passed flight test at the Patuxent River Naval Air Station, Maryland. Solid state power supplies, flight controls and engine controls were among the electronics equipment in production.

Electron beam welding continued to expand into the aerospace and mass production fields. The Ford Motor Company put into its production line a machine designed to weld flywheels at high rates, and United Air Lines became the first airline to use electron beam welding for engine and other maintenance work.

Near the end of the year Hamilton Standard added composite materials to its diversified product line. Using technology developed by United Aircraft Research Laboratories, it began working on improved methods for making boron and other coated filaments.

With the discontinuance of United Aircraft Corporate Systems Center, Hamilton Standard took over that division's activities in electronics, guidance, and information and environmental systems. These included development of the inertial sensor assemblies for the Apollo Lunar Module's abort guidance system and projects to automate the bibliographical operations of the Library of Congress. It also took over management of the former Corporate Systems Center facilities in Farmington, Connecticut.

A 200,000 square foot electronics plant was occupied by Hamilton Standard at mid-year, bringing the total engineering, manufacturing and office facilities to more than 2,000,000 square feet.

SIKORSKY AIRCRAFT
DIVISION OF UNITED AIRCRAFT CORPORATION

Sikorsky Aircraft in 1967 continued a steady increase in production that had begun the year before. Two new helicopters, the U.S. Air Force HH-53B and the U.S. Coast Guard HH-3F, flew for the first time.

Sikorsky was reorganized late in 1967 into 2 main subdivisions: Air Transportation Systems and Surface Transportation Systems. The latter subdivision took over the high-speed TurboTrain program of United Aircraft Corporate Systems Center, which was discontinued as a division of the corporation.

Two Sikorsky-produced aircraft, U.S. Air Force HH-3Es, made helicopter history with a nonstop flight from New York to London and Paris. The 2 were refueled by HC-130 tanker planes during the 4,270 mile crossing. The HH-3Es landed at LeBourget Airfield in Paris after nearly 30 hours in the air. An aerial refueling probe, designed by the Air Force and Sikorsky, proved itself dramatically on this flight and was added to operational HH-3E and HH-53B helicopters for long-range rescue work.

Variety was the key to Sikorsky production figures. Five basic helicopters—the S-58, S-61, S-62, S-64, and S-65—were built in at least 15 different configurations. The S-61 series, for instance, included the U.S. Navy SH-3D, the U.S. Air Force HH-3E and CH-3E, the U.S. Coast Guard HH-3F, the Malaysian Air Force S-61A, and the commercial S-61L and S-61N. Sikorsky helicopters were delivered to all U.S. military services, many foreign military services, and commercial operators in the United States and abroad.

HH-3Es, called "Jolly Green Giants" because of their camouflage paint, continued to distinguish themselves as rescue helicopters in Vietnam. The 2 ocean-hopping HH-3Es, after a brief interval in Paris, were shipped to the combat area. The 3rd Aerospace Rescue and Recovery Group, credited with 597 combat saves in Vietnam—many by HH-3Es—was awarded the Presidential Unit Citation in 1967 for "exceptional gallantry in support of operations against an opposing armed force." HH-3Es flew deep into North Vietnam to rescue downed airmen. CH-3E and CH-3C transport versions of the HH-3E were used as utility vehicles, mixing spot rescue and counter-insurgency missions with cargo assignments, carrying everything from 105 millimeter howitzers to downed aircraft.

CH-54A Skycranes (S-64s) were used by the Army's 1st Cavalry Division to carry troops, fuel, engineering equipment, vehicles, guns, other aircraft, and supplies. The first CH-54As of a sizable Army re-order (following an initial order in 1964 for 6 Skycranes) were delivered to Vietnam and to Fort Rucker, Alabama. These second-generation cranes carried improvements suggested by field reports, including engine air particle separators to protect the twin turbine powerplants from sand and other debris. Separators also were devised by Sikorsky engineers for Marine CH-53A helicopters. With the Army order for additional CH-54As came an order for portable vans. The vans will be used as combat hospitals, command posts, maintenance quarters, and communications centers. CH-54As will deliver the vans to areas where they are needed most.

SH-3As and SH-3Ds (the latter powered by growth engines) continued as Navy antisubmarine warfare helicopters. SH-3As operating from carriers in Vietnam waters also were used as search and rescue helicopters, braving storm and darkness, refueling from surface vessels, and evading both enemy terrain and guns to pick up downed airmen. RH-3As, the first operational mine countermeasures helicopters in U.S. Navy history, joined the *U.S.S. Ozark*, first mine countermeasures support ship in Navy history, for a test cruise to Europe. At the same time, in 1967, Marine CH-53As were fitted with mine countermeasures kits for evaluation.

The HH-3F, another S-61 model, first flew in late 1967, carrying the most sophisticated navigation, communication, and instrument systems ever devised for a search and rescue helicopter. A 6-month test period will precede first deliveries to the Coast Guard in 1968.

The Coast Guard flew HH-52As (S-62s), with single turbine engines, wherever floods, hurricanes, ship collisions, or other emergencies decreed the need in 1967. HH-52As, assigned to land bases in Puerto Rico, Alaska, and the Hawaiian Islands, as well as bases encircling the continental U.S., also were used to complement Coast Guard cutters fitted with helicopter landing platforms and Coast Guard ice-breakers equipped with hangars.

Foreign military deliveries were significant. The first of a number of S-61A-4 helicopters went to the Malaysian Air Force for use as troop and cargo transports. An SH-3D went to Gruppo Fratelli Agusta, Sikorsky licensee in Italy, as the prototype for an Italian navy antisubmarine warfare helicopter. S-62As were delivered to the Nationalist Chinese government in Taiwan and to Thailand. S-58s were delivered abroad under the U.S. government's military assistance program.

Sikorsky continued license agreements with Westland Aircraft Ltd. of England, where SH-3Ds were being produced for the British Navy, and with Sud Aviations of France and Mitsubishi Heavy Industries Ltd. of Japan. Technical assistance agreements continued with Vereinigte Flugtechnisch Werke G.m.b.H. of Germany, and Royal Netherlands Aircraft Factories Fokker.

Although most helicopters produced by Sikorsky in 1967 were delivered to the military services, commercial sales remained steady. Helicopter airlines in 5 different countries were using Sikorsky helicopters as passenger and cargo carriers. In the U.S., Los Angeles Airways and San Francisco and Oakland Helicopter Airlines established new passenger records with S-61Ls and S-61Ns, respectively. Sikorsky helicopters also were used in construction and offshore oil rig work.

The S-58 helicopter, a single-piston-engine model first flown in 1954, still rolled off the production line in limited quantities. More than 1,800 had been produced by Sikorsky in the 13 years through the end of 1967.

The 4 turbine-powered models produced were the S-61, S-62, S-64, and S-65, twin-turbine aircraft except for the S-62.

The S-65, called the CH-53A by the Marine Corps and the HH-53B by the Aerospace Rescue and Recovery Service of the Air Force, was produced on an accelerated schedule. The big assault transport saw action for the first time in Vietnam in both Marine and Air Force markings. Marine CH-53As flew men, arms, and supplies to fill crucial battle needs. At Sikorsky's main plant in Stratford, Connecticut, other CH-53As were test flown with growth engines and an integrated helicopter avionics system (IHAS) expected to improve instrument capability. In one test flight, a CH-53A carried 20,000 pounds both externally and internally at a gross weight of 46,000 pounds. Air Force HH-53Bs lost little time between first flight and initial delivery. This new, long-range rescue helicopter quickly passed aerial refueling tests and was

Sikorsky employees put finishing touches on Marine Corps CH-53A helicopters.

equipped with the same refueling probe as the smaller HH-3E.

Sikorsky maintained and expanded its leadership in the medium helicopter commercial field. A sixth S-61L was delivered to Los Angeles Airways. An S-61A was turned over to an Oregon operator for power line construction. S-62As went to offshore rig suppliers in Alaska and the Gulf of Mexico.

The S-64 Skycrane was demonstrated as a prime mover in the commercial field. The S-64 showed its ability to quickly unload a container ship and thus avoid lengthy delays in crowded or inadequate ports. Oil producers studied the S-64 as a potential heavy lifter. The S-64 was considered, too, for a Skylounge system in the Los Angeles area, the helicopter lifting mobile vans from downtown Los Angeles to the airport.

Commercial, as well as military, helicopters went to foreign users. An S-61N was produced for Brunei Shell in the Malaysian chain. Another S-61N went to Greenlandair. Two S-62As were delivered to Ansett-ANA of Australia for use in offshore oil work.

A complete study of the vertical take-off and landing (VTOL) aircraft's position in the transportation complex of the future was undertaken by Sikorsky in 1967. Beyond the present S-61L and S-61N, the study indicated, were the compound S-65, available in 3 to 5 years, and the stowed rotor, available in 10.

Research continued at Sikorsky, covering these and other designs. Growth versions of existing aircraft were developed on drawing board and flight simulator. Included was the CH-54B, with 3 engines and the ability to lift nearly 18 tons. The S-61F, a streamlined S-61 helicopter fitted with wings and forward-thrust engine more than 2 years earlier, continued to fly over Long Island Sound, collecting data that will help shape the final design of future compounds. Titanium rotor blades were ordered for testing in connection with the design for an advancing blade concept (ABC) helicopter, carrying 2 counter-rotating main lifting rotors on a single axis and an optional pusher-propeller in the rear. Refinements were added to a stowed-rotor concept long studied at Sikorsky. The stowed-rotor would be able to take off and land as a helicopter and, rotor blades stopped and retracted, would be able to fly as a fixed-wing plane.

NORDEN
DIVISION OF UNITED AIRCRAFT CORPORATION

During 1967, Norden division of United Aircraft Corporation stepped up its production of advanced airborne radar and cockpit display systems, broadened its components business, and expanded its electronic activity into the communications field.

First delivery of a Norden multi-mode radar system was made to Lockheed-Georgia Company for the Air Force C-5A jet transport, the world's largest aircraft. Flight-testing of the radar system began in anticipation of the first flight of the C-5A in 1968. The system provides high-resolution ground mapping, automatic low-level terrain following, terrain avoidance, weather warning and beacon operation. It will help the Air Force to deliver the heaviest Army equipment direct from the United States to locations anywhere in the world and land on relatively unprepared airfields. The C-5A will become operational in 1969.

The division also shipped to Teledyne Systems Corporation the first terrain-following radar for Teledyne's integrated helicopter avionics system (IHAS), which will provide the Marine Corps CH-53A helicopter with low-level capability, night or day in adverse weather. The IHAS radar, like other Norden radars, employs the phase interferometer technique, which provides the high data rate necessary to accomplish simultaneous mapping, navigation, automatic terrain following and terrain avoidance modes. Flight testing was conducted during 1967 and the IHAS system was scheduled to become operational in 1968.

Late in the year, Norden delivered to the Lockheed-California Company the first radar system for the AAFSS (advanced aerial fire support system), for the Army's AH-56A armed helicopter, the Cheyenne. The Norden radar will give all-weather, low-level capability to the Cheyenne.

Production continued on search and track radar systems for the Grumman A-6A Intruder, which saw increasing service in Vietnam with carrier-based Navy squadrons and land-based Marine squadrons. Using Norden radar, the aircraft's 2-man crew can seek out targets obscured by night or weather conditions. Targets and geographical features can be "seen" by means of cockpit viewing screens which provide a visual representation of the ground and air below and in front of the aircraft. Accompanying Norden computer equipment provides the crew with continuous flight data. Norden was also producing ground test equipment to support these radar systems.

In the video field, Norden delivered to Teledyne the first cockpit display system for IHAS. The viewing screen presents in both analog and digital format all critical flight information—course, heading, altitude and speed—and, as well, a representation of the terrain in the path of the helicopter. Similar equipment will be installed in the Cheyenne. Development continued on the integrated cockpit displays for the Mark II avionics system for the General Dynamics F-111D tactical fighter. The F-111 will be equipped with a vertical situation display, multi-sensor display, and a head-up, or see-through display. The F-111, with Mark II improvements, will be able to penetrate more safely, and find and destroy targets more easily.

Norden during 1967 set up a separate facility in Bridgeport, Connecticut, to produce its electronic and electro-mechanical components. The division won contracts from The Boeing Company to provide pressure ratio transmitters and N_1 tachometer transmitters for the Pratt and Whitney Aircraft JT9-D engines that will power the Boeing 747 transport. Production of analog-to-digital converters for aerospace and industrial application increased during the year.

Norden added telecommunications to its capabilities late in the year when it took over the telemetry operations of the former Vector division of United Aircraft in Trevose, Pennsylvania. The new Norden Communications Products Department was furnished with in-house resources for the development, production, integration and support of systems operating over the VHF, UHF and microwave spectrum. The Norden equipment was selected for such important programs as Gemini, Apollo, Saturn and Shrike.

UNITED TECHNOLOGY CENTER
DIVISION OF UNITED AIRCRAFT CORPORATION

Reliable performance of hardware produced by United Technology Center for use in the nation's space programs and advances by the division in the research and development of new processes, materials, propellants and rocket propulsion systems took place during 1967.

In January, April and July, the Air Force Titan III-C was boosted from its launch pad at Cape Kennedy by UTC's 120-inch solid propellant rockets working in tandem with a combined thrust of close to 2,500,000 pounds. During these 3 flights alone, the versatile space launch vehicle placed 19 satellites into orbit while carrying out some of the most intricate space maneuvers yet attempted. Since the maiden flight of the Titan III-C on June 18, 1965, the multimillion pound thrust booster stage of the vehicle performed perfectly in 9 straight launches.

UTC's high-performance FW-4 upper stage solid rocket has performed just as well. Of the 20 flown aboard Scout, Delta and Thor space launch vehicles, 19 have performed reliably, and in 1967, FW-4s placed 3 communications satellites on station, as well as an Italian San Marco scientific satellite, launched from a site in the Indian Ocean off the east coast of Africa. An additional 25 of these versatile solid rockets have been earmarked for a variety of space missions.

Still in a solid vein, smaller and less powerful UTC rockets performed a variety of tasks as retrorockets for both the Titan II ICBM and the Titan III-C. Sixteen of these rockets are used during each Titan III-C launch to separate the booster stage from the core vehicle when the 86-foot tall stage-O rockets reach burnout.

Hybrid rocketry, so-called because both solid and liquid propellant rocket technology are applied in this type of propulsion, made significant strides during the year.

UTC successfully developed and flight-tested the nation's first hybrid rocket propulsion system destined for operational use as the power plant for the Air Force Sandpiper advanced target missile. In addition, the division fabricated and successfully ground-tested a 38-inch diameter, 40,000-pound-thrust hybrid rocket for the Air Force at its Coyote, California, Development Center. This was the largest rocket of its kind ever fired, and it confirmed that the performance of booster size hybrids can be accurately predetermined. This was a major objective of the program.

Another important and highly successful research firing by UTC involved the static test of a solid propellant motor capable of meeting the stringent demands for an advanced surface-to-air missile. The test, carried out mid-year at the Naval Ordnance Test Station, China Lake, California, was flawless, and instrumentation confirmed that a special propellant additive developed by UTC substantially reduced radar interference by the rocket's exhaust plume without affecting motor performance.

During 1967, UTC gave a good deal of attention to the development of more efficient and economical methods of fabricating the large steel rocket cases used in its 120-inch rocket motor program. Working under contract to the Air Force, UTC achieved several milestones.

One, accomplished in conjunction with NTW Missile Engineering of Los Angeles, California, was reached in March, when a 120-inch rocket segment case was successfully fabricated by the internal roll extrusion process. The result was a case of 42 Rc hardness, with a controlled wall variation of .007 inch and an as-extruded finish of 2–3 rms overall.

Another, reached with the cooperation of the J. W. Rex Company of Lansdale, Pennsylvania, was the shear spinning of a 120-inch rocket case. The shear spinning process involves extrusion of a one-piece cylindrical preform over a full-length mandrel by a pair of diametrically opposed rollers. The technique affords reduced production time as well as a more reliable and economical product.

UTC researchers were also responsible for two other important advances in 1967, one in the materials area, the other in propellants.

In October, it was revealed that a new composite material had been developed which could withstand the extremely hot exhaust gases of advanced rockets. Called wire-wound, plasma-spray-bonded tungsten, it was used in rocket nozzles and withstood temperatures well above tungsten's normal melting point of 6,170 degrees for over 60 seconds. Developed under a contract from the Air Force Rocket Propulsion Laboratory, the new material is believed to have many other possible applications, such as high-temperature furnaces and hot gas generators, X-ray and linear accelerator targets, leading edges of supersonic aircraft control surfaces, and heat shields for space reentry vehicles.

For some years, scientists planning space missions to other planets were faced with a problem: how to insure that no living organisms from earth would inadvertently contaminate a foreign body when a space vehicle landed on it. In subjecting space vehicles and their numerous components to heat sterilization processes, it was found that the high temperatures involved were detrimental to rocket propellant performance.

UTC announced during 1967 that it had produced a solid rocket propellant that could successfully withstand the rigors of dry heat sterilization. In fact, the new propellant was able to more than stand the heat sterilization requirements set by Jet Propulsion Laboratory, which demand 6 53-hour cycles at 275 degrees Fahrenheit.

By way of diversification, UTC continued to produce Techite pipe at its pilot plant in Sunnyvale, California, and to install it in test projects throughout the state. Techite, a plastic mortar pipe designed for use in fluid conveyance systems, was developed from knowledge gained in research and development of glass fiber rocket motor cases.

ELECTRONIC COMPONENTS DIVISION OF UNITED AIRCRAFT CORPORATION

During 1967, United Aircraft formed the Electronic Components division at Trevose, Pennsylvania. With this consolidation of United Aircraft's microelectronics capabilities, the Vector division was discontinued.

The new Electronic Components division became the microelectronic center of the corporation, producing semiconductor devices, hybrid circuit components, and integrated circuits for use in communications applications. The transistor devices were being supplied for special high power/high frequency communications, guidance and control, high-reliability satellites, and telemetry systems. Special environmental capability includes radiation hardening for operation in environments to 10^{14}nvt.

Hybrid circuit components for similar applications included microminiature voltage controlled oscillators, low-level differential amplifiers, video amplifiers, digital interface circuits, and functional blocks. Electronic Components division expanded its integrated circuit capability to include high frequency/high power switching devices, dielectrically isolated master dice, BiFET Gates, MOS Multiplexers and large-scale integrated circuits.

WESTINGHOUSE ELECTRIC CORPORATION

AEROSPACE DIVISION

One of the major developments of the year at the Aerospace Division was a computer-designed radar antenna that greatly reduces the amount of "clutter" entering a radar receiver. The work was carried out under a contract from the Air Force Systems Engineering Group, Wright-Patterson AFB, Ohio.

Most of the unwanted clutter entering a radar receiver is the result of reflected side-lobe radiation. Side lobes are portions of an antenna's radiation outside the main beam and usually of much smaller intensity. When reflected from the ground or objects other than the target, however, they may have as much energy as signals reflected from the target.

Clutter is especially bothersome when airborne radar is used to look for penetrating aircraft. Such aircraft would fly at low altitudes, and radar signals reflected from them might be lost in side-lobe signals reflected from the ground.

The new antenna is a 2-dimensional, wave-guide slot array unit.

In another development, airborne mapping radars were used to supply data to NASA's earth science resources program. The mapping, or side-look radar can cover large areas in a single pass in almost any kind of weather both day and night.

By varying the radar signal characteristics and the processing methods, these airborne radar systems can be used for large-scale topographic mapping, agronomy investigations and making profile studies of geological formations. Other possible applications include sea ice mapping, sea state determination, polar ice cap profiling, subsurface profiling, and soil moisture content analysis. All these phenomena can be studied using high-quality radar imaging techniques.

In another project carried out for NASA, Aerospace Division engineers designed and built the second in a family of solid-state image converters. The new converter is part of a long-range program to develop a solid-state television camera with imaging characteristics equivalent to those of a conventional vidicon camera.

The heart of the system is a monolithic 100 by 128 element array of phototransistors fabricated on a ½-inch-by-½-inch silicon substrate. The 12,800 phototransistors of the mosaic can "see" 6 shades of gray with a resolution of 100 lines at speeds up to 60 frames per second. The solid-state system is inherently smaller, lighter and more rugged, uses less power and is more compatible with integrated circuitry than its vidicon counterpart.

A NASA-Aerospace Division product was sent to the moon in 1967. The Anchored Interplanetary Monitoring Platform (AIMP) was launched on July 19 to orbit the moon. The AIMP satellite was measuring the characteristics of interplanetary space including dust particle distribution, solar and galactic cosmic rays, and the magnetohydrodynamic wake of the earth in the interplanetary medium.

SURFACE DIVISION

The first site in the 487L low-frequency survivable-communications system was turned over to the Air Force in April 1967. The communications equipment for the system was being built for the U.S. Air Force by the Surface Division of the Westinghouse Defense and Space Center.

A large number of receivers were to be dispersed throughout North America, but only a few transmitter sites will be needed because of the effectiveness of very low frequency (VLF) for long-range communications. Airborne equipment will also be used to augment the ground equipment.

The first transmitter, located at the Hawes site near Barstow, California, can transmit several kilowatts of power from its antenna tower, which is over 1,000 feet tall.

The transmitter site consists of 3 major elements: the control-receiver subsystem, the transmitter subsystem, and the antenna subsystem. The control-receiver subsystem includes the necessary system controls and 7 receivers and high-frequency and ultrahigh-frequency communications equipment associated with the VLF system. The VLF transmitter subsystem consists of the transmitter and the associated connecting equipment. The antenna includes a coupling network to accept the high power from the transmitter.

This is the first transmitter of such high power in which all the components are solid state. The total output power is generated by 22 identical amplifiers. With this modular approach, the number of spare modules that need to be stocked is substantially reduced. As solid-state devices are very efficient converters of regular AC power into RF energy, the transmitter's conversion efficiency is in excess of 80 percent.

To insure meeting the transmitter reliability requirements, 2 extra modules are built into the transmitter. In the event of a failure in any one of the 22 modules, that module and another that constitute a pair are automatically cut out of the circuit; the transmitter will continue to operate at a full power output. The failed unit can then be removed, repaired and put back in the transmitter.

In another development, Westinghouse splash detection radars, supplied by the Surface Division, were installed on Kwajalein Atoll in the Pacific Ocean. The atoll, located more than 4,000 miles southwest of the United States, is near the end of the Western Test Range and is being used by the U.S. Army to test its Nike-X antimissile system. The splash detection radars can detect and locate a landing missile with sufficient accuracy to assure positive scoring and rapid recovery.

UNDERSEAS DIVISION

Highlighting Underseas Division news of 1967 was the September 26 dedication of the new Ocean Research and Engineering Center, one of the most modern oceanographic and ocean engineering facilities in the country. The center is located on the shore of the Chesapeake Bay, 7 miles east of Annapolis, Maryland.

Marine operations, deep submergence and oceanic resources are the 3 main groups in the center's organization. Some of the work these groups were engaged in included a study contract in the Navy's deep submergence search vehicle program, the Deepstar manned submersible program, diver life-support systems, search and measurement acoustic systems, and underwater optical systems. Scientists and engineers engaged in the Center's work utilized engineering, materials, life support, transducer and optics laboratories, and a digital-analog hybrid computer facility.

One of the key laboratories at the center is its "man-rated" pressure facility. The heart of this facility is 3 pressure chambers which are capable of being pressurized independent of each other. The entry chamber is a sphere about 6 feet in diameter. It will be connected by a pressure-tight hatch to a second chamber which is about 9 feet in diameter and 11 feet long. Divers and researchers can live for days or weeks at a time in this chamber, a necessary characteristic for saturation diving work. A third chamber, a sphere about 9 feet in diameter, is positioned below and toward the end of the second chamber. This chamber is also connected to the second by a pressure-tight hatch. This last chamber can be partly filled with water to provide realistic conditions for testing equipment and techniques.

One of the first research programs being carried out in the new pressure facility consisted of experiments in saturation, or prolonged submergence, diving to depths of 1,000 feet. These experiments were to be used as the basis for diving tables and techniques used with the division's Cachalot-850 saturation diving system. This is a 2-chamber system in which crews of 4 to 6 divers are kept under working-depth pressure for periods ranging from a few days to 2 weeks in a pressure chamber on the surface. This chamber, usually mounted on a barge, has facilities to permit the divers to live, sleep and eat between their shifts in the water.

The other chamber of the system is the submersible or diving chamber. Pairs of divers are transported from the surface chamber to the work site in this chamber. The pressure in it is the same as that in the surface chamber and the same as the pressure of the water at the working depth.

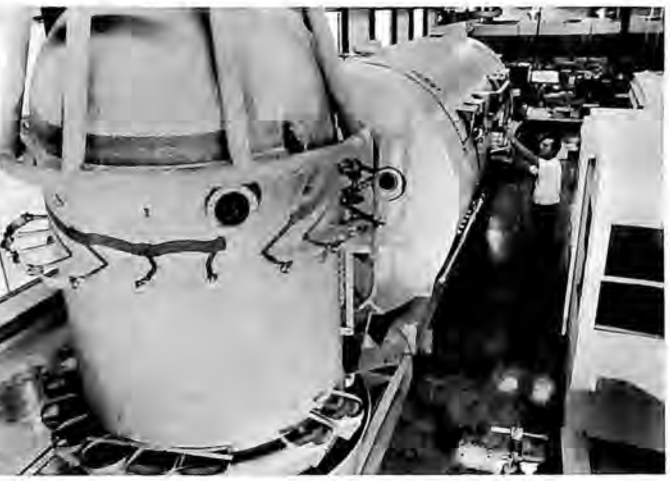
When a 2-diver team goes to work, the men go through a pressurized transfer lock in the end of the surface chamber which has been mated to a similar lock in the side of the diving chamber. They close the lock hatches, and the support crew separates the diving chamber from the surface chamber. The diving chamber, which is 10 feet in height and 5 feet in diameter, is lifted from its pad, swung out over the water and lowered in the water to the work site by a crane. While the chamber is being lowered, the divers put on their special diving suits and breathing apparatus. The diving suit, developed by Westinghouse, is called the Diurene wet suit and has internal tubes through which warm water is circulated, keeping the diver warm. The breathing apparatus consists of a breathing vest, 2 canisters of carbon dioxide absorbent, and a face mask with an internal oral-nasal mask.

A special breathing mixture is necessary in deep diving for two reasons. Nitrogen in air gives divers under pressure nitrogen narcosis, the "rapture of the deep," and must be replaced by another inert gas. A special mixture is needed also because oxygen under pressure becomes compressed and higher in density;

too high a concentration of oxygen is toxic to humans. Helium, although costly, is the most common inert gas and is, therefore, used most widely in deep diving.

When the diving chamber reaches the working depth, the hatch in its bottom is opened by the divers who go out through it and connect the long hoses that supply their breathing mixture. Attached to the gas hoses are a telephone line by which the divers can talk to and hear the surface support crew, electric power line for lights, an instrumentation cable, and the warm water hose for their Diurene suit. After working their shift, the divers are brought back to the surface in the diving chamber which is remated to the surface chamber. Another team takes their place and descends to work.

Prolonged submergence diving is economically advantageous at depths beyond about 150 feet. A diver using conventional decompression diving spends most of his useful time in decompression and relatively little (30 minutes to an hour) at work. Using prolonged submergence techniques with the Cachalot-850's predecessor, the Cachalot-450, the Underseas Division has been able to keep divers working for periods up to 6 hours at a time. Six divers also demonstrated for the first time in mid-June of 1967 that man can work effectively in the open sea at depths to 600 feet. Operating in teams of 2, they made the dives in the Gulf of Mexico off the Louisiana coast working on underwater oil well equipment that had been placed on the bottom for the demonstration. With Cachalot-850, engineers expected to achieve working depths of 850 feet by early 1968 and 1,000 feet within a year if needed.



The Cachalot-850 prolonged submergence or saturation diving system is outfitted at Westinghouse Underseas Division's Ocean Research and Engineering Center for dives to depths of 1,000 feet.

Other activities during the year found the Underseas Division becoming involved in a study program to develop a preliminary prototype design for the U.S. Navy's Deep Submergence Search Vehicle (DSSV). This is the first of a sophisticated, maneuverable class of vehicles capable of descending to depths of 20,000 feet to perform search and recovery operations.

Construction was undertaken in 1967 of DS-2000, the second in the division's family of Deepstar manned submersibles, which will be used as a working tool for scientific underwater operations at depths to 2,000 feet. The pressure hull of the DS-2000 is cylindrical to provide more internal volume per unit strength than is found in the spherical shape of most smaller deep-diving vehicles. It is 10 feet long and 5 feet in diameter and is composed of 2 hemispherical heads and a cylindrical mid-section. For maximum safety, the hull is pressure-resistant and positive-buoyant, thus not requiring power to return to the surface. The DS-2000 also has a system for accurately controlling altitude, velocity and depth.

In June 1967, Westinghouse purchased the assets of the 7 Sanford Brothers corporations which specialize in conventional diving services and in salvage, construction and maintenance for the petroleum industry. The companies were being operated as a wholly owned Westinghouse subsidiary under the name of Sanford Marine Services, Inc., and were being directed by the Underseas Division.

An underwater station where men could live and work for a month at a time beneath the sea was conceived in 1967 by the division as part of a study for the U.S. Naval Engineering Laboratory at Port Hueneme, California. This station would house a 5-man crew and be linked to a guide cable anchored to the ocean's floor. Several of these doughnut-shaped stations could be stacked to accommodate an undersea community of scientists. The living space in the underwater station would include all life support equipment, with emphasis on the safety, comfort and recreational features for the crew. All equipment, lighting and utilities will probably be powered by a nuclear isotope power source.

During the year the Underseas Division also undertook a study for the National Science Foundation in Washington, D.C., of an Arctic research drift vessel which would enable scientists to conduct longer and better research expeditions in the future. Design specifications call for quarters to house 45 men and space for several years' food supply in addition to several laboratories, medical and recreational facilities, an electronic equipment repair and machine shop, a hangar for snow-removing equipment and aircraft, and a small nuclear reactor for internal power.

ASTRONUCLEAR LABORATORY

The first laboratory model of an electron-beam welder capable of joining metals together under space conditions was designed and constructed in 1967 by engineers at the Westinghouse Astronuclear Laboratory for the National Aeronautics and Space Administration's Marshall Space Flight Center in Huntsville, Alabama. This model was not intended for flight but was a prototype which incorporated the basic structure and performance considered essential for space application.

Electron-beam welding is among the newest techniques for metal joining and is the most desirable method in many ways. The welding is so rapid that the heat in the weld has no chance to spread to the surrounding metal to make it brittle and susceptible to cracking. The process also produces exceptionally deep, strong, uniform welds and it can be applied to a variety of metals and alloys.

A unique feature of the new Westinghouse welder is that it is completely self-contained. Using a 500 watt-hour battery of silver-zinc cells, the welder produces a 20,000-volt, 100-milliampere, tightly focused electron beam for more than 5 minutes. Separate silver-zinc cells are used to heat the tungsten filament that generates the beam. Both battery packs, the welder's high-voltage generator and its control circuitry are housed in a sealed vessel which is pressurized with inert sulfur hexafluoride gas. The electron gun which produces the beam used in welding is an integral part of the pressure vessel, although the gun itself operates in a pressure of less than one-millionth of an atmosphere. In the laboratory, the gun and the material to be welded are located inside a vacuum chamber to simulate space conditions. An advanced version of this unit for use by NASA in an in-orbit welding experiment was being built.

A new program started at the laboratory was a power-producing unit which can operate for a decade in the frozen, inaccessible reaches of the Arctic, producing electricity from self-generated heat. The unit is called a radioisotopic generator. It will use a radioisotope-strontium 90 to produce heat and convert it directly into electricity by means of a thermoelectric converter to be developed by Minnesota Mining & Manufacturing. The U.S. Atomic Energy Commission selected the Astronuclear Laboratory for negotiation of a contract to develop the radioisotope power system called SNAP-23A. The contract called for development and testing of 7 prototype models.

Scientists at Astronuclear also began work during the year on a miniature atomic-powered steam engine that one day may provide the pumping power for an artificial human heart. A radioactive isotope would provide heat to turn distilled water into steam to operate a tiny 4-cylinder engine. The engine in turn would operate a 3-cylinder hydraulic pump to supply power to the blood pump for the circulatory system. The power source unit, weighing about 7 pounds, would be implanted in the user's abdominal cavity and probably be anchored to the pelvis. Tubes will connect the unit to the artificial heart itself.

The year also found the Astronuclear Laboratory, in conjunction with the company's Research Laboratories, developing a solid-state ultraviolet light detector to detect fires and incipient explosions. This work was done under a contract to the Air Force Aero Propulsion Laboratory at Wright-Patterson Air Force Base, Ohio. Within microseconds after detection, the device produces a photovoltage which can be used to operate a system that extinguishes the fire or explosion. The device is fabricated from a single crystal of silicon carbide and is operable to 500 degrees Centigrade. It is nearly blind to polar ultraviolet radiation and cannot be triggered by sunlight. The detector is unique in its sensitive response to ultraviolet and its ability to operate at high temperatures.

Consulting services to aid small businesses in becoming established in the aerospace and defense industry became available in 1967 from the laboratory. These services included proposal preparation, contract negotiation and administration, manufacturing engineering, purchasing and subcontracting, planning and scheduling, quality control and reliability.

AEROSPACE ELECTRICAL DIVISION

During 1967, the Aerospace Electrical Division made available a new tester that enables faster, more accurate testing for faults in windings of motors, generators and many types of transformers and electromagnetic coils. The surge comparison tester is for use in manufacturing maintenance and repair of rotating electrical equipment. It indicates the presence of faults (shorts, grounds, or dissimilarity in number of turns) by comparing the impedance in two identical windings. Its sensitivity is such that it will show a single difference in a number of turns, or a short between turns even in large windings with hundreds of turns.

The tester delivers a low-energy, high-voltage transient to the test winding, alternating the direction of the voltage 60 times per second. Each cycle is shown on a cathode ray tube. Only one trace appears on the tube if no fault is present while 2 different wave forms appear if some fault causes the impedance between 2 windings to be different. Parts under test are protected from unwanted transients by protective circuitry.

In another 1967 development, the Aerospace Electrical Division made available a compact gun actuator motor for use under extreme environmental conditions and very high shock loads. These motors operate from a 28-volt direct current power supply for both airborne and ground-based applications and are designed to resist rain, salt spray and fungus. They can operate in temperatures from minus 65 degrees to 160 degrees Fahrenheit at altitudes from 0 to 50,000 feet. One motor configuration was successfully tested by the U.S. Army on a gun with recoil shock loads estimated in excess of 100 g's. Some of the new motors were in service on the M-5 helicopter grenade launcher used on the armed UH-1B Iroquois and the armored CH-47 Chinook helicopters.

MARINE DIVISION

The major event of the year at the Marine Division was the receipt of a $51,700,000 contract to develop a launching and handling system for Poseidon, the U.S. Navy's large and powerful fleet ballistic missile. Since original work began in 1956, the Sunnyvale, California, plant has been the prime contractor for launching and handling the Polaris fleet ballistic missile. Since then, launchers for all 41 Polaris-equipped U.S. nuclear submarines, each carrying 16 Polaris missiles, have been produced at the plant.

The new contract released initial funds for design, development and manufacture of Poseidon launchers on a pilot production basis. Advanced systems planning will make it possible to change over the launching facilities of most existing Polaris submarines to Poseidon with relative ease and the capacity of the steam eject system for Polaris missiles can be increased to launch the Poseidon missile.

The development contract is step 2 in a 3-phase program leading ultimately to equipping the United States' underwater nuclear fleet with the Poseidon missile deterrent weapon twice as accurate as the Polaris and carrying double the payload. The first was termed the project definition phase. The third phase will be the actual production contract.

"Operation Skycatch" was a launcher test performed in 1967 at the San Francisco Bay Naval Shipyard in which a dummy of the Poseidon missile was launched as it would be from a submarine except that a giant crane overhead caught it in midair. A series of test launchings showed that the Westinghouse shipyard facility in San Francisco was ready to proceed with the intensive testing needed to develop Poseidon launchers.

RESEARCH LABORATORIES

In May 1967, a Westinghouse research scientist disclosed the development of an automated system for measuring the electrical resistance on a microscopic scale of the "junctions" of semiconductor devices, where 2 electrically opposite semiconductor materials merge into one another. With this new system the whole job is done automatically and more precisely, with 1,000 times greater resolution and at least 10 times faster. The new technique is so exacting that it makes its measurements on only a billionth of a cubic inch of material. At the same time, the system plots the measured data continuously on a gragh and punches out a paper tape that feeds the information into a computer for calculation. When done conventionally by hand, these measurements require at least a minute each, but the new system cuts this time to 6 seconds.

The resistance measurements are made by lowering a precision probe into contact with the semiconductor surface and applying to the probe a voltage of about 5 millivolts. The resistance reads out directly on a meter. The contact is flat and circular (about 3/10,000th of an inch in diameter) and presses against the semi-conductor surface with a pressure of 1,500,000 pounds per square inch. This pressure is applied through a combination air-mechanical system to minimize probe and surface damage.

Once a measurement is made, the probe lifts and the sample automatically steps a few thousandths of an inch to the next reading location, where another resistance value is taken. The stepping action is accurate to within 1/10,000th of an inch.

Work supported by the metallurgy section of the Naval Air Systems Command brought about the use of high-frequency sound waves by Westinghouse research scientists to make metal rolling an easier task. Using ultrasonic vibrations, the atomic arrangement of the metal is rearranged 20,000 times a second during the rolling process. High-frequency vibrations are introduced into the metal by placing an ultrasonic transducer inside the rolls of an 8-inch by 8-inch, 2-high, laboratory-type rolling mill. The purpose of the transducer is to convert electrical energy into mechanical motion of high frequency. Several theories were being tested regarding the ultrasonic vibration of a metal during rolling including such ideas as: (1) less work or energy is required to deform the metal, (2) a metal's rolling temperature can be lowered, and (3) thinner gauges can be rolled.

In 1967, Westinghouse research engineers also began tackling the problem of air pollution from furnace smokestacks with a unique, high-temperature-type fuel cell. This cell offers promise for monitoring the furnace fire by sniffing out the amount of unused oxygen that escapes up the stack. The job of the fuel cell is to keep the oxygen content at the correct level for the hottest, cleanest fire possible. Normally, the cell generates electric power when oxygen and a gaseous fuel, such as hydrogen, are fed into it. When operated without this supply of fuel, the cell becomes one of the fastest and most sensitive oxygen detectors known.

In this system, a sample of the flue gases in the furnace stack is fed continuously to the detector. The sensing fuel cell responds only to the free oxygen present in the gas mixture, giving an electrical signal that indicates any amount of excess or deficiency in oxygen level. This information is fed to an electrical control system that automatically adjusts the feed rate of air and/or fuel entering the furnace until the specified oxygen content of the flue gases is maintained. The system can be made to provide continuous monitoring of the combustion process while responding rapidly to departures from optimum conditions.

Another development of 1967 at Research was the discovery of ultrahigh speed phosphors that light up and dim in less than one ten-billionth of a second. Phosphors are materials that glow when exposed to radiation or other forms of energy as a TV does when cathode rays strike a phosphor coating on the inside. The new phosphors are faster than any known previously.

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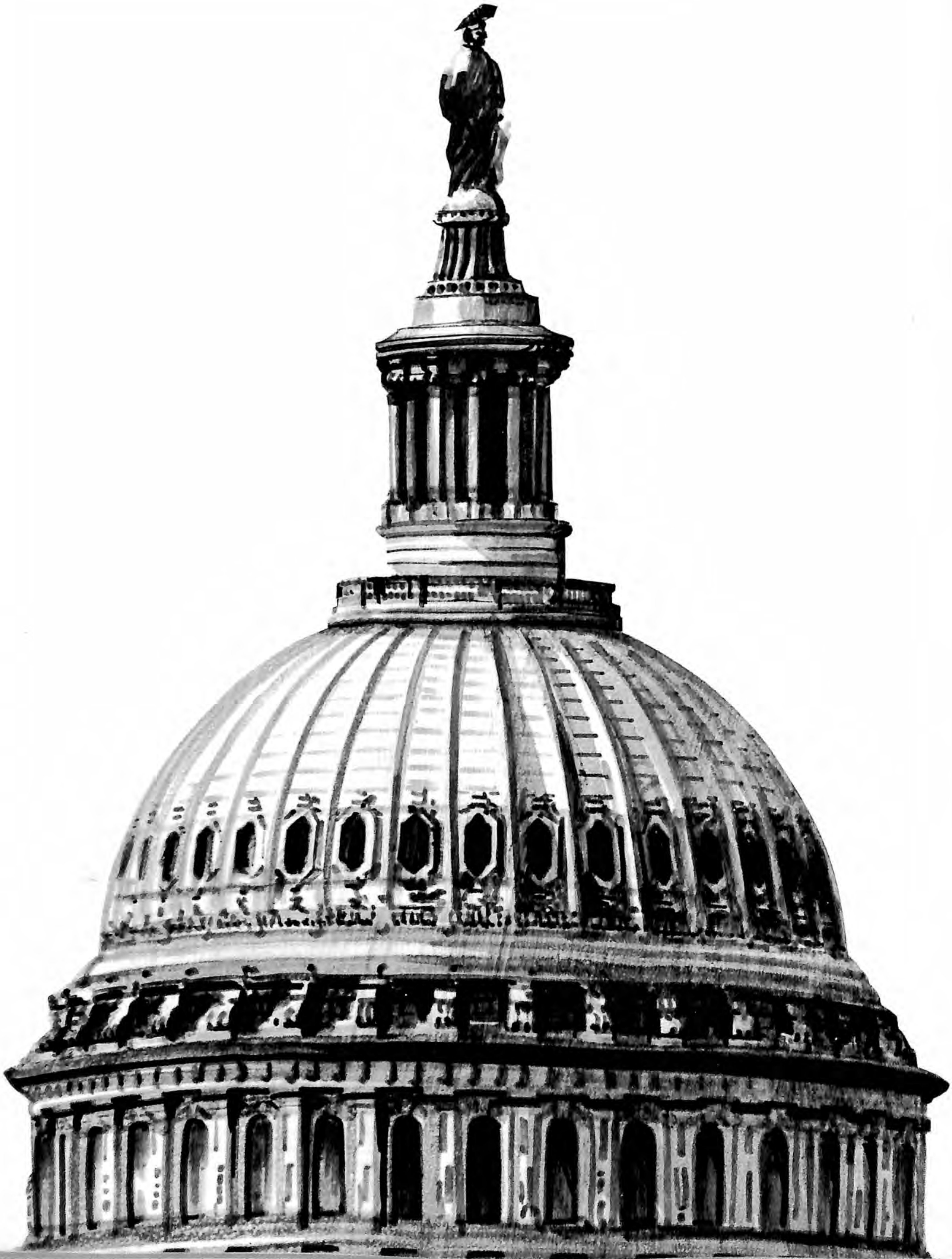


During the fiscal year 1968, ending June 30, 1968, government funding for all types of research and development work was expected to run to about $16 billion, roughly the same as the previous year, exclusive of Vietnam support R&D. By far the major portion of the funds was to be allocated to aerospace programs, although a direct dollar breakdown is not possible because some agencies were involved in both aerospace and non-aerospace research and development and the budget lists only totals without regard to type of program. The enormous range of government research and development projects precludes even a catalog listing herein, but this section contains the highlights of 1967 in those agencies primarily concerned with aerospace research and development. Additional detail on unclassified projects is contained in the individual company résumés in the Aerospace Industry section and in the Reference Section.

GOVERNMENT RESEARCH AND DEVELOPMENT

ATOMIC ENERGY COMMISSION

The year 1967 was a year of progress (more nuclear power plants were being built and ordered than ever before); a year of predictions (scientists and statesmen were looking to a future made richer by the hundreds of peaceful applications of nuclear energy); and a year for looking back to the beginnings. It marked man's 25th year of partnership with the atom.

On December 2, 1967, President Johnson, AEC Chairman Glenn T. Seaborg and Italian President Saragat participated in an international program via communications satellite commemorating the first sustained controlled nuclear chain reaction. It had taken place, exactly 25 years before, in secret, beneath the stands of the University of Chicago's football stadium. To honor the occasion, the University was host to a 2-day symposium of more than 250 scientific leaders; it placed an especially commissioned sculpture by Henry Moore on the site of the experiment. President Johnson's remarks included an offer to open all U.S. nuclear facilities, excluding only those with direct national security significance, to international inspection as part of a non-proliferation treaty.

The surge of new private nuclear power plant announcements continued unabated in 1967. The continuing trend by electric utilities towards "going nuclear" resulted in another forecast by the AEC of generating capacity.

The AEC in 1967 anticipated that nuclear power plants would have a generating capacity of between 120,000 and 170,000 net electrical megawatts by the end of 1980, representing about 36 percent of the total national output. The forecast is a revision of one prepared by the AEC in 1966, which estimated an installed capacity at the end of 1980 of between 80,000 and 110,000 megawatts, representing about 25 percent of the national output.

As of November 1, electric utilities had made known plans for 30 nuclear power plants. Utility organizations ordered 28 reactors (21 for plants announced in 1967 and 7 for plants previously announced) with a total capacity of about 23,110,000 kilowatts.

The utility nuclear activity was greater than the pace set in 1966 when 28 plants with a capacity of about 23,000,000 kilowatts were announced. Twenty-one reactors were ordered in 1966.

As of November 1, 1967, there were 16 operable nuclear power plants; 17 being built; 42 planned for which reactors had been ordered, and 12 additional plants in planning status.

The AEC in 1967 issued a supplement to a 1962 report to the President on the status of U.S. civilian nuclear power. The supplement covered the changes that occurred in the intervening years and considered the 1967 AEC program in relation to the recommendations of the earlier report.

The 1962 report recommended early construction of plants of the most competitive reactor types; development, construction and demonstration of advanced converter reactors to improve the economics and the use of nuclear fuels; and intensive development and later demonstration of breeder reactors to fill the long-range needs of using fertile as well as fissionable fuels.

The report suggested 3 phases of application for nuclear power, with related development effort. It was expected in 1962 that light water reactors (phase 1) would soon become economical in high power cost areas and in accordance with industry response to that prospect, the Commission's research and development programs on light water reactors have been limited in scope and size. Several advanced converters (phase 2) were being developed, in accordance with the 1962 report recommendations, to provide better use of nuclear resources pending full development of breeders. Intensive development of the high gain breeder (phase 3) over the long term was undertaken as recommended by the 1962 report.

Work continued during the year on the No. 1 priority program: the development of safe, reliable, economic liquid metal-cooled, fast breeder nuclear power reactors.

The AEC selected Richland, Washington, as the site for its Fast Flux Test Facility, the major fuels and materials test irradiation facility in the fast breeder reactor development program.

In another action related to the fast breeder program, the Atomic Energy Commission executed a contract with the Atomics International division of North American Rockwell Corporation for operation of a newly established Liquid Metal Engineering Center in the Santa Susana Mountains near Los Angeles, California.

Three nuclear power plants started up and a fourth operated at full power, all for the first time, during the year.

The 50 megawatt LaCrosse (Wisconsin) Boiling Water Reactor, owned by the AEC and operated for it by the Dairyland Power Cooperative, operated for the first time in July. The other 2 reactors were those in the Connecticut Yankee Atomic Power plant of the Connecticut Yankee Atomic Power Company at Haddam Neck, Connecticut, (462 megawatts) and in the San Onofre Nuclear Generating Station of the Southern California Edison and San Diego Gas and Electric Companies at San Clemente, California (430 megawatts).

The 40 megawatt Peach Bottom (Pennsylvania) Atomic Power Station operated for the first time at full power in May. The station, owned and operated by the Philadelphia Electric Company is a forerunner for commercial high temperature gas-cooled reactors.

A contract between the government and the Metropolitan Water District of Southern California for a dual-purpose nuclear power and desalting project in California was transmitted to the Congress for approval. The $444,000,000 project, to be located on a 43-acre man-made island offshore of Bolsa Chica State Park in Huntington Beach, will include 2 nuclear reactor steam supply systems capable of producing 1,800 megawatts of electricity and a system for desalting water at the rate of 150,000,000 gallons per day.

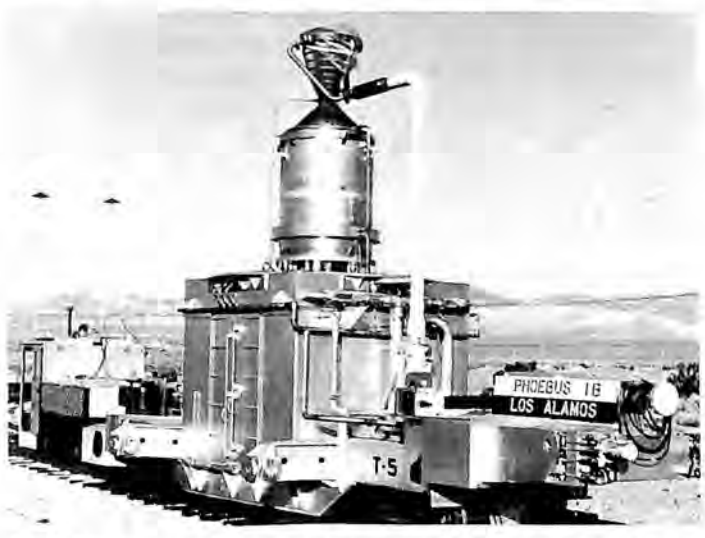
Participants in the project, designated Bolsa Island Nuclear Power and Desalting Plant, besides the Metropolitan Water District, are the Department of the Interior, Atomic Energy Commission, the City of Los Angeles Department of Water and Power, the Southern California Edison Company and the San Diego Gas and Electric Company.

In another development, the AEC received from the 3 utilities applications for permits to construct the 2 nuclear reactors for the dual-purpose plant. The applications will be reviewed by the AEC Regulatory Staff and the AEC's Advisory Committee on Reactor Safeguards.

During the first 3 quarters of 1967, electric utilities had applied to the AEC for licenses to construct 21 nuclear power reactors to be scattered throughout the nation.

During 1967 2 states—Louisiana and Arizona—were granted authority to govern the uses of radioactive materials within their borders. The number of states sharing this authority with the AEC was 17 at year-end.

The Space Nuclear Propulsion Office at Jackass Flats, Nevada—operated by the AEC and NASA—continued testing reactors for nuclear-powered rockets. In February, a Phoebus 1B reactor was operated at the design power of 1,500 megawatts for 30 minutes, the



In February, a Phoebus 1B reactor was operated at design power of 1,500 megawatts for 30 minutes as part of the AEC/NASA Rover program for the development of nuclear-powered space rockets.

maximum time planned. In July, the more powerful Phoebus 2 successfully underwent a "cold flow" test series; that is, a thorough test of the equipment without nuclear fuel in the reactor. These tests were part of the Rover program to develop nuclear-powered rockets for deep space flights.

The first nuclear power generator in space marked its sixth anniversary in June. At that time, the generator had operated one year beyond its 5-year design life. The historic generator, developed by the Atomic Energy Commission, had traveled by year-end about 944,286,000 miles (over 32,600 times around the earth) and it continued to provide power aboard the Navy's experimental navigational satellite 4-A. The grapefruit-sized, 5-pound, 3-watt nuclear generator was installed to supplement solar power on the 175-pound drum-shaped satellite which at year-end was still signaling intermittently to tracking stations around the world.

Looking ahead to future use of nuclear generators, plans were proceeding for the launch of a weather satellite with SNAP generators. The Nimbus B weather satellite, scheduled for launch by the National Aeronautics and Space Administration in 1968, was to have 2 SNAP generators. Each provides about 30 watts of electrical power to the experiments on board. Solar cells provide another 200 watts.

The Atomic Energy Commission was testing the first model of a cardiac pacemaker designed to be powered eventually by nuclear energy. The device, an electrical pulse generator, was being developed for the medical treatment of "heart block," a relatively common cardiac disease that causes interruption of the normal stimulus to the heart.

The model was electrically powered and was being tested to evaluate the design and to gain information to improve fabrication and assembly methods. Test results indicated that the basic design was satisfactory. The test was to be followed by tests early in 1968 of several nuclear-powered devices and then by extensive testing with animals before the pacemaker is considered suitable for human use, possibly in the early 1970s.

Four firms were selected by AEC to conduct design studies of a radioisotope engine to power pumps which would assist or replace functions of a diseased or damaged heart.

Other new radioisotope systems included 2 sediment density gauges employing radioisotope techniques: an ocean-bottom gauge using cesium-137 and a gauge for measuring sediment in moving waters in reservoirs and waterways which uses the radioisotope cadmium-109.

The AEC and the Air Force successfully ground tested a plutonium-238 powered water recovery system for use aboard space vehicles in extended manned flights. The device converts human fluid wastes into potable water. A swimsuit heater for divers, also powered by plutonium-238, was developed by AEC and delivered to the U.S. Navy for deep-sea feasibility tests. A promethium-147 powered heater designed to eliminate errors in aircraft guidance systems caused by temperature changes was soon to be delivered to the Air Force.

An agreement for the nation's first experiment using a nuclear explosion to stimulate natural gas production was signed on January 31 by the Department of the Interior, the Atomic Energy Commission, and the El Paso Natural Gas Company. The nuclear test portion of the experiment, "Project Gasbuggy," was conducted on December 10 in New Mexico.

In August, Columbia Gas System Service Corporation proposed a joint experiment, "Ketch," to confirm the technical feasibility of using contained underground nuclear explosions to create underground storage for natural gas.

In October, Kennecott Copper Corporation proposed an experiment, "Sloop," to study the use of nuclear explosions to fracture low-grade copper ore deposits for copper recovery by in-place leaching techniques.

CER Geonuclear, representing a group of 18 oil companies and related industrial firms, proposed to the AEC and the Department of the Interior an experiment to study the feasibility of using an underground nuclear explosion to fracture oil shale and to recover the oil by an in-place retorting (heating) process.

Early in the year, the Commission announced the establishment of an Advisory Panel on High Energy Physics, headed by Professor Victor F. Weisskopf, Massachusetts Institute of Technology.

A new advanced zonal centrifuge was developed as a result of a joint effort of the AEC's Oak Ridge National Laboratory and the National Institutes of Health's National Cancer Institute. The centrifuge can produce sufficient purified vaccine for inoculating millions of people. It was developed to help study the role played by viruses in the production of human cancer.

Chairman Seaborg, on September 9, announced the discovery of the heaviest atom definitely identified by man—an isotope of element 101 (mendelevium). The isotope has a half-life of 2 months, which may make it possible to produce it in sufficient quantity for investigation of its chemical and other characteristics. The study of elements heavier than uranium (element 92) is important in understanding the common elements on earth as well as cosmology.

The Stanford Linear Accelerator Center was dedicated on September 9. The 2-mile long building houses the world's longest research instrument and is one of the most complex and precise machines ever built. Its energy is higher by a factor of 10 than any other linear accelerator in the world, and prior to its dedication had exceeded its design goal by producing more than 20 billion electron volts.

The AEC received Congressional authorization to perform design work on the proposed 200 BEV Accelerator Laboratory at Weston, Illinois. A contract was signed with the Universities Research Association to do the preliminary design work and to arrive at definitive project cost estimates necessary for the next step of requesting construction funds for the facility.

The AEC's "Atoms for Peace" program, in its 13th year, continued to broaden its development of the peaceful uses of atomic energy with foreign countries and international organizations.

The United States again demonstrated its strong support of the International Atomic Energy Agency by providing funds to the Agency, equipment grants, fellowships, special nuclear materials, technical information and consultants. For the seventh year, Dr. Glenn T. Seaborg, Chairman of the AEC, headed the U.S. delegation to the Agency's General Conference in Vienna in September. It was the 11th annual conference of the IAEA, which now has 98 member states.

In May, the Commission revised its organization in the area of safeguards in order to carry out more effectively its responsibilities for safeguarding special nuclear materials under the Atomic Energy Act. It established an Office of Safeguards and Materials Management to have overall responsibility for national and international safeguards and inspections programs. It also set up a new Division of Nuclear Materials Safeguards to administer safeguards for special nuclear materials held by AEC licensees. And it established an Advisory Committee on Nuclear Materials Safeguards to advise the Commission on safeguards matters.

In August, the first international safeguards inspection of reprocessing of spent fuel from a power reactor was held at the Nuclear Fuel Services, Inc., plant near West Valley, New York. The inspection was conducted by a team from the International Atomic Energy Agency in Vienna, Austria.

In response to the increasing uranium requirements for the rapidly developing nuclear power industry, U.S. uranium mining interests sharply revised upward their plans for exploration and development drilling.

As a result of a survey announced in August by the AEC's Grand Junction (Colorado) office, plans of 49 companies called for approximately 53,800,000 feet of drilling in the years 1967 through 1970. In comparison, during the entire decade of 1951 through 1960 a total of 52,800,000 feet of drilling was recorded.

Approximately 250,000 tons of U_3O_8 would be required through calendar year 1980 to provide fuel for the projected installed capacity of 120,000 to 170,000 electrical megawatts of nuclear power by 1980.

In relation to this projected requirement, the estimate of known reserves capable of being produced for $8 per pound of U_3O_8 was about 140,000 tons as of January 1, 1967.

A fourth plutonium production reactor at the Hanford plant was placed in standby in July, reducing the number of AEC operating production reactors to 9—5 at Hanford and 4 at the Savannah River plant near Aiken, South Carolina. The curtailment in plutonium production was expected to result in fiscal year 1968 cost savings of $6,000,000.

The AEC announced on March 21 that, after carefully weighing all factors, it had concluded that national security interests would best be served if privately sponsored work on the gas centrifuge process for separation of isotopes were discontinued.

Also in March, the Commission agreed to cooperate with the Atomic Industrial Forum in its study of the feasibility and desirability of transferring to private industry one or more of the AEC's gaseous diffusion plants.

In June the AEC made public previously classified information on the capacity of its gaseous diffusion plants to produce enriched uranium. This will permit the nuclear power industry in the United States and other countries to make judgments concerning the adequacy of the Commission's 3 gaseous diffusion plants to meet worldwide nuclear fuel requirements for power reactors.

Surface ships of the nuclear navy were becoming battle-hardened in Vietnam. The aircraft carrier Enterprise and the guided-missile frigate Bainbridge completed their second assignments and the guided missile cruiser Long Beach completed her first assignment during the year.

By year-end, Congress had authorized 107 nuclear powered submarines, including one deep submergence research vehicle, and 8 nuclear-powered surface ships. Of these, 74 submarines and 4 surface ships had been placed in operation. They had steamed over 9,660,000 miles without ever having to abort a mission because of reactor plant failure.

The United States continued its underground nuclear test program, as allowed under the terms of the limited test ban treaty. As of December 1, the AEC had announced 24 weapons-related underground explosions at its Nevada Test Site.

The AEC also continued to investigate and develop possible supplemental test sites in the Hot Creek Valley of central Nevada and Amchitka Island, Alaska, remote areas which may be suitable for tests of higher power. A calibration test to help determine the suitability of the central Nevada area was tentatively planned for early 1968.

From mid-September to mid-October, the AEC and Department of Defense jointly conducted a non-nuclear exercise in the Pacific Ocean area to maintain facilities and personnel in a state of readiness for atmospheric testing, if ever required.

DEPARTMENT OF DEFENSE

For the fiscal year 1968, the Department of Defense was expected to obligate close to $8 billion for research and development projects. This figure included a supplemental funding request which allocated $135,000,000 for research and development directly related to the Vietnam conflict. Also included, aside from the service budgets, was some $200,000,000 for exploratory development projects administered by the Advanced Research Projects Agency. Foremost among these was Defender, a broad program of research and exploratory development in the field of ballistic missile defense, penetration aids and defense against satellites. For Defender, ARPA was allocated $118,000,000. The bulk of all DoD research and development funding involved aerospace projects, but no breakdown was available. Highlights of the major DoD research and development programs are contained in the résumés of the individual services which follow.

AIR FORCE

Military needs continued to pace the nation's science and technology programs and the Air Force Systems Command, responsible for about 31 percent of the Air Force budget, continued to have an important portion of this effort.

General James Ferguson, Commander, Air Force Systems Command summed up the command's role when he said: "Traditionally, the mission of research and development has been futuristic. It remains so. But the future is any point ahead of us in time. It can be 10 seconds, 10 minutes, or 10 years away."

Throughout 1967, command efforts were generally directed in 5 major areas. These were limited war support for Southeast Asia (SEA) operations, management of Air Force scientific and technical resources, the national space effort, new aeronautical developments, and technological advancements.

Virtually every new system, weapon, or item of aerospace equipment entering the Air Force's operational inventory is a product of Systems Command's research, development, modification, and acquisition competence. These front lines of technological ability extend to the combat areas of Southeast Asia where a Systems Command liaison office team of research and development personnel identifies needs technology can help solve.

Announcement was made in April of a new, compact 7.62 millimeter Gatling-type minigun for use in South Vietnam, which had an electrically powered reloading system and larger ammunition capacity than the original guns they replaced. Three of the 6-barrelled miniguns firing through gunports in the side of the modified C-47 "Dragon Ship" transports have a combined rate of fire of 18,000 rounds per minute.

A new stick-on patch, devised by engineers at the command's Air Force Materials Laboratory, Wright-Patterson AFB, Ohio, made possible the rapid repair of small holes in airplanes caused by enemy small arms fire in Vietnam. It comes in convenient, ready-to-mix kits, including an epoxy resin and curing agent, and costs only about a dollar per kit.

In September, the Aeronautical Systems Division announced the successful adaptation of a polyurethane foam—originally used in racing cars at the Indianapolis "500"—for use in aircraft fuel tanks. Installed in the fuel tanks of combat aircraft in Vietnam, the new material will greatly reduce fire and explosion hazards in the event of a direct hit on the tank by machine gun tracer bullets or other incendiaries, as well as suppress slosh in the tanks during flight.

A new type body armor and special helmet decreased the vulnerability of Air Force crewmen to small arms ground fire during rescue, defoliation, and ground support missions. Its use was revealed in October. The body armor, covering the back and chest, is made of a ceramic material backed with nylon. The helmet quickly proved its merit under fire when a pararescue man was hit in the head by shrapnel while his helicopter was engaged in a dangerous rescue mission. He was knocked down but the ballistic helmet stopped the fragments, leaving him unharmed.

USAF Systems Command developed a new body armor and special helmet for use by crewmen in rescue, defoliation and ground support missions. A2C Duane Hackney exhibits helmet which saved his life (note shrapnel strike).

In December, the command announced Operation Shed Light, a program to devise more reliable and accurate means of tactical weapons delivery in any weather, around the clock, in limited war actions such as that in Vietnam. The concerted Air Force effort was being carried out largely through research and development resources of Systems Command.

In the management area, several major actions were taken to increase the command's ability to respond promptly to the changing needs of the Air Force. Support for the fighting forces in SEA received additional emphasis with the appointment of Brigadier General William S. Chairsell as the newly created assistant for SEA. General Chairsell, whose office is located at the command's headquarters, Andrews AFB, Maryland, reports directly to General Ferguson.

The Director of Laboratories (DOL), a new command headquarters staff function, was established in March under the leadership of Brigadier General Raymond A. Gilbert. The DOL provides policy and technical direction to all phases of the laboratories, programs and activities, thus providing better coordination and response in meeting the needs of the command.

The Command's Ballistic Systems and Space Systems Divisions, located at Norton AFB, California, and Los Angeles AFS, California, respectively, were realigned on July 1 to form a new Space and Missile Systems Organization (SAMSO), with headquarters at the Los Angeles AFS. SAMSO is the major Department of Defense development agency for this nation's present and future space and ballistic missile programs.

The year marked the end of 10 years since the orbiting of the first man-made satellite. During the year, Systems Command continued to push back the frontiers of the new environment of space.

In January, Major William Knight, assigned to the Air Force Flight Test Center, Edwards AFB, California, set an unofficial speed record when he flew the X-15A-2 at 4,534 miles per hour.

Aeromedical Research Laboratory scientists of the Aerospace Medical Division, Brooks AFB, Texas, conducted experiments using chimpanzees to study effects of rapid decompression to a near vacuum. The chimpanzees were exposed for periods of up to 3 minutes to the near vacuum of 150,000 feet altitude and survived without noticeable effects. The tests were announced in February.

The Air Force Western Test Range acquired a 2-man submarine in March to help locate reentry vehicles fired from Vandenberg AFB, California, into the Eniwetok Atoll.

The third PRIME (Precision Recovery Including Maneuvering Entry) launch occurred in April. PRIME is part of an Air Force research program to explore the feasibility of maneuverable lifting body spacecraft. Launched on a ballistic trajectory down the Western Test Range by an Atlas booster, the spacecraft was recovered in mid-air. Since all test objectives were completed in 3 launches, a planned fourth and final launch was cancelled.

A cluster of 4 small experimental solar conversion cells rode into a 60,000 nautical-mile orbit in early May to seek possible solutions to threats on the life of solar cells. They were lifted aboard a Vela Nuclear Detection Satellite. The devices, known as Lithium Drift Solar Cells, show promise of long life since they are designed to heal themselves after bombardment by solar particles.

Announcement was made in June of 4 additional research pilots assigned to the Manned Orbiting Laboratory (MOL) Program, bringing the total to 16.

Direct long-haul communications halfway around the world, using high-orbiting satellites, became a reality in July when the Initial Defense Communications Satellite System was declared operational for the Pacific area. Almost immediately, traffic over the Hawaii-Saigon segment exceeded 1,000 calls per week. Army developed ground terminals located in Hawaii, the Philippines, and in Vietnam, were linked to United

States communications centers by means of 25 orbiting satellites.

An all-metal payload shroud for Air Force Titan III booster vehicles was announced in September. The shroud protects sensitive instrumentation of scientific payloads during launch and flight through the earth's atmosphere. Once through the atmosphere, it separates into 3 sections and is jettisoned.

In the field of aeronautics, the first contingent of the new Air Force O-2 aircraft, a military version of the commercial Cessna 337 Super Skymaster, arrived in South Vietnam in June for use by forward air controllers and psychological warfare pilots. It replaced the older O-1E Birddog.

July saw the nation's newest flight research vehicle, the X-24A, rolled out and presented to the public. The piloted, flat-iron shaped, wingless lifting body is powered by a rocket engine and will explore the flight envelope and speed regimes of rocket-powered lifting bodies from orbital speed to landing speeds. The Martin-built X-24A will be flight tested at Edwards AFB, California, as part of a joint Air Force/NASA lifting body program.

A $28,000,000 contract for 8 C-9A twin-jet aircraft, to be used for aeromedical evacuation, was awarded during August to McDonnell-Douglas Corporation. Deliveries were expected during late summer 1968.

The completion of the turbofan engine mockup for the Air Force A-7D tactical fighter 6 months ahead of time was announced in October. The single-engine A-7D will have a maximum speed of more than 650 miles per hour and will carry more than 15,000 pounds of ordnance. The engine was being built by Rolls Royce, Ltd., of the United Kingdom. Airframe contractor was Ling-Temco-Vought of Dallas, Texas.

A new, all-weather landing system (AWLS) for the Air Force C-141 was certified by the Federal Aviation Administration in October. AWLS increases the capability of the big fanjet cargo-troop carriers to make "pinpoint" landings during bad weather. The system can bring in the 145-foot long, 316,000-pound Starlifter for a landing within 12 feet of either side of the runway center line and within 300 feet of either side of a determined touchdown point.

Also in October, the world's largest aircraft began to take shape at Lockheed's Marietta, Georgia, plant, when 3 main sections of the Air Force's C-5A Galaxy's fuselage were joined for the first time. The aircraft was scheduled for completion early in 1968.

The first production model of the F-111 made its initial flight during February. On October 16, the first operationally configured production model F-111A supersonic tactical fighter aircraft was delivered to the Tactical Air Command (TAC). It landed at Nellis AFB, Nevada, after a 1,000-mile "automatic" low-level flight from the General Dynamics plant at Fort Worth, Texas. Once airborne, the F-111A's terrain-following radar caused climb-dive signals to be fed into the aircraft's autopilot by an on-board analog computer. A built-in safety factor caused the system to check continuously on its own operation and, if something went wrong, to automatically direct the aircraft to a higher altitude.

A reconnaissance version of the F-111A made its first flight in mid-December. It was the fourth version of the versatile variable sweep-wing craft to enter flight testing. The RF-111A houses cameras, radar, and infrared sensors in the weapons bay which are operated through a specially designed digital computer reconnaissance control system.

A major effort of the command is continued expansion of the technological base from which today's and tomorrow's military needs are forged. Accomplishments in the field of electronics and communications are indicative of these efforts.

Development of hollow steel spheres for use in aerospace ball bearing assemblies were announced during April. They were expected to reduce the weight of space and aircraft, yet were stronger than solid spheres.

In early May, the Electronic Systems Division was given a key role in the development of the first tactical satellite communications system for the Department of Defense. The new communications system will be capable of handling a large number of calls or messages at one time by providing a single point relay directly to and from a commander and his tactical units in the field. Although separated from their units by thousands of miles, commanders would not be faced with communications delays currently associated with multiple interconnecting terminals.

Seed Tree, an underwater communications cable around the Indo-China peninsula, was completed in May, 6 weeks ahead of schedule. Developed by the Electronic Systems Division, it marked the third such system installed in Southeast Asia. The Defense Communications System will put military field commanders in direct communication with top decisionmakers in the United States.

In June, the command revealed a new, transportable, "fold-away" radar which can be set up or taken down in only 20 minutes. Known as the TPS-44, the lightweight equipment was designed for use in the forward control post of the 407-L Tactical Air Control Center.

A new type space communications recording and optics tracking system, known as the Apollo Range Instrumented Aircraft (ARIA), made its debut early in 1967. It was a modified C-135A jet transport instrumented to meet support requirements for Apollo and other military and civilian space programs. ARIA is a joint development effort by Air Force Logistics Command, Systems Command and McDonnell Douglas Corporation.

At Systems Command's Air Force Avionics Laboratory, Wright-Patterson AFB, Ohio, engineers succeeded in transmitting voice conversations over a six-mile-long laser beam. It worked by aiming the beam from the pistol-shaped transmitter of one laser unit at the receiver and talking into a lapel microphone. Sound was transmitted on the beam, collected by the receiver's lens focused on a detector, and then amplified.

Air Force engineers tested communications between two airborne aircraft by way of a satellite as part of a tri-service test conducted during August. The new system allows messages to be sent between terminals up to 10,000 miles apart. The satellite was in an earth orbit 20,000 miles above the equator. Working together on the project were the command's Space and Missile Systems Organization (SAMSO), Los Angeles, California, and Aeronautical Systems Division (ASD), Wright-Patterson AFB, Ohio.

ARMY

As in previous years, a large part of the Army's 1967 research and development effort was concentrated on the versatile helicopter and associated V/STOL types of aircraft.

A major development program under way was the Advanced Aerial Fire Support System (AAFSS), designated by the Army the AH-56A Cheyenne. This compound helicopter, being developed by Lockheed Aircraft Corporation, is the first armed helicopter designed from its inception to integrate the aerial vehicle, avionics, weapons, and fire control into an advanced state of the art aerial weapon system. The program was progressing at a rapid pace. Following

The Army's major aircraft development program involved the AH-56A Cheyenne, the first armed helicopter designed from inception to integrate vehicle, avionics, weapons and fire control.

roll-out of the first vehicle in April 1967, 3 more prototypes of the 10 ordered were completed by year-end. First flight occurred in September 1967 and flight testing was highly satisfactory. It was anticipated that the Cheyenne would approach its top speed of 220 knots by the end of calendar year 1967. Army tests were to begin in the summer of 1968.

In another major program, the Army continued development of the AH-1G/HueyCobra attack helicopter. Production contracts were awarded. Deployment of the AH-1G to Southeast Asia began in August 1967.

In its part of a tri-service program, the Army continued active experimentation and study of a variety of V/STOL aircraft including the Bell X-22, the LTV XC-142, and the Canadair CL-84. The Army was also looking at other answers to the vertical lift requirement, notably the compound or composite type winged aircraft.

The Army's Lockheed XH-51A compound aircraft set an unofficial world's rotorcraft speed record in June by flying 302.6 miles per hour off the Southern California coast near Oxnard. The XH-51 also participated in Army tests during October to determine the effect that high-speed nap-of-the-earth flight has on the pilots of helicopters.

The Army placed priority on the development of helicopter weapons systems and methods to increase the battlefield survivability of both aircraft and crews. Improvement in weapons systems lethality received major emphasis through the development of larger warheads and airburst fuzes for ammunition. In the realm of aircraft survivability, developments in armor protection, crash resistant fuel cell material and modified fuels were expected to lead to definite increases in the survivability of Army aircraft in the future.

On September 18, 1967, the Secretary of Defense announced the decision to deploy Nike-X in an area defense of the United States (including Alaska and Hawaii) against the ICBM threat from the Chinese Peoples Republic. In addition, some Minuteman fields will also be defended by a second level of defense. The deployed system was renamed the "Sentinel." The name Nike-X was retained to denote the advanced development of the Army's ballistic missile defense system. Research and development on both the Sentinel and Nike-X systems was to continue at the Kwajalein Test Site. The Sentinel system consists of the Spartan and Sprint missiles, the Perimeter Acquisition Radar (PAR) and the Missile Site Radar (MSR). The high acceleration Sprint missile has been under test at White Sands Missile Range since 1965. Kwajalein was being readied for full-scale intercept tests of both the McDonnell Douglas-built Spartan and the Martin Company's Sprint. ICBM missiles will be used as targets. They will be fired from Vandenberg AFB toward Kwajalein.

In advanced development, the Chaparral missile, built by Aeronutronic Division of Philco-Ford, was undergoing extensive firing tests at White Sands Missile Range as part of the Engineer and Service Test Program that is designed to exercise a new missile system to its maximum capability. During these tests, Chaparral, a Sidewinder 1C modified for ground-to-air use, repeatedly demonstrated its capability to intercept high performance target drones. The Chaparral will provide the U.S. Army a highly mobile air defense system for use in the forward areas of the field army.

After 8 years of development and exhaustive testing of Redeye, the Army produced an air defense system capable of dealing a knock-out blow to low-flying enemy aircraft over the forward combat area. Service tests were completed and training was being conducted at Ft. Bliss, Texas. Built by the Pomona Division of General Dynamics Corporation, the shoulder-fired antiaircraft missile system has been a joint Army-Marine Corps program from its inception.

Ling Temco Vought's Lance missile system was in advanced stages of development. Although research and development was continuing on the missile, the ground support equipment, consisting of the self-propelled launcher, the transporter loader, the light-weight launcher and miscellaneous ancillary equipment, was committed to production in June 1967.

A significant event in the Lance program in 1967 was the authorization to proceed with the development work which would increase the range capability of Lance. This decision followed the successful test demonstration of a concept which revealed that the Lance range could be greatly extended by minimum modification to the basic Lance missile. The improved missile, when successfully developed, will be launched from the standard Lance ground support equipment.

In May 1967, the Secretary of Defense approved the SAM-D Program for advanced development and a letter order contract was signed with Raytheon Company. In November 1967, after definitization, a contract for advanced development was executed. SAM-D is the latest generation of air defense systems designed for battlefield and continental defense roles in the 1970s.

In early 1967, Hughes completed delivery of the Missile Mentor air defense command posts to the U.S. Army Air Defense Command. The Mentor systems replaced the Missile Master and some of the BIRDiE (Battery Integration and Radar Display Equipment) Systems in the Army's inventory.

Litton Industries was awarded a contract for Air Defense Battery Terminal Equipment. The Battery Terminal Equipment is designated the Data Converter, Coordinated Air Defense System AN/GSA-77. It was designed to replace the Fire Unit Integration Facility and the Coder-Decoder Group performing the integration function. This system will represent the first application of micro-electronics technology to this type of equipment. The application of this technology enabled the Army to reduce the weight of the Fire Unit Integration Facility from 5300 pounds to 128 pounds and its size from 700 cubic feet to less than 4 cubic feet.

The Pershing missile system was undergoing a ground support equipment improvement program. Major features of this program included improvements to the erector launcher and the programmer test station, and the addition of a Battery Control Center to improve command and control. The improved system will be mounted on wheeled vehicles, M656 type, instead of the tracked vehicle mounts earlier deployed. The wheeled version will have improved road mobility and will reduce vibration during travel.

In the space research area, the Army continued its highly successful SECOR geodetic satellite program, being used by the Corps of Engineers to locate the positions of islands and the North American datum. Objective of the program is to improve knowledge of the earth's diameter and to connect all major geodetic datums. The SECOR system was producing accuracies of one part in 200,000. In June, the Army launched another SECOR, the ninth of the series, and at year-end SECOR 10 was being prepared for early 1968 launch.

In the field of tactical communications, the first research and development satellite, LES-5 (Lincoln Experimental Satellite) was successfully launched on July 1, 1967. Tests were conducted with Army ground terminals and airborne and seaborne terminals proviced by the Air Force and Navy. Additional research and development tests, both technical and operational, were planned with satellites to be launched late in 1968.

NAVY

With its "cradle to grave" responsibility for aircraft and airborne weapons, the Naval Air Systems Command's research and development activities for 1967 included continued test efforts of both aircraft, weapons systems, and aeronautical targets.

Highlighting the year's activities was the deployment of the A-7A Corsair II with the operating forces at sea. The A-7A completed the final phases of its Board of Inspection and Survey trials in early 1967. In excess of 30,000 flight hours of fleet training were accomplished at east and west coast naval air stations. The first A-7A squadron deployed to combat operations in Southeast Asia in November and at year-end was engaged in daily light attack missions from *USS Ranger* in the South China Sea. The compressed development schedule of approximately 2 years from initial flight to combat deployment was unparalleled in recent Navy aircraft history.

Development efforts continued on the A-7E and the U.S. Air Force A-7D scheduled for initial deliveries in late 1968. These aircraft incorporate a head-up display (HUD), inertial platform, digital computer, improved ground mapping radar, and the M-61 gun system.

Testing of the General Dynamics F-111 Fighter continued during 1967. The F-111 is the first production aircraft that incorporates a variable sweep wing and an afterburning turbofan engine. By December 1967, the 5 F-111Bs delivered to the Navy had accumulated in excess of 700 flight hours.

Five Navy pilots participated in Navy Preliminary Evaluation (NPE) during the period 19 March 1967 to 29 June 1967. The test aircraft was the first Super Weight Improvement Program (SWIP) F-111B. The aircraft also incorporated aerodynamic changes to reduce drag and increase lift.

A Glide Slope Evaluation was conducted by a selected team of 5 Navy pilots during July 1967. The program was conducted to further define carrier suitability deficiencies reported during the NPE. The Glide Slope Evaluation team recommended incorporation of an Approach Power Compensator (APC) and Direct Lift Control (DLC) on the F-111B. Flight testing of an F-111B with APC and DLC commenced in late 1967 in preparation for carrier suitability trials in 1968.

At year-end, the research and development configured F-111B #5 was undergoing catapult and arrestment tests at the Naval Air Systems Command's Patuxent River Air Test Center. In the spring, an F-111B was expected to be tested on a Kitty Hawk-class carrier.

Two of the F-111Bs were assigned to Hughes Aircraft Corporation for development testing of the Airborne Missile Control System (AMCS) and Phoenix missile. The first guided launch of a Phoenix Missile from the F-111B occurred in March 1967 and the first supersonic separation of an unguided Phoenix from the F-111B occurred in July 1967.

In the F-4 Phantom program, the F-4J, which incorporates improved radar and uprated engines, entered BIS trials in 1967 at the Naval Air Test Center, Patuxent River; Naval Missile Center, Pt. Mugu; and Naval Weapons Evaluation Facility, Albuquerque. The 3 locations are field activities of the Naval Air Systems Command. Four of 5 scheduled phases were completed, with the fifth phase scheduled for completion early in 1968.

Navy Preliminary Evaluations were conducted on the F-4K for the Royal Navy and the F-4M for the RAF. These aircraft incorporate the Rolls Royce Spey fan jet engine and UK produced avionics equipment. Both utilize a version of the radar introduced in the F-4J. Carrier suitability demonstrations were in progress and Navy Acceptance Trials were to begin at NATC Patuxent River in 1968.

Tests were completed on a modification to the Martin Baker seat in the F-4 to give it a zero speed, zero altitude. The modification also includes a command sequence feature to enable either crewman to eject the other. Tests were conducted at ground level at speeds varying from zero to 600 knots with various size/weight dummies. Test results were being analyzed and certification for full 0-0 operation was expected early in 1968. Initial deliveries to the fleet were made and retrofit installations were in progress.

The F-4 spin test aircraft was lost when it entered a flat spin from which recovery could not be effected. Film coverage of the program was being utilized to produce a training movie on F-4 spin characteristics and recovery techniques. The project pilots conducted briefings at all Navy and Marine Corps F-4 stations to ensure maximum dissemination of all spin information and they were also visiting USAF F-4 bases. Studies were in progress to determine future action.

Under the E-2 project, Grumman Aircraft Engineering Corporation completed contract definition of the E-2A/APS-111 interim follow-on airborne tactical data system (ATDS) aircraft in the fall of 1967. This effort included successful development, fabrication and demonstration of the APS-111 radar in the E-2A.

Litton Data Systems Division completed production on 4 of 5 prototype models of the L-304 microelectronic general-purpose computer. Concurrent with acceptance of the fourth prototype, a letter contract was awarded to GAEC for the E-2A MOD AX program, which includes replacement of the present computer programmer with the L-304 in 52 E-2A aircraft.

The F-8D/E modification program to F-8H/J configuration made its initial delivery in August 1967 of an F-8H at the contractor's plant in Dallas, Texas. After testing of radar improvements and the newly installed Sidewinder Expanded-Acquisition Mode (SEAM) change, the airplane was delivered to the Naval Air Test Center at Patuxent River, Maryland, for Navy tests. The second F-8H was also delivered in August 1967 to the Carrier Suitability Branch of Flight Test Division for instrumentation, field catapult and arrested landing trials, and at-sea trials in *USS Enterprise* on December 11–16, 1967. The airplane performed satisfactorily at its new 24,000 pound carrier landing weight. As a result of these trials, it was recommended that the elevator position input change should be incorporated into the Approach Power Compensator to improve the F-8's performance under pitching deck and/or high, gusty wind conditions.

Successful testing of the Naval Air Systems Command's project A-NEW, a Navy in-house continuing effort to refine Anti-Submarine Warfare (ASW) techniques and equipment by emphasizing human factors, reliability, and maintainability, resulted in a decision to incorporate the A-NEW system in the P-3 Orion aircraft. This ASW system, utilizing an airborne general-purpose digital computer to integrate improved navigation, sensor, and armament systems is known as the P-3C Weapon System. The P-3C developmental activity schedule during 1967 included the following:

- The A-NEW developmental system, flying a modified P-3A airframe, successfully completed 150 flights including a concurrent evaluation in a fleet environment operating in competition with fleet P-3B aircraft against submarine targets. The A-NEW aircraft was substantially superior to the P-3B in this competition. The human factors improvements were identified in detail for incorporation in the P-3C. ASW equipment advances and problem areas were noted and corrective actions determined.
- The selection of manufacturers for the P-3C ASW electronics equipment was made and pre-production quantities were placed on order for delivery in early 1968.
- Construction and evaluation of a full scale "space arrangement aid" for determination of P-3C equipment and crew station locations was completed.

• Airframe construction of the YP-3C prototype aircraft was completed. Installation of wiring, equipment racks, and cockpit instrumentation was in process. The YP-3C was scheduled to fly in July 1968.

• Finally, a full scale P-3C avionics tests facility used to perform P-3C systems integration was installed in a laboratory located at the airframe contractor's plant. Pre-production equipment will be inspected, tested, installed and operated to determine system effectiveness and to provide data for reliability analysis.

The P-3B aircraft in production for fleet ASW use will phase out of production at the end of 1968. The P-3C Weapon System with its significantly higher ASW kill/detection ratio will be produced and incorporated into fleet use in 1969.

At the Naval Air Test Center, Patuxent, flight evaluation of two innovations in the automatic flight control of helicopters was completed. First was a Flight Path Control System for ASW helicopters. This system is capable of complete control of helicopters including point-to-point navigation, transition from cruise to hover to cruise conditions, and point-to-point control of the vehicle over a pre-programmed ASW dipping pattern. The system uses a digital computer to generate the control signals which are fed into the vehicle Automatic Stabilization Equipment.

The second new system developed was a Hover Augmentation System (HAS). This system provides a marked reduction (4 to 1) in pilot effort required to maintain a helicopter in a precisely controlled hover. The system features an acceleration sensing means to generate control signals required to maintain an accurate hover. The test pilots gave this system a Cooper rating of 1.5, an unusually good rating for a helicopter in a hover.

The development of an airborne fire fighting system which dispenses "light water" from a helicopter was completed. "Light water" is a new fire extinguishing agent developed by the Naval Research Laboratory. Its superior fire killing properties, coupled with the high mobility of the helicopter, provides a significant advancement in the capability of quelling large aircraft fires and rescuing personnel from crashed aircraft.

The North American OV-10A production airplane which differed from the early prototype YOV-10A airplane in wingspan (40 feet vice 30 feet), engine shaft horsepower (715 vice 660) and booms moved outboard six inches on each side, made its first flight in July 1967. Two preliminary evaluations were conducted by the Naval Air Test Center, Patuxent River, on the production OV-10A, and the contractor continued the envelope expansion to 430 knots, 8g and rough field development tests. The All Services Evaluation Group at Patuxent received 3 YOV-10A airplanes and conducted an operational evaluation including cargo and paratroop drops, unprepared surface landing and take-off operations, and tactics development, demonstrating the capabilities of the airplane by conducting joint operations at Eglin AFB, Florida, and the Marine Corps Air Facility New River, North Carolina. Delivery to both the Marine Corps and Air Force was expected in early 1968.

Under a Naval Air Systems Command-administered contract in the Tri-Service V/STOL program, a vertical take-off and landing airplane, designed by Bell Aerospace, was tested during the year. First flight for the X-22A was in January and in December the 100th successful test flight was recorded. Total flying time

The Bell X-22A, being tested under a Naval Air Systems Command-administered contract, made 100 successful flights during the year. The experimental V/STOL logged 40.9 hours.

logged during the year was 40.9 hours. All tests were conducted at the Niagara Falls, New York International Airport adjacent to Bell's main plant. The X-22A development program was to continue through 1968.

A new look in mission training aircraft will be in evidence in fleet training centers soon. The first 2 Grumman TC-4C airplanes were accepted in October and December 1967 respectively. Eventually, a total of 9 of these aircraft will be in service with the Navy and Marine Corps.

The TC-4C is a Grumman Gulfstream I, modified for use as an A-6 bombardier/navigator trainer. Powered by 2 Rolls-Royce Dart turboprop engines, its performance features are quite similar to commercial versions of the airplane. Navy modifications consist of installation of the A-6A avionics system in a new nose and in the interior cabin. Besides the conventional Gulfstream cockpit, cabin space is provided for 4 trainee consoles, a 2-seat side-by-side cockpit simulator, and one instructor to conduct the training of the 6 students aboard.

Contractor avionics demonstration flight tests and the Navy Preliminary Evaluation were conducted in November 1967. Grumman's structural demonstration flights were performed in December. The 2 airplanes were delivered to Naval Air Test Center, Patuxent River, a field activity of the Naval Air Systems Command, in early January 1968 for Board of Inspection and Survey service acceptance trials, which were to be completed during February 1968. Delivery of the third airplane, which will be the first one for the fleet, was scheduled to occur in late January or early February.

Flight and ground tests of the Navy's Phoenix Missile System continued in 1967. This system consists of the missile (XAIM-54A), the Aircraft Missile Control System (AWG-9) and the Missile Launcher (MAU-83A/84A). XAIM-54A is a long range, high performance weapon with all-weather capability. Data from the AWG-9 radar is processed by a solid state, high speed digital computer and displayed on a 10-inch cathode ray tube and a 5-inch multimode storage tube.

The first guided missile (Phoenix G-9) to be launched from an F-111B aircraft was fired in March 1967. This launch accomplished the first test of the aircraft, the AWG-9 and Phoenix missile working as a system. An inert Phoenix missile was used in the first supersonic missile separation from an F-111B, which occurred in July 1967. Weapons bay environmental tests with Phoenix missile T-20 in an F-111B were completed satisfactorily in August 1967. By the end of 1967, a total of 5 successful, and one partially successful, Phoenix missile launchings had taken place since the inception of live missile firings in May 1966. The Phoenix Flight Test program was entering the period of more intensive missile firings.

The MK 47 Mod 0 rocket motor, which propels the XAIM-54A, successfully completed qualifications testing in December 1967, after having experienced difficulties early in the program. All development tests on an alternate rocket motor, MK60 Mod 0, were completed and the contract option for the qualification phase was exercised in December 1967.

The AWG-9 entered the pilot production phase with the award of a pilot line contract in April 1967.

The Anti-Radiation Missiles, Shrike and Standard ARM, were in full production. Advanced versions of both systems progressed through research and development in order to improve the total capability of the Navy and Air Force. Associated aircraft of the Navy and Air Force were configured to launch these missiles.

The XBQM-34E Firebee II supersonic target for air-to-air and surface-to-air missiles entered the captive flight phase in December at the Naval Air Systems Command's Missile Center, Point Mugu, California. The growth-version target, successor to the subsonic BQM-34A, is capable of supersonic flight (Mach 1.5) at 60,000 feet and Mach 1.1 during low level runs. Designed as an air-launched target from the DP-2E aircraft with an alternate ground launch capability, the target is equipped with passive radar reflectors such as the Luneberg lens, active traveling wave tube augmentation devices and will carry and operate electronic countermeasures equipment.

The QT-33A drone target aircraft entered manned flight testing at the Naval Air Development Center, Johnsville on 20 November 1967. Due to the continuing requirement for drone target aircraft to be utilized in RDT&E and operational evaluation of surface-to-air and air-to-air missile firings, this program commenced in January 1967 to provide a follow-on for the QF-9G/J. No Live Operator (NOLO) flight testing was to be conducted at the Pacific Missile Range.

The Contract Definition Phase (CDP) for an Automatic Formation Drone Control (AFDC) system was completed in November 1967. The AFDC system will be capable of controlling up to 4 targets in a precise maneuvering formation from 50 to 50,000 feet with a target separation of 200 to 2,000 feet. Evaluation of the CDP reports will result in an Engineering Development contract for prototype equipment to be evaluated at the Naval Weapons Center, China Lake.

In support of avionics, the Naval Air Systems Command's rework facility at the Naval Air Station, Alameda, California, continued work in 1967 on the "Van" program. Vans are unsophisticated containers—which look like moving vans without wheels—that house the sophisticated equipment required to maintain complex avionics systems on Navy aircraft in forward areas. Capable of being air transported, these self-contained units are completely air conditioned, and the work shelves that line the inside walls are engineered specifically to accommodate test equipment needed to rework, rebuild, and recalibrate aircraft avionic systems.

A complex (depending on the type aircraft) of 3 to 6 vans can be air transported to remote air bases, manually unloaded onto detachable running gear, transported to a parking area, and then lowered to the ground using built-in jacking facilities. The van complex can be off-loaded, set up, and made fully operational in approximately 8 hours, or moved to an entirely different base in a matter of days. The vans were in successful operation at remote Atlantic and Pacific bases.

With the increased complexity of modern aircraft structures and the need to ensure safety throughout a long life, the Naval Air Systems Command continued studies in 1967 on Non-Destructive Testing (NDT) and Non-Destructive Inspection (NDI), a program designed to reduce the risk of airframe failure.

For many years the aerospace industry has been plagued by an inability to predict accurately either the fatigue life or the fatigue strength of individual structural components. The accompanying structural fatigue failures have resulted in regrettable loss of life and aircraft, but the major operational impact has been unscheduled "down-time" with resultant deterioration in combat readiness.

The complete destructive testing of an aircraft or individual component is becoming more costly with each successive new model produced. The advent of the space and nuclear age brought this problem sharply into focus. No less important however, is the ever increasing cost of manned aircraft. Ten years ago the cost of a static destructive test for a bomber type airframe was approximately $3,500,000. Today, a similar test for a supersonic transport costs about $25,500,000.

To supplement the destructive tests it is necessary to check periodically every similar aircraft throughout its working life. This is done by thorough visual inspection or "sampling" of critical areas. If the structure is inaccessible for visual "sampling," or where the suspected defect might be too small to be seen with the naked eye, Non-Destructive Testing (NDT) or Non-Destructive Inspection (NDI) techniques are then used. The Non-Destructive Inspection (NDI) techniques most readily recognized in the Aerospace industry are magnetic particle inspection and liquid penetrant inspection.

The remaining Non-Destructive Testing (NDT) techniques become more specialized and require trained technicians to interpret the results of the tests. The NDT methods include radiography, ultrasonic testing, and eddy current testing.

All of the techniques of NDT/NDI were either already being effectively utilized or were under consideration and evaluation for possible beneficial application to Naval aviation.

FEDERAL AVIATION ADMINISTRATION

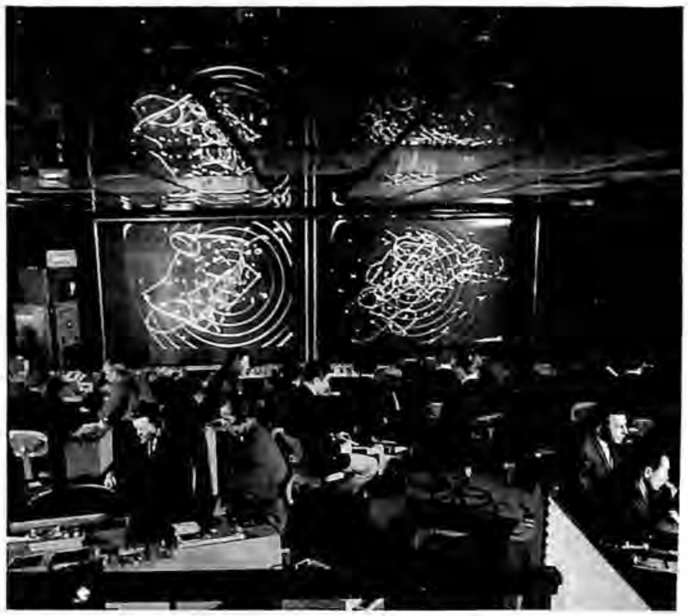
The Federal Aviation Administration relies upon research and development projects to support its efforts to improve air safety and advance civil aviation. Responsibility for most of the FAA's research and development projects is delegated to the Systems Research and Development Service (SRDS), the Aircraft Development Service (DS), the Office of Aviation Medicine and the Civil Aeromedical Institute at the agency's Aeronautical Center, Oklahoma City, Oklahoma.

To acquaint the aviation community with FAA sponsored research and development projects under way, the agency held its first annual "Report To Industry" meeting at its Washington, D. C., headquarters in June 1967. Among topics discussed were: Development and Implementation of National Airspace System Airport, En Route and Communication Programs; V/STOL (vertical and short take-off and landing) Transportation; Air Navigation; Safety Programs; and Aeromedical Research.

In December, FAA joined with other governmental agencies and industry/government groups to sponsor a symposium to encourage industry to develop a Pilot Warning Instrument capable of alerting pilots of a potentially hazardous traffic situation in the air.

Unlike the more complex and costly computer-driven Collision Avoidance System, under development for use by the airlines, the lower priced system would provide a pilot only with the essential information needed to locate other aircraft in the immediate area. The more sophisticated CAS evaluates a potential hazard in the air and suggests evasive maneuvers for use by the pilot. FAA research demonstrated that development of a CAS was possible and could work effectively. The agency was cooperating with industry in development of a CAS.

The greatest number of research and development programs were managed by the agency's Systems Research and Development Service. SRDS has the responsibility for performing or arranging for the research, development and engineering required to plan and design equipment needed to provide a high degree of automation for control of air traffic within the National Airspace System. During 1967, SRDS engineers completed the specifications for automation of the nation's 62 busiest Terminal Radar Control (TRACON) rooms. Automation of TRACON rooms and a plan developed by the agency's National Airspace System Program Office (NASPO) to automate the Air Route Traffic Control Centers in the National Airspace System is part of an overall plan to modernize air traffic control facilities.



At its National Aviation Facilities Experimental Center, FAA was testing 9- by 12-foot large screen projection displays which provide a composite picture of radar/beacon video and computer-processed alphanumeric flight data for air traffic controllers.

The new system of semiautomated terminal and en route facilities will provide automated radar display of aircraft identification, altitude and ground speed marked with alphanumeric (letters and numbers) tags. The alphanumerics will appear as a luminous block of coded information on a controller's radar display. The data blocks will be electronically attached to the correct radar blip, and automatically follow the blip across the screen. In addition to providing the identity, altitude, tracking and ground speed, the system can be equipped to report an aircraft's attitude (whether climbing, descending or in level flight).

By contrast, without the benefit of the new system the controller must memorize the identity of each blip on the radar screen or write coded information by hand on small clear plastic markers (shrimp boats) and manually move the markers across the radar screen as the blip moves indicating the new position of the plane. Controllers view a 2-dimensional (range and bearing) radar of each plane even though a plane may be equipped with an altitude transponder. The third dimension, altitude, must be radioed by the pilot to the ground-based controller.

The semiautomated system also will perform other necessary functions such as: automatic coordination and transfer of flight control of an aircraft between controllers working adjacent sectors within an air traffic control facility and between facilities, automatic updating of flight information, automatic printing and distribution of flight data to control sectors, error checking of a pilot's and controller's actions, automatic processing of flight plans and electronic display of significant in-flight weather conditions. Eventually, when the system becomes fully automated, the equipment will perform additional air traffic control functions, such as predicting impending traffic conflicts and suggesting ways of resolving them, flow control advice in congested traffic situations and pre-planning the sequence of arrivals at airports.

FAA's predecessor, the Civil Aeronautics Administration, first began research and development work in air traffic control automation in 1951 and these efforts led to various improvements in the system. After a Presidential Task Force issued the Project Beacon Report in 1961, urging expanded use of automation in air traffic control including use of alphanumeric tags, the FAA stepped up experimental work.

By 1964, the FAA-developed Advanced Radar Traffic Control System was being field tested at the Atlanta Airport, and the Stored Program Alpha-Numerics at the Indianapolis ARTCC. In 1967, the latter system, renamed the Beacon Alpha-Numerics (BAN) was transferred to the New York Air Route Traffic Control Center for operational use. Eventually, all FAA Centers —there were 21 in the continental U.S. air traffic control system during 1967—and the more than 300 FAA airport control towers will be integrated into the automated system. As implementation of the semiautomation of the air traffic control system proceeds, the design will be continually updated to take advantage of technical advances and changing needs.

Other SRDS programs included development of an All Weather Landing System to permit automatic landings under zero visibility weather conditions. Many such landings already were completed in 1967 tests at FAA's National Aviation Facilities Experimental Center near Atlantic City, New Jersey.

SRDS personnel began testing very high frequency radio voice communication via satellite between a ground-based air traffic controller in Alaska and an FAA flight crew in an agency aircraft flying over sections of the United States and the Pacific Ocean. Messages were sent and received successfully by way of the National Aeronautics and Space Administration's Applications Technology Satellite—hovering in synchronous orbit above Christmas Island in the Pacific Ocean. VHF channels via satellite provided static- and fade-free communication in the successful FAA tests. The FAA hoped to test satellite capabilities in areas of communication, data acquisition and navigation.

Other areas of SRDS research included wake turbulence, clear air turbulence, control of birds on and around airports, cost/benefits analysis of televised radar for general aviation, comparison of manually prepared and computer generated techniques for weather forecasting, evaluation of a high-gain VHF/UHF communication facility, radioisotope taxi guidance system feasibility study, and separation of aircraft in the North Atlantic area.

FAA's Aircraft Development Service pursued continuing programs of aircraft safety development in civil aviation. The service continued its research and development investigations of methods of fuel containment following crashes. Investigations of aircraft accidents showed that many passengers who survived the initial impact of a crash died in post-crash fires fed by materials on the interior of aircraft and fuel spilling from tanks. DS was developing fire resistance standards for materials used on aircraft interiors and was testing thickened fuels, which do not ignite as readily or burn as rapidly as liquid fuel.

In an effort to provide more rapid ways of emergency evacuation following a crash, DS was working on a design of an emergency exit system using an explosive technique to open doors. Methods of rating flammability characteristics of gelled fuels also were under development. Studies of ways to eliminate deadly smoke and toxic gases spewing from the burning of plane interiors were under way.

A project by DS proved that grooved runways provide increased traction for aircraft, particularly during periods of heavy rain when the hard surface becomes wet and slippery. Various airports, including Washington National which is operated by FAA, later grooved one or more runways.

A series of projects was undertaken to determine how lightning strikes may affect an aircraft in flight and develop lightning protection measures for aircraft fuel systems. Another project on determination of flame propagation hazards to an aircraft fuel system was initiated during 1967.

DS studied the reaction of 120 pilots operating a transport aircraft under simulated severe turbulence conditions. Development of an optimum stall warning method for light aircraft pilots was the object of another DS project. A program to test the fatigue and fracture toughness of high strength aircraft steel was initiated.

The Aeromedical Applications Division of the Office of Aviation Medicine plans, administers, coordinates and evaluates research work conducted at the Civil Aeromedical Institute. The division also has the responsibility of human factor data gathering, processing and analysis with relation to aircraft accident investigations and bioengineering—application of life sciences information for aircraft design.

An important development of the Institute during 1967 was the antismoke hood, a device designed to protect passengers' eyes and respiratory tract from smoke, noxious fumes and heat, and provide an extra 3 to 5 minutes of breathable air in event of emergency evacuation of an aircraft. The hood is made of fireproof material and protects a passenger from burn damage to his face, ears, head and neck.

In another project the Institute was responsible for the initiation of designs for a universal simulator for advanced aircraft such as the supersonic transport and large jets. The unit will be used in smoke and lighting studies, to evaluate escape devices and exit features during evacuation. Other studies were concerned with impact survival research, proper installation of shoulder harnesses, effects of alcohol on flying, side facing seats and proper torso restraint, executive jet decompressions and small window size in aircraft, cockpit noise levels, pilot rehabilitation relative to heart disease, and inflight physiological monitoring of student pilots.

The FAA-managed supersonic transport development program moved in 1967 from the competitive design phase into the prototype construction phase. On May 1, 1967, contracts were signed with Boeing and General Electric for construction of 2 SST prototypes.

The prototypes will be built by The Boeing Company and a nationwide team of subcontractors and suppliers and will be assembled at the Boeing Developmental Center in Seattle, Washington. General Electric Company will build the engines, each of which will produce more than 60,000 pounds of thrust.

With its newest design refinements, the U.S. SST is a 318 foot long titanium airplane with variable-sweep wings. With wings set at 30 degrees, fully loaded take-offs will be made at about the same speed and using less runway than 1967 jetliners. Landing approach speeds at the same wing sweep setting will also be about the same as big jets.

During subsonic flight the SST prototype's wings will be swept to an intermediate position of 42 degrees. With the wings at this setting the airplane will cruise efficiently at speeds equal to those of subsonic jetliners. For supersonic flight, the SST's wings, pivoting on giant bearings, will sweep back to 72 degrees, mate with the horizontal tail into a single lifting surface, and reduce drag for cruising at Mach 2.7 (1,800 miles per hour), almost 3 times the speed of sound.

Slotted trailing-edge flaps and leading-edge slats bordering 85 percent of the SST's wing will provide added lift for take-off and landing. The super jet prototype will climb rapidly after take-off and will approach for landing at low engine power setting. This will mean lower sound level in communities under the take-off and landing flight path of the SST. Additional sound-reduction features will be built into the engines.

The SST will have a canard surface, like a small wing, near the forward end of the fuselage. The canard provides the primary longitudinal control in flight, but is assisted by the tip elevons and elevators on the horizontal tail for landing and take-off. Wing-spoilers are used for direct-lift control to help vary the landing approach path by increasing or decreasing wing lift.

The U.S. SST prototype airplanes will be fitted out for flight tests. The forward cabin will contain flight test instrumentation and recorders, with positions for flight-test engineers. The aircraft will contain tanks for the water ballast used to vary the airplane's center of gravity and payload for testing. Just forward of the wing, a section of the fuselage will be fitted with an airliner passenger interior including 52 seats, a galley and a lavatory. The entire upper deck will be pressurized and air-conditioned, as will the baggage compartment in the forward lower deck.

The first SST prototype was scheduled to fly by the end of 1971 with the second one not far behind. The initial flight test phase should be completed by the middle of 1972, and this experience will provide the technical basis for proceeding into the certification and production phases of the SST. If all goes well, the production model could be certificated and ready for airline service by 1975.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The nearly flawless flight of NASA's Saturn V rocket on November 9 was a major achievement for the space agency in 1967. It was, furthermore, a tribute to the large number of industrial contractors and university research teams whose skills and knowledge in science and technology made Saturn V possible.

Destined to launch American astronauts on a round-trip journey to the moon, the 36-story-high Saturn V collected enough data on its first flight to fill a standard encyclopedia during each minute of its 8-hour, 36-minute mission. By way of comparison, in Project Mercury flights, first in the manned space vehicle program, data obtained was equivalent to a standard printed page produced every second.

Driven by engines producing 7,500,000 pounds of thrust, plus second and third stages, and with more than 1,000,000 moving parts, the great rocket lofted Apollo 4 some 11,234 miles into space. From there, the lunar vehicle was propelled in a 25,000-mile-per-hour dive back to a planned splash-down in the Pacific north of Hawaii. Heat that developed in the dive reached temperatures of around 5,100 degrees Fahrenheit.

The flight proved the Saturn V booster and the Apollo heat shield for their designed functions. It also retrieved in some measure the Apollo program from its low point suffered in the flash fire during a test on the launch pad at Cape Kennedy on January 27. The fire, which killed Astronauts Virgil I. Grissom, Edward H. White II, and Roger B. Chaffee, necessitated major changes in the Apollo Command Module. Most of the combustible materials were eliminated and the spacecraft's hatch, through which the crew enters and exits, was redesigned so that it could be opened very quickly in case of emergency.

Another major NASA effort during the year was the Surveyor lunar soft-lander series, in a continuing mission to explore possible landing sites for the Apollo program.

Surveyor 3, after a rough, bouncing landing on the moon April 19 due to failure of its closed-loop radar, televised over 6,000 pictures. A surface sampler experiment also found that 6-inch pebbles had a bearing strength of 10 pounds per square inch.

Surveyor 4, sent aloft in July, stopped signalling seconds before its scheduled landing, and was presumed to have crashed or blown up.

Surveyor 5, despite a fuel system leak requiring ground controllers to change the landing plan as it sped toward the moon, dropped safely in the target area on the southwest edge of the Sea of Tranquillity.

Highlight of its mission was the first on-site analysis of the composition of a heavenly body. A 6-inch square metal box sensor was lowered to the lunar surface on command from earth. Detection devices measured the rebound of atomic particles striking lunar material. The readings, translated into radio pulses, were transmitted to scientists on earth. Much of the material examined was found to be basalt, common to our world. The 600-pound spacecraft returned more than 18,000 pictures before being shut down for the 2-week lunar night.

With Surveyor 6 came a new achievement in spacemanship. The spacecraft, which landed on the moon early in November in the Central Bay, was relaunched by remote control from Jet Propulsion Laboratory, Pasadena, California, to land about 8 feet from its original resting spot. The craft's small vernier rockets—one on each of its 3 legs—were fired simultaneously for 2½ seconds for a 6½-second flight.

Immediately after touchdown, the Surveyor trained its TV camera on its old landing position. Spectacular pictures showed clearly where the landing pads had sunk into the soil, and also revealed the area burned by the vernier engines when the craft took off. By pairing the new pictures of the surface with those taken before the moon hop, scientists will be able to get a stereoscopic view of the moonscape.

Important data on how life forms might develop in a weightless condition accompanied by radiation, and how such effects might influence life forms, was gained from the 45-hour journey in orbit of Biosatellite II. Launched from Kennedy Space Center on September 7, the spacecraft was returned to earth after 17 orbits, somewhat earlier than planned because of a massive tropical storm moving into the recovery area.

The capsule carried hundreds of thousands of plant and animal life forms. Preliminary findings of space condition effects on living forms and their progeny could be made in the first few months following the capsule's return.

Wheat seedlings were found to grow faster in space than on earth. Their roots, moreover, curved upward and to the sides instead of down. Pepper plant leaves folded down and turned under.

A biologist in charge of the bacteria experiment said there were indications that "stuff in space grew better and to a greater density than the same stuff on earth."

Experiments on other life forms, such as insects and tadpoles, were still undergoing study at year-end.

Three more vehicles in the Lunar Orbiter series carried out Apollo support photographic missions in 1967, looking for suitable landing sites for astronauts to land on the moon.

All 5 Orbiters, from the first launched in August 1966 to the last in August 1967, were highly successful. The wealth of photographic detail gained from the series stands as the definitive source of lunar surface data to date. Both front and back faces of the moon were mapped in their entirety.

The largest part of Orbiter 5's mission was assigned to photographic targets of primary scientific interest to permit more detailed interpretation of lunar surface phenomena than was possible before.

International communications via satellite were augmented in 1967 by 3 launches by NASA for the Communications Satellite Corporation.

Intelsat II-B was positioned over the equator in the Pacific near the international dateline. Telephone, TV and teletype messages were relayed through its circuits by ground stations on the U.S. mainland, Hawaii, Japan and Australia. It also will assist in fulfilling Project Apollo communications requirements, and provide military communications between Hawaii and Japan, and Thailand and the Philippines.

Intelsat II-C, called Canary Bird, was placed in high Atlantic synchronous orbit to serve as a switchboard for 4 continents. It also will be a key relay point between earth controllers and the Apollo lunar mission.

Intelsat II-D, final launch of communications satellites for the year, went into stationary orbit over the equator southwest of Hawaii. It will act as insurance in case of failure of Intelsat II-B whose only spare transmitting tube failed. Meanwhile, the 2 Pacific satellites doubled the capacity of spaceborne commercial communications traffic relaying between North America, Hawaii and Asia.

These satellites were launched by NASA for Comsat Corporation on a reimbursable launch support basis. The vehicles were developed from experimental spacecraft pioneered by the space agency.

Two more weather satellites were launched by NASA during the year for the Commerce Department's Environmental Science Service Administration.

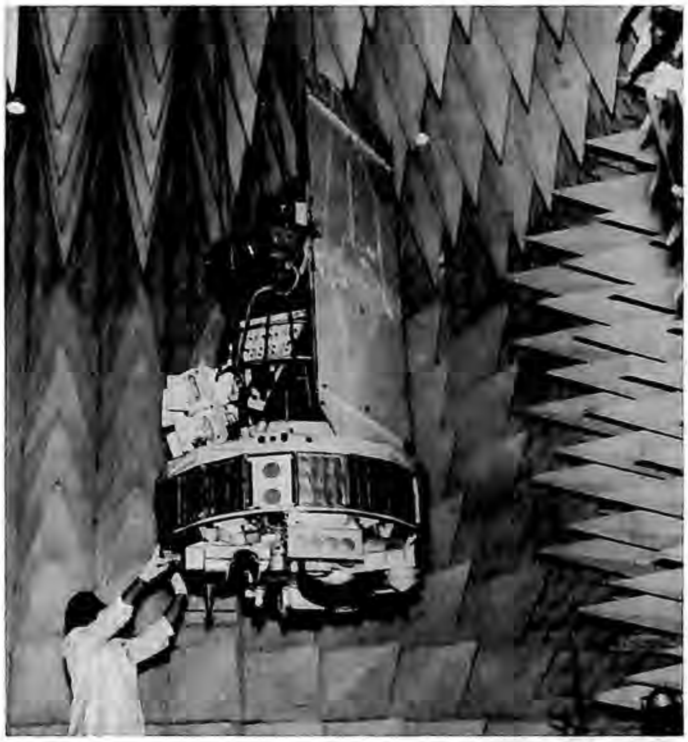
ESSA IV (NASA's TIROS-B), an advanced version of "cartwheel" configuration, which turns in orbit so that its instruments and camera always aim toward the earth, was placed in a nearly polar sun-synchronous orbit on January 26.

ESSA V, carrying an advanced Vidicon Camera System, was launched into sun-synchronous polar orbit on April 20 from the Western Test Range, California.

The ESSA program is the world's first operational satellite system providing practical weather data covering the entire earth on a continuing daily basis.

ESSA VI, launched November 10, carried 2 TV systems used for the Automatic Picture Transmission (APT) ground stations. The cameras photograph the earth's cloud cover every 6 minutes. The pictures are sent automatically to any properly equipped ground station within a 2,150 mile range of the spacecraft. Each photo covers an area of 4,500,000 square miles.

Following ESSA IV's launch in January, APT receiving stations increased from 180 to 305, 216 in the U.S. and 89 in other nations.



NASA was readying Nimbus B, second generation weather satellite, for 1968 launch. Here engineering model of the spacecraft undergoes radio frequency interference tests.

The third Orbiting Solar Observatory to be lofted by NASA was launched in early March. It carried small telescopes and optical sensors to study the sun's radiation. Other instruments were examining solar radiation effects on the earth's atmosphere and ionosphere.

Two successful launches in the Interplanetary Monitoring Platform (IMP) program were made, the first on May 24 and the second in July. IMP-E, renamed Explorer XXXV, went into lunar orbit July 22 for detailed study of the earth's magnetosphere. IMP-F, Explorer XXXIV, was investigating the region between the magnetosphere and the shock front created when the sun's particles meet the magnetosphere.

Meanwhile, NASA's fourth Orbiting Geophysical Observatory, launched in July, was studying earth-sun relationships during a period of mounting solar activity to complement near solar minimum activity data previously gathered.

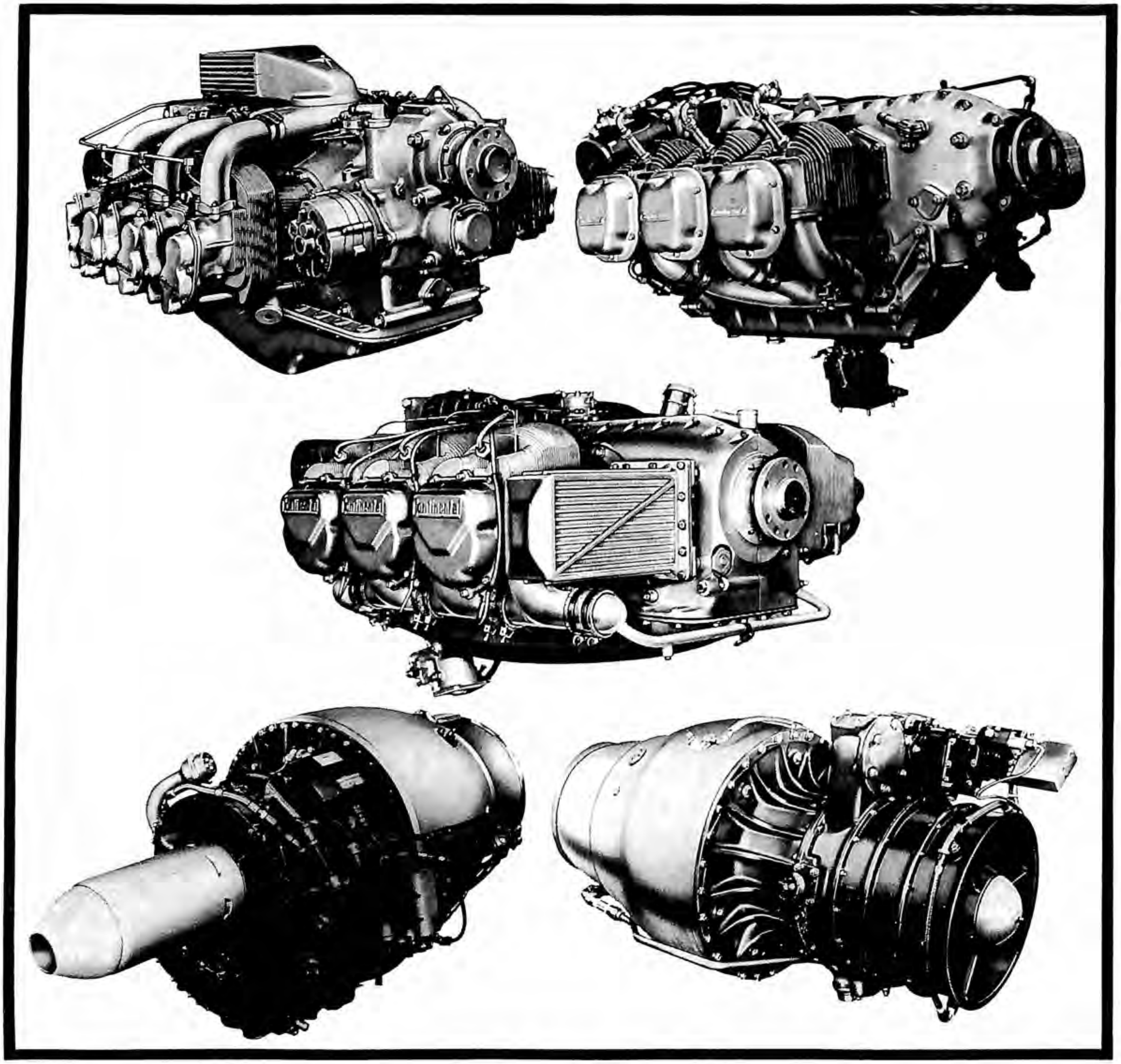
An unplanned "race" developed when Russia's Venus 4 space probe, launched on a 4-month flight on June 12 to our nearest, most mysterious sister planet, was followed 2 days later by Mariner 5 on a similar mission: to probe the cloud-shrouded Venerian atmosphere and collect data on its radiation and magnetic environment.

Mariner V flew within 2,500 miles of its target planet on October 19, while the Soviet spacecraft parachuted recording instruments toward the surface 2 days earlier. Data radioed back by the NASA vehicle revealed that Venus is a "psychedelic hell-hole" where optical images are so distorted by the dense, largely carbon dioxide atmosphere that a visitor might see the back of his own head. The heavy atmosphere bends light in such a way that the horizon would appear to a visitor to curve upward, giving him the impression of being in a hole.

Mariner V also found that Venus, in addition to being very hot, has only a weak magnetic field.

While the Mariner V Venus mission was in progress, space engineers sent commands to the Mariner IV Mars spacecraft to check its camera and data storage system for the first time since the spacecraft transmitted its historic close-up pictures of the Red Planet in 1965. The vehicle, in operation 4 years after launch, had traveled more than 1.5 billion miles in solar orbit, and engineers were interested in the condition of the camera and the ability of the data storage system to record on magnetic tape after long exposure to space conditions. The equipment responded normally, but its nitrogen gas supply was expected to run out within a few weeks.

As NASA entered into its tenth year, the crew for the first manned Apollo flight planned for the summer of 1968 was selected. They are Astronauts Walter Schirra, Don Eisele, and Walter Cunningham.



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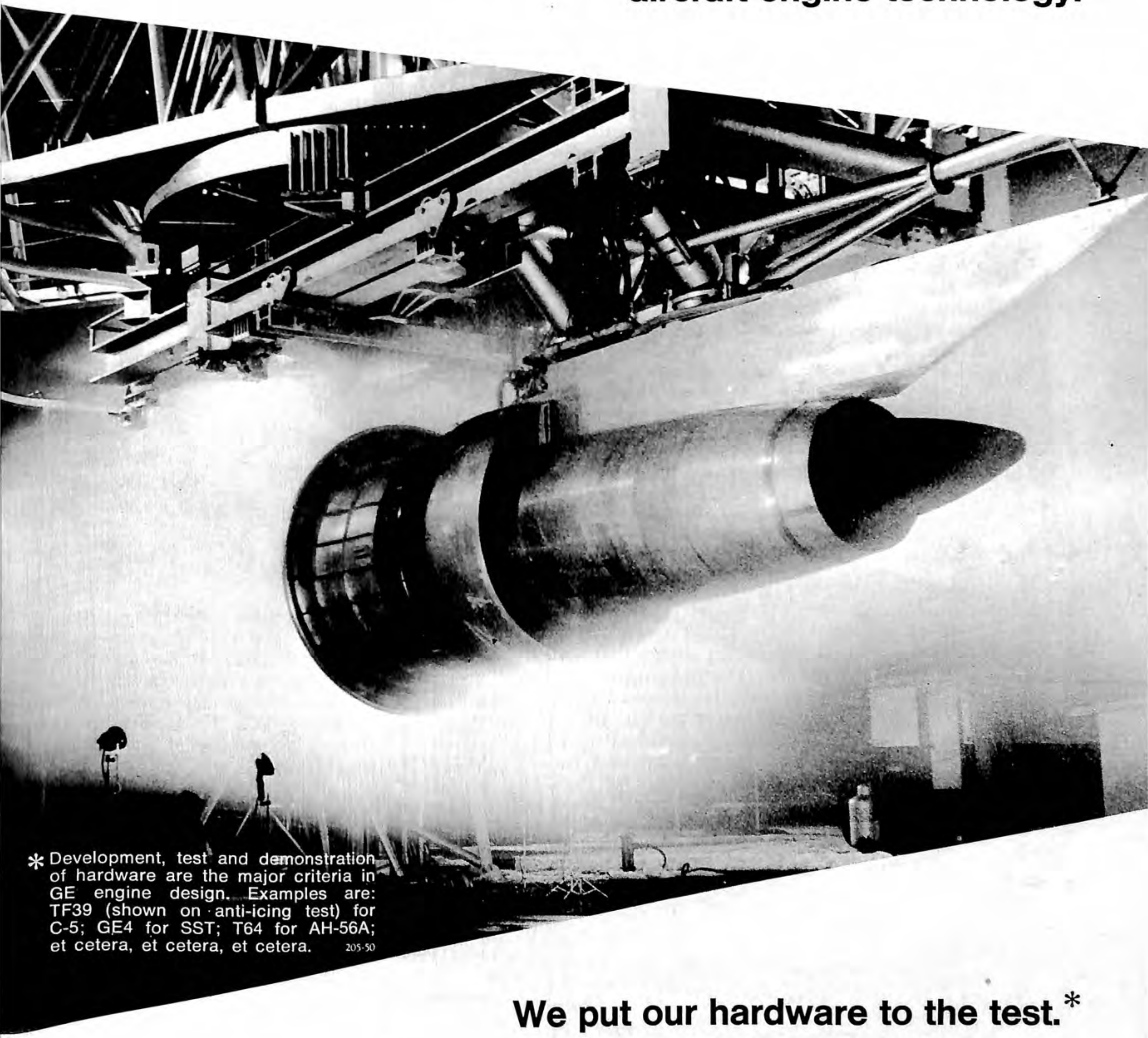

* Development, test and demonstration of hardware are the major criteria in GE engine design. Examples are: TF39 (shown on anti-icing test) for C-5; GE4 for SST; T64 for AH-56A; et cetera, et cetera, et cetera. 205-50

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AIRCRAFT ENGINE GROUP

GENERAL ELECTRIC

CIVIL AVIATION

THE AIRLINES

Reflecting their continuing investment in new flight equipment, the scheduled airlines of the United States achieved record highs in service during 1967.

They carried approximately 134,000,000 passengers nearly 100 billion passenger miles, an increase of more than 22 and 24 percent, respectively, over 1966, and increased their cargo service (mail, freight and express) by 21 percent, to more than 3.5 billion cargo ton miles.

To help provide this additional service, the airlines took delivery of 387 new aircraft during 1967 valued at $2.1 billion. Including the 1967 deliveries, the 5-year (1967–1971) airline equipment program added up to 1,124 aircraft valued at $8.3 billion.

The following tabulation shows a breakdown of aircraft received and scheduled for delivery during the 1967–1968 period:

	Jets and Turboprops	Valued at
Received in 1967	387	$2.1 billion
Scheduled for delivery:		
1968	444	2.7 billion
1969	200	1.4 billion
1970	69	1.5 billion
1971	24	.6 billion
TOTAL	1,124	$8.3 billion

At year-end, the airline industry was among the top 7 U.S. industries in annual capital investment. In 1959, at the beginning of the jet era, capital expenditures totaled nearly $700,000,000. In 1966, capital expenditures topped the $1 billion level for the first time in airline history, reaching a total of $1.5 billion. In 1967, the $2 billion mark was passed and during 1968 the airlines anticipated delivery of about 444 aircraft at a cost of $2.7 billion.

The operating efficiency of new aircraft and related equipment has enabled the airlines to provide a better buy for the public. In 1962, it cost domestic passengers 6.45 cents to fly a mile. By 1966, the cost had been reduced to 5.83 cents. For the first 9 months of 1967, it was down further to 5.60 cents. This 13.2 percent drop in average airline fares since 1962 gains point when measured against a cost of living increase of over 7 percent during the same period. In the 4-year period as a whole, it represented a total saving to the traveling public of over a half billion dollars.

These promotional fare reductions were made possible under a variety of conditions, the major ones being the family fare plan, youth fares, the military standby program, and "Visit USA" and "Discover America" fares. In addition, numerous weekend and excursion fares vary with the carrier.

While the variety of promotional fares offered by the airlines has helped to stimulate travel, these reductions are also lowering the average revenue per passenger mile, or yield, the airlines receive from their passengers. The problem here is that if expenses continue to rise and if yields continue to decline the result could lead to lower profits and a drain on earnings at a time when the airlines are counting on a stable level of earnings to finance their massive expansion program.

To help make certain that the nation's airport system will be adequate to meet the future needs of air transportation, the airlines established in 1966 a new Airport Facilities Department within the Air Transport Association (ATA). The department embarked upon a program to assist all airline airports in the orderly and timely development of their facilities to serve the increasing volume of air passengers and air cargo, as well as the new family of high capacity aircraft that will be introduced within the next few years. Under this program, every airport used by the airlines will be analyzed to determine its future requirements. In this way it is hoped that not only will realistic airport facility planning be accomplished, but that such planning will be turned into steel and concrete realities in time to meet the public demand for improved and efficient airport services.

Growing public demand for air travel has not only had its affect on the kind of equipment the airlines are buying, the kind of airports that must accommodate this equipment, but also on airline techniques for handling passengers.

Through 1967, the airlines had invested more than $150,000,000 in new computerized reservations systems. As to tickets, they are in the process of developing an automatic ticketing system which passengers can operate themselves and which promises to provide tickets and confirmed reservations in 80 percent less time than it takes today.

By way of solving the baggage problem, industry invested $100,000 in an automatic baggage-delivery system (1967 saw a demonstration of the prototype model) designed to deliver a passenger's bag to him anywhere in the terminal area in under 3 minutes after being removed from the plane. The need for the system was compellingly demonstrated during the year when one airline's first extended DC-8 flight landed at Miami with 535 pieces of luggage. The aircraft coming into service in the early '70s will carry twice as many pieces.

During 1967, the airlines made noteworthy progress toward developing an airborne collision avoidance system (CAS), a device that can detect potential collision threats, tell the pilot what evasive maneuver to make and when to make it.

Evaluation of the system was to begin early in 1968 and was expected to continue through 1969.

Another air traffic control development of significance last year involved the use of satellites. Late in 1966, the airlines began to participate in air-ground communications tests over the Pacific using a satellite of the National Aeronautics and Space Administration known as ATS-1 (Applications Technology Satellite). The airlines did this believing that VHF (very high frequency) satellite relay would result in reliable, static-free communications over oceans and ultimately over uninhabited portions of the world as well.

So successful were the tests that on November 21 a test was conducted over the Atlantic. During the entire trip, the engineer on the flight talked directly and repeatedly with officials of his company in New York. In addition, transmissions to and from the aircraft via the satellite were monitored in London, Frankfurt, Hamburg and Buenos Aires. The industry believes that VHF satellite relay will result in a greatly improved air-ground communications system. Hopefully, it will become operational in early 1970.

During 1967, airline employment increased by about 13 percent to some 280,000 men and women. As of September 30, total payrolls were $2.425 billion, up from $1.855 billion in 1966. The average salary was $8,950, compared to $7,907 as of September 30, 1966.

For the 12 months ending December 31, 1967, the airlines experienced a safety rate of 0.23 per 100,000,000 revenue passenger miles, one of the lowest in the history of U.S. commercial aviation. The rate in 1966 was 0.07 and in 1965, 0.31.

NEW AIRCRAFT ON ORDER OR DELIVERED
TO U.S. SCHEDULED AIRLINE INDUSTRY 1967–1971
(December 31, 1967)

Manufacturer	Model	Total Aircraft Delivered or on Order	1967	1968	1969	1970	1971
Bell	JetRanger	2	1	1	--	--	--
Boeing	B-707	176	83	58	35	--	--
	B-720B	3	3	--	--	--	--
	B-727	262	113	109	40	--	--
	B-737	131	--	75	56	--	--
	B-747	88	--	--	--	64	24
BAC	BAC-111	8	4	4	--	--	--
Cessna	180/185	1	1	--	--	--	--
Convair	440	2	2	--	--	--	--
	660-240°	12	6	6	--	--	--
	580°	50	28	22	--	--	--
	990	2	2	--	--	--	--
De Havilland	DHC-6	1	--	1	--	--	--
	Otter	1	1	--	--	--	--
Douglas	DC-8	7	1	6	--	--	--
	DC-8-60	111	23	41	45	2	--
	DC-9	214	81	109	24	--	--
Fairchild Hiller	FH-227	28	28	--	--	--	--
	F-27	2	1	1	--	--	--
	FH-228	3	--	--	--	3	--
Lockheed	L-382B/100	5	5	--	--	--	--
Nihon	YS-11	10	--	10	--	--	--
Sikorsky	S-61	3	2	1	--	--	--
Short	Skyvan	2	2	--	--	--	--
Total—All Aircraft		1,124	387	444	200	69	24

°Conversions of piston to turboprop aircraft

AIRCRAFT IN SERVICE AND ON ORDER BY U.S. SCHEDULED AIRLINE INDUSTRY
(December 31, 1967)

	Manufacturer	Model	In Service		On Order	
FIXED WING						
Jet	Boeing	B-707	329		93	
		B-720	135		---	
		B-727	393		149	
		B-737	---		131	
		B-747	---		90	
	BAC	BAC-111	56		4	
	Convair	CV-880	45		---	
		CV-990	11		---	
	Douglas	DC-8	138		6	
		DC-8-60	23		88	
		DC-9	143		133	
	Fairchild Hiller	FH-228	---		3	
	Sud Aviation	Caravelle	20		---	
		Total		1,293		697
Turboprop	Canadair	CL-44	21		---	
	Convair	600	45		1/	
		580	74		2/	
	De Havilland	Otter	1		---	
		DHC-6	1		1	
	Fairchild Hiller	F-27	48		1	
		FH-227	56		---	
	Grumman	G-21/P6A	2		---	
	Lockheed	Electra	108		---	
		L-382B/100	10		---	
	Nord Aviation	262	12		---	
	Pilatus	P-6A	7		---	
	Short	Skyvan	2		---	
	Vickers	Viscount 700	46		---	
	Nihon	YS-11	2		10	
		Total		435		12

1/ 6 conversions of piston aircraft to turboprop.
2/ 22 conversions of piston aircraft to turboprop.

	Manufacturer	Model	In Service		On Order	
Piston	Convair	240	9		---	
		340	10		---	
		440	67		---	
	Douglas	DC-3	56		---	
		DC-6	109		---	
		DC-7	31		---	
	Lockheed	Constellation	6		---	
		Super Constellation	31		---	
	Martin	404	62		---	
	Others		60		---	
		Total		441		---
		TOTAL FIXED WING		2,169		709
HELICOPTERS						
Turbine	Bell JetRanger		2		1	
	Boeing Vertol	107	7		---	
	Sikorsky	S-61	9		1	
		S-62	1		---	
		Total		19		2
Piston	Bell	47-G	4		---	
	Sikorsky	S-58C	3		---	
		Total		7		---
		TOTAL HELICOPTER		26		2
		TOTAL SCHEDULED INDUSTRY		2,195		711

AIR CANADA

Record passenger traffic, new aircraft, and new and improved services to the U.S. highlighted Air Canada's activities in 1967, Canada's Centennial year.

Expo '67 and nationwide celebrations of the country's 100th birthday helped to increase the number of passengers carried during the first 9 months to 4,847,000, a 17 percent increase over the same period in 1966. Air freight traffic was slightly lower than in the corresponding period in 1966 when a U.S. airlines strike pushed volume to a high of 89,743,000 pounds. Air Canada recorded a profit in 1966 and forecasted another profitable 12 months in 1967.

The Canadian flag carrier took delivery of 12 long-body Douglas DC-9 twin jets and 4 elongated DC-8 jetliners in 1967. The 94-passenger DC-9-32 was being

Air Canada took 1967 delivery of 4 new DC-8s.

used on the company's short-to-medium length routes in Canada and the U.S. On order were 18 long-body DC-9s, 3 elongated DC-8s, and 3 standard DC-8s for delivery in 1968–69. Air Canada operated 101 aircraft on 66,214 miles of unduplicated air routes.

A daily DC-8 jetliner service between Montreal, Toronto, and Los Angeles was inaugurated on September 29 following bilateral negotiations between the Canadian and U.S. governments. The Canadian airline also introduced nonstop daily service to Miami from Montreal and Toronto with 2 additional daily flights beginning December 15, and daily/direct DC-9 jetliner service between Montreal and Chicago.

To provide more modern and efficient service to air freight customers, Air Canada opened a new cargo terminal in Calgary on April 17, was doubling the capacity of the Toronto terminal for the end of 1967, and building new terminals in London, England, and Winnipeg for 1968.

The Canadian national airline constructed a unique helical-roofed pavilion at Expo '67 which told the story of man's yearning to fly, his early triumphs, and today's achievements in the air. More than 2,000,000 people from all over the world visited the $1,500,000 exhibit.

ALASKA AIRLINES

The announcement of the purchase of one Boeing 747 was made at the Alaska Airlines stockholders annual meeting in August. Delivery is expected in 1971.

Passenger increase in 1967 required an additional jet and a Convair 990 was purchased from Varig Airlines.

Two more L-382 Hercules airfreighters were added to the fleet and they served well on the North Slope in the Arctic hauling oil rigs. The company held a one-year lease agreement in Ecuador hauling oil rigs for Texaco.

Merger plans were being pushed to completion between Cordova Airlines/Alaska Airlines and Alaska Coastal Airlines/Alaska Airlines. It was hoped these transactions would be finalized by the end of 1967. With these mergers consumated, Alaska Airlines will be able to serve approximately 92 percent of the Alaska population.

Alaska Airlines was granted a temporary service into Sitka and received authority from the Civil Aeronautics Board to continue this service until such time as the Board can review the request for permanent authority to serve this community with direct jet service from both Seattle and Anchorage.

Applications were filed with the Civil Aeronautics Board for service from Anchorage to Hawaii; to Minneapolis/St. Paul to Portland, Oregon and California points; and a direct route Los Angeles/San Francisco to Anchorage/Fairbanks, a completely new route concept.

The company moved into a $1,800,000 new hangar located at Seattle-Tacoma International Airport in August. This facility provided Alaska Airlines with a more efficient operation of repair of equipment, maintenance, and compact location of headquarters personnel.

The airlines held a management agreement with Alyeski Ski Resort, 40 miles south of Anchorage. Plans were on the drawing board for many improvements in accommodations and ski areas for the near future.

A new Alaska Airlines office was opened in Washington, D.C., during 1967. The company continued to refurbish its ticket and freight offices throughout the system in the Gay Nineties decor established in 1966. Late August brought the official opening of the new Alaska Airlines ticketing office at the Northern Lights Shopping Center in Anchorage. This office will operate the same hours as the shopping mall to permit best possible service to the traveling public.

New tour buses were put into operation at the Nome station, as well as increased hotel accommodations with the addition of a 16-room wing to the company's Nugget Inn.

ALASKA COASTAL AIRLINES

The year 1967 was one of continued growth and change for Alaska Coastal Airlines. System figures for the airline's Southeastern Alaska routes showed boarding 136,195 revenue passengers, transportation of 3,973,904 pounds of cargo and 2,379,973 pounds of mail during the first 9 months. This represented a substantial increase over the year 1966.

Although the airline did not introduce any new equipment, several changes resulted in the airline's operation, among them the introduction of Convair 240 service for Juneau and the new Sitka Airport. Prior to construction of the airport, Sitka was served only by amphibious aircraft. The airline's new turbo-powered Grumman amphibian proved highly successful and greatly aided the airline's operations. (The major equipment of Alaska Coastal Airlines is amphibious.)

Highlighting the year's changes was the company's announcement of a plan to merge with Alaska Airlines, which at year-end was in the final phase of negotiation. The merger will bring improved service to the residents of Southeastern Alaska and open new markets for the carriers.

ALLEGHENY AIRLINES

Allegheny Airlines solidified its position as number one among the 12 U.S. regional airlines during 1967 through a number of major events.

Highlighting this period of outstanding progress and growth was the October 18th announcement that agreement had been reached on all terms leading to a merger of Allegheny and Lake Central Airlines.

The agreement is subject to approval by the Civil Aeronautics Board and the Allegheny and Lake Central shareholders. If approved, the merger was expected to become effective about April 1, 1968. Allegheny Airlines will be the surviving corporation with corporate headquarters and executive offices remaining in Washington, D.C.

Under existing certifications, the route system created by the merger of the 2 carriers would approximate 4,000 miles, a network extending from Boston south to Norfolk, west to Chicago and southwest to St. Louis.

The 2 airlines, pre-merger, served 9 common points—Washington, D.C., Baltimore, Buffalo, Cleveland, Detroit, Pittsburgh, Erie, Wheeling and Parkersburg, West Virginia.

Route applications before the CAB would provide still further expansion of the territory served by Allegheny and Lake Central.

Allegheny had pending before the CAB requests for new authority to serve Chicago nonstop from Pittsburgh, Cleveland and several New England cities, new service to Lexington, Kentucky and nonstop authorities from Pittsburgh to Boston, New York, Hartford/Springfield, Baltimore and Buffalo. In addition, Allegheny was seeking nonstop service from Milwaukee to New York and key New England points, and was an applicant in the Bermuda Service Investigation.

Allegheny service was initiated into Toronto, Canada, and Allentown-Bethlehem-Easton, Pennsylvania. Additional operating authorities newly awarded Allegheny by the CAB included: nonstop between Pittsburgh and Nashville and Memphis; Baltimore and New York; Baltimore and Boston; Philadelphia and Boston; Washington, D.C. and Boston; Washington, D.C. and Hartford/Springfield, and Albany, Baltimore and Philadelphia.

Lake Central proposed new service in the Gulf States—Midwest Service Investigation linking Chicago with Nashville, Memphis and New Orleans. The Chicago-Memphis and Chicago-Nashville service would offer both nonstop and one-stop flights, while Chicago–New Orleans would provide one-stop flights via Indianapolis, Cincinnati and Louisville.

For the year ending June 30, 1967, the 2 companies boarded over 3,000,000 passengers and produced 610,327,000 revenue passenger miles and 8,545,000 cargo ton miles.

During the year 1966, Allegheny alone boarded a record of 2,031,756 passengers—a mark that was surpassed in mid-October 1967.

On September 15, Allegheny completed an intensive program to convert its fleet to 100 percent turbine power. The accomplishment represented the fruits of a multimillion dollar project that was launched little more than 2 years earlier.

"Fun and Sophistication" was the theme of Allegheny's new fall/winter hostess uniforms.

Under existing equipment programs of both Allegheny and Lake Central, the combined fleet by the end of 1967 was to consist of: 6 DC-9-30 fan jets, 43 Convair 580 jet props, 10 F-27J jet props, and 12 Nord 262 jet props.

Scheduled for delivery by mid-1968 were 6 more DC-9-30 fan jets and one more Convair 580 jet prop. Options were held for 6 additional DC-9-30 fan jets for delivery during the first 6 months of 1969.

AMERICAN AIRLINES

There were colorful developments in American Airlines' passenger services during 1967, there were improvements and expansions in schedules and routes, and there were significant advances in the flight and maintenance areas.

The 3,000 stewardesses of American Airlines discarded their traditional uniforms in September and donned an "American Beauty" wardrobe that revolutionized all concepts of airborne attire. In a test conducted early in the year, more than 1,000 passengers endorsed the chic and modern wardrobe by an 8 to 1 margin. Features of the trend-setting outfit include a choice for in-flight wear of 3 dresses in basic red, white or blue, and replacement of the traditional hat in favor of hairbows to be worn to suit individual tastes. Teams of American Airlines stewardesses made tours of Europe and the United States during the fall, highlighting American's new look in stewardess costuming and selling European travel agents on the features of President Johnson's "Visit U.S.A." program.

One member of the team was American stewardess Patty Poulsen, who was crowned queen of the world's stewardesses at an international contest in Uruguay. She competed against stewardesses from 16 countries.

American's pattern of service continued to grow. New nonstop roundtrip service added during the year included Toronto–Los Angeles, Toronto–Chicago, New York–San Diego, St, Louis–Phoenix, San Antonio–San Francisco and Newark–San Francisco. Within an hour after Canadian Government approval of new nonstop services between Toronto–Chicago and Toronto–Los Angeles, American announced its all-jet schedules on the routes. The first nonstop jet service from Dayton to Dallas was added on August 1st and one-stop roundtrip service between Houston–Cleveland and Newark–Tennessee was inaugurated during the year. The first direct air service to Palm Springs, California, by a transcontinental airline was inaugurated by American early in December under authority granted through a CAB exemption order.

To serve more effectively the heavily travelled commuter-type segments on American's system, the airline began Jet Express service between New York's LaGuardia Airport and Boston in February. LaGuardia–Washington schedules were adjusted in July for a similar pattern on that route and LaGuardia–Chicago Jet Express was started in December. Following introduction of the Boston Jet Express service American carried more than 35,000 passengers a month, about 24 percent of the market, up from the 3 percent it carried in January. On the New York–Washington run, American had 19 percent of the market in July when it started the Jet Express service. The carrier's market penetration rose to 26 percent by September—35,400 passengers were using the service that month. The Chicago Jet Express provides some 32,070 weekly jet seats between New York and Chicago.

Astrolog was introduced in September. This is a system which records pilot techniques and takes readings on the engines' performance. The cost to the company to equip its entire fleet will be $17,000,000. Because Astrolog has such a great impact on air safety, American agreed to make it available to all other commercial airlines and private carriers in the world.

Besides Astrolog, the Operations Department claimed other laurels during the year. American's Winnie Gilliland was given the Federal Aviation Administration's national award for the airline mechanic who has contributed most to the safety of flight during the year. Mr. Gilliland devised an improved test procedure for a component of the automatic pilot system of Boeing 727 jets. Also, with the full backing of the FAA, American's maintenance experts developed an advanced concept called "Monitor Maintenance" which has enabled American to attain new levels of jet engine reliability while providing significant control over costs.

A revolutionary color movie system, called Astrocolor, made its debut on American in January. Astrocolor has 14 screens installed within the overhead hat rack. It allows freedom to passengers who prefer to listen to popular or classical stereo music, or who prefer to work on business or just look out the window. Astrocolor, made by Bell and Howell, is scheduled on all American Airlines transcontinental nonstop flights.

In the spring, American introduced Sky Club, an improved coach service. Featuring the atmosphere of a club in the sky, it includes roomier seating, special Sky Club hostesses on duty in terminals to greet and assist passengers, a selection of entrees for superb Sky Club meals, and games for children.

Dissatisfied with the present baggage situation, American invited the airline industry to share in developing a revolutionary high-speed baggage handling system that may cure the mounting congestion of baggage at airports. The system is designed to deliver bags from any point in a sprawling airport like Chicago's O'Hare to any one of hundreds of places there in a maximum of 180 seconds. Being tested in Detroit, the system is produced by Teletrans Corporation.

As the year was drawing to a close, the company announced plans for a multi-million dollar Academy of Flight where its professional pilots will receive graduate-level training for the supersonic and other highly advanced transports of the 1970s.

The Flight Academy will have some half-dozen buildings arranged in an attractive university-style setting to house classrooms, a safety research center, cockpit training aids, and similar facilities. When completed in 1969, the Academy will be the focal point of an educational complex which will be the largest airline personnel training center in the world.

The complex will include American's Stewardess College, whose current size will be tripled. The Flight Academy and College will be located on an 80-acre campus adjacent to a new supersonic-age airport being constructed between the Texas cities of Dallas and Fort Worth.

Fun was in store when top U.S. business leaders teamed up with stars of professional baseball and football in a unique golf tournament sponsored by American Airlines February 10–12. The American Astrojet Golf Classic, a $30,000 54-hole event, was held at the La Costa Country Club, near San Diego, California. Proceeds of the 3-day tournament went to the Camp Development Fund of the San Diego Council, Boy Scouts of America. Winners of the event were Pittsburgh Pirates second baseman Bill Mazeroski and Washington Redskins safety Paul Krause.

Innovations and new ideas were evident in the Freight Department also. In May, American Airlines became the first major trunk airline to adopt a "Zero Defects" program in its freight system. Employees voluntarily pledged to do the job right the first time under the well-known "ZD" program. In all, 18 separate measures are applied to rate each jetfreighter city's staff. The overall result will be a better freight service for American Airlines customers.

Besides increasing its jet freighter fleet by 40 percent, American's freight ton miles for the first three quarters of 1967 rose to an all-time high of 366,000,000 (including its Military Airlift Command contract operations across the Pacific), despite the fact that the 1966 figures reflected the additional freight carried by American as a result of the 43-day strike against 5 other U.S. trunk airlines.

During the year, American committed as many as 4 707 jetfreighters at one time to the MAC Pacific operation. American's MAC performance reliability averaged 97 percent since its inception in November 1966.

A new advertising campaign was launched by airfreight's new agency, Fuller & Smith & Ross.

Revenue passenger miles for the first 3 quarters were up 11.3 percent to 10,107,902,000. Net earnings for the 10 months ended October 31, 1967, were $45,542,000. While this figure was slightly below the 1966 figure, reflected in the 1966 earnings was the additional traffic carried by American as a result of the 43-day July-August IAM strike, less $29,000,000 paid to the struck airlines under a mutual aid agreement. Revenues totaled $699,266,000 for the first 10 months of 1967, an increase of 15.4 percent over the total for the same period in 1966.

Repeaters in 1967 were "Music 'Til Dawn" and the Astrosphere. "Music 'Til Dawn," sponsored by American Airlines, began its 15th year of good music through the night. The program is aired over 10 different radio stations in 10 major cities.

Astrosphere toured the nation's major shopping centers bringing the airplane seat to the consumer's doorstep. The Astrosphere is a huge 45-foot-high inflatable structure which houses 128 first-class 707 Astrojet seats laid out to create the impression of an airline cabin. Approximately 1,000,000 people at 29 shopping centers visited the unit this year.

Among the awards received by American this year were the "Builders of a Greater Arizona" medallion award for bringing national recognition to the state. American is the first company ever to receive the award. In addition, the Sign & Display Industry magazine promotion award was won by American for its "Discover America" program. Esquire Magazine made the company a winner of its "Business in the Arts Award." Also, the Institute of Outdoor Advertising gave American 2 awards in 1967, one for a painted outdoor bulletin and another for a travel poster.

During the year American submitted its brief on the important transpacific route case to the CAB. The proposed schedule pattern provides 54 daily one-way transpacific flights with combination aircraft and 38 weekly all-cargo flights. The flights would provide through-plane service between numerous mainland cities and 15 Pacific points, including Honolulu and Tokyo.

Other Pacific activity during the year included a joint venture between American Airlines and the Korean Government to build a 500-room luxury hotel in Seoul, Korea. Completion of the $11,000,000 hotel was scheduled for 1969.

Sky Chef Inc., a subsidiary of American, purchased the airline catering kitchen at the Honolulu, Hawaii, airport.

BONANZA AIR LINES

Bonanza was engaged with Pacific and West Coast airlines in a merger proceeding to form a new airline tentatively named Air West as the end of 1967 drew near.

A Civil Aeronautics Board hearing was held on the proposal in Washington, D.C., in November, with a recommendation by the examiner to follow at a later date.

Combined, the 3 companies would provide service to 8 western states and a portion of Canada. All 3 had route applications before the Civil Aeronautics Board, including one by Bonanza of service through the Phoenix/Tucson gateway to Guaymas, LaPaz, Mazatlan and Puerto Vallarta.

Earlier, the U.S. and Mexican governments agreed on the new route during bilateral negotiations which had been requested by Bonanza.

Approval of both the merger and the Mexican route would create an airline with service from Canada to Mexico. Air West would employ some 3,000 persons initially, with that number expected to grow very quickly to 4,000.

Passenger traffic on Bonanza alone was expected to soar more than 18 percent in 1967 over the previous year, from 848,063 to 1,004,626.

Expedited hearings on the Service to Tucson Case and the Salt Lake City–Las Vegas–Southern California Case were completed in 1967, and a hearing on the proposed Mexican route was, as noted above, also finished.

Examiners in the Tucson and Mexican cases both recommended that Bonanza be granted virtually all the authority sought in each proceeding. The Tucson case would give Bonanza new authority to operate nonstop between Tucson, on the one hand, and the cities of San Diego and Los Angeles, California; Las Vegas and Reno, Nevada; and Salt Lake City, Utah, on the other.

It would also permit service between Tucson and all cities on Bonanza's two northern and its southernmost routes—the 5 cities named above plus Phoenix, Kingman, Grand Canyon, Page and Yuma, Arizona; Cedar City, Utah; El Centro and Santa Ana, California.

The Salt Lake case involves a route between Salt Lake City and Cedar City, Utah; Las Vegas, Palm Springs and San Diego. This authority would also allow Salt Lake City to Los Angeles service via Las Vegas.

Bonanza's all turbine-powered fleet continued to grow with the addition of more DC-9 fan jets. The carrier had 5 before year-end plus 12 F-27A turboprops. Two more DC-9s were on order for 1968 delivery.

BRANIFF INTERNATIONAL

A massive fleet modernization and expansion program, begun shortly after Harding L. Lawrence became Braniff International's new president in April 1965, was completed in 1967; and this, coupled with new route awards and the merger of Panagra into the Braniff system, enabled the airline to continue its rapid growth throughout the year.

During 1967, Braniff placed in service 23 new jet airliners to increase its jet and jet-powered fleet to 69, and at year-end was providing all-turbine powered service to every city on its extensive route system throughout the United States, to Mexico and South America, and on transpacific and Atlantic flights for the Military Airlift Command. The last piston-engine aircraft was phased out of the Braniff fleet on September 4.

The jet deliveries to Braniff during 1967 were of the latest models available, including the 2 longest-range aircraft manufactured in the world: 4 Boeing 707-320C Intercontinentals and 5 Douglas DC-8-Super 62s, plus 14 of the highly popular Boeing 727 tri-jets.

The deliveries of the latter, 9 of which were "QC" or quick-change models, brought the Braniff 727 fleet to 24, with 18 of them in the quick-change version. The "QCs" are capable of conversion from an all-passenger configuration to a fully loaded all-cargo or combination cargo-passenger configuration in 30 minutes, and are used by Braniff in passenger service by day and in jet freighter operation at night.

One of Braniff's 727QC jets loads cargo-filled cocoons in front of the airline's new $1,500,000 cargo facility at Dallas Love Field.

Delivery of the 727QCs enabled the airline to expand its all-cargo jet service from an initial system of 3 cities, inaugurated in August 1966, to a year-end 1967 network of 14 U.S. cities throughout the Braniff domestic system.

Cargo service to the Latin American countries on Braniff's system was not overlooked, either. During 1967, the airline increased its all-cargo jet freighter service to 4 flights weekly in each direction between the U.S. and South America, and expanded its service to include all but 4 cities served by Braniff in Latin America: Cali, Colombia; Antofagasta, Chile; and Rio de Janeiro and Sao Paulo, Brazil. Permits to operate all-cargo service to and from the Brazilian cities were pending government approval.

In January 1967, Braniff completed its $30,000,000 purchase of Panagra, a U.S. flag airline formerly jointly owned by Pan American World Airways and the W. R. Grace Co. and operating exclusively in South America. The merger of the 2 airlines became effective on February 1.

With the merger, Braniff began operating 30 round-trip passenger flights weekly between the U.S. and South America, with departure times spread more evenly around the clock to facilitate business and tourist travel between the continents. Later in 1967, the weekly frequency was increased and additional nonstop service offered.

The year also saw Braniff's domestic route system expanded with the initial award by the Civil Aeronautics Board in the Pacific Northwest-Southwest route case. On June 13, Braniff inaugurated thricedaily jet service over a new route linking Dallas/Fort Worth and San Antonio with Portland and Seattle/Tacoma.

The Pacific Northwest-Southwest case was also reopened by the CAB during 1967, and as year-end approached, the airline was actively prosecuting the deferred portion of its application in the case, which included improved access to Houston on the newly awarded route, the addition of Salt Lake City and New Orleans, authorization to operate turn-around service between Denver and the Pacific Northwest, and the extension of its present St. Louis-Kansas City service on to both Portland and Seattle.

As 1967 neared an end, Braniff was also an active participant in 17 other route cases pending before the CAB.

The airline has applied for service between 17 mainland co-terminals and Hawaii and to the Far East, Australia and New Zealand; for new southern transcontinental routes across the U.S.; and for improved access with nonstop privileges from major gateways in the U.S. to points served in South America.

Other route applications pending CAB action were Braniff proposals to expand its route system between points in the Gulf States and the Midwest; from Minneapolis/St. Paul to Denver, Los Angeles and San Francisco and from the Twin Cities and Milwaukee to the East Coast; from Seattle/Tacoma and Portland to California, Las Vegas, Dallas/Fort Worth and Chicago; from Omaha and Des Moines east and west on transcontinental routes; from Miami to London; from Houston to Cozumel, Mexico; and from the Northeastern U.S. to the Bahamas.

In addition to its extensive domestic U.S. route system and international service between North and South America, Braniff also, during 1967, saw its participation in Military Airlift Command contract service expanded to the point where the airline was operating the third largest civilian MAC charter service.

As a result of its expanded operations and fleet modernization, Braniff continued throughout the year to set ever-higher traffic records. For the 9-month period ended September 30, the airline reported a total of 3,510,199,000 revenue passenger miles flown, an increase of 56.5 percent over the same 3-quarter period in 1966. Cargo ton miles flown, reflecting the growth of the Braniff all-cargo jet system, were up 127.5 percent over the first 9 months of 1966, to a total of 84,-257,000 ton miles.

CANADIAN PACIFIC AIRLINES

Among the highlights of 1967 for Canadian Pacific Airlines was the addition of 4 199-passenger DC-8-63s, which abruptly altered the airline's problem from one of equipment shortage to a new one of having large blocks of seats to fill on many routes. Three of the DC-8s were delivered early in the year and a fourth came at mid-year.

Preliminary results for 1967 indicated that net income would be down despite total transportation revenue of around $95,000,000, about 16 percent above 1966. The latter resulted from gains of 18 percent in passenger revenue, 16 percent in cargo and 31 percent in airmail revenue. Charter revenue was down considerably as late delivery of new equipment precluded development of any sizeable charter program.

In the passenger field, North Atlantic business to and from Eastern Canada was up 34 percent, due mainly to the attraction of Expo '67 in Montreal, additional immigrant traffic, and, to a limited degree, new lower group fares.

Revenue increases of from 10 to 15 percent were recorded on the Orient, South American and Polar (Western Canada–Netherlands) routes. Addition of a new nonstop Toronto-Honolulu service late in 1966, plus the continuing popularity of the Pacific islands as a year-round vacation destination, resulted in a 20 percent improvement in Canada-Hawaii business.

Within Canada, transcontinental revenue for 1967 was down slightly, despite heavy Expo traffic. This was attributable to the fact that 1966 revenues on this route were inflated due to labor stoppages encountered by other carriers, and to the added competition of nonstop flights by Air Canada.

On the B.C.-Yukon-Alberta routes, revenues increased about 10 percent, but the rate of growth slowed due to a decrease in the level of construction activity with completion of several hydro and forest industry projects.

Site preparation for CPA's new $24,000,000 maintenance and overhaul base to be built at Vancouver International Airport was virtually completed. This major facility, which will be capable of handling the large subsonic and supersonic jets of the next decade, will take shape during 1968 and was expected to be completed in the spring of 1969. It will meet CPA's maintenance requirements for the next 20 years.

CPA's employment total, now over 4,000 people, was expected to continue to grow with added services. The airline foresaw requirements for a greater degree of technical competence, people with a high degree of specialization and more sophisticated knowledge of their specialty. It anticipated that wage rates for such people would be higher and would require an increasing share of the revenue dollar.

CONTINENTAL AIRLINES

The year 1967 was the year of the "New Look" at Continental Airlines. In October, the carrier announced a program aimed at broadening Continental's overall image to include the many new domestic and international activities the company has become involved in over the past few years. At the heart of the program was the new trademark, a dynamic oval with flaring contrails running through the center. It replaced Continental's Thunderbird, which (in one form or another) served as the company's trademark since 1944. The new symbol and the entire program were designed by Saul Bass & Associates of Los Angeles.

A major example of the new image program was the repainting of Continental's fleet of 37 Golden Jets. The paint scheme features 3 stripes (gold, lacquer red, and rich orange) from nose to tail on an all-white body. The tail remains gold, which is the only part of the previous design Bass retained. The new symbol appears in black on the gold tail and in red just in front of the name "Continental," which is lettered in black on the white fuselage forward and just above the gold stripe. The orange and red stripes (middle and bottom respectively) sweep to the very end of the plane, and the gold stripe flows up into the golden tail.

Continental's new paint scheme, shown on the Boeing 727, was introduced in October. It is a bold combination of orange, red and gold, incorporating the company's new corporate signature on the forward fuselage.

Continental at year-end had under way the biggest capital expansion program in its history, involving an outlay of more than $400,000,000 during the 1965–70 period. The money is being used for 46 new pure jets, including spare parts and related ground facilities; for maintenance base expansion and construction in Los Angeles and other major route cities, for jet training simulators, and for a new IBM 360/Model 65 Management Information System.

The 46 new jets (about a third of which had been delivered by year-end) include 19 Douglas DC-9Cs, 2 Boeing 720Bs, 9 Intercontinental Boeing 707-320Cs, 13 Boeing 727-200s, and 3 Boeing 747C Superjets. These new aircraft will more than double the company's fleet, which became pure jet early in 1967.

On November 6, Continental introduced a radically different promotional fare based on a progressive discount for multiple-destination travel. The new tariff, known as Visit the C.S.A. (Continental States of America), provides substantial discounts on multiple-stop trips. A few months earlier, Continental won CAB approval to introduce a new round-trip tour basing fare set at 120 percent of the current *one way* coach fare, and in 1966, the airline introduced an adult standby fare which allows persons 22 years and over to fly at one-third off the already low economy fare on certain nighttime flights between Chicago, Kansas City, Denver and Los Angeles. Continental pioneered economy fares when it introduced its three-class-service concept (first class, coach and economy on the same jet) on the Chicago–Los Angeles route in 1962. The tour basing fare went into effect June 1, 1967, and the adult standby rates were initiated August 1, 1966.

In April 1967, the Civil Aeronautics Board awarded Continental an important addition to its route system in the Pacific Northwest-Southwest Route Case. Under the terms of the award, Continental was authorized to provide service between the coterminals Houston and New Orleans and the coterminals Seattle and Portland via Oklahoma City, Tulsa, and Wichita; however, a portion of the case was postponed because of legal considerations and Continental has filed an application for the right to serve another 12 cities on the route, including Dallas, Denver, Salt Lake City, and Boise.

Overseas contract operations continued to increase substantially, with the company having flown approximately 4.5 billion revenue passenger miles in international service since starting Military Airlift Command flights in the fall of 1964. Continental was awarded a fixed military airlift contract for fiscal 1968 of $53,600,000 compared with fixed contracts of $29,400,000 for fiscal 1967, $7,500,000 for fiscal 1966, and $2,900,000 for fiscal 1965, the first year the company began Military Airlift Command operations.

In the more than 3 years Continental has been flying for the Military Airlift Command, the carrier has earned an enviable reputation for efficiency. During 1967, Continental's fleet of 320Cs had an average daily utilization of 16 hours and 5 minutes each, and the high-time 320C averaged 16 hours and 45 minutes daily; both were records for all commercial jet airliners. Continental's domestic utilization record was equally impressive. The company's Boeing jets were averaging about 14 hours a day and the DC-9s nearly 12 hours a day. Both figures were well above the industry average.

On another front, the wholly-owned subsidiary, Continental Air Services, was operating within Southeast Asia providing general aviation services for private construction firms and the U.S. Agency for International Development.

Economic prospects for the Trust Territory of the Pacific Islands were substantially brightened recently with the award of a 5-year contract for jet air service there by Continental. The contract, awarded by the Department of the Interior, which administers the Territory, called for twice-a-week jet air service for the islands of Truk, Saipan, Majuro, Palau, Ponape, and Koror, with service to Guam and Honolulu contingent upon action by the Civil Aeronautics Board.

Continental planned an intensive program to promote travel to the Trust Territory and will construct a hotel on each of the 6 islands receiving air service. The hotels will be built at the rate of 2 a year for 3 years. They each will have 25 rooms and a bed capacity of 50 and will be so constructed as to allow for expansion in the future. The air service will be provided by Air Micronesia, a company formed in 1967 by Continental, Aloha Airlines of Hawaii, and United Micronesia Development Association, Inc. (UMDA).

Continental announced plans to build a 100-room hotel on Guam near Guam International Airport. Partners in the venture are Lockheed Aircraft Service Company and Hyatt Corporation of America. The hotel will include a restaurant, bar, swimming pool, and the other usual tourist ammenities. Continental also held an option to lease a 15-acre site in American Samoa and was involved in another hotel development project in Hawaii with 2 island firms. Additionally, Continental operated sales offices in Honolulu and Tokyo to stimulate travel to the Mainland United States by residents of the Orient and the Pacific and to encourage travel on Continental while in America.

One of Continental's biggest efforts in coming years will be to get commercial routes between the Mainland U.S., Hawaii, South Pacific and Orient. Continental's was one of the broadest applications on file, encompassing North, Mid and South Pacific proposals. The company felt its extensive experience in this part of the world through military airlift operations and CAS and its other business involvements in the Pacific and the Orient make it an exceptionally strong contender in the case.

Continental had 3 Concorde supersonic transports on order and expected to be the first domestic carrier to offer SST service in the United States. The company also held reserved delivery positions for 3 U.S. SSTs to be built by Boeing.

One of the major changes at Continental in 1967 was the introduction of a new management concept in its field sales and service operations aimed at increased marketing flexibility. Under the new structure, a single marketing executive in each city has overall responsibility for the total sales and service effort, providing each market area with the kind of personalized, individual attention it warrants. This change constituted the concluding step of a company streamlining process which began in June 1966, when Continental announced a realignment of top management. The completion of this restructuring left the airline in a position where it can take better advantage of marketing opportunities as they develop and where it can comfortably accommodate the increasingly rapid growth it has been experiencing and which is expected to continue through the years ahead.

One important indicator of Continental's financial stability was that at the end of the third quarter of 1967, the airline had bank and institutional financing aggregating $168,600,000 on an unsecured basis and at favorable interest rates. Continental's net income for 1966 was $17,200,000 ($5.26 a share), compared with $10,400,000 ($3.26 per share) for 1967. The 1967 income figure is exclusive of gain from a non-recurring special item of $1,600,000 (51 cents per share). The 1966 results marked the year as the best in the company's history.

DELTA AIR LINES

Fiscal 1967 was an excellent year for Delta, an excellence measured tangibly by new highs in sales and in earnings.

In summary, Delta carried a record 9,400,000 passengers over a record 6.4 billion revenue passenger miles. Net earnings were a record $49,190,000 or $7.72 per share including a $2,400,000 gain on the disposition of flight equipment.

Operating revenues of $397,836,000 were an all-time high, and a 25 percent increase over the previous highs set in the preceding fiscal year.

Delta carried 9,422,422 revenue passengers on its domestic and international routes. This total, too, was an all-time record and a gain of 25 percent over passenger totals for 1966, a jump past both the 8- and 9-million marks for the first time. Revenue passenger miles increased 28 percent to a new record of 6,415,467,000

The 9,000,000 passengers, and their joint travel of over 6 billion revenue passenger miles, produced $362,368,000 in revenue, a 24 percent gain over 1966.

The passenger revenue growth was diluted by a 3 percent decrease in passenger mile yield, due to the continuing effect of promotional and other discounted fares. It is not at all certain that the discounted fares produced a commensurate increase in Delta revenues, but the benefits of air travel were brought to an ever-increasing market and young people and servicemen have been benefitted particularly.

It is estimated that, exclusive of pre-strike and post-strike effects, the 43-day stoppage of 5 major trunk lines in July and August added 271,000,000 revenue passenger miles and $17,000,000 in revenue above Delta's forecast for the same period.

Operating revenues from other sources—mainly freight, express, and mail—totaled $35,468,000. Freight and express ton miles increased 22 percent over 1966, reflecting the additional capacity provided by the L-100 airfreighters. Mail ton miles were up sharply by 70 percent and mail revenue reached $11,000,000 for the year.

The year showed earnings of $49,190,000, or $7.72 per share and was the 20th consecutive year to show a Delta profit. The comparative figure for 1966 was $34,554,000.

Shortly after the end of the fiscal year, the directors voted an increase in the cash dividend to 30 cents per share, for the September 1, 1967, quarterly payment.

Industry, nuclear power, tourism, climatic conditions and air traffic, both passenger and cargo, into and out of the South, steadily increased. Barring any economic geopolitical upheavals, there seemed little likelihood that such an increase will diminish. Five years ago Delta broke all air travel records in Atlanta when in one month it boarded 100,000 passengers. With the advent of more jets, boardings continued to increase and in 1967, during one month in Atlanta, Delta boarded 228,000 passengers. Five years ago a Delta milestone was reached when in a single year 1,000,000 passengers were boarded. This figure was reached in April 1967, and the 2,000,000th passenger was boarded in October 1967, a month ahead of 1966.

A number of years ago Delta foresaw an unusually large increase in air traffic. This was based on the probability that the forthcoming jet airplanes would be highly successful; as such it pioneered in 1959 the Douglas DC-8 and in 1960, the Convair 880. In 1965 it pioneered the DC-9 twin fanjet and the all cargo Lockheed L-100.

To supplement its jet program, Delta embarked on the construction of the South's most modern jet maintenance facility and later on its all computer Deltamatic Reservations System. In 1967 plans were announced to establish a $7,000,000 computer center in Atlanta that will nearly double the original availability. The new facility was expected to be ready for occupancy in early 1968 and will accommodate Delta's needs over the next decade. Construction continued during the year on the jet maintenance facility, which, when completed, will result in a 90 percent increase in operational capacity.

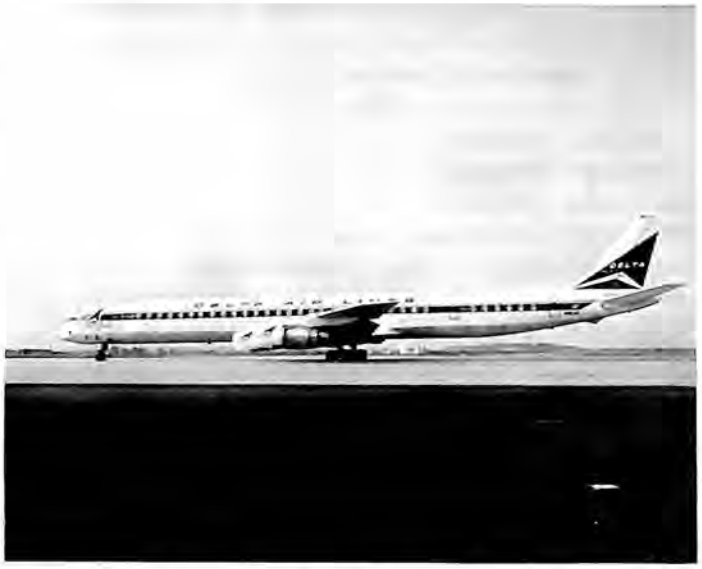
Delta's system terminal facilities received continual expansion and modernization during 1967. Nowhere was this more evident than in Atlanta, where 10 new aircraft gate positions continued under construction at a cost of over $7,000,000. Work on the 2 new 5-gate position rotundas was expected to be completed in July of 1968. At that time the airline will have 24 jet gate positions at its Atlanta terminal.

Delta inaugurated service with its new 195-passenger DC-8, the world's largest commercial jet airplane, over its Southern Transcontinental Route in 1967. At the end of the year 3 of these airplanes were in service. The Super DC-8s provided greatly improved and expanded service on the high density routes from cities such as Chicago and Detroit to Florida.

During 1967 Delta's jet fleet was strengthened by the addition of 3 Super DC-8s, one standard DC-8, 12 89-passenger Super DC-9 twin fanjets and one standard DC-9. In 1968, Delta expected to receive 25 Super DC-9s and 4 Super DC-8s. Orders or options were placed for 5 375-passenger Boeing 747s. By 1971, if all orders and options are exercised, Delta will operate 21 standard DC-8s, 18 Super DC-8s, 16 Convair 880s, 73 DC-9s (including 15 standard Models), 5 375-passenger Boeing 747s and 3 Lockheed L-100 freighters. The airline held delivery positions for 3 U.S. built supersonic transports.

Deliveries of additional jet equipment allowed Delta to expand its jet service to additional smaller cities. In 1968 piston airplanes will operate into fewer cities and by 1969, only into those cities which do not have adequate jet airport facilities. It was expected that the last piston airplane, the Convair 440, would be phased out of service in the spring of 1969.

The financial outlay for Delta's new jet aircraft program will exceed $800,000,000. To facilitate the financing for this new equipment, Delta, in 1967, arranged with 25 of its system area banks a $175,000,000 loan, believed to be the largest ever negotiated in the Southeast.



Delta took delivery of 3 DC-8-61s (shown), one standard DC-8 and 13 DC-9s during the year.

To meet the challenge of the jet age, the era of the giant jets which is immediately ahead, Delta in October 1967 broadened its executive base by the appointment of 10 new officers as assistant vice presidents. These Delta veterans combine a wealth of airline experience. By year-end 1967, the airline had a total of 16,000 employees.

Delta applied to the Civil Aeronautics Board for authority to serve a number of international and domestic routes. Categorically it desires to operate from its Southern Tier Cities of Atlanta, Miami, New Orleans, Houston, Dallas and the West Coast Cities of Los Angeles, San Francisco, and San Diego to Hawaii, Tokyo, Osaka, Seoul, Hong Kong and Manila. It also asked for authority to fly the Atlantic from its domestic cities of Atlanta, Miami, Dallas, Houston and New Orleans via the Washington and Philadelphia gateways to London, Paris, Frankfurt and Rome. Domestically it sought authority to serve the Rocky Mountain cities of Denver and Salt Lake City from the South and it would fly to and provide new service for San Antonio, Cleveland, Huntsville and Nashville.

EASTERN AIRLINES

In 1967 Eastern Airlines resumed its expansion, which had been slowed somewhat by labor troubles during the previous year. It was the year of "Grow Power" in which not only did Eastern's revenue passenger and cargo mileage show substantial increases but its routes were lengthened through merger and new authorizations granted by the Civil Aeronautics Board, its fleet of modern aircraft greatly amplified, its ground support facilities likewise modernized and enlarged, and its personnel given new training opportunities.

This was also a year in which Eastern entered new fields of diversification through acquisition of important resort hotel facilities in Puerto Rico and Hawaii.

Passenger boardings for the full 12 months exceeded 19,318,000 and revenue passenger miles were 11,171,693,000. Load factors generally showed improvement over 1966, with the January through December average reported at 60.7 percent.

Contributing largely to these results were the increased availability of seats on Eastern flights between the 95 airports served in 28 of the United States, parts of Canada and Mexico, and the islands of Bermuda, Puerto Rico and the Bahamas. On a single record day, June 30, Eastern carried 73,430 passengers; and in a single record month, August, 1,774,068 passengers, reconfirming the airline's position as the free world's second largest in this respect.

Thirty-nine new aircraft were added in 1967, bringing Eastern's jet fleet up to 138. These included one Douglas DC-9-10; 18 Douglas DC-9-30s; 6 Douglas DC-8-61s; and 14 Boeing 727 "Quick Change" Whisperjets. Arrangements were also made to dispose of 29 Lockheed Constellations, which were being gradually phased out of service. Orders were placed for 37 more jet aircraft for future delivery. Among the additional aircraft ordered were 2 British-French supersonic Concordes, bringing Eastern's total order to 6; 3 Boeing SSTs, raising to 5 the number for which the company has reserved delivery positions; 4 Boeing 747 "jumbo jets"; 2 long-range, large capacity Douglas DC-8-63s; 11 more Douglas DC-8-61s; 12 short-range Douglas DC-9-30s; and 9 of the dual-purpose passenger/cargo Boeing 727QCs. The investment in the new subsonic aircraft alone amounts to $236,000,000.

To provide funds for purchasing such increasingly costly aircraft and for other capital improvements, Eastern arranged new financing through the issuance of $75,000,000 in convertible subordinated debentures towards year-end. Earlier, stockholders had approved a doubling in the number of authorized shares of common stock (of $1.00 par value) from 15 to 30 million, and the issuance of 2,000,000 shares of preferred stock ($100.00 par value), permitting its Board of Directors flexibility in development of future plans and achievement of such long range goals as diversification through merger or acquisition of attractive properties.

Such a merger was consumated early in the year, when Eastern acquired the routes of Mackey Airlines, linking five points in Florida with the Bahama Islands and opening up this popular resort area to new potential tourist markets in the East, Mid-West, South and Southwest.

A significant acquisition, marking Eastern's entry into the hotel business, came with purchase from Laurance S. Rockefeller of a controlling interest in 2 of his finest resort properties, the Mauna Kea Beach Hotel, in Hawaii, and the Dorado Beach Hotel, in Puerto Rico, together with a share in their management company, Rockresorts.

In mid-December, Eastern's Board of Directors elected Floyd D. Hall, who had served as the company's president for the past 4 years, to the post of chairman and chief executive officer; Arthur D. Lewis, formerly senior vice president and general manager, to succeed Mr. Hall as president; Todd G. Cole, formerly senior vice president–finance and administration, to vice chairman of the board and chairman of the finance committee; and Charles J. Simons, formerly vice president and controller, to vice president and chief financial officer.

Several important reorganizations took place during the year within Eastern's internal organization, notable among them being the creation of an Operations Group headed by Samuel L. Higginbottom, vice president, with combined responsibilities for Customer Services, Flight Operations, Engineering and Maintenance, and System Control; creation of an enlarged Properties and Facilities Department under Markham S. Cheever, staff vice president, in the Finance and Administration Division; creation of a new Law Department headed by W. Glen Harlan, vice president; and a revised and strengthened Marketing Division under George S. Gordon, vice president.

Among the latter's marketing innovations was creation of an Eastern Travel Club ("etc") with its own exclusive hotel and resort facilities for the membership, and attractively priced vacation packages appealing to a wide range of single and married folk. With over 40,000 members in good standing as the year drew to a close, plans for expansion were already well under way for this venture.

Eastern's unique no-reservations, pay-on-board, high-frequency Air-Shuttle linking Boston–New York/Newark-Washington was able to hold its position as the prime mover of people over the Northeast Corridor in spite of vigorous competition from other carriers. Terminal improvements were completed at Washington National Airport; new Douglas DC-9-30 jets seating 107 passengers were introduced early in the year and by the year's close almost all first sections were being operated with this modern equipment. By spring of 1968 it was contemplated that all piston aircraft will have been retired from Air-Shuttle operations and that back-up service with extra sections will be provided by a large fleet of Lockheed turboprop Electras.

Most noteworthy new service added by Eastern during 1967 was the extension of its routes over the

"Aero Space Corridor" from Melbourne and Orlando, Florida, via Huntsville, Alabama, and St. Louis, Missouri, to the Pacific Northwest at Portland, Oregon, and Seattle, Washington. This service, inaugurated on June 13, placed Eastern for the first time on the U.S. West Coast and made it a truly transcontinental airline.

International service linking Toronto, Canada, with Florida, inaugurated late in 1966, was further expanded during 1967 to include direct nonstop flights between Toronto-Tampa and Toronto-Miami. New service was also introduced between Toronto-Buffalo-Pittsburgh-Atlanta.

While Eastern continued to press its applications for various new routes across the Pacific to Hawaii, New Zealand, Australia and various points in Southeast Asia, it also introduced new requests for domestic routes which would extend its services from the twin-cities of Minneapolis/St. Paul to Los Angeles or San Francisco, and give it access to Kansas City en route between St. Louis and the presently served points of Seattle and Portland.

In May, Eastern flew its first transatlantic mission, ferrying one of its big DC-8-61 jets for an appearance at the Paris Air Show. Then, starting in July, Eastern gained further valuable experience in operating large aircraft over long routes through its contract with the Military Airlift Command for the carrying of military personnel and their dependents. Initially its MAC flights, to which 2 DC-8-61 aircraft were assigned, were between McGuire Air Force Base, New Jersey, and points in Germany, Spain and the United Kingdom. Starting in October Eastern began transpacific flights from various bases in the United States to Vietnam via Honolulu, Wake Island, and either Guam or Manila.

A CAB hearing examiner in October recommended Eastern for new service authorization between New York and Washington, D.C., on the one hand, and Kingston and Montego Bay, Jamaica, on the other. The Board's decision on this was awaited at year-end.

Preparations for continued growth and expansion of air travel and air shipping were carried on throughout the year. Some 130 acres of desirable undeveloped real estate were purchased in Woodbridge, New Jersey, fronting on the Garden State Parkway, for investment as a future industrial park and site for Eastern's $5,000,000 regional reservations center. Work was started also on a new 12-story office building, to contain reservations facilities, at San Juan, Puerto Rico, and plans were announced for a $2,500,000 project to double the size of the regional reservations center at Charlotte, North Carolina, and to build a $2,300,000 reservations center in Atlanta.

At Miami new executive offices were constructed at a cost of $3,500,000, and a $1,600,000 building to provide accommodation for Eastern's new IBM-360 reservations computer equipment was completed as was a $1,000,000 building to house a regional reservations center.

The airline industry's most modern automated cargo distribution terminal was placed in service by Eastern in Atlanta during the latter part of the year. This facility, costing $1,400,000, utilizes highly sophisticated, automatic sorting devices built by the American Machine & Foundry Company, to speed the interchange of freight, express, mail and even preloaded enclosed pallets used in containerized service.

In January Eastern occupied new cargo terminal space at New York's J. F. Kennedy International Airport, and in December at San Antonio. As 1967 ended, work was progressing on other new cargo facilities at Toronto, San Juan, and Detroit Metropolitan airport, for early occupancy in 1968. When completed, these will add materially to this airline's capabilities for handling the expected increases in traffic as more of the "Quick Change" Boeing 727s go into service.

A school for training travel agents and Eastern employees in reservations, tariffs, ticketing procedures and other pertinent matters affecting sales was instituted during the year at Coral Gables, Florida, and it received, industry-wide acclaim.

Notable among the preparations Eastern was making for advent of the supersonic age was the appointment of one of the nation's most knowledgeable and experienced test pilots, Scott Crossfield, as system director of research and development for flight. Mr. Crossfield was the first man to reach Mach 2 in the X-15, and he has operated this experimental aircraft at speeds of up to Mach 6. Under his leadership and instruction Eastern expected to be ready for SSTs when they arrive.

FLYING TIGER LINE

Flying Tiger Line at year-end was ready to embark on a $25,000,000-plus program of facilities' expansion and modernization, in preparation for the phasing in of a new fleet of 17 DC-8-63F Jumbo Jet airfreighters, expected to start arriving in the spring.

The investment in the new fleet in itself amounted to $207 million, including spares and ground support equipment.

Extensive planning of facility and ground support requirements to accommodate the new fleet were under way throughout 1967, and as many as 8 stations were to be affected in the first phase of the system-wide improvement and modernization program in 1968.

Concurrently, a more subtle change was taking place within the sales and marketing element of the company as it, too, geared to make full use of the competitive advantage Flying Tiger Line will have with its new fleet of Jumbo Jets.

Realignment of the marketing function, which includes sales, was completed in 1967. A system of regional sales managers was set up in the United States, the Far East and Europe, and the domestic and international sales roles were fully integrated, organizationally. In the past, the 2 had functioned separately.

FTL has applied for transpacific authority which, if granted, would connect the carrier's domestic system with 8 major Far East points—Tokyo, Seoul, Okinawa, Taiwan, Hong Kong, Manila, Saigon and Bangkok, as well as Guam and Hawaii. Final Civil Aeronautics Board action on this case could come about in 1968.

In 1967, the airline asked that 12 new cities be added to its present domestic system, and in December a further 8 communities petitioned the Board to be included in the application, which brings to 20 the number of cities that FTL could be authorized to serve if the CAB approves the application. The cities are:

Charlotte, North Carolina; Atlanta, Georgia; Norfolk, Virginia; Nashville, Tennessee; St. Louis, Missouri; Oklahoma City, Oklahoma; Minneapolis–St. Paul, Minnesota; Indianapolis, Indiana; Syracuse, New York; Baltimore, Maryland; Washington, D.C.; Denver, Colorado; Kansas City, Missouri; Columbus, Ohio; Phoenix, Arizona; Omaha, Nebraska; and Norfolk, Newport News, Hampton and Williamsburg, Virginia, as a hyphenated point.

The growth history of Flying Tiger Line's present 14-city domestic system is in itself a reliable indication of the market potential of the new cities the carrier seeks to serve.

For instance, 1967 traffic required the introduction of two additional CL-44 turboprop freighters into domestic service which, in turn, created a need to lease 2 Boeing 707-320Cs to replace them in the transpacific military charter market.

Also, freight traffic to and from the Northwest reached the point where it justified the introduction of direct service to and from points East. Both Seattle and Portland were provided direct service, whereas previously all inbound and outbound traffic to and from those points was routed through San Francisco.

As of December 31, 1967, the few Lockheed Super Constellation aircraft still in service with the Flying Tiger Line were retired from use. Thus, at year-end, the domestic common carriage fleet was comprised of CL-44s in its entirety.

However, introduction of the DC-8-63F Jumbo Jets into domestic service in 1968 was to mark the beginning of the transition to an all-jet fleet by late 1969. Initially, the big jets will serve major market points such as Los Angeles and San Francisco in the west, Chicago and Detroit in the midwest, and New York and Boston in the east.

All these stations, along with 2 others, are included in the first, or 1968, phase of the facilities' modernization program. The other 2 are Newark and Cleveland.

Initially, only 6 of the stations will be equipped with automated in-terminal pallet handling equipment, but all of the 8 stations will be equipped with fully-mechanized on-ramp loading and off-loading equipment.

Modernization plans for 1968, on an individual station basis, were as follows:

- Los Angeles: Completion of terminal expansion project and aircraft ramp extension work by February. The capacity of the freight terminal building will be doubled, and the ramp extended to accommodate 4 Jumbo Jets. In-terminal and on-ramp handling equipment to be installed.
- Newark: Modification of freight terminal dock area to accommodate 2 Jumbo Jets, for completion in September, and installation of in-terminal and on-ramp handling equipment.
- New York: Development of an all-new freight terminal facility, with accommodation for 2 Jumbo Jets, and installation of in-terminal and on-ramp handling equipment.
- Detroit: Development of an all-new freight terminal facility on a new 9.5 acre site, with accommodation for 3 Jumbo Jets, and installation of in-terminal and on-ramp handling equipment.
- Chicago: Expansion of ramp and hydrant fueling facilities to accommodate 6 Jumbo Jets, and increase freight terminal by as much as 100 percent. Installation of in-terminal and on-ramp handling equipment.
- Boston: Anticipating move to newer facility in September, which will more than double terminal capacity and allow for accommodation of 2 Jumbo Jets. Installation of on-ramp handling equipment.
- Cleveland: Installation of in-terminal and on-ramp handling equipment.
- San Francisco: Move to larger facility, with double capacity, completed in November 1967. Installation of in-terminal and on-ramp handling equipment slated for August 1968. New facility will accommodate 3 Jumbo Jets.
- Philadelphia: Acquire new 6.5 acre site for all-new freight terminal at the airport's new cargo complex, with construction of facility and on-ramp handling equipment to begin early in 1969.

In addition to the facilities investment described above, the Tigers were also to complete construction of a new $2,000,000 flight training facility at its Los Angeles headquarters in January 1968. The structure will house a DC-8-63F flight simulator, procedural and evacuation trainers, and electronic student response system, classrooms and offices.

FRONTIER AIRLINES

Progress through expansion of routes, services and equipment was the theme for the growth of Frontier Airlines in 1967.

The highlight of the year was the October 1 merger of Central Airlines into Frontier Airlines. The combination of Central's and Frontier's route systems made Frontier the fourth largest scheduled carrier in unduplicated route miles within the continental United States. With 114 cities in 14 states, Frontier became second in the number of communities served among all scheduled carriers.

In less than a month after the official merger, which got expedited handling by the Civil Aeronautics Board, through flights were operated between the merged systems. This made possible one-carrier through-plane service to connect oil-producing areas of Montana and Wyoming with the oil supply and headquarters centers in Oklahoma and Texas. It also made for an easier flow of passenger traffic on an east/west basis for both through-plane service and connecting service. With Frontier Airlines the surviving carrier in the merger, there was an expansion of the general offices of the company in Denver, Colorado. A new $10,-000,000 Maintenance Operations Base in Denver, to be ready in the spring of 1968, makes it possible to absorb offices of the merged company into a far more attractive, spacious setup.

In 1967, the award of nonstop authority in the major Denver–St. Louis market to Frontier Airlines by CAB action in its far-reaching decision in the Pacific Northwest/Southwest Area Case, gave Frontier the opportunity to prove its ability to operate competitively in the long-haul market. Prior to June 1967, a single round-trip interchange service had been operated between St. Louis and Denver. On June 13, Frontier began 5 daily round-trip flights operated with 99-passenger Boeing 727 equipment between these terminal cities. Two of the flights were nonstop and 3 of the flights served Kansas City as an intermediate point. In October, a sixth round-trip was operated between Denver and St. Louis via Kansas City flown with 727 aircraft.

Another CAB decision gave Frontier new routes into the Montana cities of Bozeman and Missoula providing nonstop service between these 2 cities and Salt Lake City and through-plane service to Denver via Wyoming. The traffic generated in these 2 cities exceeded forecasts based upon one year of traffic development which indicated the need for the air service to this isolated section of Montana.

For the past 5 years, Frontier has been a leader of the airline industry in the introduction and development of low-cost promotional fares. In 1967, these fares continued to attract hundreds of thousands of additional passengers with a resulting increase in passenger revenues. One of the most successful of the carrier's fares is the Family Plan. In 1967, it was expected to attract over 180,000 passengers and bring in revenues of close to $4,000,000. This would represent a 36 percent increase in passengers and a 31 percent increase in revenues over 1966 showings. The carrier's Standby Fare, available between certain city pairs, was expected to generate nearly 45,000 passengers and bring in revenues just under $2,000,000. Among the dozen promotional fares available on Frontier, it was expected that over 600,000 passengers would travel on a reduced fare to bring in over $11,-000,000 in revenues. Promotional fare passengers constituted approximately 45 percent of the 1,340,000 passengers which Frontier expected to carry in 1967.

During the year, Frontier placed orders for $75,-000,000 worth of new jet equipment. In addition to the 5 Boeing 727-100s which it operated in 1967, the airline was to acquire 5 727-200s with first deliveries

Frontier ordered 5 Boeing 727-200s to supplement the 5 -100s the airline operated in 1967.

in February 1968. In addition, Frontier had an order for 5 Boeing 737-200s and an option for 5 more 737-200s with delivery expected in 1969. During 1967, Frontier negotiated for 16 additional jet-prop Convair 580 conversions which will be added to the 22 CV-580s presently operating on the carrier's system.

With recommendations from hearing examiners in a number of route cases, Frontier hoped to expand its operations into other major new markets in the early part of 1968.

HAWAIIAN AIRLINES

Passenger and equipment advances surpassing any other carrier in the 50th State marked 1967 as a highly significant year for Hawaiian Airlines.

Island-born John H. Magoon, Jr., president of Hawaiian Airlines, reported that the airline carried over 1,000,000 passengers for the first time in Hawaiian's history.

A total of nearly 1,250,000 passengers were carried in 1967. In addition, direct pure jet DC-9-30 service was inaugurated on an exclusive basis by Hawaiian to Kona airport with the first of its 2 DC-9-30s. Due to the advanced high-life wing characteristics of the Series 30 DC-9 fan jet, Hawaiian was able to initiate service to the 4,400 foot runway airport tourist destination on the western coast of the big island of Hawaii. In 1968, improved flap settings will allow nearly full capacity on landings and take-offs for the 115-passenger DC-9-30 aircraft.

Delivery of the first of 3 new stretch DC-9 aircraft increased Hawaiian's pure jet fleet serving all major islands to 3 DC-9s. Two more were to be delivered in the spring of 1968 and 1969.

The balance of Hawaiian's fleet at year-end included 8 Super 640 Jet Power Convairs, 6 carrying 56 passengers each, one combined passenger-freighter and one pure freighter, and 2 60-passenger Jet Power YS-11s. Each of the turboprop aircraft is powered by the advanced Rolls-Royce Dart-10 engine, far more powerful than any other turboprop in inter-island service.

Passenger service was greatly increased in 1967 with the adoption of the piece-baggage concept by the airline. This allows any passenger to carry free of charge 2 normal size pieces of luggage. Additional luggage is charged at $1 for each piece with the exception of oversized items such as foot lockers or golf bags, for which the passenger is charged $2 each.

Hawaiian's revenue for 1967 from total passenger, cargo and other sources was estimated in excess of $15,000,000. Assisting this revenue increase for Hawaiian was the airline's lifting of nearly 38,000,000 pounds of inter-island air freight.

Hawaiian continued its proud record that since November 11, 1929, when scheduled inter-island air service was inaugurated by the airline, no fatality has befallen a single passenger or crew member. Over 12,000,000 passengers have been carried in the airline's 38-year history.

LAKE CENTRAL AIRLINES

Lake Central Airlines began 1967 by returning the jet-powered Nord II to scheduled passenger service. Each of the 12 aircraft was phased into operation between the end of February and the first of May.

The Nord fleet had been withdrawn from service on August 12, 1966, when power plant difficulties were encountered. After extensive investigation by the Federal Aviation Administration, Civil Aeronautics Board, Nord-Aviation, the airline and other aeronautical authorities, the problems were identified and a combination of modifications and revised operating procedures were developed.

The Nord IIs were returned to service with the full approval of the Federal Aviation Administration, but not before adversely affecting operating expenses for the first 6 months. In order to maintain a marketable service pattern, the company has had to maintain its DC-3 aircraft in fully operational condition. As a result of this situation, maintenance expenses were substantially greater.

On May 1, L. Thomas Ferguson became president and chief executive officer of Lake Central Airlines. Upon assuming office, he immediately undertook an extensive reorganization program which was completed in early September.

This included the introduction of 5 promotional fares within 5 weeks. Youth, Military, Group, Weekend, and Government fares were announced during this time.

Ferguson's main objective, however, was to improve the airline's on-time and completion factors.

In order to meet this requirement, major rescheduling efforts of the entire system were undertaken. These new schedules were designed to provide greater revenue returns at lower operating costs, improve dependability by regrouping resources, and to take advantage of the increased number of nonstop authorities which were provided by the Civil Aeronautics Board the past year.

One of the additional major factors affecting Lake Central's ability to provide a dependable product has been the necessity of maintaining 4 different types of aircraft. Ferguson initiated plans to reduce the fleet makeup from 4 aircraft types to 2 by January 1, 1968, making it all turbine-powered. This would include Convair 580s and Nord IIs.

Route strengthening plans include proposed new authority east to New York and south to the terminal cities of Memphis, New Orleans, Nashville, and Dallas. Filings were made with the Civil Aeronautics Board for all of these extensions and decisions will probably be made in 1968.

All of the airlines' major corporate systems and its organization structure were under study and many changes were made to provide improved efficiencies and lower unit cost, particularly in the area of aircraft maintenance.

On July 1, Lake Central expanded its service to St. Louis, Missouri, with 10 turbine-powered flights daily between Indianapolis and the "Gateway to the West." This brought the total of cities served to 49 in 10 states in mid-central America and the District of Columbia.

In October, Lake Central began boasting "there's something new in the air," and introduced its advertising program for 1968: "The Airline With A Heart." More than $100,000 was spent during the first 3 months in the initial phase of a nearly half-million dollar program, the most extensive in the airline's history.

Lake Central's new look featured white, stylized hearts on a bright red background on all aircraft tails, a radical departure from the usually conservative airline color scheme.

This completely coordinated program also included heart-shaped luggage tags emblazoned with "Love At First Flight," heart pins worn by all employees, counter cards, decals, mailers, folders, etc. An original musical theme was also being used extensively throughout the 1967 program.

In addition, "The Airline With A Heart" was being introduced to thousands of potential customers through billboards, direct mail, magazines, airline publications, and personal sales calls on Lake Central accounts.

Also in October, Lake Central Airlines carried more passengers than during any previous month in its history. This was the second time within 3 months that the airline established a new boarding record.

President Ferguson credited the increased boardings to improved maintenance operations and to the new advertising and sales program that was launched early in the fall.

Lake Central's promotional theme featured "The Airline With a Heart."

The October total of 67,761 surpassed the August 1967 record of 65,825 passengers carried throughout the system. The October 1967 total was more than 7 percent higher for the same month one year earlier.

Fifteen Lake Central stations also exceeded the October 1966 totals.

In addition to surpassing the 1966 total, 5 of these airports set all-time records for passenger boardings.

Detroit led the group by boarding 5,401 passengers, a 110 percent increase over October 1966 when 2,614 were carried.

Lake Central set another record by boarding more passengers Friday, October 21, than on any other day. The all-time high of 3,235 passengers broke the previous one day record of 3,208 set Friday, October 28, 1966.

On October 23, officials of Lake Central and Allegheny Airlines presented a merger application to the Civil Aeronautics Board for what may become the largest local service carrier in the nation.

The application followed a joint meeting of the 2 boards in New York on October 18 when agreement was reached on all terms leading to a merger of the 2 companies.

Under the terms of the agreement, one share of Allegheny's common stock would be issued for each 2 shares of Lake Central's common. One and one-quarter shares of Allegheny common would be issued for each share of Lake Central preferred stock.

If approved by the Civil Aeronautics Board and Lake Central and Allegheny stockholders, the new airline—to be known as Allegheny Airlines—will employ about 4,000 persons and the route system will approximate 4,000 miles stretching eastward from Chicago and St. Louis to all major east coast cities between Boston and Norfolk/Newport News, Virginia.

Under existing equipment programs of both companies, the combined fleet by the end of 1967 was to consist of 6 DC-9-30 fan jets, 43 Convair 580 jet-props, 10 F-27 jet-props, and 12 Nord II jet-props.

Six more DC-9-30 fan jets and one more Convair 580 jet-prop were scheduled for delivery by mid-1968.

Options were held for 6 additional DC-9-30 fan jets for delivery during the first 6 months of 1969.

LOS ANGELES AIRWAYS, INC.

On October 1, 1967, L. A. Airways passed the 20-year mark of scheduled helicopter operations between Los Angeles International Airport and Southern California Suburban Communities. During this period, the company has been at the forefront of development in direct lift transportation and has attained many industry "firsts," particularly in the field of aircraft maintenance, equipment utilization, and instrument flying techniques.

Over 1,500,000 passengers have flown on L. A. Airways since inauguration of scheduled passenger service on November 22, 1954. In addition, 88,000,000 pounds of air mail and 36,000,000 pounds of air express have been carried.

Passenger traffic continued to show substantial gains during the first 9 months of 1967; 338,094 passengers were carried, a 30 percent increase over the same period in 1966.

With the addition of the 6th S-61 aircraft to the fleet, flight schedules were substantially increased on July 1, 1967. A 7th aircraft was on order, for delivery in 1968.

To meet the continuing public demand for its service, the company, on July 11, 1967, opened a new Marketing Center at Los Angeles International Airport. In addition to greatly enlarged sales and training facilities, the new center is also the home of an updated, centralized reservations system.

Scheduled service to the newly constructed Downey Heliport commenced on October 3, 1967, with an initial schedule of 12 flights a day.

On October 12, 1967, groundbreaking ceremonies took place in Pomona, California, to mark the beginning of a unique and far-reaching program to create a downtown transportation center serving the Pomona Valley area. LAA's operations were to be moved from the existing heliport 1½ miles west of the center of Pomona to the downtown site by the end of the year.

L. A. Airways was pressing research and development of the "Mixed-Mode" Transportation Center concept, which contemplates a multi-story structure supporting a roof-top heliport, with parking facilities and transportation-related activities at lower levels. The company's wholly owned subsidiary, Skyports, Inc., was being activated to investigate, among other things, the potential of such structures.

MODERN AIR TRANSPORT, INC.

The year 1967 was one of the most significant periods in the 20 year history of Modern Air Transport.

During the year the airline matured from a small carrier engaged primarily in the movement of troops from one military camp to another, to a supplemental carrier operating throughout Canada, United States, Mexico and Hawaii.

During 1967 the operational management of the airlines changed with the assignment of Morten S. Beyer, formerly with TWA and Saudi Arabian Airlines, as Executive Vice President and General Manager. Mr. Beyer has had a wealth of experience in supplemental type airline operations and has been instrumental in the reorientation of operational policy and future planning for the company.

The largest customer of Modern Air has been its parent Company the Gulf American Corporation. This activity involves the air transport of Gulf American customers from various points throughout the United States to the South Florida area.

With the establishment of an active sales force during 1967, Modern Air was also busily engaged in the conduct of commercial charter flights throughout the United States, Mexico and to Hawaii.

In recognition of the need for expeditious movement of military personnel to various training camps and ports of embarkation in the United States, Modern Air was the first supplemental to employ jet equipment on its charter flights in support of Military Traffic Management and Terminal Service (MTMTS) airlift requirements.

A significant change in operational policy for the airline was the exclusive employment of jet equipment and the retirement of propeller aircraft. Modern Air owned 5 DC-7Cs, 4 Martin 202s, and 4 DC-3s. All of these aircraft were retired from active airline service and were being used for special flying activities. At year-end Modern was utilizing all jet equipment, 3 Convair 990A aircraft. Two additional 990s were to be delivered in early 1968.

Serious consideration was being given to the acquisition of additional jet equipment in the future, with studies being conducted on the employment of 2 or 3 engine jet aircraft for domestic operation and larger 4-engine aircraft for international flying requirements.

With its wealth of management talent experienced in the conduct of supplemental airline type operations, Modern Air had developed a team to provide operational and technical management for the organization of airline activities abroad. This capability has been made available to the Agency for International Development and the Department of Defense.

The company at year-end employed approximately 225 personnel. It had a broadly based management organization and was a largely self-sufficient operation with a high order of in-house maintenance capability. Modern Air looked forward to expanded activity in 1968 and continued growth with the acquisition of additional modern equipment and increased flying operations.

MOHAWK AIRLINES

During 1966 Mohawk Airlines took delivery of additional BAC One-Eleven fan jets and FH-227 prop-jets to bring its fleet complement to 10 One-Elevens and 18 FH-227s. This completed the airline's original $60,000,000 fleet re-equipment program which was begun in 1962 when Mohawk became the first regional carrier in the United States to order a pure jet aircraft. Four more One-Elevens were ordered and were to be delivered during 1968.

During the year, Mohawk increased its fleets of BAC One-Elevens (shown) and Fairchild Hiller FH-227s to 10 and 18, respectively.

For the first month of 1966 Mohawk operated a reduced flight schedule as a result of a strike by mechanics which grounded the airline's piston engine Convair 440s. In what is believed to have been a first in the industry, Mohawk continued to fly its jet and prop-jet aircraft throughout the strike, using supervisory personnel to maintain the jet aircraft. No airline in the past has been able to continue operation when hit by a mechanics' strike, but because of the greater reliability of the turbine powered aircraft and because Mohawk's jet aircraft were virtually brand new, the airline was able to operate 78 percent of its pre-strike service. The strike ended January 30.

In February Mohawk concentrated on rebuilding its service and laid plans to implement flights on new routes granted by the Civil Aeronautics Board in what was called "the most important CAB decision in Mohawk's history."

The decision, which realigned Mohawk's major east-west Route 94, gave the carrier vast new nonstop and one-stop authorities, most of which are in direct competition with American Airlines, one of the largest trunk airlines. The new authorities included nonstop routes between Detroit, on the one hand, and Rochester, Syracuse, Utica, Albany, Binghamton, Ithaca, Elmira and White Plains, on the other.

The decision also gave Mohawk nonstop authority between Cleveland and Albany and made permanent the airline's temporary nonstop authority between Buffalo and Detroit and between Hartford, on the one hand, and Syracuse, Rochester and Buffalo, on the other. One-stop authority between Buffalo and Boston and 2-stop authority between Detroit and Boston were also granted.

During March the CAB granted Mohawk authority to operate flights to Montreal from Burlington, Vermont, a service which was inaugurated in time for Expo '67 and proved to be extremely successful. Also during March, the CAB named Mohawk as one of 2 airlines to be considered for possible new routes resulting from an investigation into the need for direct service between northern New England and Chicago.

In April the airline reported to stockholders a profit for 1966 of $1,242,522, or 42 cents a share, and held dedication ceremonies for a new $4,000,000 jet training center. The new center, dedicated to Edwin A. Link, member of the Board of Directors and inventor of the Link Trainer, contains 50,000 square feet of classroom space and 2 computer-directed flight simulators. One simulator duplicates actual flight conditions of a BAC One-Eleven; the other duplicates an FH-227. Both simulators receive their information simultaneously from a single digital computer, making Mohawk the first airline to have such a system in operation as well as the first regional airline to have its own simulator-equipped training center.

In addition to using the center for all initial and recurrent training of its own personnel, from pilots to ticket counter agents, the airline embarked on an ambitious contract training program which has brought pilots from airlines all over the world to the center for both simulator and aircraft flight training. More than $250,000 in training was contracted in the first 6 months of operation.

In June, Mohawk announced the purchase of 2 IBM 360, Model 50 computers to greatly speed and improve its reservations system. The new computers, which will be in operation by the fall of 1968, will provide instantaneous, complete reservations information directly from the computer, eliminating the need for a supplementary hand-written card file. The IBM computer is the first to be designed for reservations use by an airline the size of Mohawk and incorporating all of the features of larger airline computers. Information will be fed directly to an agent's display screen at reservations and ticket counter locations throughout the entire Mohawk system.

Also in June, Mohawk asked the Civil Aeronautics Board for authority to fly nonstop between Buffalo and Minneapolis/St. Paul. The application was later amended to include Milwaukee. In asking for the route the airline said nearly 100,000 passengers currently fly between Central New York and Milwaukee Twin Cities each year, and all are forced to either transfer at heavily congested terminals or undergo lengthy layovers at the O'Hara bottleneck.

A jet night coach freighter service named Night Cap Jets was begun August 1 in both directions between Boston and Detroit. The flights provide overnight delivery of mail and freight between those cities, plus 3 intermediate cities, as well as passenger service at fares which are below comparable bus fares. Started on an experimental basis in cooperation with the U.S. Post Office, the night service made a profit from the very beginning. As a result, more night freight service was planned, including a run between Newark and Buffalo which began operating in early December. Air taxi operators under contract to the Post Office deliver mail to connect with the Mohawk freighters at the intermediate points of Albany, Syracuse and Buffalo.

Mohawk stewardesses were given a new look in September with a bright fashion ensemble designed and produced for the airline by Saks Fifth Avenue. The "uniform that doesn't look like a uniform" was created to represent what a young lady would wear while traveling. It consists of an apple green A-line gabardine dress, matching double-breasted wool twill coat, black canvas rain coat, high boots and deep purple accessories. For serving in flight, the stewardesses slip on a bright yellow server which has large pockets and ties in the back. The airline's 200 stewardesses created a fashion show in the air when they appeared in the new outfits.

Later in the month, Mohawk began serving 2 new cities, Bridgeport, Connecticut, and Islip, Long Island with 2 round trips per day.

In October the CAB granted Mohawk its first fare increase in 6 years by approving a "regional fare" for the airline. The regional fare raised propeller fares to the level of jet fares and reduced long-haul jet fares in an effort to make the fare structure more equitable with the cost of service, since short flights are more costly to operate than long flights.

Route cases were the major newsmakers in the later part of the year as Mohawk was awarded one major new authority and applied for several more. Service was scheduled to begin early in 1968 between Albany, White Plains and Washington, an authority which the CAB granted Mohawk after a 7-year attempt to secure the route. The route was also another step in Mohawk's program to develop major flight services at suburban airports, thus eliminating the delays caused by congestion at main metropolitan airports and at the same time saving considerable ground travel for commuters who live in the suburban areas. From White Plains alone Mohawk at year-end offered nonstop jet service to Washington, Detroit, Buffalo, Rochester, Boston and Albany, with propjet service to a number of other Upstate New York points.

The airline made a bid to extend its route structure even farther west by asking the CAB for authority to fly between Buffalo, Louisville, St. Louis and Kansas City. In its application the airline said its direct, single-plane service on the route would cut by an average 31 percent the time it currently takes to travel by air between Upstate New York cities, Louisville and St. Louis. In the Upstate New York–Kansas City market, Mohawk would provide the only single-carrier service.

NATIONAL AIRLINES

National Airline's activities in 1967 were geared to the most extensive program of equipment acquisition and facilities improvements ever undertaken by the Coast-to-Coast-to-Coast carrier.

The company's expansion and improvement programs were being undertaken, President L. B. Maytag explained, to improve National's competitive position in the industry during a period when commercial aviation is one of the fastest growing segments of the nation's economy.

While National in 1966 ordered 25 Boeing 727 "long jets" with 138-passenger capacity and one DC-8-61 with seating capacity of 210, the projections of air travel increase prompted the ordering of another of the Super DC-8s and 2 747 jumbo jets, the latter to be delivered in 1970.

In the fall of 1966, the airline received 3 regular 727s, thus giving added capacity throughout 1967. The first of the stretched DC-8s was received and placed into service in August 1967, and in the early part of November National inaugurated 2 additional flights daily in its New York–Miami market by utilizing two 727 "quick change" jets under an arrangement with Airlift International, Miami-based cargo carrier.

Delivery of the 727 "long jets" was to be started in December 1967 and continue through July 1968, and the additional Super DC-8 was scheduled for March 1968 delivery.

Upon completion of these deliveries and the concurrent phasing out of 13 Electras in service, National will double its fleet and will offer jet service only to the 43 cities served by the carrier. National still expected to be the first domestic trunk carrier to achieve this coveted status.

To keep ground facilities and passenger services abreast of the expanding capacity and traffic, National inaugurated a series of improvements at numerous terminal facilities and was pressing construction of its new and highly modern terminal at John F. Kennedy airport in New York. Pending opening of this new terminal, the old terminal was extensively improved, with the passenger concourse being enclosed and provided with heating and air conditioning and with the baggage handling area being enlarged.

National also inaugurated service to LaGuardia Airport and was the only carrier operating nonstop flights between Florida and the 3 Greater New York terminals, JFK, LaGuardia and Newark.

Development was started during 1967 of a new and highly sophisticated central reservations system to replace the company's existing, but improved, 5 central reservations centers. Under the new system all of National's 800 agent stations will be connected to central computers. Reservations agents will receive any data required on a TV-like screen. Complete details will be available on all flights to include availability of seats and the customers' complete reservations records, incorporating names, itinerary, phone contact and any special orders, including meal service.

On November 2, at special previews in New York, Miami and Los Angeles, the airline unveiled its "new new look" to be put into effect in December 1967 on a system-wide basis.

National's "sunshine look" is reflected in the new markings of its aircraft, which include a stylized sunburst in orange and yellow painted on the tail.

The change-over, estimated to be a $2,000,000 promotional undertaking, includes the use of an orange and yellow sunburst emblem as the primary identification of the aircraft, and of National's promotional material. Matching color lines of orange and yellow will run the entire length of the airline's silver and white jets.

Stewardesses will don high-styled dresses rather than uniforms, created by William Travilla, an Academy

Award-winning Hollywood designer, and each stewardess will have dresses in 3 different colors—orange, lemon and lime.

The colors and sunburst emblem are derived from National's home-base state of Florida and the interiors of the planes will accent sunshine colors in drapes, curtains, pillows, seat covers and rugs. The theme will be carried to National's terminal ticket counters and offices throughout the system, and ticket agents—both male and female—will have attire based on the same colors as the stewardess dresses. Green foliage and sunburst colors will create a "Florida Oasis" at each station.

Since National's fiscal year ends on June 30 each year, the last fiscal year—which included the 43-day shutdown because of the machinists' strike in the summer of 1966—turned out to be only the second best in the airline's history, with net income of $17,000,000 from operating revenues of $179,000,000. The operating revenues approximated those of the prior record year. And despite the long idle period, both capacity and revenue passenger miles reached record highs. Available seat miles were up 4 percent to 5.77 billion and revenue passenger miles up one percent to 3 billion.

The start of the new fiscal year was auspicious. Records were set in all categories for the July–September first quarter. Net income for the period was $4,327,000 from operating revenues of $49,527,000, against the strike-induced loss for the 1966 period. Available seat miles of 1.66 billion and revenue passenger miles of 897 million also were first quarter records.

Month-against-month, the airline set new capacity and traffic records from November 1966 through October 1967, with indications that the same type of traffic growth would continue with the addition of new equipment and improved services planned for the future.

NEW YORK AIRWAYS

New York Airways, following a record-breaking year in 1966, was on its way to another in 1967 according to preliminary passenger figures.

According to the estimates, the scheduled helicopter airline carried 452,451 revenue passengers during the first 10 months of 1967, despite the fact that New York had been plagued with bad flying weather much of the period. This compared with 446,125 passengers carried during the first 10 months of record 1966.

In March of 1966, New York Airways instituted service between Teterboro Airport in northern New Jersey and John F. Kennedy International with an intermediate stop on most flights at the heliport on top of the 808-foot Pan Am Building in mid-town Manhattan.

With the addition of Teterboro, New York Airways served 4 airports—Kennedy (with 2 stations), LaGuardia, and Newark, as well as the Pan Am Building and Wall Street Heliports in Manhattan.

In February, the airline received authority from the FAA to establish powerplant overhaul periods under the first propulsion system reliability control program approved for helicopters.

The system, developed at New York Airways, increases the time between overhauls to 1,500 hours on the General Electric CT58 turbine engine used in the 7 Boeing V-107-II helicopters in the New York Airways fleet. This is the highest time between overhauls approved for any scheduled helicopter air carrier.

Of the more than 450,000 passengers transported during the first 10 months, almost 124,000 embarked or debarked at the Pan Am Building; 310,000 were carried on the inter-airport and Wall Street route and 13,000 between Teterboro and Kennedy.

By the end of October 1967, New York Airways had signed joint fare agreements with 32 international carriers and 7 domestic airlines. The reduced fares for those connecting passengers utilizing the helicopter line ranged from 50 percent to no charge at all.

In the 1966 New York Airways annual report, released in April of 1967, Robert L. Cummings, president of the airline reported a 72 percent increase in passenger traffic over 1965. Some 527,000 passengers were carried, compared with 306,000 the previous year. In addition, revenue passenger miles increased from 6,170,000 in 1965 to 9,370,000 in 1966; revenue ton miles increased 45 percent and the load factor of 60.5 percent was the highest for the year among the domestic trunk, local service and helicopter air carriers of the United States.

Commercial revenues, not including contract payments by Pan American World Airways and Trans World Airlines, increased from $3,026,000 in 1965 to $4,833,000 in 1966, a new high for scheduled helicopter carriers.

Also in 1966, New York Airways' Certificate of Public Convenience and Necessity authorizing the company's operations was made permanent. At the same time the Civil Aeronautics Board also granted a 5-year Area Exemption Order authorizing the airline to operate between all other points within the larger New York/New Jersey/Connecticut metropolitan area extending from Trenton to New Haven.

Moreover, in the same proceeding, the Board confirmed an expansion of these authorizations redefining the company's mission as the provision of "community center service and inter-airport service" without any restriction as to the type of aircraft which might be used.

The effect of this important change was to make clear that New York Airways services may be performed not only with helicopters but with any type of flight equipment suitable for the authorized mission.

In line with the above, New York Airways was carefully looking at STOL aircraft, and in particular at the McDonnell Douglas 188 and the DeHavilland Twin Otter.

NORTHEAST AIRLINES

The year was one of transition for Northeast Airlines as the carrier completed final phases of its modernization program.

In December, the line received the first of the new 727-200 stretch tri-jets built by Boeing, the longest commercial tri-jet in the world. It also added DC-9-series 30 planes and 727-100 jets as it built toward its all-jet fleet of 35 planes.

Northeast became the first U.S. carrier flying nonstop from Montreal to Miami, became the first carrier flying nonstop from Hartford, Connecticut, to Miami, and also began new or additional services during 1967 to Tampa, Jacksonville, Fort Lauderdale, Philadelphia and Baltimore. Frequencies also increased so that during the 1967–68 winter season the line had available 150 percent more seats than in 1966–67.

Marriott In-Flite Services, Inc., took over management of all Northeast catering operations under the first contract of its type in airline history.

Carl Ally, Inc., of New York became the new advertising agency for the line, planning a massive campaign to start with the new year.

At the same time, the line applied for a series of new routes, including applications to fly to Bermuda, the Bahamas, the Caribbean, and to link Miami and Tampa with Los Angeles and San Francisco via New Orleans, Houston and Dallas. Northeast also applied for permission to fly from Northern New England to the Great Lakes, and became a party to the Twin Cities–Milwaukee Long-Haul investigation. Northeast also asked permission to link Miami and London. These followed government action giving the line a permanent certification to fly to Florida.

In a year-end statement, Northeast President F. C. Wiser said: "We are confident that 1968 will bring further progress in our program to develop New England's airline into one of the major air carriers in this country."

NORTHERN CONSOLIDATED AIRLINES

The year 1967 was a very active and important year for Northern Consolidated Airlines. In March, President Raymond I. Petersen of Northern Consolidated and President Sigurd Wien of Wien Air Alaska announced an agreement of merger between these 2 pioneer Alaska airlines. This merger will form the largest Alaska-based air carrier and will comprise a new route system covering virtually the entire state of Alaska and over 150 communities. It was expected that the merger will be consummated during the early part of 1968 and the surviving corporation would be Northern Consolidated Airlines.

Of equal importance, in May the Civil Aeronautics Board granted Northern Consolidated a temporary authority to operate between Alaska's 2 largest cities, Anchorage and Fairbanks, on a nonstop basis. This authority was granted until a determination is made at a later CAB hearing on permanent status for the route. Impressive records and performance were compiled since this May initiation in spite of strong competition. With the pending merger this direct route will establish the main and vital corridor between the merged routes.

New turbine equipment for the bush was put into operation with 2 Twin Otters and one Short Skyvan. This made NCA an all-turbine fleet except for summer tour amphibian bush aircraft. This has brought better service with more modern equipment to the many smaller Alaskan communities. These new twin turbine aircraft, representing a capital investment of approximately $1,200,000, have automatic pilots and all-weather capability which is revolutionizing service to many communities which have never had the convenience and advancements that these aircraft can offer.

Northern Consolidated's Katmai tours and fishing camps enjoyed the best season ever in 1967, with a 20 percent increase over 1966. This increase was brought about primarily by rapid growth in tourism in the State of Alaska. The National Park Service increased its service to visitors, which was making Katmai National Monument a prime tourist attraction.

Northern Consolidated maintained its perfect safety record despite greatly increased flying because of the addition of the Anchorage-Fairbanks route. The year 1967 passed 1966 in numbers of revenue passengers and revenue ton miles of mail and promised to be a record year for all classes of traffic.

Northern Consolidated went public on its stock in January 1967. All issues were immediately subscribed.

Plans continued for the Boeing 737-200C jet which was scheduled to be delivered during the latter part of 1968. With the pending merger, these 737-200C jets will become even more important because of the 8,500 mile route system.

NORTHWEST ORIENT AIRLINES

During 1967, Northwest Orient Airlines experienced growth in profits, in its fleet expansion program, in the number of cities it serves and in its number of personnel.

Profits for Northwest during the first 9 months of 1967 topped $45,000,000, as compared with $37,-209,935 for the same period during 1966. The airline expected to reach a revenue of $400,000,000 by the end of the year.

Ten new fan-jets were delivered during 1967 and the airline announced an order for $104,000,000 in new jets from The Boeing Company during November. Included in the order were 16 727-200s, 2 727-100s, and one 707-320B. The airplanes will be delivered during 1968 and 1969.

Northwest was also expecting delivery of 10 previously-announced 707-320B/Cs. The airline's fleet of fan-jets will total 100 aircraft with the delivery of these 29 planes.

The carrier also had 10 Boeing 747s on order, scheduled for delivery in 1970, and Northwest has deposited funds to guarantee early delivery position for 6 United States supersonic transports. Delivery of the SSTs was expected to begin in 1975.

Northwest Orient's $104,000,000 equipment order included 16 Boeing 727-200s (shown), 2 727-100s and a 707-320B.

Two new cities were added to Northwest's routes during the year. Osaka, Japan, received its first service from the airline on April 1, and Hilo, Hawaii, service was begun on December 17.

The airline had applications filed with the Civil Aeronautics Board requesting permission to serve Boston, Memphis and Nashville, New Orleans, Denver, Omaha, Los Angeles, San Francisco, and Bermuda.

During the summer months of 1967, Northwest hired its 10,000th employee, more than doubling its employment figures in the last 20 years. At the same time, the payroll grew to about $82,710,000.

Personnel promotions during 1967 included the appointment of 4 new vice presidents. Clayton R. Brandt was named Vice President—Purchasing and Stores; Robert W. Campbell was appointed Vice President—Budgets; Richard Kitchen was promoted to Vice President—Public Relations; and James A. Abbott was named Vice President—Orient Region.

During 1968, Northwest anticipated traffic gains, as measured by revenue passenger miles, of 15 to 17 percent. The airline was also looking for an increase in profits with the percentage increase in costs reduced from 1967.

OVERSEAS NATIONAL AIRWAYS

For Overseas National Airways, the year 1967 was one of many milestones.

The supplemental carrier, based at John F. Kennedy International Airport in New York, became an all-fanjet airline, phasing out DC-7 aircraft it had been leasing for 2 years.

During October and November, ONA took delivery of 3 Douglas DC-9-30F jets, the first convertible stretched DC-9s delivered to any airline. The first 2 were being used in LOGAIR (LOGistic AIRlift), the Air Force Logistics Command's system in which civilian carriers transport cargo to 75 bases within the continental United States on a scheduled basis. The DC-9s were the first pure jet aircraft ever to be used in LOGAIR, one entering service on November 1 at Wright-Patterson Air Force Base in Ohio. Overseas National had a $5,700,000 contract for LOGAIR operations during fiscal 1968.

The third stretched DC-9 was to be used for military and commercial passenger charters, replacing a DC-9 which ONA had leased from a scheduled carrier from June until December; this aircraft was operated in scheduled service between New York and Montreal from June until September under a lease arrangement with Air Canada. ONA's fourth DC-9, to be delivered in February of 1968, will be used for both passenger and cargo operations.

The company also ordered a 250-passenger DC-8-63F for delivery in October 1968 and another stretched DC-8, which was scheduled to join the fleet during 1969. ONA had an option on a second stretched DC-8 for 1969 delivery.

Overseas National's fleet expansion program was facilitated by a public offering of 420,000 shares of the company's stock made in July, which realized $8,500,000. The airline's shares are traded on over-the-counter market. Revenues for 1967 amounted to approximately $20,000,000, double those for 1966. Half of these were derived from military charters and half from commercial activities.

The company's operating authority was enlarged by 2 awards from the Civil Aeronautics Board. In addition to the transatlantic operating authority which it had received late in 1966, ONA was awarded permanent domestic operating authority, including inclusive tour charter authority. In a separate award, ONA received Caribbean operating authority; a decision on inclusive tour charter authority in this area was deferred pending court action on the legality of international inclusive tour charters.

During 1967, the transatlantic continued to be the company's prime commercial market with the domestic area, particularly Hawaii, contributing significantly to passenger miles and revenues.

Overseas National was the first supplemental to fly inclusive tour charters to Europe, operating a flight to Amsterdam in April. The airline was also the first American charter carrier permitted to operate inclusive tour charters into the United Kingdom, receiving permission from the British Board of Trade for a series of 13 such flights during the late summer and early fall.

As its contribution to the Citizens Summer Committee program under which New York's Mayor John V. Lindsay enlisted the support of businesses in the City's efforts to maintain order during the difficult summer months, Overseas National took 1,750 youngsters from ghetto areas on airplane rides around the City. It had originally been planned to provide 1,000 such rides but contributions of their services by ONA's suppliers and the Port of New York Authority made it possible to nearly double the program.

In Operation Kidlift, ONA carried 1,750 youngsters from New York's ghettos on rides around the city, the airline's contribution to Mayor Lindsay's Citizens Summer Committee program.

Early in 1967, Overseas National enlarged its headquarters at Kennedy Airport. The new facilities include a training center equipped with the most modern training devices available. The company conducts both ground and flight training for other carriers in addition to schooling its own flight personnel.

With the retirement of its piston aircraft and the commencement of all-jet operations, Overseas National anticipated greater economies in its flight operations and increased revenues in all markets during 1968.

OZARK AIR LINES

Ozark Air Lines, the youngest local service carrier, started its air transportation system in 1950 with 4 DC-3s. In 1967, it truly entered the jet age, completing a planned turbine fleet and eliminating almost all DC-3 service.

Starting the year with only 3 DC-9 jets and one FH-227B prop-jet, the fleet at year-end totaled 6 DC-9s and 21 all new Fairchild-Hiller FH-227Bs. Service with 14 Martin 404s and 7 F-27s was completely eliminated as the planes were sold, and DC-3 service remained in only 14 of the company's 59 cities. It was anticipated that even here, all-turbine equipment would be used in the near future as all but 2 of the system's airports were improved for the new equipment.

It all started in mid-1966 when the first new twin jets were delivered, followed in December with the first new stretched Fairchild. This made Ozark one of the first to introduce 2 entirely new airplanes in its fleet in one year.

Then, in 1967, delivery of the new FH-227B prop jets continued at a rate of about 2 a month, until the entire fleet of 21 was delivered and placed in service by November. In August and September, the 3 additional DC-9 jets were delivered, and more and more of the system's cities acquired improved all-turbine service.

Adding to the excitement of new equipment at Ozark, the company was authorized new routes and service and filed for several new routes which would greatly expand the company's system. The first new authorization was for flights between Louisville and Indianapolis, introduced in January. Both cities were on the system, but not with direct service. The new authority opened up direct air transportation to the south for Indianapolis, and to the north for Louisville.

Then, in August, Ozark introduced the only nonstop service between St. Louis and Milwaukee, providing the only air transportation between these 2 cities without going through Chicago. Ozark had provided one stop service for several months, but with the new nonstop and pure jet equipment, the trip is made in less than an hour.

In addition, Ozark was granted an exemption by the Civil Aeronautics Board to replace Braniff International at Rochester and Waterloo, Iowa. With the new authority, Ozark provided service from the Twin Cities to Kansas City, with stops at Rochester, Waterloo, and Des Moines. This added Des Moines–Kansas City authority to the system, and improved authority from the Twin Cities, Rochester, and Waterloo to Kansas City.

New authority requested by the company included routes to Washington, D.C., New York, Seattle, Anchorage, Los Angeles, and San Francisco. Other pending route applications would put the carrier into such cities as Detroit, Houston, Dallas, Little Rock, and New Orleans.

In addition to 3 more DC-9s, Ozark acquired a fleet of 21 Fairchild Hiller FH-227Bs (shown) during 1967.

The first vast new route requests included Anchorage from Chicago through Calgary, Canada, and Seattle/Portland from Omaha. The latter application also included new service to such cities already on the system as Kansas City, Denver, St. Louis, and the Twin Cities.

Almost within days of this application, Ozark sought out the east coast as it requested authority for a route from Peoria, Illinois, to New York, via Washington, D.C. Such a route would actually start in Sioux Falls, going through Sioux City, Waterloo, to Peoria. Champaign/Urbana and Springfield, Illinois, were listed as co-terminals with Peoria.

Then, in October, Ozark again approached the nation's 2 coasts with requests for service from Omaha and Des Moines to both New York and Los Angeles and San Francisco with intermediate stops.

In September, another nonstop authority was requested between Chicago and Des Moines with service on to Omaha.

In traffic, the company continued its tremendous growth of recent years, breaking monthly records almost every month. In addition, daily records were broken and then broken again; for example, on September 1, with 6,708 passengers, and then again on October 20 with 7,048 riders.

For the third year in its short 17 year history, Ozark topped the 1,000,000 passenger mark, in August, several weeks ahead of 1965 and 1966. Through September, the carrier had transported 1,305,389 travelers over its 12-state system.

To continually improve and promote its service for these ever increasing passengers, Ozark took several steps during the year, including adding new city ticket office facilities in Minneapolis/St. Paul and St. Louis, and adding the Midwest Bank Credit Cards to its other 5 credit plans.

In addition, it continued the Discover America program, and added several new tariff plans.

New tariffs include an expanded group fare, which produced saving on one way and round trips to every city on the system. It applies to 10 or more persons departing together, but they may return individually. This was followed by a new weekend fare, offering travelers a $30 fare to any city or number of cities on the system during Saturday and Sunday.

In October, the company went to economy class fare on its equipment for the first time, offering both first class and coach on its DC-9 jets. The former 78 passenger plane for Ozark was changed to 14 first class and 60 jet coach seats for this new fare. The prop first class tariff remained throughout the system, giving the company 3 levels and offering direct competitive fares in competitive markets.

A flight advisor/coordinator position was added to the operations crew during the year to help improve passenger relations. His duties include routing changes, cancellations, and holds for passengers, oriented toward operations which will be economically best for the company, while providing for the needs of Ozark's passengers. The position had been tried on a trial basis, and proved so satisfactory it was made permanent.

Also, to provide better service for passengers, new express flights were added to link Chicago and several mid-Illinois cities, including Peoria, Champaign/Urbana, Decatur, and Springfield. With 8 round trips daily, these cities were linked more directly to the Chicago gateway.

Continuing its outstanding safety record, Ozark was awarded a National Safety Council award for its 1966 record. The company did not experience a passenger or crew fatality during the year, and received the Council's Award of Merit. Ozark has received a safety award every year since its beginning in 1950.

Rounding out the year for Ozark Air Lines, it was listed on the American Stock Exchange in May, and with this and the other activities during the year, the company's stock proved very active. Starting the year at about 8 points, it hit a high of just over 22, and then split with each stockholder getting an extra share for each he held.

Thus, 1967 could be considered a highly successful and exciting year. Ozark Air Lines looked toward 1968 with new routes, and more jet planes in mind, increasing both the all new jet powered fleet and the size of the youngest local service carrier's system.

PACIFIC AIR LINES

Pacific Air Lines celebrated the start of 1967 by moving into a new general office building at the San Francisco International Airport, a multi-million dollar installation which also includes new hangars capable of housing 727s.

New jet services were added during the year and the 727 fleet was increased to 3; the Martin 404s were retired from service.

Orders were placed for 8 Boeing 737s, and the first was expected to be delivered in March 1968.

G. Robert Henry became the new president of Pacific during the summer of 1967 and Larry Decker became the senior vice president of marketing.

The big news of the year was the proposed merger of Pacific with West Coast and Bonanza. The merger was pending at year-end; it required the approval of the Civil Aeronautics Board and the stockholders of all 3 airlines.

PAN AMERICAN WORLD AIRWAYS

Pan American World Airways, Inc., marked its 40th anniversary on October 28, 1967. In the 4-decade span, Pan Am rose from a 2-plane airline to a corporation whose assets exceed $1 billion.

On October 28, 1927, a Pan Am Fokker tri-motor plane airlifted 7 bags of mail from Key West, Florida, to Havana, Cuba, to inaugurate U.S.-flag international air transport service.

At the end of 1967, the airline's fleet of more than 140 Jet Clippers were traversing some 79,000 miles of routes that linked 121 cities in 84 countries on 6 continents.

At year-end, Pan Am was also operating the largest overseas hotel chain in the world through its wholly-owned subsidiary, Inter-Continental Hotels Corporation; providing technical assistance to the national airlines of foreign countries, in cooperation with the U.S. Government; marketing and servicing the Fan Jet Falcon through its Business Jets Division; playing a key supporting role in U.S. space exploration via its Aerospace Services Division; and deeply involved in national interest programs.

In the last 40 years, Pan Am has flown more than 70,000,000 passengers, approximately equal to the combined populations of France, Belgium, the Netherlands, Luxemburg and Denmark. From its first 8-passenger Fokkers, through the famed ocean-spanning flying boats to today's 575-mile-an-hour jetliners, Pan Am Clippers have flown more than 2 billion miles.

Pan Am marked the 40th anniversary of its first flight. Shown here is the whole Pan Am organization of October 1927, the ground and flight crews and the company's lone Fokker tri-motor.

During 1967 total revenue passenger miles flown increased 13 percent and total revenue cargo ton miles flown increased 10 percent. Revenues in 1967 were up about 13 percent but profits slipped by about 10 percent.

At the May 2 annual meeting, shareholders approved a 2 for one stock split and later directors increased the quarterly dividend to 10 cents a share on the split shares. This compared with the previous quarterly dividend rate of 15 cents per share on the unsplit shares.

Undelivered orders for aircraft, both subsonic and supersonic jets, totaled $1.6 billion at year-end. Undelivered orders for the subsonic jets, including 25 747 jets, totaled $857,000,000. The 23 supersonic jets (15 SSTs and 8 Concordes) scheduled for delivery after 1971, were estimated to cost an additional $750,000,000. Pan Am's 1967 fleet consisted of more than 140 Jet Clippers.

Pan American continued as the major single airline supporting the National Defense effort in Vietnam. A total of 23 Pan Am Clippers, including 10 long range jets and 13 Clippers, were committed to this effort. The 13 Clippers were assigned to a special Rest and Rehabilitation, provided by Pan American to the government at cost. A total of 475,000 military personnel were flown from forward areas in Vietnam to furloughs in various major cities in the Western Pacific. At year-end, 1,100 American servicemen a day were being flown away from the war area for their week of rest.

As a result of a CAB decision, Pan Am inaugurated a twice-daily service across the United States to serve international passengers, cargo and mail. New York became a stopover on Pan Am's round-the-world service, both Eastbound and Westbound. Pan Am was able to offer at New York round-the-world and transpacific air service that spans the United States. This new eastbound-westbound "across the United States" service was made possible on November 17, when the Civil Aeronautics Board granted Pan Am temporary authority, pending final decision in the Transpacific Route Case, to serve New York City as a coterminal point on the company's transpacific routes.

On July 7 at London, a Pan American Boeing 707 made the first fully automatic approach and landing with 112 passengers aboard the history-making flight. On July 11 Pan Am made its 10,000th round-the-world flight. Its first round-the-world flight was flown on June 17, 1947.

At the outbreak of the war in the Middle East, Pan Am, at the request of the U.S. Department of State, flew 2,208 evacuees out of the area while, at the same time maintaining its other world-wide operations with a minimum of inconvenience to customers.

The Board of Directors approved the final agreement with the Port of New York Authority, whereby Pan Am will operate and develop Teterboro Airport, New Jersey, and Republic Aviation Airport at Farmingdale, Long Island. Both airports will be developed as first-class general aviation airports and will provide alternate accommodations for the business aircraft and air taxis that now account for about 33 percent of the traffic at Kennedy, LaGuardia and Newark Airports. Republic and Teterboro will be operated by the Metropolitan Airports Division of Pan American.

During 1967 Pan Am renamed its Guided Missiles Range Division the Aerospace Services Division. Since 1953 this division has assisted in the pre-launch planning and preparation as well as the actual launch and post-launch activities of over 1,600 missile space flights at Cape Kennedy. Total investment in range facilities at year-end was well over $2 billion. Pan Am had more than 6,500 employees supporting these operations.

During 1967 Inter-Continental Hotels, a wholly-owned Pan American subsidiary, opened or acquired 5 hotels. At year-end, the total number of hotels open to the public was 38. The first to open in 1967 was the Hotel Ambassador and the Hotel Continental, followed by the Hotel Intercontinental Rawalpindi, Lahore, and Quito.

Pan American Fan Jet Falcon, the twin jet business aircraft, continued in demand during 1967. The aircraft, which is marketed and supported in the Western Hemisphere by the Business Jets Division of Pan Am, was sold to 84 corporate customers in the United States and Canada. In addition, Pan Am retained 2 as demonstration models. Pan Am's total order at year-end stood at 160 with an option for an additional 40.

SFO HELICOPTER AIRLINES

SFO Helicopter Airlines' passenger traffic increased 25 percent for the first 10 months of 1967, compared to the same period in 1966. In August, SFO announced that its net profit for the first 6 months of 1967 amounted to $94,583 as compared to a loss of $41,165 for the first 6 months of 1966.

SFO's profitable operations were supported by its contract aircraft maintenance facility in which it maintained large fixed wing aircraft, including DC-8s and 707s for Airlift International, Seaboard World, and Saturn Airways, among others. Revenues from the maintenance of aircraft for customers increased from $1,100,000 for the first 6 months of 1966 to $1,400,000 for the first 6 months of 1967, and the maintenance activity for the balance of the year continued at a high level.

Substantial sums were invested in the training of SFO's maintenance personnel and in equipping the facility to be able to provide the finest possible maintenance support for fixed wing carriers and for SFO's helicopters.

SFO successfully engineered and developed and secured FAA approval for the installation of engine inlet deflector screens to protect against ingestion of birds and other foreign objects into the CT58 jet helicopter engines. This was a "first" in the helicopter industry. Another first was the procedure in effect during 1967 of fueling SFO helicopters with their rotors turning, which was commenced in October. This procedure permits faster turn-around with increased utilization during prime hours of operation.

The application of SFO's affiliate, National Capital Airlines, Inc., for a Certificate of Public Convenience and Necessity to operate scheduled helicopter service in the Washington, D.C./Baltimore areas was heard by an examiner of the CAB in October, together with the applications of others. SFO believed its record of economy, growth, and non-subsidized operation, on which the program of National Capital Airlines was based, gave NCA an excellent chance of being awarded this certificate.

A new heliport was being completed by the San Francisco Public Utilities Commission in downtown San Francisco, and service to this important point was to be commenced by February 1, 1968.

SFO continued to provide scheduled helicopter service to the San Francisco, Oakland, and San Jose Airports, and to Downtown Oakland, Berkeley, Palo Alto, Marin County, and Contra Costa County. Load factors increased approximately 6 percent in the first 10 months of 1967 as compared to the same period of 1966.

SOUTHERN AIR TRANSPORT, INC.

The year 1967, Southern Air's 20th year of operation, saw the Miami based airline operating newly acquired Boeing 727C and Douglas DC-7CF aircraft.

Southern Air's Pacific Division was operating the fleet of 3 Boeing 727Cs and one Douglas DC-6A/B aircraft on contract to the Military Airlift Command, flying daily cargo and passenger services between Japan, the Philippines, Guam, Saigon, Bankok, Taipei and Okinawa. The passengers were military personnel and dependents on change of station, leave or special duty, or civilian government employees and dependents. The cargo ranged from a spare jet engine to critical medical supplies.

Douglas DC-7CF service in the Atlantic Division was initiated with the carriage of racehorses from Miami to New York, Louisville, Lexington, Los Angeles, and Baltimore. Many of the thoroughbreds transported were stake winners along with Kentucky Derby hopefuls. The aircraft later were utilized for the carriage of military supplies to Europe as well as domestic points.

In addition to the DC-7s, Southern Air was also operating 3 Curtiss C-46s and 2 Douglas DC-4s providing charter cargo service to the Bahamas, the Caribbean Area as well as domestic markets.

An increasing volume of the Bahamian cargo was carried by Southern Air. Office, warehouse and handling facilities were being added to the Bahamian operation. Shipments of furniture and foodstuff for the resort hotels and live pullets for a local processor were among the cargo carried. Television star "Flipper" managed several flights during the year to Nassau for location filming.

As in the earlier years, during the summer and early fall months daily flights of dairy cattle to Puerto Rico and other Caribbean Islands were not uncommon. In the summer of 1967, the best in Southern Air's history, many of the farmers restocked their dairy herds for future milk production. Domestic traffic also set new company performance records. A number of the largest U.S. corporations utilized Southern Air to move emergency or strategic materials for urgent jobs.

Although Southern Air did not operate passenger aircraft in the Atlantic Division during 1967, plans were being made to develop this authority for the near future.

TRANS CARIBBEAN AIRWAYS

For Trans Caribbean Airways, 1967 was a year of important route expansion, with the expectation of even greater route awards in the near future. The airline's fleet increase was spectacular since, just after the end of the year, its capacity was triple that of a year earlier.

A milestone was added to Trans Caribbean's history when the President on May 24th approved the CAB's permanent certificate of public convenience granting Trans Caribbean Airways the San Juan–Washington, D.C. Route, serving Washington through Dulles International Airport. On October 19th, TCA inaugurated its first flight from Washington to San Juan. This new route, along with Trans Caribbean's successful New York/San Juan service, added substantially to its position in the booming Caribbean market.

On October 26th, the CAB examiner's decision recommended that Trans Caribbean authorization be expanded to include scheduled service from co-terminals New York/Newark and Washington to St. Thomas and St. Croix in the Virgin Islands, both on direct service and via San Juan. It was also recommended that TCA be awarded new routes from New York/Newark and Washington to Curacao and Aruba in the Netherlands Antilles and to Port-au-Prince, Haiti. Trans Caribbean, under the examiner's recommendation, would be the sole U.S. flag carrier operating direct service from New York/Newark and Washington to Haiti, Aruba and Curacao. The examiner's report stated, "Trans Caribbean, by reason of its diligent and pioneering efforts to develop traffic at this point (Aruba) . . . is the logical carrier to be awarded certificate authority to provide the required service."

Two Boeing jets, a 707 and 720, were leased by Trans Caribbean in August, with an option to buy. Additionally, TCA took delivery of 2 of its 3 new DC-8F Super 61 fanjets, with the third to be delivered early in 1968. The passenger configuration of the Douglas stretch jets included 16 first class seats, 30 de luxe tourist seats and 177 thrift seats. With a total fleet which provided a tripled capacity, Trans Caribbean was prepared, by the end of the year, for its giant thrust.

The Civil Aeronautics Board, in the fall, approved TCA's application to provide ground transportation between downtown Washington and Dulles Airport, at no additional charge to its passengers. A beautiful, historical building at 3600 M Street was refurbished and named The Trans Caribbean Airways Key Bridge Terminal, offering a luxurious new check-in facility conveniently located at the threshold of Washington's entry to Dulles. Using magnificent Spanish decor, TCA also opened an impressive Washington Ticket Office at 1480 New York Avenue. This address also houses the headquarters for TCA's new Washington District Sales Division, whose marketing activities cover Washington, Virginia, Maryland, West Virginia, Delaware and Pennsylvania. Another unique service in line with Trans Caribbean's entry to the Washington market was their introduction of the first tourist excursion fare from Washington to San Juan, the Virgin Islands and Aruba, a truly great bargain.

For the first time, a daily service was planned by Trans Caribbean Airways from Newark Airport to both San Juan and Aruba. Although TCA had certification for years to use Newark Airport as a co-terminal, it was unable to do so for lack of space at Newark. Arrangements were also being made for a downtown-Newark Trans Caribbean ticket office.

Traditionally, Trans Caribbean Airways has introduced many promotional fares and imaginative package tours. One of the most exciting in 1967 was the Fiesta Caribbean, which promoted the concept of a European Grand Tour in the Caribbean, with Puerto Rico as the start, via jet by Trans Caribbean from New York, and interconnecting visits, via Caribair, to the other ports of call. Thus, a European adventure could be had a few short hours from home since each Fiesta island provided the flavor, color and culture of its continental counterpart. Puerto Rico for Spain, Aruba and St. Maarten for Holland, Guadeloupe and Martinique for France, St. Thomas and St. Croix for Denmark, Antigua and Barbados for England, "Capturing the Old World in the New." Another fabulous holiday vacation promoted by TCA was the "Swing Two Islands" which offered 2 islands for the price of one: Puerto Rico, with a swing to Aruba, or Puerto Rico and the Virgin Islands.

During the year, Trans Caribbean advertising and promotion was based on the "Flying Island . . . All the fun and flavor of Puerto Rico when you get to the terminal." This theme was based on the Airline's unique knowledge of Puerto Rico and the Caribbean. It featured original Puerto Rican art, cuisine, design and friendliness. The advertising in all major media in all cities on the route highlighted the various aspects of the "Flying Island." The passengers' ramp steps were decorated with authentic Puerto Rican tile designs. The menus featuring the finest native and continental cuisine were decorated with original paintings of Puerto Rico commissioned by Trans Caribbean.

TRANS INTERNATIONAL AIRLINES

Trans International Airlines, the first all-jet supplemental air carrier, enjoyed a record year during 1967. Estimated gross revenues rose to a record-breaking $35,000,000, while the company continued to increase its ratio of commercial to military sales.

TIA introduced a 250-passenger plane into commercial service in June 1967. The DC-8-61 stretch jet, designed by McDonnell Douglas for charter type activities, made it possible for the company to significantly reduce charter air fares, both foreign and domestic.

Flying an average of over 15 hours a day, the plane logged a record-breaking 42,000,000 passenger-miles during its first month of service, while carrying more than 10,000 passengers to 10 European countries. A second stretch jet was delivered to TIA in the latter part of November 1967. In addition, TIA expected delivery of a third stretch in January of 1968 and thereafter was to accept delivery from Douglas of 2 DC-8-63 stretch jets in the latter part of 1968 and early 1969.

TIA ordered 2 Boeing 727-100C aircraft for delivery in April and May of 1968.

By the end of 1967, TIA had increased its passenger seat availability by some 240 percent over 1966.

In June 1967, TIA, which was the first supplemental air carrier to offer its common stock to the public, became a member of the New York and Pacific Coast Stock Exchanges, thereby expanding the marketability of its stock for the benefit of its shareholders.

TIA became the nation's largest commercial charter operator. The company places great emphasis on the domestic ITC market, and during 1967 flew a large number of these tours. In August 1967 TIA passed the $1,000,000 mark for ITCs to Hawaii. In October, the company signed a $13,000,000 contract with American International Travel Service, a Boston based travel agency, for ITCs through April 1969. The company maintained a heavy charter schedule across the North Atlantic and was making plans to expand its service to South America and the Orient.

TIA had CAB authority to operate charter flights, both affinity and ITC, within the U.S. and between the U.S. and all other points in the world except Canada and Mexico.

TIA placed the stretch jet into service for the Military Airlift Command on October 3, 1967, with a seating configuration of 219 passengers, the largest jet in MAC service. Approximately 50 percent of TIA's revenues in 1967 were derived from MAC.

In September 1967, the Boards of Directors of TIA and Transamerica Corporation, a large San Francisco holding company, announced agreement in principle whereby TA would acquire the stock of TIA on a stock exchange basis valued at approximately $125,000,000.

TIA believed the ever-increasing demand for low-cost air travel would enable the company to continue its rapid growth pattern, and it planned additional expansion of its charter activities throughout the free world.

TRANS-TEXAS AIRWAYS, INC.

Trans-Texas Airways, Inc., celebrating its 20th year of service to the Southwest, saw a number of significant changes within the company framework in 1967. The Houston-based local service airline serves 65 cities in 6 states and the Republic of Mexico and, in 1967, was the only regional carrier to be awarded an international flag carrier certificate. In addition, TTA has the longest international route of all the local service airlines.

In the first 9 months of 1967, TTA's passenger boardings increased 20 percent over 1966 to 1,075,781 and commercial revenues increased 17.4 percent to $19,999,822. For the third quarter, passenger boardings increased 11.8 percent over the same quarter in 1966 while commercial revenues increased 18.5 percent to $6,980,726.

TTA took delivery on its fourth Douglas DC-9 Pamper-jet November 9, and the 75-passenger multi-change aircraft was placed into scheduled service the following day. Two other DC-9s were received during the year, with the first being inaugurated in March 1967 and the second in October 1967. TTA inaugurated its initial Pamper-jet service in October 1966.

TTA added 5 DC-9 Pamper-jets during the year.

Pamper-jet service at year-end was being provided to Santa Fe, the capital of New Mexico, a city never before receiving a jet; and to Memphis, Tennessee, Midland/Odessa, Texas, and Albuquerque, New Mexico. In addition, with the delivery of the fourth Pamper-jet, pure jet service was increased for Houston, Austin, Dallas, Midland/Odessa, and San Antonio, Texas. TTA began its Dallas–Midland/Odessa nonstop flights July 1, 1967, after CAB approval was granted in June.

Delivery of 3 more Pamper-jets was expected late in the year and early in 1968. TTA also held an option on 8 more DC-9s.

On December 1, TTA inaugurated a new express check-in commuter type service between Dallas and Houston. There will be 10 nonstop Pamper-jet flights northbound from Houston to Dallas and 10 more southbound from Dallas to Houston every weekday.

In addition, TTA's 17th jet-powered Silver Cloud 600 went into service November 1. Nineteen of these 40-passenger aircraft, after being converted from the Convair 240 prop version, were to be flying by the end of the year, with the 25th and last slated to go into service in May 1968. At that time, TTA expects to be all turbine-powered.

The airline was given final CAB approval November 6 for the $725,000 sale of 16 of its 17 Douglas DC-3s.

Houston Aircraft Brokers, Inc., bought the airplanes, 89 Pratt & Whitney engines, and $58,000 worth of spare parts for the DC-3s.

The year saw the opening of a large new maintenance facility at the TTA station serving Midland/Odessa, Texas. Official dedication of the new hangar was October 5. Also, construction began on a similar hangar at Dallas Love Field, with completion slated for late 1967.

On August 10, 1967, TTA's executive office personnel moved from their downtown Houston headquarters into a new facility at the airline's general office complex at Houston International Airport. Transferring were TTA's chairman of the board, president, and legal, public relations, research, advance schedules, and current schedules departments.

October 11, the twentieth anniversary date of TTA saw several significant changes within the executive framework. At a board of directors meeting R. Earl McKaughan, founder and chairman of the board, asked to resign from active participation in the airline and was unanimously elected chairman emeritus and founder. He will serve in an advisory capacity. President R. E. "Dick" McKaughan became TTA's chief executive officer.

Other organizational changes included the naming of 2 new vice presidents: Joe C. Crawford, vice president—administrative services is responsible for the airline's training, purchasing, personnel, inventory control, properties and facilities and data processing divisions; J. L. Herring, vice president—operations, will oversee TTA's flight, maintenance, customer services, flight planning and inflight services divisions. In addition, the board approved the appointment of Captain A. J. High, a 20-year veteran of TTA, as vice president—flight.

Minnesota Enterprises of Minneapolis, Minnesota, purchased controlling interest in TTA in April 1967. ME is headed by Carl Pohlad, president of Marquette National Bank of that city.

In route case proceedings, TTA's research department was active in 1967. TTA testified in the Reopened Pacific Northwest-Southwest Service Investigation, the Central Airlines, Inc. Route 81 Investigation, and the Gulf States–Midwest Points Service Investigation. Applications were filed for the Southern Tier Competitive Nonstop Investigation, the Dallas/Fort Worth–Phoenix Nonstop Case, and the Service to Albuquerque Case.

Important fare modifications occurred during the year. For example, the TTA Youth Fare card, formerly $10, was altered to a $3 charge and as of October 28 young adults may use the TTA identification card to purchase half-fare or 66⅔ percent fare on most other carriers. In addition, young travelers may make confirmed reservations. Other fares being promoted were the Discover America Fares, the Excursion Fares, the Group 10 Fares and TTA's Family Plan, as well as the Military Stand-by Half Fares.

In line with improved passenger relations, TTA, as of April 1967, honored not only the airline's own travel card, but also American Express, Carte Blanche, and Diners Club cards for charging TTA travel.

Also associated with improved service was the installation of Pamper-matic into Houston's reservations control center. The computerized reservations system, which went into full operation August 12, promised to be the answer to quicker and more efficient handling of reservations, both on-line and off-line.

TRANS WORLD AIRLINES

Trans World Airlines in 1967 became the first airline to switch to all pure-jet operations in U.S. domestic service as well as on international routes, and embarked on major facilities construction for the coming generation of giant Boeing 747 and supersonic transports.

The airline also in 1967 inaugurated service to East Africa and acquired through merger Hilton International Company which operates 42 hotels in 28 countries around the world.

"In terms of added seat-miles, TWA in 1967 increased its service to the public by 31 percent," said Charles C. Tillinghast, Jr., president. "On the basis of actual results for 10 months and estimates for November and December, we expect to fly some 12,600,000 passengers a total of almost 14,000,000,000 passenger-miles. These estimates, representing increases of 29 and 33 percent respectively, reflect the 43-day strike against 5 airlines, including TWA, in the previous year."

Cargo volume rose 32 percent to an estimated 432,500,000 ton-miles carried in 1967, Mr. Tillinghast said. Within the 3 categories of this record cargo volume, freight ton-miles were estimated at 310,900,000, up 28 percent over 1966; air express ton-miles at 15,800,000, up 11 percent, and mail ton-miles 105,700,000, a boost of 46 percent.

TWA took delivery on 31 new jets in 1967. On April 6, the airline retired its last passenger-carrying propeller-driven aircraft, a triple-tailed Constellation, thus becoming the first airline to go pure-jet in U.S. domestic service. TWA had, in 1961, switched to an all-jet operation on its transatlantic routes through Europe, Africa, and Asia.

With the inauguration of Boeing 727 QCs (quick-change between passenger and cargo interior) on May 12, TWA retired its last 2 piston-powered Constellations from cargo service. By year-end, TWA's all-jet fleet numbered 170 units, including 15 Cargojets.

During the year TWA completed arrangements to acquire 47 more subsonic jetliners and 2 more U.S. supersonic transports (SSTs). The 47 aircraft, along with other acquisitions will raise the TWA subsonic fleet to 245. Included in the program are 22 Boeing 747s.

In addition, the TWA program included 6 British-French Concorde SSTs and 12 U.S. SSTs for service in the 1970s. The first to place an order for the U.S. SST, TWA held No. 1 delivery position.

In a series of major steps to meet the challenge of servicing the next-generation airliners, TWA in 1967 started construction on supersonic-size ground facilities:

• Flight Wing One, expected to be the world's first air terminal designed wholly for the age of the 747s and SSTs, will double the size of the Trans World Flight Center at New York Kennedy International Airport. The $19,800,000 "terminal of tomorrow" will

Work started on TWA's Flight Wing One, the $19,800,000 "Terminal of Tomorrow," to be opened in 1969 for use by Boeing 747s and, later, SSTs.

be an extension of the Eero Saarinen-designed TWA Center which was acclaimed by architectural critics of many nations when it was dedicated in 1962. Flight Wing One, designed to accommodate up to 10 aircraft, will be opened in autumn 1969 preparatory to inaugurating Boeing 747 service in 1970.

• Also ready when the 350-passenger Boeing 747s arrive will be a $33,000,000 expansion of TWA's huge Technical Services Center at Mid-Continent International Airport at Kansas City, Missouri. The structure will accommodate 4 Boeing 747s (tail height: 64 feet) or 4 U.S. SSTs (length: 318 feet).

• The Trans World Flight Hostess Academy, announced in July, will be activated in 1969. Combining classrooms, residences and recreation facilities, the academy will sprawl over a 34.4-acre campus in residential Overland Park, Kansas, just 20 minutes from downtown Kansas City, Missouri. TWA was training 1,200 flight attendants yearly at the airline's Jack Frye International Training Center for pilots and attendants in downtown Kansas City. The new academy will be equipped to train upwards of 4,000 flight attendants a year.

On April 29, 1967, TWA inaugurated service to Kenya, Tanzania and Uganda in East Africa. The service reduced by 3½ hours the previous travel time between the United States and the 3 East African nations. Elapsed time, via Athens, was under 17 hours.

TWA introduced a number of new nonstop services on its U.S. routes during the year, including Pittsburgh–San Francisco, Philadelphia–San Francisco, St. Louis–Denver, New York–Oklahoma City, Dayton–Los Angeles and Indianapolis–Los Angeles. In the winter, TWA was offering more than 24,300 jet seats on 176 transatlantic flights weekly, the highest wintertime frequency in the airline's history.

TWA virtually doubled its all-cargo service effective October 16. The company's schedule pattern reflected an increase from 9 to 15 units in its Cargojet fleet and a doubling of all-cargo schedules on U.S. routes. International cargo frequencies were increased from 16 to 26 weekly.

In March TWA petitioned the Civil Aeronautics Board for southern transcontinental route authority linking Miami/Fort Lauderdale and San Francisco/Oakland via New Orleans, Dallas/Fort Worth, Houston and Los Angeles/Long Beach. It also applied for authority between Atlanta and California via Texas.

In October the airline filed for new authority in the CAB's Twin Cities–Milwaukee Long-Haul Service Investigation over the following segments: Minneapolis/St. Paul (Twin Cities) and Milwaukee to New York, Philadelphia, Washington/Baltimore and Twin Cities to Portland and Seattle. TWA asserted that it could provide through-plane service to Europe which was not available from the Twin Cities–Milwaukee areas.

In November, TWA filed for authority to provide an extensive pattern of new air service between major Midwest cities and Dallas/Fort Worth, Houston and San Antonio. While TWA was serving Midwest cities St. Louis, Detroit, Kansas City and Chicago, it was not serving the Texas cities.

Also in November, TWA requested service to White Plains, New York, from Chicago, Cincinnati, Cleveland, Pittsburgh, and St. Louis.

In the CAB's Transpacific Route Investigation, meanwhile, TWA sought commercial routes across the Pacific (TWA flies the Pacific daily to Saigon under contract to the Military Airlift Command). The TWA route system at year-end stretched from the U.S. West Coast eastward two-thirds of the way around the world to Hong Kong on the opposite shore of the Pacific. TWA proposed to link its Pacific terminals with routes serving Formosa, Japan, Hawaii, Alaska, Seattle/Tacoma and Portland.

TWA, one of 18 applicants in the case, sought Pacific rights to fight increasingly vigorous competition by the world's airlines in the booming Pacific and round-the-world travel markets. In its case before the CAB, TWA noted that "there is a crying need for decisive action to strengthen the U.S. position in transpacific air routes." TWA claimed that its long international experience and extensive route system which ties together 42 U.S. and 24 cities in Europe, Africa and Asia would enable it to serve this national need better than any of the other applicants in the case. TWA said it would cut fares between mainland U.S. cities and Pacific points by more than 40 percent and offer a $995 round-the-world excursion fare. The company proposes an initial operation of 186 flights a week between Hawaii and mainland U.S. cities and 116 weekly flights spanning the entire Pacific.

The merger of Hilton International Company into TWA became effective May 9, 1967. Hilton International is operated as a wholly owned TWA subsidiary. With the opening of the Curacao Hilton on December 11, Hilton International operated 42 hotels in 39 cities in 28 countries outside the continental United States.

TWA provided scheduled service to 10 of the international cities where Hilton has hotels.

UNITED AIR LINES

United Air Lines experienced its most rewarding year in 1967, shattering industry records by carrying approximately 24,000,000 passengers and attaining new highs in cargo volume.

The record year was foreshadowed in August when the company became the first commercial airline in the world to exceed 2 billion revenue passenger miles in a single month. It was in August 1964, that United first reached the billion passenger mile mark.

Keeping pace with traffic growth, the company took delivery on 42 jets in the year, including 4 standard DC-8s, 6 Super DC-8s, 15 Boeing 727QCs and 17 standard Boeing 727s. These additions increased the jet fleet to 231 aircraft.

As part of its advance to all-jet operations by the end of 1969, United placed orders for 54 more jets in summer and also announced that options had been exercised to purchase 25 other jets. The 79 aircraft, costing $690,000,000, represent one of the largest jet acquisitions ever made by an airline.

Delivery of the 79 additional jets will begin in late 1968 and continue into 1971. By types, they are 3 Douglas Super DC-8F Jet Freighters, 5 Super DC-8s, 6 Boeing 727 QCs, 10 DC-8-62s, 13 Boeing 747s, 17 Boeing 727-222s and 25 Boeing 737-200s.

United later in the year exercised options to purchase 5 more Boeing 727-222s, which will be delivered in mid-1969. With these aircraft, plus those ordered previously, the company will have a fleet of more than 400 jets by the end of 1971.

The first Super DC-8 was placed in service between California and Hawaii on February 25. Other developments in Hawaiian service included the adoption of common fares between the Mainland and all major points in the Islands. United also began direct service between Hilo, Hawaii, and the California gateway cities on October 1.

Service between Toronto and Chicago was inaugurated in August, with 3 daily round trips. The addition of Hilo and Toronto increased the number of cities served by United's system to 114.

Blue Carpet Service, an upgrading of coach travel, was introduced on transcontinental nonstop flights and immediate success prompted its extension to 6 other major markets. As part of this development, United's Boeing 720s were converted from a 3-class (first, standard and coach) to a 2-class configuration (first and coach).

In 1965, aware that many of the major airports were becoming increasingly inadequate because of rapid traffic growth, United began an airport planning program within its Facilities and Property Department. The object was to determine the improvements required both now and in the future and, with the cooperation of other airlines, to develop Master Plan Reports for the guidance of local airport authorities.

As a result of this program, Master Plan Reports for 20 of the nation's largest airports were presented in 1967 through the Air Transport Association. The reports provided data on airline needs for gates, hangars, terminal space, cargo buildings and other facilities. Recommendations were also included on requirements for runways, access highways, parking lots and related auxiliary features.

Master Plan Reports on airports at intermediate cities served by United were in preparation and these were to be followed by reports on airports at smaller communities. The program, first of its kind in the industry, was enthusiastically received.

Among new facilities completed in 1967 were 2 structures at United's headquarters. One was an 8-story adjunct of the Education and Training Center, which will be used for stewardess training. The other was a 2-story building to house the staff and central equipment for "Unimatic," which will become operative in 1968 as the most extensive computerized reservations and information system in the world.

Indicative of United's 1967 record year were the highs achieved for the first 9 months. The company

United introduced its Douglas Super DC-8s (bottom) on Hawaiian routes early in the year.

carried 17,918,000 passengers as compared with 12,945,000 in the corresponding period of 1966, a gain of 38 percent. This increase and those that follow below, must, however, be viewed in light of the 1966 strike by airline machinists which held operations at a standstill for 43 days.

Revenue passenger miles for the 9 months totaled 14,171,142,000, an increase of 50 percent. Freight ton miles were 323,663,000, up 42 percent; mail ton miles, 80,853,000, up 47 percent; express ton miles, 16,091,000, up 20 percent. Nine-month earnings reached $63,088,859 as against $22,143,171 the previous year.

UNIVERSAL AIRLINES, INC.

The year 1967 was a year of changes and development for Universal Airlines.

In January, the company officially changed its name from Zantop Air Transport, Inc. to Universal Airlines, Inc. Universal Consolidated Industries, a New York-based privately-owned holding company, acquired Zantop Air Transport late in 1966.

In order to meet the growing demands of air cargo and military and civilian charter business, Universal placed an order for 2 DC-8-61CFs, delivery date April 1968, and 4 DC-9-30CFs, delivery date March–June 1969. The company also placed an option for 2 additional DC-9-30CFs, delivery in mid-1969.

A major change for the company was that by mid-June Universal had moved from facilities at Detroit Metro Airport to much larger quarters at Willow Run Airport, Ypsilanti, Michigan. The company occupied an entire hangar with over 200,000 square feet of hangar and office space entirely under one roof. A $1,000,000 cargo building was contemplated for construction in the near future.

The Universal Airlines fleet, domestic and international, was serving the industrial points of the U.S., the military and charter groups with 12 stations around the country, over 60 aircraft, and over 2,000 persons skilled in operations, communications, traffic, sales, service, and related areas.

During 1967, Universal expanded its operation by flying military cargo to Vietnam. In February, the company embarked on a new operation, that of CAM flights, and greatly increased its commercial passenger charter operation.

The company was providing air service for the U.S. Navy and U.S. Air Force, and the year 1967 brought a $19,500,000 military contract. The fleet served 32 Air Force bases in the eastern half of the U.S., providing vital air freight connections within the Air Force Logistics Command, Strategic Air Command and aerial ports of embarkation. The company operations for the U.S. Navy consisted of serving 18 key Navy installations, coast to coast. This operation supported the U.S. Navy fleet domestically and provided a link in the world-wide supply line of the U.S. Navy.

The 1968–69 arrival of the jet fleet will allow the company to expand all its operations, both cargo and passenger, within the U.S., Canada, and Mexico, which are the areas of the company's operating authority.

WEST COAST AIRLINES

Action aimed at the creation of a new airline covering 8 Western states and destinations in Canada and Mexico made 1967 one of West Coast Airline's most significant years. The move, at year-end awaiting Civil Aeronautics Board approval anticipated in early 1968, was made on September 12, when West Coast, Bonanza and Pacific Airlines filed an application to merge.

Ratification of the action would create a regional airline comprising more than 74 unduplicated stations in Washington, Oregon, California, Nevada, Arizona, Utah, Idaho and Montana. A fleet of 61 aircraft would serve the more than 100 destinations in the United States, in addition to Calgary, Alberta, Canada, and under provisions of an action by the CAB, the Mexican vacation communities of Mazatlan, Puerto Vallarta, and La Paz.

Name of the merged airline will be Air West unless a legal technicality emerges, in which case the new entity would take the name of West Coast Airlines. Nicholas Bez, Sr., West Coast's president, will head the new firm.

Continuing a pattern of passenger volume growth, West Coast by the end of 1967's third quarter had carried approximately 50,000 more passengers than over the corresponding 1966 period. By the end of October, the line had carried 590,797 passengers, compared to 534,908 during 1966. During 4 of the months, volume was up over 20 percent.

The passenger volume continued a chain of unbroken gains for the line dating back to January 1964.

The merger move was but one of the many forward steps taken by West Coast Airlines during 1967, a year marked by equipment additions that saw WCA nearly double its DC-9 fanjet routes. Delivery of 2 of the Douglas jets, coupled with a CAB service award, extended new nonstop service into Salt Lake City and Boise. This completed pure jet service to all major West Coast interline connecting points, including San Francisco, Portland, Seattle, Spokane, Boise, and Salt Lake City. Other cities also receiving DC-9 service at the end of 1967 included Eugene, Medford, Walla Walla, Tri-Cities, and Yakima. Further expansion was planned in 1968 with the arrival of the new DC-9 Series 30.

Utilizing "MiniLiners," twin-engine Piper Navajo planes, West Coast Airlines brought new speed and convenience to low density route segments in Washington, Oregon, Idaho and Utah. Four of the 8-place planes were purchased at $144,000 each.

West Coast's announcement of the addition of its fleet of the new 58 passenger Fairchild 228 placed further emphasis on the corporate slogan, "the best planes for the best service." Three of the 500 mile per hour twin jets were purchased for 1970 delivery, with options for 5 additional aircraft. The total purchase price was $25,000,000, including spares. The Fairchild 228 is designed to service routes of less than 100 miles from runways of under 4,000 feet. The new aircraft will feature Rolls Royce advance-design fanjet engines. West Coast Airlines was also operating Fairchild F-27 turboprop planes, which it introduced to U.S. service in 1958.

New, sophisticated ground equipment went into service during 1967 to match the improvements in the air. The Electronic Data Processing Department completed a program of computer reading of paper tapes from field dispatch messages. This permits computerizing of such data as passenger boarding by segments, delay and ground performance analysis, and adherence of flight to schedule. The result is a weekly analysis of revenues and schedule performance.

Linking of Salt Lake City to West Coast's Central Reservations Center in Seattle placed 80 percent of the line's passenger reservations through a sophisticated call distribution system designed and engineered by Pacific Northwest Bell. The line's communication network at year-end included an automated cross office teletype switching system, connecting West Coast stations with the world's airlines. Similarly, West Coast's accounting department has been computerized.

During the year, West Coast Airlines accepted a far reaching assignment aimed at increasing the efficiency of inspections through a program designated ROPAR (Regional Operators Program for Airframe Reliability). Under ROPAR, which met in Seattle for the first time in February 1967, 10 regional airlines operating DC-9s united to combine data and operating experience to control DC-9 airframe structural inspections. West Coast accepted the coordinating function of collecting data and producing monthly reports. Because of the centralization of information, standards can be established which should preclude problems in areas covered by the program, and therefore reduce the number of samples required by each airline on an individual basis. Phase one of the program was approved by the Federal Aviation Administration in September.

Keeping pace with equipment improvements and additions were the continued expansion of West Coast service areas during 1967. Award of nonstop service between Medford, Oregon and San Francisco was received from the CAB, with service beginning in February.

Even more significant was West Coast's route application for nonstop service from Seattle and Portland to San Francisco and Los Angeles. If awarded, the new service would provide through plane service to major California ports from the burgeoning Northwest area served by West Coast.

The need for public awareness of West Coast's new route and equipment improvements was recognized in the creation of a new sales education department. The new department provides in-depth corporate indoctrination, continued training and upgrading of all personnel.

West Coast's travel promotion efforts received top recognition at the American Society of Travel Agent's world convention at Athens, Greece, where the company publication, "Air West," received the annual Popular Photography Magazine award for "the most effective use of photography to promote travel."

WESTERN AIR LINES

For Western Air Lines, the major event of 1967 was the merger with Pacific Northern Airlines. Consummated on July 1, the merger extended Western to 9 cities in Alaska.

The company immediately began an intensive campaign of promoting travel to Alaska. Western announced a plan to establish an Alaska Business Council dedicated to the economic development of the state, much as the railroads helped develop areas of the U.S. during the 19th Century.

Western at year-end served 44 cities in 12 western states, Alaska, Canada and Mexico, covering 14,156 route-miles.

The company was participating in some 30 route cases in which it sought expanded route authority stretching from the East Coast across the nation and as far west as Bangkok.

On July 1, Western inaugurated service to Vancouver, British Columbia, serving the city from Los Angeles, San Francisco and Portland.

Changes in Western's board of directors included the addition of Arthur G. Woodley, former president and founder of PNA, now vice president for Western; and the resignation of Goodrich Lowry, former chairman of the board of Northwest Bancorporation. Lowry was appointed director emeritus.

Financially, Western netted $11,063,000, or $2.26 a share, for the first 10 months of the year. This was down 33 percent from $16,561,000, or $3.43 a share, for the like period in 1966. The 1966 figure included increased traffic due to the strike against 5 other carriers.

Operating revenues for the 10-month period were $159,773,000, compared to $148,318,000 a year earlier. Load factor for the period was 57.4 percent, compared to 61.1 percent. The break-even point was 49.4 percent, versus 47.5 percent.

A major cause for the reduced earnings in 1967 was a decline in yield due to the many discount fares in effect. The yield dropped from 5.69 cents per mile for the first 10 months of 1966 to 5.38 cents.

Western carried nearly 4,250,000 passengers during the first 10 months of 1967, an 8 percent increase over the like 1966 period.

The number of Western employees increased from 5,200 to 7,300. In addition to company growth, this reflected the addition of 700 PNA employees.

Western's fleet at year-end numbered 51 aircraft. This included 27 Boeing 720B fanjets, 3 720 models, 12 Lockheed Electra II prop-jets, 6 Lockheed Constellations and 3 Douglas DC-6Bs.

Western opened a new "off-line" office in Washington, D.C., staffed by Henry M. deButts, assistant vice president of government and industry affairs. DeButts was former assistant to 2 chairmen of the Civil Aeronautics Board. The company also appointed an account executive to the Washington office to handle sales activities.

WIEN AIR ALASKA

Civil Aeronautics Board hearings were held during 1967 on a merger of Wien Air Alaska of Fairbanks and Northern Consolidated Airlines of Anchorage, with a decision expected early in 1968. If approved, the merged company would be known as Wien Alaska Airlines. The combined routes would total 8,604 unduplicated miles to serve 152 communities in Alaska and 2 in the Yukon. With the exception of Fairbanks, Anchorage and Juneau, the region served is a low density area almost completely dependent on air transportation for mail, freight and passenger service. Both of the companies are pioneer airlines in Alaska, and operate the same kind of equipment—F-27 propjets, Twin Otters and Pilatus Porters. Each airline had a B-737 on order for delivery in 1968.

Despite a flood which hit Fairbanks in August and quickly tapered off the tourist season a month early, more than 5,000 visitors traveled on Wien Air Alaska to the tour destinations of Ft. Yukon, Barrow, Kotzebue and Nome. Two additional F-27s had been leased to handle the greatly increased tourist volume during the summer.

Wien took the delivery on the first of 2 Twin Otters on November 25. The second was expected to be delivered in February of 1968.

Revenue passenger miles for the first 9 months of 1967 totaled 20,731,000, an increase of 2.5 percent over the previous year. An application for a new direct route from Juneau to Minneapolis–St. Paul–Chicago was filed with the Civil Aeronautics Board.

WORLD AIRWAYS

World Airways enjoyed substantial growth during 1967; continued its record of pioneering leadership and was accorded significant honors for the high quality and safety of its performance.

Record highs in revenues and earnings were achieved as the company expanded its organization and its fleet, while substantially increasing both its commercial charter and its Military Airlift Command traffic.

Recognition of World leadership in business management and financial performance came in the annual survey by *News Front* magazine in its listing of the best-managed U.S. corporations based on sales and profit figures. World was one of the half-dozen companies of the 1,500 U.S. corporations reviewed which placed in the top 100 to qualify in each of the 3 criteria applied to identify the best-managed corporations. World's performance in each of these criteria were: (1) percent of profit to stockholders' equity, 37.5; (2) profit as a percent of sales, 18.8; and (3) percent of sales increase over the previous year, 50.5.

World's operational performance was accorded new laurels when, for the third consecutive year, the company was awarded the nation's highest airline safety award, the "Award of Honor," presented by the National Safety Council. World has been the only U.S. airline, supplemental or scheduled, to receive the "Award of Honor" in each of the last 3 years.

The company also became the first airline to receive the U.S. Air Force's "Zero Defects Award" in recognition of the achievement of World's "Perfection/Not Correction" program.

During 1967 World took delivery of 9 new jets, 3 707-320C fan jets and 6 727 tri-jets, adding 1,245 seats for a 160 percent increase over its average capacity during 1966. At year-end, the fleet included 15 Boeing jets representing an investment of $125,-000,000 in equipment and related parts. The carrier, largest supplemental airline in the world, also had on order 3 Boeing 747s, with an option on a fourth, and had reserved delivery positions for 3 U.S. supersonic transports. Financing arrangements for the $72,000,000 B-747 program were completed with the Bank of America.

In line with the equipment expansion program, over 400 new employees joined the firm, bringing the total payroll to over 1,300 people. New offices were opened in Dusseldorf, Germany, and Houston, Texas, bringing worldwide sales offices to 12 in number. In addition the company opened operations and passenger handling offices in Japan, John F. Kennedy International Airport (New York), Gatwick Airport (London), Paris and Frankfurt.

In view of its growth and to broaden the base of its policy making group, the company also elected to its board 3 new directors of international prominence in diplomatic, business, financial, legal, and travel affairs. The new directors are Chinn Ho, prominent international financier, publisher, hotel developer and Hawaii civic leader; George Killion, chairman of the board of Metro Goldwyn Mayer and a director of American President Lines, Natomas Company and the Communications Satellite Corporation; and Sir Percy Rugg, chairman of the Greater London Council, largest local government authority in the world, who has provided legal representation for World Airways in the United Kingdom and Europe since 1955.

Also, to provide greater depth in management, the company established new regional sales vice presidential posts for the Eastern U.S., and for Europe, Africa and the Far East, and a new position of vice president—maintenance and engineering in Oakland.

By the latter part of 1967, World's commercial transportation revenues were over 62 percent higher than during the same period in 1966, and a further increase of 65 percent in commercial business was anticipated for 1968. Over 860 commercial charter flights, carrying an estimated 179,000 passengers, were made during 1967. Highlighting the growth in commercial business was the successful completion of the Berry World Travel's 1967 Inclusive Tour Charter program, the first large-scale ITC program to be implemented since the Civil Aeronautics Board authorized ITCs in 1966. The Berry World program involved 49 flights between May and November from New York, Chicago, Los Angeles and Oakland/San Francisco to the Hawaiian Islands, carrying 8,000 vacationers, with an unprecedented 98.8 percent utilization of available seat capacity.

The initial World-Berry World 1967 program proved so successful that arrangements were made for a 4-fold increase in the program during 1968. The 1968 program includes 199 flights over a 12-month span starting in January which would carry 32,000 tourists on 11 separate tour plans to the Hawaiian Islands, the Orient, California and Las Vegas. In addition to the series of ITC charters scheduled to the Orient in 1968 for Berry World Travel, a series of ITC's was being programmed to Europe and other foreign destinations.

World and other supplemental airlines were granted authority to continue to book and to operate international inclusive tour charters pending their appeal to the U.S. Supreme Court on the authority of the Civil Aeronautics Board to authorize such charters. The decision which is being appealed does not involve the domestic inclusive tour charter authority of the supplemental airlines.

In 1967, group affinity, or pro rata, charters continued to be the largest source of World's commercial business and showed the largest growth. Over 600 transatlantic flights of this type were flown, compared with 246 in 1966. These included the airlift of over 1,800 Boy Scouts from Stockholm, Copenhagen, Zurich, Frankfurt, Brussels and London to the 1967 World Jamboree in Idaho. Following the Jamboree, the British Scouts were flown from Spokane, Washington, to San Francisco, Portland, Kansas City, Denver, Richmond, Detroit, Indianapolis, Salt Lake City and Chicago for "Hospitality Weeks" before their return to England. World continued its program of transpacific flights for many different organizations.

To promote group affinity charters, World embarked in October on a $1,000,000 dollar advertising-promotion program designed to call attention to the economic and other advantages of affinity charters to civic, business, social, religious, labor, educational, athletic, fraternal, ethnic and other recognized organizations. One of the first to make use of color in Sunday travel pages, the program appeared in major dailies in New York, Chicago, Los Angeles, San Francisco, as well as in leading U.S. foreign language publications and the travel trade press.

The third type of charter service provided by World, the single entity group, also showed favorable growth in both Atlantic and Pacific operations for such blue chip companies as United Motor Service and Frigidaire Divisions of General Motors, Olivetti-Underwood Corporation, Sealy Mattress, Philco-Ford Corporation, Hotpoint Division of General Electric, Ford of Canada and Dempsey-Tegeler, national investment firm.

The largest single entity program by World in 1967 was a sales incentive tour by 4,500 sales personnel and wives of the United Motor Service and Frigidaire Divisions of General Motors from 23 mainland U.S. cities to Maui, the "Valley Island" of Hawaii, for a 6-day holiday.

Recognition of World's performance for Western Electric in flying personnel and cargo between Oakland and the Pacific island of Kwajalein came in the renewal of World's contract for this operation for the seventh consecutive year. The flights provide transportation for engineers, technicians and their families, plus cargo, to and from the Kwajalein test site which is operated by the Army's Nike X Project as a research development and test facility.

The company's military business for the fiscal year which began July 1, 1967, was more than doubled with the award of a Military Airlift Command "fixed" contract calling for a minimum guarantee of $26,648,869 for the ensuing 12-month period for airlift by 707s of military personnel and cargo between Travis Air Force Base and the Far East. The "minimum guarantee" contract in the previous fiscal year was for $12,841,402.

Just one year and 6 days after its first public offering of stock, World Airways made airline history on April 24 when it became the first supplemental airline to have its shares listed on the New York Stock Exchange. To broaden the base of its stock distribution the company announced in mid-June a two-for-one stock split, increasing the number of shares outstanding from 5,000,000 to 10,000,000.

World's maintenance subsidiary, World Air Center, made significant advances in 1967, performing maintenance services on World's growing jet fleet and showing an increase of more than 30 percent in revenues from work on aircraft of other carriers.

Two related new projects with constructive significance to unemployed and under-employed residents of Oakland as well as the advancement of aviation technology were undertaken by World during 1967. In February the company signed a 40-year lease with the Port of Oakland for the construction of a giant new $10,600,000 "super-jet" hangar and office complex to be built on a 60-acre site near the new passenger terminal at Metropolitan Oakland International Airport. It will be the first hangar in the west designed specifically for the new generation of jet aircraft including the Boeing 747, the Boeing SST and the Lockheed C-5A. It also will serve as international headquarters for World Airways.

On September 15 dedication ceremonies were held on the hangar site as a highlight of the 40th Anniversary Celebration of Oakland International Airport. Guest of honor at the ceremonies was The Honorable George P. Miller, U.S. Congressman from Alameda County since 1944, in whose honor the facility has been named.

World Airways planned a 1968 construction start on this \$10,600,000 hangar complex for the airline and its subsidiary, World Air Center, at Oakland International Airport.

In July, World announced the formation of an aviation training school, the World Institute of Aeronautics, to be operated as a wholly-owned subsidiary of World Airways. Primary function of the school is to train Oakland residents who are either unemployed or underemployed for aviation positions. Initial emphasis was being placed on the training of mechanics. H. Gene Little, formerly chairman of the Aeronautics Department, College of San Mateo, was named dean of the Institute.

In April, World filed an application with the Civil Aeronautics Board for authority to operate scheduled transcontinental nonstop jet service at an initial one-way "thrift service" fare of \$79 per person between East Coast co-terminal points of New York/Newark and Washington/Baltimore and the West Coast co-terminal points of Oakland/San Francisco and Ontario/Long Beach/Los Angeles.

The company also pursued its earlier application for low-cost transpacific services and submitted its brief to the CAB examiner in the Trans-Pacific Route Investigation in September. At year-end, both cases were pending.

VERTICAL LIFT AIRCRAFT

Helicopters set new records in 1967 in the number of lives saved, new jobs done, and export sales.

Helicopters in Vietnam continued their outstanding performance as rescue vehicles. During 1967, the Army Medical Service helicopters accomplished over 94,000 medical evacuations. Since 1962, there have been over 182,000 medical evacuations. The mortality rate has been reduced to less than 2 percent. However, in the U.S. on an average day, 130 persons die in highway crashes. In a year, there are more than 53,000 deaths and more than 1,900,000 disabling injuries from highway accidents.

In 1966, the Congress enacted two significant laws —the Highway Safety Act and the Motor Vehicle Safety Standards Act. Their purpose was to reduce drastically the appalling loss of life and property, and the injuries occurring on the nation's highways. The Department of Transportation was charged with implementing these Acts and the National Highway Safety Bureau was created to administer the laws.

As a first step in 1967, the National Highway Safety Bureau sent a draft proposal of criteria for emergency medical services and highway safety to the governors of the 50 states asking for comment, and further requested that implementation of the finally approved standards must begin by December 31, 1968.

These criteria included proposed standards for ambulance service, in certain areas for helicopter ambulances and hospital heliports. Under the fiscal year 1968 budget, multi-million dollar funds were to be available for the planning of demonstration projects. These will include tests of helicopters.

As part of the Vertical Lift Aircraft Council of the Aerospace Industries Association program to encourage the establishment of hospital heliports and to assist the states in developing emergency medical services, copies of a staff report "Death on our Highways—A National Disease," together with reprints reporting use of highway helicopters were sent to all U.S. governors. Many reported plans and programs already under development.

To assist with this important national highway safety program, the manufacturers were developing ambulance helicopters. Two turbine models, the Bell Jet-Ranger and the Fairchild Hiller FH-1100, with 2 inside litters and seats for pilot and medical attendant, were being certificated and were to be available by mid-1968.

Under the Highway Safety Act of 1966, Pennsylvania was the first state authorized to conduct a helicopter highway patrol test.

Copters, Inc., in cooperation with the State Police, State Department of Health, Pennsylvania Department of Highways and the Pennsylvania Aeronautics Commission, using matching state and federal funds, provided the aircraft and operated a 14-hour daily patrol from the Pennsylvania State Police Barracks in Philadelphia.

Inaugurated in November 1967, this 12-month test patrol uses a Bell helicopter equipped with special large doors which permit the installation of one inside litter and space for a specially medic-trained State Trooper.

Five Philadelphia area hospitals were cooperating by providing heliports and medical staff for the patrol helicopter.

The Chicago Police and Fire Departments were providing a helicopter highway patrol as a public service. Using its available radio network, the patrol can be alerted of an accident, fly to the site and transport the casualties to the Trauma Center at Cook County Hospital. The hospital's ground level heliport (50 feet by 50 feet fenced, lighted, paved and marked) is just off the expressway, close to the entrance of the Emergency Clinic. Emergency missions were running at the rate of 30 each month and rising, with at least a third involving transportation of injured persons.

The experiment initiated in the City of Lakewood, California, in 1966 to provide round-the-clock aerial patrol continued. The Los Angeles County Sheriff's Department, the City of Lakewood, the President's Office of Law Enforcement Assistance and the Hughes Tool Company's Aircraft Division were cooperating by providing personnel, helicopters and matching funds for the experiment, known as Project Sky Knight.

The helicopter, never more than 2½ minutes from any part of the city, proved a deterrent to criminal activity. In Lakewood, according to FBI reports, the crime rate dropped by 8 percent, while the crime rate throughout the nation increased by 9 percent.

The 1967 Directory of Helicopter Operators—Commercial—Executive—Civil Government and Helicopter Flight Schools in the U.S. and Canada listed 1,023 operators operating 2,438 helicopters. Based on this survey by the AIA's Vertical Lift Aircraft Council, the 1967 totals represented an increase of 10 percent in the number of operators and 5 percent in the number of helicopters as compared with the 1966 totals.

The largest increase in operators—21 percent—was in the number of companies and executives that own and operate helicopters. Civil government agencies show the largest increase in the number of helicopters operated, an increase of 30 percent over the 1966 total.

This growth in the civil use of rotary wing aircraft reflected the effective role of helicopters as the air arm for law enforcement agencies, for patrol, crime control, and rescue and as a time and money saving tool of industry.

Continuing growth increased the need for the establishment of public use city-center and hospital heliports. For example, of the 1,225 helicopter landing facilities listed in the 1967 edition of the VLAC's Directory of Heliports/Helistops in the United States, Canada and Puerto Rico, more than half were privately owned.

In addition to proving itself for crime control, the helicopter demonstrated other new capabilities during 1967.

The helicopter was tested and proved successful for the rapid, safe transport of premature babies. St. Francis Hospital in Peoria, Illinois, pioneered in "premie" helicopter transport and with a specially designed lap incubator brought "premies" to the clinic from a distance up to 150 miles. Now the Newborn Center at Denver Children's Hospital is testing a similar service for the Rocky Mountain area.

The world's first strike helicopter, the Bell HueyCobra, went into action in Vietnam in the fall of 1967. This high-speed, tandem-seat gunship has proved an outstandingly effective combat weapon.

The Skycrane helicopter continued to retrieve downed aircraft in Vietnam and was also used to offload supplies from ships. This technique could be used to supply cities lacking seaports.

Even with the increased requirement for military helicopters and the continuing growth in the number of civil helicopter users, 1967 exports more than doubled in units and value over 1966. Thirty Fairchild Hiller FH-1100 helicopters were ordered by Okanagan Helicopters, the largest number of commercial helicopters ever ordered at one time.

In 1967, revenue passenger miles flown by the 3 scheduled helicopter airlines—Los Angeles Airways, Inc., New York Airways, Inc., and San Francisco & Oakland Helicopter Airlines, Inc.—totaled 30,300,000 as compared with 25,240,000 in 1966. This was an increase of about 20 percent. The fourth airline, Chicago Helicopter Airways, Inc., was scheduled to resume regular service between Chicago's Midway, O'Hare and downtown Meigs airports by early spring of 1968.

Eleven of the 15 member companies of the Vertical Lift Aircraft Council had 72 models in production, ranging in size from 1 to 72 places. In addition, there were 14 flight test, research and development models.

GENERAL AVIATION

Two reports issued during 1967 by the Federal Aviation Administration documented the significant position of general aviation in the nation's transportation.

At mid-year, the traffic count at airports where control towers are maintained showed that for the first time, officially, an airport without airline service headed the list as the busiest civil airport in the world. Traffic movements are recorded by the FAA only at 309 of the more than 10,000 airports. Three of the 4 busiest airports according to tower traffic count have either no airline service or less than an average of 7 scheduled departures a day.

The estimate for 1966 of general aviation flight hours released late in 1967, showed more than 21,000,000 total hours, an increase of 26 percent over the estimate for 1965. Some industry observers contended this estimate of 21,000,000 flight hours, which carried general aviation aircraft more than 33 billion miles, was conservative.

About 160,000 new student pilot permits were issued during 1967, an increase of nearly 25 percent over the previous year. This averaged one new pilot beginning training every 3 minutes and 24 seconds throughout the year.

The U.S. general aviation manufacturing industry produced 13,577 airplanes having an estimated retail value in excess of a half-billion dollars. This was the second largest year in the history of the industry, topped only by 1966. More than 2,000 of the year's production were multi-engine airplanes with more than 250 of these being turbine-powered.

Despite a decrease below 1966 totals, 1967 production and sales of general aviation type aircraft remained at a high level.

At year-end, the FAA reported approximately 112,000 airplanes on the active list. The ratio of general aviation airplanes to airlines grew to approximately 56 to one.

Pressurization, turbo-charging and aircraft of greater seating capacity designed specifically for commuter airline requirements appeared in greater numbers during 1967.

During 1967, the major manufacturers in the U.S. were producing nearly 100 models of general aviation airplanes.

The commuter airline—or scheduled air taxi, or third level airline—continued to make significant strides in both numbers of operators and passengers carried. At the beginning of the year there were about 125 of these airlines operating and by the end of the year the figure was near the 200 mark. An accurate tally is difficult to obtain because some operators begin service on a trial basis, or for operation during seasonal travel periods.

However, the growth line was definitely up. More than 2,000,000 passengers were carried by these commuter lines during 1967. In addition, the Post Office Department began spreading air mail operations to greater numbers of points through increased use of commuter airline and air taxi facilities.

Recognition of the importance of general aviation to the local and national economy received a boost during 1967 with the release by the FAA of a study of the airport and its influence on the community economy. In this study the FAA surveyed 5 airports in communities of various sizes and documented the relationship of general aviation facilities to industrial and economic growth of the areas.

General aviation's safety rate continued to show dramatic improvements. Unofficial tabulations showed the number of accidents remained almost the same as previous years despite millions of more flights.

Airports and air traffic management systems continued to be the major problems facing general aviation as well as the scheduled airlines. The tremendous growth of the number of persons travelling by air—both in their own airplanes and as fare-paying passengers—strained the capacity of terminal buildings, parking lots and runways at some airports during certain peak times of the day.

Additionally, the en route and terminal requirements in the airspace brought about by more airplanes and the rapidly advancing capabilities and demands of general aviation to operate under adverse weather conditions was resulting in delays for landing and departing aircraft.

During the year, the number of high schools offering aviation education doubled over the previous year and educators at all levels exhibited interest in bringing aviation classes to students.

Employment in general aviation increased significantly in 1967 as manufacturers increased plant capacity and flight training schools turned out more pilots. The 1968 outlook was for even greater gains.

We are many things to many people.

Say you want to build the world's largest jetliner. Then we can help you get it off the ground with engines that deliver up to 45,000 lbs. of thrust.

Or maybe you need a heavy lift helicopter. Then we have the Skycrane. It lifts 10 tons.

Or if you're looking for the newest in radar. Rocket boosters. Life support systems. Marine and industrial gas turbines. Telemetry. Or high-speed rail transportation. United Aircraft is all those things, too.

But depending on who you are, you'll think of us as Pratt & Whitney Aircraft. Hamilton Standard. Sikorsky Aircraft. Norden. United Technology Center. Or Electronic Components.

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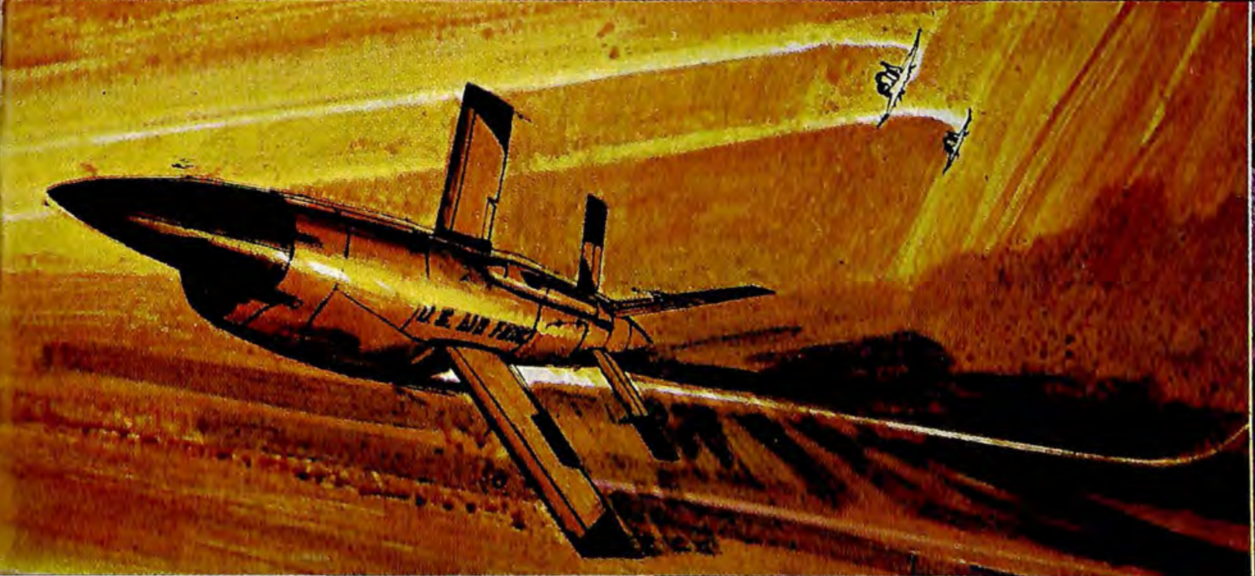


An Aerospace Capabilities Report on Beech Aircraft Corporation

This electron beam welder is a prerequisite for fabrication, to extreme tolerances, of such space age metals as titanium, inconel and maraging steel. It is symbolic of the advanced aerospace technology you'll find throughout the Beech Aircraft Corporation. Facilities, tools, men and management at Beech are tuned to the future. Their contributions are important in today's strength. Their capabilities are many. Take a look.

These Beech contributions stem from a tradition of superior performance

It all started with the first Beechcraft Model 17 "Staggerwing" biplane, designed and built from a revolutionary concept in 1932. It was far advanced in aerodynamics and engineering for its day. It was *planned* that way... and it *succeeded*. By 1936, the Model 17 so dominated the many air races of the day that a familiar (and still true) phrase was coined: "It takes a Beechcraft to beat a Beechcraft".

When World War II struck, Beech was ready to expand and mold its facilities and leadership to meet the urgent needs of America and its allies. As with so many companies, 1940 to 1945 were years of fantastic growth and accomplishment for Beech. Beech Aircraft Corporation emerged from those years with a strong organization and leadership that used the war experience as fine tooling for the further development of its capabilities.

Beech capabilities now include nearly the entire spectrum of research, development, testing and manufacture in aircraft, flight equipment, aerospace and related fields.

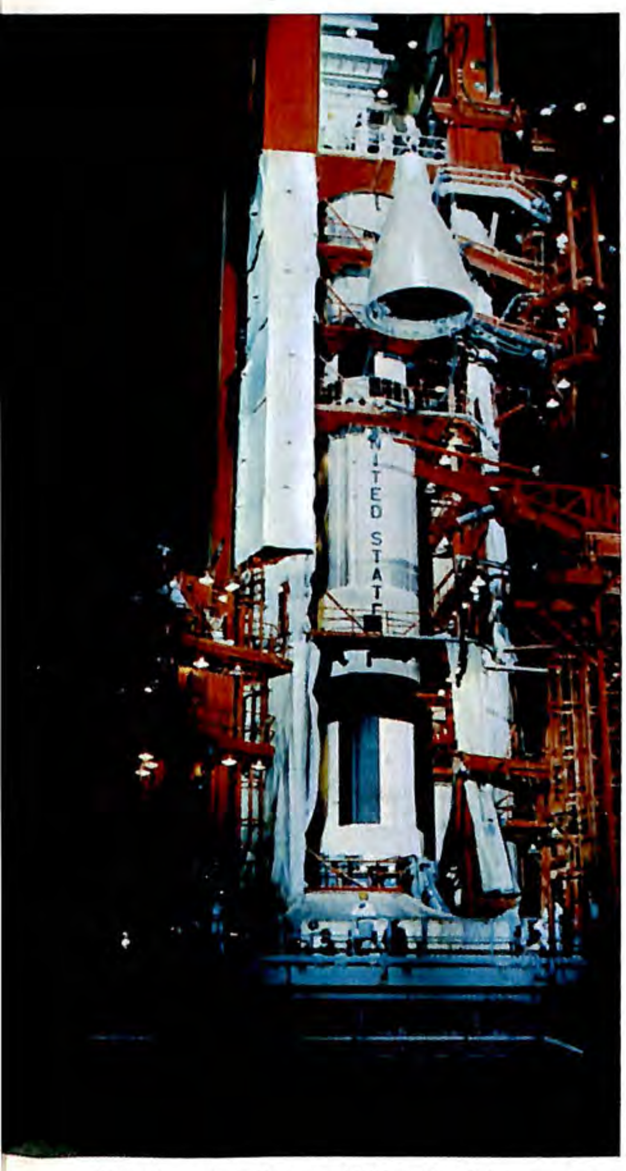
Tailored to meet 90% of the needs for U. S. Army utility requirements, this Beechcraft U-21A is delivered off-the-shelf. It is quickly convertible to use as a staff transport, an aerial ambulance or a high-capacity cargo carrier. The U-21A joins the Beechcraft U-8 family of aircraft that has established an outstanding record of performance for the military at home and abroad.

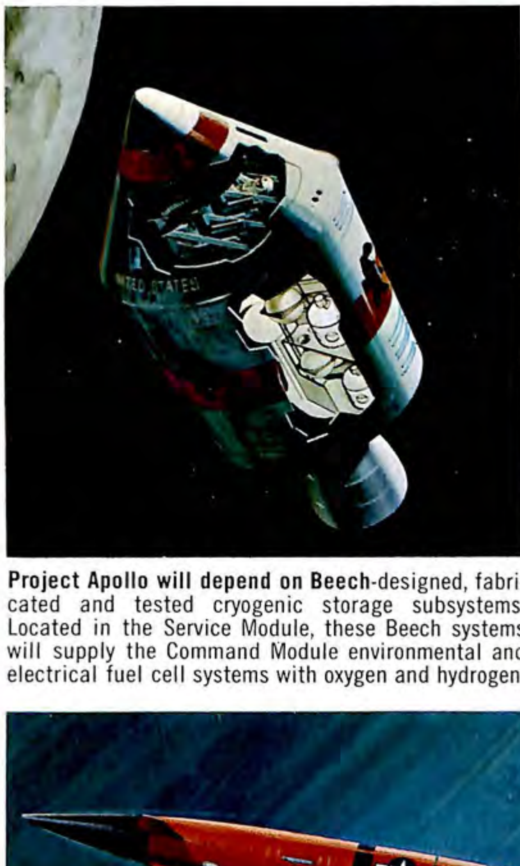
This Turbo-Baron, one of the latest in the extensive Beechcraft family for business, is the world's fastest light twin. Pilots around the world are still saying: "It takes a Beechcraft to beat a Beechcraft." Dealers and distributors with complete service facilities are located in 50 countries throughout the world. Beechcrafts for business include a complete line from the 2-place single-engine Musketeer III to the new 17-place Beechcraft 99 Airliner.

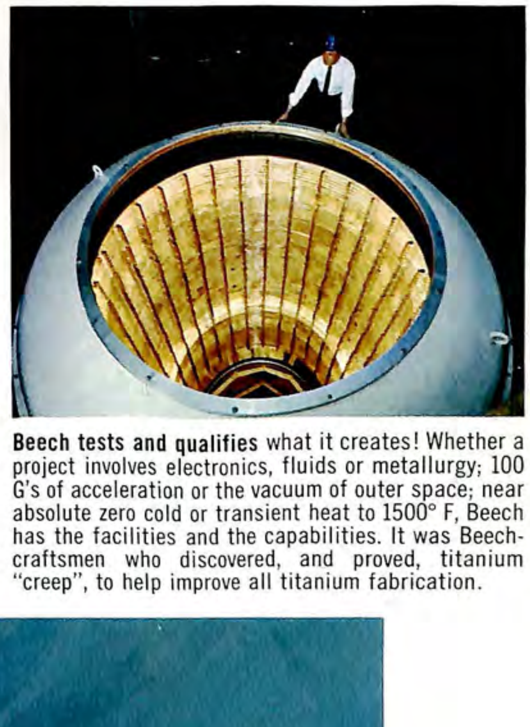
The U. S. Air Force Special Air Missions fleet praised this Beechcraft VC-6A for its great first year's record. The report shows a 95% ready rate and a 100% record for mission completion. Advanced engineering and design of this member of the Beechcraft family of mission support aircraft assure its future.

Almost every prime contractor in the aviation and aerospace industries has used Beech's exceptional capabilities for R&D, manufacture and testing. These capabilities are demonstrated in the work Beech performs for Lockheed's great C-141A "Starlifter." Beech builds flaps, ailerons, nose landing gear doors and wing spoilers... and provides tooling and engineering design services.

Liquid nitrogen on the Lunar Module will be loaded by a Beech–developed and fabricated A.G.E. system, including an air transportable dewar incorporating a revolutionary, Beech-developed thermal protection system that reduces the weight-to-capacity ratio from the usual 5.8 to 1.0 down to a startling 1.9 to 1.0.





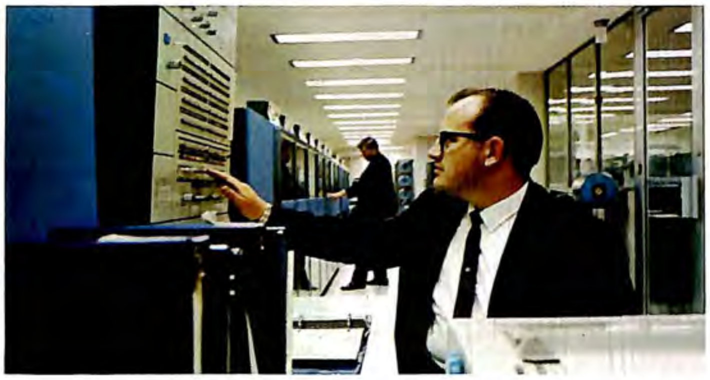


Project Apollo will depend on Beech-designed, fabricated and tested cryogenic storage subsystems. Located in the Service Module, these Beech systems will supply the Command Module environmental and electrical fuel cell systems with oxygen and hydrogen.

Beech tests and qualifies what it creates! Whether a project involves electronics, fluids or metallurgy; 100 G's of acceleration or the vacuum of outer space; near absolute zero cold or transient heat to 1500° F, Beech has the facilities and the capabilities. It was Beech-craftsmen who discovered, and proved, titanium "creep", to help improve all titanium fabrication.

Beech proved its capabilities for A.G.E. and cryogenics management at the Gemini launch site. The entire Aerospace Ground Equipment systems for providing liquid oxygen and liquid hydrogen to the Gemini spacecraft tanks were Beech responsibilities. Representing Beech capabilities in R&D, testing and fabrication, performance is a matter of history.

The only U. S. Navy target missile system managed by a single company, this AQM-37A is an example of Beech ability to perform complete weapon systems management. Beech was awarded the contract in design competition with 26 other capable aerospace manufacturers. A complete Beech family of target missile systems has been designed and produced to match all present defense training requirements. Speeds range from Mach .52 to Mach 3; altitudes from sea level to 90,000 feet. Beech is now conducting feasibility studies beyond Mach 7 and at orbital altitudes.



One out of every 14 Beechcraftsmen is an engineer with one or more degrees. Of over 2,000,000 square feet of floor area, one in nine is devoted to laboratories, engineering and tooling.

The complete systems management capabilities of Beech has been proved through a wide range of "total" assignments. Beech management accepts no limitations . . . not even those imposed by "state-of-the-art".

Beech Imaginuity . . the catalyst

The creative imagination to penetrate to the heart of a problem that didn't even exist yesterday – plus the knowledge, talent and ingenuity required for a satisfactory solution – combine to make Beech's greatest capability. We call it Beech "Imaginuity".

The facilities, personnel and experience of Beech are at your disposal. May we discuss with you how we can put them to work for you?

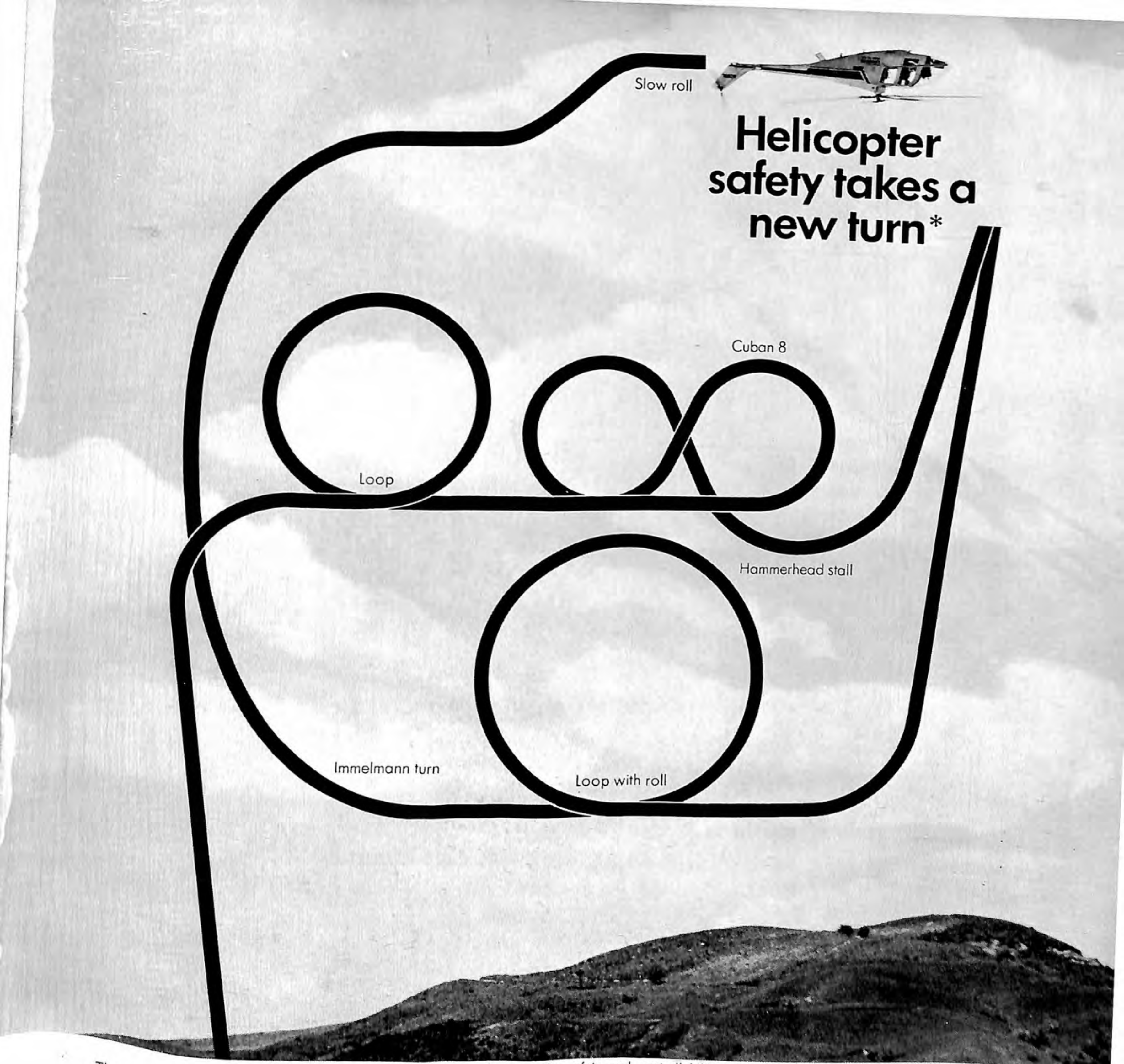
For experience in depth . . .

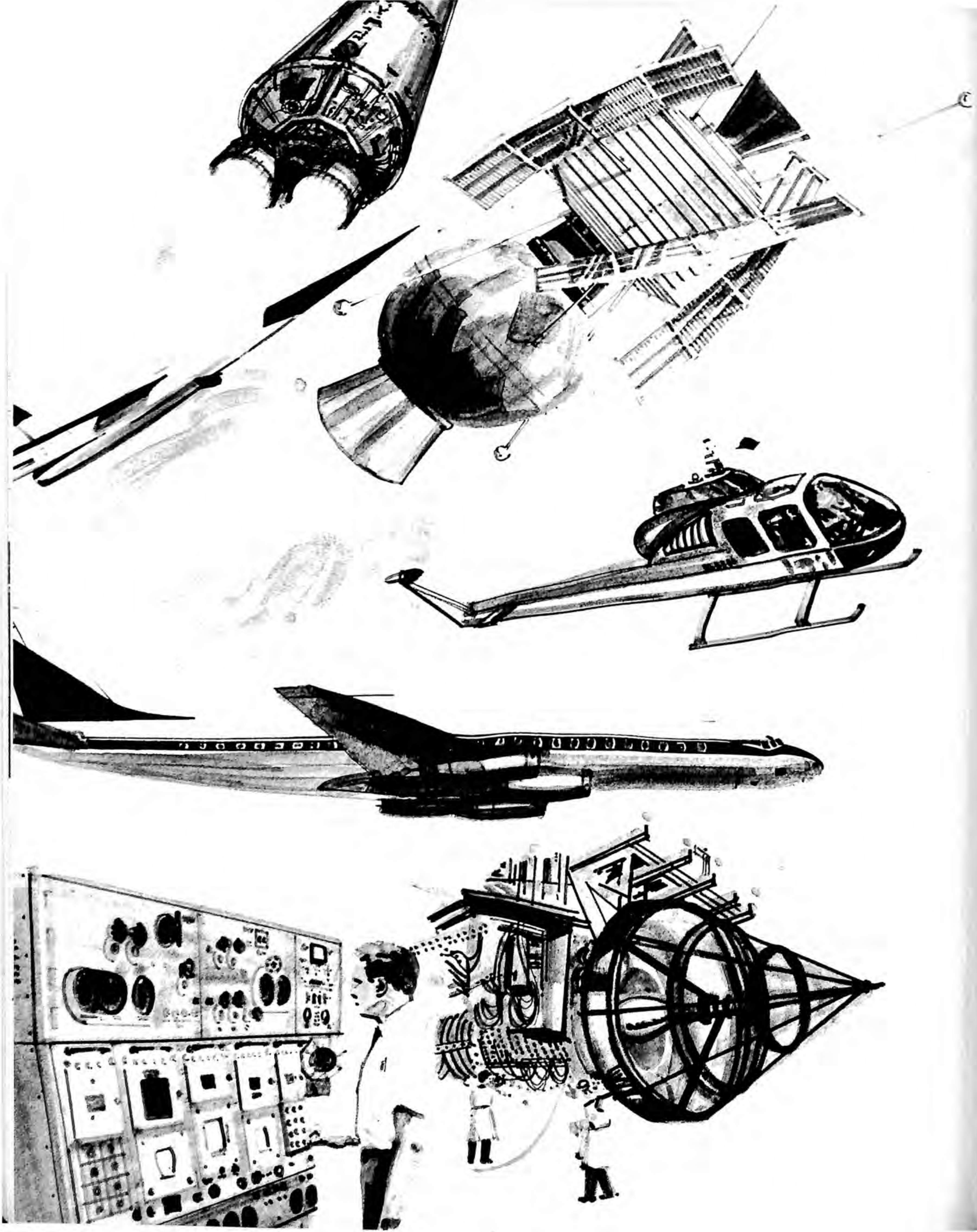
Look to Beech Capabilities!

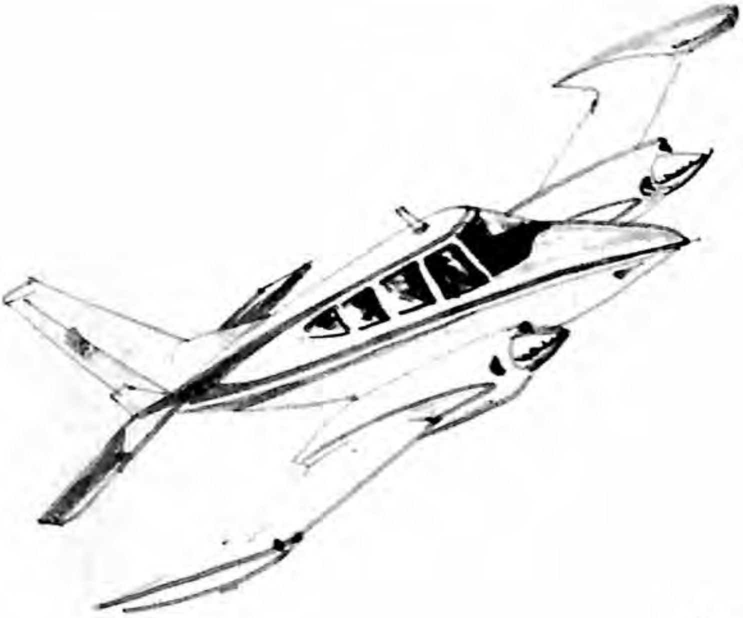
For full information about how you may take advantage of Beech's experience in systems management and proven capabilities in designing, developing, manufacturing and testing of components for aviation and aerospace projects, write, wire or phone Contract Administration, or Aerospace Marketing, Beech Aircraft Corporation, Wichita, Kansas 67201, U. S. A.

Beech *Aerospace Division*

Beech Aircraft Corporation, Wichita, Kansas; Boulder, Colorado


Helicopter safety takes a new turn*
Slow roll
Loop
Cuban 8
Hammerhead stall
Immelmann turn
Loop with roll





The following pages, designed for reference use, contain specifications, performance and other data on well over 650 products of the aerospace industry. In addition to the primary products—aircraft, engines, missiles, targets and drones, sounding rockets, spacecraft and launch vehicles—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. Although more than 160 systems are listed, they constitute only a fraction of the industry's extremely broad product line; the selection is intended only to be representative rather than all-inclusive. For easier reference, missiles and spacecraft are organized by functional groups, such as surface-to-surface missiles or meteorological satellites. All other products are arranged in alphabetical order by name of the parent manufacturing company. For specific listings consult the index. The term *prime contractor* used throughout this section refers to the builder of the product listed, regardless of whether it is a primary product or a subsystem, military or commercial.

REFERENCE SECTION

PREGNANT GUPPY (B-377PG)

Prime Contractor: Aero Spacelines, Inc.

Remarks

Following the formation of Aero Spacelines in 1961, the company 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

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, the Super Guppy is a modification of the Boeing Stratocruiser family. It incorporates the wing, flight deck and forward fuselage of the turboprop-powered C-97J together with 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-P7WA 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 cargos, 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 26 feet 7 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 145,000 pounds; engines 4 Pratt & Whitney Aircraft R-4360 piston-type.

Performance

Cruise speed 250 miles per hour; payload 35,000 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 41 percent of the turboprop market and 21 percent of the total turbine-powered aircraft market. Newest version has increased payload and performance among its refinements.

Specifications

Span 50 feet, 3 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; cruising range, including 45 minute reserve, at 21,000 feet, 1,283 statute miles; rate of climb, 2 engines, gross weight, 2,000 feet per minute; service ceiling 2 engines, gross weight, 32,900 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 market. Largest aircraft yet to be marketed by Beech Aircraft, the Beechcraft 99 Airliner is designed to meet proposed government regulations relating to scheduled commuter operations. Versatility of loading can be achieved through an optional cargo door adjacent to the regular passenger air-stair door and use 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 among other features.

Specifications

Span 45 feet 10.5 inches; length 44 feet 6.75 inches; height 14 feet 4.25 inches; gross weight at take-off 10,200 pounds; engines 2 Pratt & Whitney Aircraft PT6A-20 of 550 shaft horsepower.

Performance

Cruise speed at 10,000 feet and maximum cruise power, 250 miles per hour; cruising range in airline use 375 miles; rate of climb, 2 engines 10,200 pounds, 1,910 feet per minute; service ceiling 2 engines 25,000 feet.

BEECHCRAFT QUEEN AIR B80

Prime Contractor: Beech Aircraft Corporation

Remarks

An established high-performance, corporate twin-engine business and utility aircraft, the Queen Air B80 offers such comfort features as 3 individual compartments to provide privacy for crew and passengers as well as restroom facilities; a center aisle and writing tables allowing passengers to work and move about in flight; optional 4-place couch interior and optional 11-place configuration with airline-style seating for commuter airline operation or high-density corporate use.

Specifications

Span 50 feet 3 inches; length 35 feet six inches; height 14 feet 2½ inches; gross weight 8,800 pounds normal—8,832 as Queen Airliner; useful load 3,620 pounds—3,232 as Queen Airliner; engines 2 380 horsepower Lycoming IGSO-540 A1D.

Performance

Cruising speed 229 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 QUEEN AIR 88

Prime Contractor: Beech Aircraft Corporation

Remarks

Offering a combination of pressurization, supercharged engines and all-weather instrumentation in a new market price category, the 7-9 place Beechcraft Queen Air 88's cabin pressurization, maintains sea level pressure to 8,200 feet. Rate is 3.8 pounds per square inch. It creates in the Model 88, 6,500-foot cabin comfort for passengers at a 16,500-foot altitude. Standard equipment on the Model 88 includes complete cabin pressurization, the required avionics and associated systems which give the Beechcraft transport all-weather capability, air conditioning, super soundproofing, deicing and anti-icing equipment, and oxygen system.

Specifications

Span 50 feet 3 inches; length 35 feet 6 inches; height 14 feet 3 inches; gross weight 8,800 pounds; useful load 2,800 pounds; engines 2 380 horsepower Lycoming IGSO-540-AID.

Performance

Cruising speed, 70 percent power at 15,000 feet, 221 miles per hour; cruising range, 65 percent power at 17,000 feet, 1,270 miles; rate of climb 2 engines 8,800 pounds 1,275 feet per minute; service ceiling 26,800 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, twin-engine airplane. Powered by reliable Pratt & Whitney Aircraft Wasp Jr. 450 horsepower engines, the current Super H18 offers fuel injection, providing even greater reliability and smoother performance. Other engineering refinements on the Super H-18 include fully enclosed landing gear; smaller wheels, which lower the nose for better visibility forward and reduce the weight; lightweight propellers; feathering accumulators; bladder-type fuel tank arrangements; tricycle landing gear option; and automatic oil coolers. Super H18's performance has been boosted to 220 mile-per-hour cruise at 66 percent power, range boosted to 1,530 miles.

Specifications

Span 49 feet 8 inches; length 35 feet 2½ inches; height 9 feet 4 inches; gross weight 9,900 pounds; useful weight 4,220 pounds; engines 2 450 horsepower Pratt & Whitney Wasp Jr.

Performance

Cruising speed at 300 horsepower per engine 220 miles per hour; cruising 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 QUEEN AIR A65

Prime Contractor: Beech Aircraft Corporation

Remarks

A swept vertical stabilizer distinguishes the economy leader of Beechcraft's Queen Air series—the Queen Air A65. The A65 also features increased range through an optional fuel supply and capability of all-weather flight with de-icing and advanced avionics equipment. 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 and 9/16 inches; gross weight approximately 7,700 pounds; useful load 2,850 pounds; engines 2 Lycoming IGSO-480-A1E6 rated at 320 horsepower.

Performance

Cruising speed 214 miles per hour; cruise range 800 miles with standard fuel, approximately 1,500 miles with optional fuel; rate of climb at gross weight; 1,300 feet per minute; service ceiling 31,300 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 that ranks in size between the light-twin Beechcraft Baron and heavy-twin Beechcraft Queen Air. Cabin pressurization allows sea level atmosphere conditions to a flight level of 10,500 feet and a cabin altitude of only 8,000 feet at 21,500 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 3.25 inches; length 33 feet 5 inches; height 12 feet 3.75 inches; gross weight 6,400 pounds; engines 2 Lycoming TIO-541 E1A4 rated at 380 horsepower each.

Performance

Preliminary engineering estimates indicate a cruise speed in excess of 260 miles per hour and cruising range of approximately 1,000 miles.

BEECHCRAFT TURBO BARON, MODEL 56TC

Prime Contractor: Beech Aircraft Corporation

Remarks

A combination of high speed and spectacular single-engine performance provided by twin 380 horsepower turbocharged Lycoming engines make the Beechcraft Turbo Baron the fastest light twin in its class. The Turbo Baron was designed expressly for high altitude instrument flight, yet retains the Beechcraft Baron's family ability 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 2,365 pounds; engines 2 Lycoming TIO-541-E1B4.

Performance

Cruising speed 290 miles per hour; range 1,074 miles on 178 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 D55 BARON

Prime Contractor: Beech Aircraft Corporation

Remarks

New exterior styling, including increased slope and area of windshield, and refined instrumentation highlight the 1968 Beechcraft D55 Baron. Twin 285 horsepower fuel-injection engines make possible safe, reliable operation from improved or unimproved landing areas as short as 1,000 feet. Actual take-off ground run needed for the fully-loaded D55 Baron is only 596 feet. Useful load of 2,266 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

Cruising speed 230 miles per hour; cruising range at 45 percent power, 142 gallons, 1,143 miles; rate of climb, 2 engines, 1,670 feet per minute; absolute ceiling 22,300 feet.

BEECHCRAFT B55 BARON

Prime Contractor: Beech Aircraft Corporation

Remarks

A new silhouette enhanced by additional sweep to the windshield line and a new paint scheme distinguish the 1968 Beechcraft B55 Baron. Lowest price of the Baron line, the B55 still offers a 225 mile-an-hour cruise, a range in excess of 1,220 miles, including reserves, and remarkable economy. Over 1,548 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

Cruising speed 225 miles per hour; cruising range, 45 percent power on 142 gallons, 1,225 miles; rate of climb, 2 engines, 1,670 feet per minute; absolute ceiling 21,000 feet.

BEECHCRAFT E95 TRAVEL AIR

Prime Contractor: Beech Aircraft Corporation

Remarks

Continued refinement of the Travel Air design in this newest model incorporates a new windshield line plus new exterior and interior styling for 1968. Seating 5 in a useful load of 1,550 pounds, the E95 Travel Air operates for less than 13 cents per mile. Twin fuel-injection engines provide top speed of 210 miles an hour and range in excess of 1,100 miles. Standard avionics plus optional autopilot and lightweight deicing equipment assure all-weather reliability.

Specifications

Span 37 feet 10 inches; length 25 feet 11 inches; height 9 feet 6 inches; gross weight 4,200 pounds; useful load 1,550 pounds; engines 2 Lycoming IO-360-B1B rated at 180 horsepower each.

Performance

Cruising speed 200 miles per hour; cruising range 1,170 miles; rate of climb, 2 engines, 1,560 feet per minute; service ceiling, 2 engines, 21,160 feet.

BEECHCRAFT TURBO BONANZA

Prime Contractor: Beech Aircraft Corporation

Remarks

Topping the Bonanza line of 4 single-engine retractable gear Beechcrafts for 1968 is the V35A-TC 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 absolute ceiling of over 30,000 feet are possible. The 4- to 6-place Turbo Bonanza features new speed-sweep one-piece windshield, new exterior paint design, 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 1,392 pounds; engine Continental 285 horsepower TSIO-520-D.

Performance

Cruising speed 230 miles per hour; cruising 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 V35A BONANZA

Prime Contractor: Beech Aircraft Corporation

Remarks

Now in its 22nd year of production, the Beechcraft Bonanza has earned its place as a classic among single-engine aircraft, representing sales in excess of $148,000,000 with over 8,550 units produced. Refinements for 1968 include speed-sweep windshield and new exterior paint scheme as well as new options in quality custom interior appointments, including communication and navigation systems. The V35A Bonanza 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 1,451 pounds; engine Continental IO-520-B rated at 285 horsepower.

Performance

Cruising 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 E33A BONANZA

Prime Contractor: Beech Aircraft Corporation

Remarks

This new Beechcraft brings a choice of swept vertical fin and horizontal stabilizer to the new Bonanza line of Beechcrafts for 1968. The Bonanza E33A offers roomy comfort for 4 to 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 6 inches; height 8 feet 3 inches; gross weight 3,300 pounds; useful load 1,400 pounds; engine Continental IO-520-B rated at 285 horsepower.

Performance

Cruising 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 E33 BONANZA

Prime Contractor: Beech Aircraft Corporation

Remarks

Economical entry in the new Beechcraft Bonanza family, the Bonanza E33 is capable of routine operation on 80-octane fuel. Its fuel injection engine provides a 185 mile-an-hour cruise, a range in excess of 1,100 miles, useful load of over 1,000 pounds and seating for 4 to 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 1,196 pounds; engine Continental IO-470-K rated at 225 horsepower.

Performance

Cruising speed 185 miles per hour; cruise range 650 miles standard, 1,170 with optional 80 gallon fuel, plus 45 minute reserve; rate of climb 930 feet per minute; service ceiling 17,800 feet.

BEECHCRAFT MUSKETEER SUPER III

Prime Contractor: Beech Aircraft Corporation

Remarks

Performance leader of the Musketeer line of sport, training, business and pleasure aircraft, the Musketeer Super III for 1968 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; 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

Cruising speed 150 miles per hour; cruise range 823 miles; rate of climb 880 feet per minute; service ceiling 14,850 feet.

BEECHCRAFT CUSTOM III

Prime Contractor: Beech Aircraft Corporation

Remarks

Interior and exterior colors, fabrics and vinyl combinations are greater than ever before in the 1968 Musketeers III. The Custom III is capable of economical operation from paved or unimproved airports. Its 165 horsepower fuel-injection engine gives a top speed of 146 miles an hour and a range of up to 906 miles, with a useful load of 1,025 pounds.

Specifications

Span 32 feet 9 inches; length 25 feet; height 8 feet 3 inches; gross weight Utility Category 2,030 pounds, Normal Category 2,400 pounds; useful load Normal Category 1,025 pounds; engine 165 horsepower Continental IO-346A.

Performance

Cruising speed 138 miles per hour; cruise range 906 miles; rate of climb 728 feet per minute; service ceiling 11,870 feet.

BEECHCRAFT SPORT III

Prime Contractor: Beech Aircraft Corporation

Remarks

Sport flying for 2 and pilot training, including limited aerobatic maneuvers, set apart the Beechcraft Musketeer Sport III for 1968. 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. Over 1,200 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

Cruising 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

Late in 1948, following a first flight on December 2, Beech Aircraft announced a new primary and basic-advanced trainer, the Beechcraft Model 45 Mentor, a single-engine, 2-place airplane. As the Model 45 Mentor, designated T-34A (photo) by the Air Force and T-34B by the Navy, joined the services, it gained universal acceptance as a highly successful postwar trainer. Eleven nations operated or still operate the versatile aircraft for pilot training and special missions, including Chile, Venezuela, Argentina, Colombia, El Salvador, Japan, Mexico, the Philippines, Spain and Turkey. The Mentor also 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 (T-34A) 2,174 pounds; empty weight (T-34B) 2,228 pounds; engine one 225 horsepower Continental O-470-13; retractable tricycle landing gear (same as for Bonanza and Debonair); tandem cockpits under continuous canopy.

Performance (T34A)

Maximum speed 189 miles per hour; maximum cruise speed 173 miles per hour; service ceiling 20,000 feet; maximum cruising range 737 miles.

T-42A INSTRUMENT TRAINER

Prime Contractor: Beech Aircraft Corporation

Remarks

The T-42A is the military counterpart of the Beechcraft Model B55 Baron and is being utilized 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 the twin-engine transition of single-engine rated aviators and light personnel transport.

Specifications

Wing 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 is arranged for 3 students and an instructor and the T-42A has a range of 7.5 hours.

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 or 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 the U-8Ds were modified to the RL-23D (RL-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 to carry litter patients as an air evacuation ambulance or 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 3⅜ inches; length 31 feet 6 15/16 inches; height 11 feet 6½ 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 cruising 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 or 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, windshield defrost and alcohol spray, and wipers permit all-weather operation. Seventy-one of the aircraft were delivered to the U.S. Army between 1959 and 1964.

Specifications

Span 45 feet 10½ 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 0-480-3 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 cruising speed at 12,000 feet, 208 knots/240 miles per hour; cruising 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.

NU-8F

Prime Contractor: Beech Aircraft Corporation

Remarks

The NU-8F is the military version of the Beechcraft corporate turboprop King Air 90. This 7-place command liaison utility transport was the first turbine-powered fixed-wing aircraft procured by the U.S. Army and served as the flying testbed for development of Beechcraft turbine-powered aircraft including the U.S. Air Force VC-6A special mission aircraft, and the Army utility series Beechcraft U-21A which is now in use in Vietnam. The non-pressurized high-speed, high-altitude, all-weather capabilities of the NU-8F allow a wide variety of military applications. The one-of-its-kind NU-8F, delivered to the Army in 1964, is stationed at Aberdeen Proving Grounds at Aberdeen, Maryland.

Specifications

Span 45 feet 10½ inches; length 35 feet 4¼ inches; height 14 feet 8 inches; empty weight 5,081 pounds; gross weight 9,300 pounds; engines 2 Pratt & Whitney Aircraft PT6A-6 turbine engines rated at 500 shaft horsepower each; 2 pilot stations, 5 passenger seats in cabin.

Performance

Maximum speed at sea level 239 miles per hour; cruise speed at sea level 239 miles per hour; cruise speed at 10,000 feet 260 miles per hour; service ceiling 27,400 feet; maximum range at 16,000 feet 1,470 statute miles.

U-21A

Prime Contractor: Beech Aircraft Corporation

Remarks

The U-21A is a military combination of the Beechcraft corporate turbine-powered King Air 90 and the 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 53½ inches by 51½ inches. It is designed to carry 10 combat-ready troops and 2 pilots or is quickly adapted to carry 3 litter and 3 ambulatory patients as an air evacuation ambulance. Beech Aircraft Corporation is under contract to produce 129 of the aircraft. About 60 had been delivered through September 15, 1967.

Specifications

Span 45 feet 10½ inches; length 35 feet 6 inches; height 14 feet 2 9/16 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 cruising speed at 10,000 feet 248 miles per hour; service ceiling 2 engines 26,100 feet; service ceiling single engine 12,200 feet; maximum cruising range 960 miles.

SK-1 HYDROSKIMMER

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The Hydroskimmer, designed and built by Bell during 1962 and 1963, is the largest and most powerful air cushion vehicle ever constructed in the United States. Built for the U.S. Navy as a research craft, the Hydroskimmer has provided technical data on the design and performance of air cushion vehicles during various test and evaluation programs over the last three years. Research programs have been conducted on Lake Erie at Buffalo, N.Y., and in the Norfolk, Virginia, area. Military missions considered for Hydroskimmer-type craft include antisubmarine warfare, landing and patrol operations, mine countermeasures, high-speed transport of personnel and cargo and rescue operations.

Specifications

Length 65 feet; width 27 feet; height 23.5 feet, plus four foot flexible trunks; engines 4 Solar Saturn marine gas turbines rated at 1,080 horsepower each; gross weight 30 tons.

Performance

Maximum speed 70 knots.

SK-3 CARABAO

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The SK-3 Carabao, designed and built by Bell Aerosystems with company funds, is a rugged and versatile air cushion vehicle capable of performing a variety of missions over land, water, ice, snow, mud and marsh. The prototype vehicle began operational testing in March 1963. During late 1963 and 1964, the Carabao completed a highly-successful series of operational demonstrations in the marshes and shallow waters of Lake Okeechobee, Florida, and on the James and Potomac Rivers. In July 1964, the Carabao demonstrated the capability of the ACV concept as a means of transport in polar regions during a month-long evaluation program in Greenland. It is presently being utilized as a training vehicle for ACV operators.

Specifications

Length 18.7 feet; width 16 feet; height 10 feet; normal gross weight 3,200 pounds; lift engine 125-horsepower Franklin; propulsion 150-horsepower Lycoming; Carabao has three circular plenum cells, or air chambers, equally spaced around its center lift fan.

Performance

Speed 60 miles per hour; endurance 4 hours; obstacle clearances 16 inch wall, 3 foot ditch, 10 foot hedge.

SK-5

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The Bell SK-5 air cushion vehicle is an American version of the SR.N5 Hovercraft produced in England by the British Hovercraft Corporation. Bell Aerosystems delivered three SK-5s to the Navy which are being employed in Viet Nam, marking the first U.S. military application of this new means of transportation. In addition, two SK-5s proved effective and reliable during a one-year demonstration project on San Francisco Bay featuring the nation's first scheduled ACV passenger service. Bell Aerosystems, in a joint effort with Skimmers, Inc., also conducted a demonstration program in Alaska to introduce this new concept of transportation to potential users.

Specifications

Length 39.2 feet; width 22.9 feet; height 16.6 feet; gross weight 15,000 pounds; engine one General Electric LM100 marine gas turbine rated at 1,000 shaft horsepower.

Performance

Maximum speed 60 knots; range 210 nautical miles; obstacle clearances, solid wall 3.5 feet, earth mound 5 feet, vegetation 6 feet.

X-14A VTOL RESEARCH AIRCRAFT

Prime Contractor: Textron's Bell Aerosystems Company

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 the National Aeronautics and Space Administration's Ames Research Center at Moffett Field, Calif., in October 1959. NASA replaced the original Armstrong-Siddeley Viper engines with General Electric J85 turbojets for increased thrust and redesignated the airplane the X-14A. Primary prupose of NASA's X-14A 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 to investigate and simulate 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.

X-22A V/STOL RESEARCH AIRCRAFT

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The X-22A research aircraft was developed by Bell Aerosystems as part of the Tri-Service V/STOL program to explore the mechanical and aerodynamic characteristics and evaluate the military potential of this revolutionary concept of flight. Under a Navy-administered contract, Bell built two of these airplanes, which make use of a dual-tandem, ducted-propeller configuration. A unique variable stability and control system is combined with high control power levels and a three-engine hovering capability to provide an extremely versatile V/STOL research aircraft. The first X-22A was rolled out on May 25, 1965; it made its first flight on March 17, 1966, but subsequently was extensively damaged in an August 1966 hard landing. The second X-22A made its first vertical take-off and transition to conventional flight on March 1, 1967. The program was scheduled to continue through the fall of 1968.

Specifications

Span 39.2 feet; length 39.6 feet; height 20.69 feet; VTOL gross weight 15,980 pounds (standard day, one engine out); engines 4 General Electric YT-58-8D turboshaft (1,250 horsepower each).

Performance

Speed 325 miles per hour; endurance three hours; range 480 nautical miles.

47G-3B-1/47G-3B-2 HELICOPTERS

Prime Contractor: Bell Helicopter Company

Remarks

The 47G-3B-1 three-place utility helicopter was first delivered in January 1963. Its successor, the 47G-3B-2, joins the Bell commercial line for 1968.

Specifications

Fuselage length 31.6 feet; overall length 43.2 feet; main rotor diameter 37.1 feet; normal gross weight 2,950 pounds; empty weight 1,794 pounds; useful load 1,156 pounds; engine Lycoming TVO-435 turbo-supercharged—(47G-3B-1) 270 take-off horsepower, (47G-3B-2) 280 shaft horsepower at 3,200 revolutions per minute.

Performance

Maximum speed 105 miles per hour; cruise speed 83–93 miles per hour; maximum range at 5,000 feet, 315 miles; rate of climb (47G-3B-1) 880 feet per minute, (47G-3B-2) 1,000 feet per minute; hovering ceiling, IGE, 20,000 feet; service ceiling 20,000 feet.

204B HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

Derived from Bell's famed military "Huey," the 204B was first delivered in April 1963. In service since 1963, it is a 10-place utility, executive, and cargo transport helicopter.

Specifications

Fuselage length 44.65 feet; overall length 57 feet; main rotor diameter 48 feet; normal gross weight 8,500 pounds;* empty weight 4,600 pounds; useful load 3,900 pounds; engine Lycoming T53-11A gas turbine, 1100 take-off horsepower.

Performance

Maximum speed 138 miles per hour; cruise speed 124–138 miles per hour; maximum range at 5,000 feet, 330 miles; rate of climb 1,600 feet per minute; hovering ceiling, IGE, 13,700 feet; service ceiling 15,800 feet.

***Note:** The 204B is certificated for 9,500 pounds gross weight with external loads.

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 32.6 feet; overall length 43.2 feet; main rotor diameter 37 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 83–93 miles per hour; normal range 324 miles; rate of climb 1,190 feet per minute; hovering ceiling, IGE, 18,000 feet; service ceiling 18,000 feet.

TH-13T 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 two-place derivative of the Model 47.

Specifications

Fuselage length 32.6 feet; overall length 43.2 feet; main rotor diameter 37 feet; normal gross weight 2,950 pounds; empty weight 2,057 pounds; engine Lycoming TVO-435-25 supercharged 270 horsepower.

Performance

Maximum speed 105 miles per hour; cruise speed 83–93 miles per hour; normal range 324 miles; rate of climb 880 feet per minute; hovering ceiling, IGE, 20,000 feet, OGE, 18,600 feet; service ceiling 20,000 feet.

UH-1C/UH-1E IROQUOIS HELICOPTERS

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1C (photo) and UH-1E are 8–10 place military utility and armed helicopters. In service since June 1965, both are still in production. UH-1C is the Army version, UH-1E the Marine Corps configuration. Both are derived from the Army UH-1B, in service since 1961.

Specifications

Overall length 53 feet; fuselage length 42.6 feet; height 12.6 feet; empty weight C 4,842 pounds, E 5,055 pounds; 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.

UH-1D/UH-1H IROQUOIS HELICOPTERS

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1D is a utility helicopter with a capacity of 12–15 seats. In service with the Army since June 1963, it is still in production. The UH-1H is almost identical to the UH-1D, except that it is powered by a 1,400-horsepower T53-L-13 engine. The UH-1H became operational in 1967.

Specifications

UH-1D: Fuselage length 44.6 feet; overall length 53.9 feet; main rotor diameter 48 feet; normal gross weight 9,500 pounds; empty weight 4,717 pounds; engine Lycoming T53-L-11 1100 shaft horsepower. UH-1H: empty weight 4,850 pounds.

Performance

UH-1D: Maximum speed 138 miles per hour; cruise speed 135 miles per hour; normal range 315 miles; rate of climb 2,350 feet per minute; hovering ceiling IGE 18,200 feet, OGE 14,000 feet; service ceiling 22,000 feet. UH-1H: Same as UH-1D, except for normal range 327 miles; hovering ceiling IGE 20,000 feet, OGE 15,600 feet; service ceiling 19,400 feet.

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 44.6 feet; overall length 57.1 feet; main rotor diameter 48 feet; normal gross weight 9,000 pounds; empty weight 4,430 pounds; engine General Electric T58-3 1,290 shaft horsepower.

Performance

Maximum speed 138 miles per hour; cruise speed 135 miles per hour; rate of climb 2,123 feet per minute; normal range 345 miles; hovering ceiling, IGE, 18,700 feet, OGE, 15,200 feet; service ceiling 22,000 feet.

YUH-1B COMPOUND HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The YUH-1B is an advanced research compound helicopter equipped with Bell's new 4-bladed rigid rotor which makes possible speeds as high as 250 miles per hour in level flight. The YUH-1B is being developed by Bell under contract with the Army Transportation Research Command; the 4-bladed rotor system was developed independently with company funds. The helicopter's normal power plant is a 1,100 horsepower Lycoming T53 engine; in addition, the craft has stub wings protruding outward from the cabin section and from the aft fuselage, and 2 auxiliary Continental J69-T29 jet engines. The YUH-1B has been flown a number of times at speeds above 250 miles per hour. The Continental engines are to be replaced with auxiliary Pratt and Whitney Aircraft engines (3,300 pounds of thrust each) to be installed for further testing in the 250-knot speed range in early 1968.

47G-5 HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The 47G-5, first delivered in January 1966, comes in two versions. The 2-place Ag-5 agricultural model (in photo), equipped with Bell's new AgMASTER chemical application system, will spray up to 14.4 acres per minute. Both the Ag-5 and the 3-place 47G-5 utility model feature low empty weight and high useful load capability. Both models are in production and in service.

Specifications

Fuselage length 31.6 feet; overall length 43.2 feet; main rotor diameter 37.1 feet; normal gross weight 2,850 pounds; empty weight (G-5) 1,590 pounds, (Ag-5) 1,550 pounds; useful load (G-5) 1,250 pounds, (Ag-5) 1,300 pounds; engine Lycoming VO-435, 220 horsepower.

Performance

Maximum speed (G-5) 105 miles per hour, (Ag-5) 90 miles per hour; cruise speed (G-5) 88 miles per hour, (Ag-5) 80 miles per hour; maximum range at 5,000 feet, 340 miles; rate of climb 1,070 feet per minute; hovering ceiling, IGE, 6,000 feet; service ceiling 10,200 feet.

47G-4A HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The 47G-4A is the latest version of Bell's Model 47 series, with first deliveries in January 1966. It is in service and in production. This three-place model is Bell's standard utility aircraft.

Specifications

Fuselage length 31.6 feet; overall length 43.2 feet; main rotor diameter 37.1 feet; normal gross weight 2,950 pounds; empty weight 1,777 pounds; useful load 1,173 pounds; engine Lycoming VO-540, 260 take-off horsepower.

Performance

Maximum speed 105 miles per hour; cruise speed 84–91 miles per hour; maximum range at 5,000 feet, 324 miles; rate of climb 800 feet per minute; hovering ceiling, IGE, 13,700 feet at 2,350 pounds gross weight; service ceiling 17,500 feet.

206A JETRANGER

Prime Contractor: Bell Helicopter Company

Remarks

The Model 206A Jetranger is a 5-place turbine-powered, light utility helicopter. It has a single 2-bladed main rotor with a diameter of 33 feet 4 inches and a 2-bladed tail rotor with a diameter of 5 feet 2 inches.

Specifications

Overall length 38 feet 9.5 inches; overall width 6 feet 3.5 inches; overall height 9 feet 6.5 inches; gross weight 2,900 pounds; empty weight 1,295 pounds; engine Allison Model 250-C18, 317 horsepower.

Performance

Maximum speed 150 miles per hour; cruise speed 135–145 miles per hour; range 400 miles at 5,000 feet; service ceiling 18,800 feet; hover ceiling OGE 7,900 feet, IGE 12,400 feet; rate of climb 1,580 feet per minute.

MODEL 209 HUEYCOBRA (ARMY AH-1G)

Prime Contractor: Bell Helicopter Company

Remarks

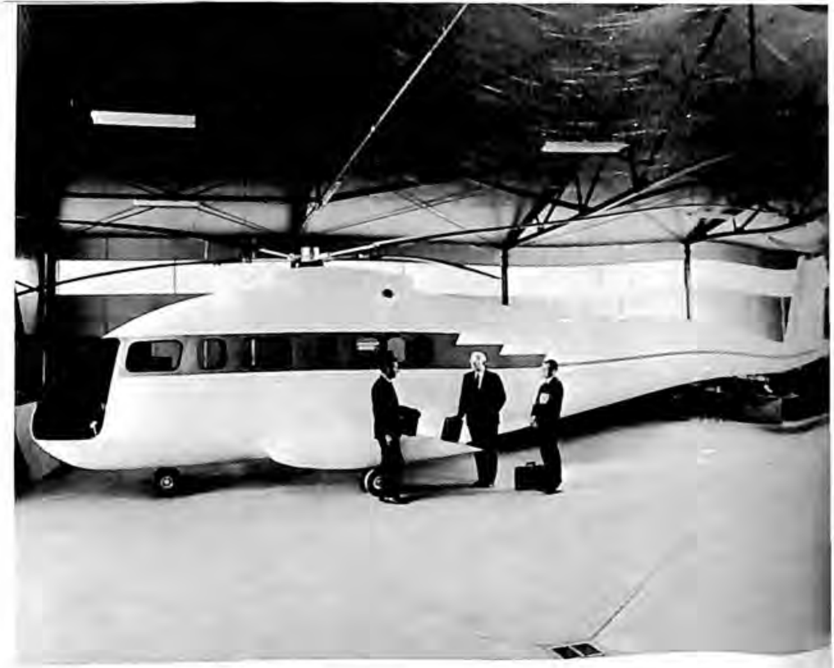
The HueyCobra, or AH-1G, is a 2-place high-speed weapons helicopter which incorporates stub wings for ordnance stores and a nose mounted turret. It has a 2-bladed, "door hinge," 44-foot diameter main rotor and a 2-bladed tail rotor. The first helicopter of this type specifically designed for the armed helicopter role, it became operational in late 1967.

Specifications

Length 44.25 feet; wing span 10 feet 11.6 inches; height 12.1 feet; gross weight 9,500 pounds; empty weight 5,132 pounds; engine Lycoming T53-L-13, 1,400 shaft horsepower.

Performance

Maximum dive speed 218 miles per hour; cruise speed without external stores up to 196 miles per hour; service ceiling 21,000 feet.



205A HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

Derived from Bell's U.S. Army UH-1D of the famed "Huey" military line of helicopters, the 15-place 205A joins Bell's commercial line for 1968. FAA certification was expected in late 1967, and first delivery for the utility/executive and cargo transport helicopter was scheduled for January 1968.

Specifications

Fuselage length 41.9 feet; overall length 57.1 feet; main rotor diameter 48 feet; gross weight 9,500 pounds; empty weight approximately 4,760 pounds; engine Lycoming T53-13A gas turbine, 1,250 horsepower.

MODEL BD-68 COMMERCIAL UTILITY HELICOPTER

Prime Contractor: Berlin Doman Helicopters, Inc.

Remarks

The Berlin Doman BD-68 is a 10–12 place helicopter which emphasizes economic efficiency and full payload ability at any density altitude. Powered by 2 turbines with optional use of 3, it features simplified, hingeless, lightweight rotor systems which are sealed and self lubricated. The low drag fuselage with water landing ability and retractable landing gear has space and weight provisions for airline passengers with baggage. The BD-68 was scheduled to make its first flight in mid-1968.

Specifications

Rotor diameter 48 feet; fuselage length 41 feet; cabin width 5 feet; 4 passenger doors; gross weight 6,000 pounds; minimum empty weight 3,250 pounds; normal fuel 200 gallons; engines 2 or 3 Allison 250-C14s.

Performance

Speed for best range, full gross, 150 miles per hour; hovering ceiling OGE 20,000 feet, rate of climb sea level to 10,000 feet, 2,000 feet per minute.

B-47E MEDIUM BOMBER

Prime Contractor: The Boeing Company

Remarks

The B-47, first multi-jet airplane produced following 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 SAC in October 1951, and the last one 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 two other aircraft firms. The bulk of the B-47s produced were bomber versions, of which the B-47E was the last. Other configurations in which the Stratojet was delivered included a variety of reconnaissance versions designated RB-47E, RB-47H, and RB-47K, some of which are still in service.

Specifications

Span 116 feet, 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 two 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 tank construction of the entire wing forms virtually one huge fuel tank. The "H" was the final model of the B-52 Stratofortress series, 744 of which were delivered to the Air Force. The last "H" was delivered on 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 TF-33 turbofan, 17,000 pounds thrust each; gear 8 main wheel 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—Dec. 20, 1957) was America's first jet airliner to go into service. First commercial flight of this four-engined jetliner was made by Pan American World Airways on Oct. 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 -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, plus new control surfaces. The -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 144 have been sold to six airlines, including three (UC-137B) to the U.S. 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 JT3C-6 turbojets of 13,000 pounds thrust (-120 model), and JT3D-3 turbofans of 18,000 pounds thrust for -120B model; tricycle gear with four-wheel bogie-type truck main units and dual nose wheels; payload is up to 181 passengers.

Performance

Speed up to 600 miles per hour; range more than 3,000 miles; ceiling over 30,000 feet.

707-320 SERIES JETLINERS

Prime Contractor: The Boeing Company

Remarks

Designed to serve very long-range routes of more than 4,000 miles, the 707-320 Intercontinental jetliner first went into service Oct. 26, 1959. First flight was January 11, 1959. It was supplanted later by the 707-320B with a range of more than 6,000 miles nonstop with a normal passenger load. The -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. Then, in 1962, a 7 x 11-foot forward cargo door plus use of integral floor tracks and a cargo handling system, and some structural strengthening, further developed the -320B into multipurpose jet called the 707-320C (in service June 3, 1963). This airplane can carry all cargo on pallets, or can be converted to carry all passengers, or a combination of both. Nearly 340 have been ordered by 33 airlines.

Specifications

Span 145 feet 9 inches; length 152 feet 11 inches; height 42 feet 5 inches; wing sweepback 35 degrees; weight 328,000 pounds for -320B, 332,000 pounds for cargo version of -320C, and 336,000 pounds for passenger version of -320C; engines 4 Pratt & Whitney JT3D-3 turbofans of 18,000 pounds thrust; tricycle gear, main undercarriage units four-wheel bogie-type trucks, dual nose wheels; payload 189 passengers for -320B and up to 202 for the -320C in all-economy, or 96,800 pounds of cargo in -320C.

Performance

Speed more than 600 miles per hour; range more than 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. Less than one year later, on October 6, 1960, a version with more powerful turbofan engines, the 720B, was introduced. The 720 differed from the -120 in that it has a shorter body, lighter structure, less fuel capacity, a redesigned inboard wing and new full-span leading edge flaps. Maximum speed was raised and required field lengths were shortened. The 720B turbofan engines gave that version greater range and allowed it to operate from still shorter runways. The "B" model went into service March 12, 1961. More than 150 of the series have been ordered by 16 airlines.

Specifications

Span 130 feet 10 inches; length 136 feet 2 inches; height 41 feet 6 inches; sweepback 35 degrees; weight 230,000 pounds (720), 235,000 pounds (720B); engines 4 Pratt & Whitney JT3C-7 turbojets of 12,000 pounds thrust for the 720, JT3D-1 turbofans of 17,000 pounds thrust or JT3D-3 turbofans of 18,000 pounds thrust for the 720B; gear tricycle with four-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 30,000 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 three engines grouped at the tail. Its three-engine configuration was designed to give the best compromise between four-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 take-off performance superior to all 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, plus the 727C (cargo/convertible) and the 727QC (quick-change cargo/convertible).

Specifications

Span 108 feet; length 133 feet 2 inches (-200 is 153 feet 2 inches); height 34 feet; wing sweepback 32 degrees; weight 161,000 pounds (for other versions it is 170,000 pound); engines 3 Pratt & Whitney JT8D-1 turbofan, 14,000 pounds thrust each; gear tricycle, dual-wheel units; payload up to 131 passengers economy class, -200 payload up to 179 passengers economy class, QC payload up to 46,600 pounds.

Performance

Speed 600 miles per hour; normal operating range 1,700 miles (-200 is 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 up to 108,000 pounds, compared to 161,000 pounds for the three-engined 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 during late 1965, the 737-100 and the six-foot-longer 737-200. Nearly 200 have been sold including cargo and quick-change versions.

Specifications

Span 93 feet; length 94 feet (-200 is 100 feet), height 37 feet; wing sweepback 25 degrees; weight 97,800 pounds (-100), 108,000 pounds (-200); engines 2 Pratt & Whitney JT8D-7 turbofans of 14,000 pounds thrust each; gear tricycle, dual-wheel units; payload 31,000 pounds (structural limit) or up to 101 passengers for -100, 31,931 pounds or up to 117 passengers for -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 rolls from the factory in late 1968, it will be the largest commercial jetliner in history. Designed to carry up to 490 passengers in all-economy seating or 360 in mixed-class configuration over long ranges, this 625 mile-per-hour aircraft offers the opportunity for a combination of new standards in low-priced air travel and luxury. Its 185-foot long, 20-foot wide cabin will permit spacious seating as well as such innovations as nurseries, lounges or theater areas. In addition, a stateroom area will be 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 will have 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; max ramp weight 710,000 pounds; engines 4 Pratt & Whitney Aircraft JT9D turbofans of 42,000 pounds thrust each; dual nose wheels, 4 4-wheel bogie type main trucks; payload up to 490 passengers in all-economy or 215,600 pounds in all-cargo version.

Performance

Speed up to 640 miles per hour, range nearly 8,000 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 USAF ordered a derivative into limited production as the KC-135A jet tanker. The tanker, incorporating a highly streamlined flying boom developed by Boeing, for the first time allowed refueling of the USAF's 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 or reconnaissance aircraft. A total of 820 KC/C-135s were built. The tankers and some transports all used water injection turbojet engines, while a "B" model using turbofans was developed and put into transport service by the USAF 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 J-57 turbojet of 13,750 pounds thrust (KC-135), four P&W 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 Agency signed a contract with Boeing for the construction of 2 prototypes of an 1,800 mile per hour passenger jetliner. The competition-winning design evolved from studies of almost 500 different configurations. It features variable-sweep wings, set at an angle of 20 degrees for take-off and low speed operations and swept to 72 degrees for flight at close to Mach 3. The 306-foot-long craft will be capable of taking off (with 250 to 350 passengers) at about the same speed and in less runway than a fully loaded Boeing 707. Most of the SST will be built of an alloy of 90 percent titanium, 6 percent aluminum and 4 percent vanadium. In photo, a mockup, subject to configuration change.

Specifications

Length 306 feet; span at 20 degree sweep 180 feet, at 30 degrees 174 feet, at 72 degrees 106 feet; wing area 9,000 square feet; height 46 feet; maximum take-off weight 675,000 pounds; landing gear multi-unit with 4 main units of 4 wheels each, 2-wheel nose gear.

Performance

Normal cruising speed Mach 2.7 or 1,800 miles per hour; normal cruising altitude 64,000 feet; maximum payload 75,000 pounds; range with 313 passengers over 4,000 miles.

CH-46D SEA KNIGHT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The CH-46D is a medium assault transport helicopter currently in production for the Marine Corps. The tandemrotor helicopter, with all-weather and shipboard capabilities, features a power blade-folding system which enables the blades to be folded automatically in winds up to 45 knots in less than one minute.

Specifications

Fuselage length 44 feet 10 inches; rotor diameter 51 feet; take-off design gross weight 20,800 pounds; take-off maximum gross weight 23,000 pounds; empty weight 13,067 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 4,823 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. It is in operation with New York Airways as a scheduled airline helicopter operating between New York's major airports, outlying suburban communities, and the PanAm building in midtown Manhattan.

Specifications

Fuselage length 44 feet 7 inches; rotor diameter 50 feet; take-off gross weight 19,000 pounds; engines 2 General Electric T58 turbines.

Performance

Maximum speed 144 knots; best cruise speed 135 knots; range more than 200 miles with reserve; payload 25 passengers plus baggage.

CH-47B CHINOOK TRANSPORT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The CH-47B Chinook is the U.S. 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 also is used to recover downed aircraft, and to evacuate refugees. An important mission is air movement of combat elements. The Chinooks can carry 44 fully equipped troops.

Specifications

Fuselage length 51 feet; rotor diameter 60 feet; take-off design gross weight 33,000 pounds; take-off maximum gross weight 40,000 pounds; empty weight 19,375 pounds; engines 2 Lycoming T55-L-7C, each with 2,850 shaft horsepower.

Performance

Cruise speed at sea level 145 knots; mission radius 100 nautical miles; service ceiling 16,300 feet; payload at maximum gross weight, 10 nautical mile mission, 19,300 pounds, 100 nautical mile mission, 15,800 pounds.

107 MILITARY TRANSPORT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The 107 military transport helicopter is now in service with the Royal Canadian Air Force, the Canadian Army, the Swedish Navy and 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 as well as a variety of other missions, including transport of cargo, fuel, and passengers.

°Specifications

Fuselage length 44 feet 10 inches; rotor diameter 50 feet; take-off design gross weight 18,700 pounds; take-off maximum gross weight 21,400 pounds; empty weight 11,251 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.

°Note: Specifications and performance listed are for the CH-113 RCAF 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 U.S. 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; take-off design gross weight 20,800 pounds; take-off 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

Specifications (Standard and Trainer Versions)

Gross weight 1,600 pounds; empty weight 975–1,005 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; wing span 32 feet 8½ inches; length 23 feet 9 inches; height 8 feet 7½ inches; engine 4-cylinder 100 horsepower.

Performance

Maximum speed 123 miles per hour; cruise speed, 75 percent power at 7,500 feet, 120 miles per hour; range at cruise speed 480 miles, with long range tanks 745 miles; rate of climb at sea level 670 feet per minute; service ceiling 12,650 feet.

Note: Model 150 is also available in commuter version with slight variations in specifications and performance.

MODEL 172

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 36 feet 2 inches; wing area 174 square feet; length 26 feet 11 inches; height (with depressed nose strut) 8 feet 10 inches; gross weight 2,300 pounds; empty weight (approximate) 1,260 pounds; baggage 120 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.

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; take-off run over 50-foot obstacle 1,525 feet; landing run over 50-foot obstacle 1,250 feet.

SKYHAWK

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 36 feet 2 inches; wing area 174 square feet; length 26 feet 11 inches; height (with depressed nose strut) 8 feet 9 inches; gross weight 2,300 pounds; empty weight (approximate) 1,340 pounds; baggage weight 120 pounds; wing loading 13.2 pounds per square foot; power loading 15.9 pounds per horsepower; fuel capacity 42 gallons engine Continental 0-300-D; propeller all-metal fixed pitch diameter 76 inches.

Performance

Maximum speed at sea level 139 miles per hour; cruise speed, 75 percent power at 7,000 feet, 131 miles per hour; cruise range, 75 percent power at 7,000 feet, 600 miles; optimum range at 10,000 feet 720 miles; rate of climb at sea level 645 feet per minute; service ceiling 13,100 feet; take-off run over 50-foot obstacle 1,525 feet; landing run over 50-foot obstacle 1,250 feet.

MODEL 180

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 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) 1,515 pounds; baggage capacity 350 pounds; wing loading 16.1 pounds per square foot; power loading 12.2 pounds per horsepower; fuel capacity 65 gallons; engine 230 rated horsepower; propeller constant speed 82 inches 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 per hour; optimum range at 10,000 feet 1,215 miles; rate of climb at sea level 1,090 feet per minute; service ceiling 19,600 feet; take-off run over 50-foot obstacle 1,205 feet; landing roll over 50-foot obstacle 1,365 feet.

Note: Model 180 also available as float plane and amphibian.

MODEL 185

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 36 feet 2 inches; wing area 174 square feet; length 25 feet 6 inches; height 7 feet 9 inches; gross weight 3,350 pounds; empty weight (approximate) 1,560 pounds; baggage capacity 350 pounds; wing loading 18.9 pounds per square foot; power loading 11.0 pounds per horsepower; fuel capacity 65 gallons; engine 6-cylinder fuel-injection; propeller constant speed diameter 82 inches.

Performance

Maximum speed at sea level 178 miles per hour; cruise speed, 75 percent power at 7,000 feet, 169 miles per hour; cruise range, 75 percent power at 7,000 feet, 660 miles; optimum range at 10,000 feet 1,075 miles; rate of climb at sea level 1,040 feet per minute; service ceiling 17,500 feet; take-off run over 50-foot obstacle 1,330 feet; landing roll over 50-foot obstacle 1,400 feet.

MODEL 210 CENTURION

Prime Contractor: Cessna Aircraft Company

Remarks

The deluxe Model 210 Certurion brings many luxury and comfort features into the single-engine class of aircraft. These include specially trimmed and sculptured interior appointments, leather bucket seats, heavy foam-padded carpeting, walnut inlaid seat backs and trim, and optional center-aisle consoles for storage.

Specifications

Span 36 feet 9 inches; length 28 feet 3 inches; height 9 feet 9 inches; gross weight 3,400 pounds; empty weight 1,960 pounds; useful load 1,440 pounds; wing loading 19.3 pounds per square foot; power loading 11.9 pounds per horsepower; fuel capacity 90 gallons standard; engine 6-cylinder 285 horsepower; propeller constant speed diameter 82 inches.

Performance

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.

Note: Turbo-system available with increased performance.

MODEL 310L

Prime Contractor: Cessna Aircraft Company

Specifications

Gross weight 5,200 pounds; empty weight 3,125 pounds; baggage capacity 600 pounds; wing loading 29.1 pounds per square foot; power loading 10.0 pounds per horsepower; fuel capacity 102 gallons; engines 2 6-cylinder fuel-injection IO-470-Us; propeller constant-speed full-feathering diameter 81 inches.

Performance

Maximum speed at sea level 237 miles per hour; maximum recommended cruise speed, 75 percent power at 6,500 feet, 219 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); take-off run at sea level over 50-foot obstacle 1,716 feet; landing roll at sea level over 50-foot obstacle 1,582 feet.

SKYNIGHT

Prime Contractor; Cessna Aircraft Company

Specifications (5,300 pound Skynight)

Wing span 36.9 feet; wing area 179 square feet; length 29.5 feet; height 10.3 feet; weight 5,300 pounds; empty weight 3,266 pounds; baggage capacity 600 pounds; wing loading 29.6 pounds per square foot; power loading 9.3 pounds per horsepower; fuel capacity 102 gallons; engines 2 Continental 6-cylinder fuel injection TSIO-470-D 285 horsepower; propeller constant-speed full-feathering 80 inches diameter.

Performance

Maximum speed at 16,000 feet 275 miles per hour; cruise speed, 75 percent power at 10,000 feet, 233 miles per hour; maximum recommended cruise range, 75 percent power at 20,000 feet, 845 miles; 75 percent power at 10,000 feet, 763 miles; rate of climb at sea level 1,924 feet per minute (twin engine), 475 feet per minute (single engine); service ceiling 29,000 feet (twin), 18,800 feet (single); take-off run (maximum performance) over 50-foot obstacle 1,513 feet; landing roll over 50-foot obstacle 1,734 feet.

EXECUTIVE 411A

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 39.86 feet; length 33.46 feet; height 11.38 feet; gross weight 6,500 pounds; engines 2 GTSIO-520 6-cylinder fuel-injection with turbochargers, 340 rated horsepower; propellers 3-bladed 90-inch constant-speed full-feathering; stall speed 84 miles per hour; maximum landing weight 6,500 pounds; empty weight 3,865 pounds; fuel capacity 175 gallons; seating 6–8; baggage allowance 930 pounds; wing loading 32.5 pounds per square foot; power loading 9.6 pounds per horsepower.

Performance

Maximum speed at 5,850 pounds gross weight at 16,000 feet 272 miles per hour; cruise speed, 75 percent power at 20,000 feet, 250 miles per hour; at 10,000 feet 227 miles per hour; normal cruise range 1,045 miles; maximum cruise range at 10,000 feet 1,325 miles; rate of climb at sea level (twin engine) 2,270 feet per minute, (single engine) 505 feet per minute; service ceiling (twin) 28,200 feet, (single) 17,200 feet; take-off run over 50-foot obstacle 1,545 feet; landing run over 50-foot obstacle 1,560 feet.

MODEL 182 AND SKYLANE

Prime Contractor: Cessna Aircraft Company

Specifications (182)

Wing span 36 feet 2 inches; wing area 174 square feet; length 28 feet 6 inches; height 9 feet; gross weight 2,800 pounds; empty weight (approximate) 1,560 pounds; baggage capacity 120 pounds; wing loading 16.1 pounds per square foot; power loading 12.2 pounds per horsepower; fuel capacity 65 gallons; 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; take-off distance over 50-foot obstacle 1,205 feet; landing distance over 50-foot obstacle 1,350 feet.

Note: Skylane version also has gross weight of 2,800 pounds; but empty weight is 1,620 pounds; other specifications identical. Performance slightly higher than above for Skylane.

SUPER SKYLANE

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 36 feet 7 inches; wing area 175.5 square feet; length 28 feet 4 inches; height (nose strut depressed) 9 feet 7.5 inches; gross weight 3,600 pounds; empty weight (approximate) 1,798 pounds; 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; propeller constant speed diameter 82 inches.

Performance

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; take-off run over a 50-foot obstacle 910 feet, total distance 1,810 feet; landing run over 50-foot obstacle 735 feet, total distance 1,395 feet.

Note: Turbo-System Super Skylane has increased performance.

SUPER SKYMASTER

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 38 feet; wing area 201 square feet; length 29 feet 9 inches; height 9 feet 4 inches; gross weight 4,300 pounds; empty weight (approximate) 2,615 pounds; baggage allowable 365 pounds; wing loading 21.4 pounds per square foot; power loading 10.2 pounds per horsepower; fuel capacity 93 gallons; engine 2 6-cylinder fuel-injection IO-360s 210 horsepower; propellers constant speed full-feathering diameter 76 inches.

Performance

Top speed at sea level 200 miles per hour; cruise speed, 75 percent power at 5,500 feet, 192 miles per hour; normal range, 75 percent power at 5,500 feet, 765 miles; optimum range at 10,000 feet 985 miles; rate of climb at sea level 1,250 feet per minute (twin engine); service ceiling 20,000 feet (twin engine); take-off run over 50-foot obstacle 1,490 feet; landing ground roll over 50-foot obstacle 1,500 feet.

Note: Turbo-System version now available.

SUPER SKYWAGON

Prime Contractor: Cessna Aircraft Company

Specifications (3,600-pound model).

Wing span 36 feet 7 inches; wing area 175.5 square feet; length 28 feet; height (nose strut depressed) 9 feet 9 inches; gross weight 3,600 pounds; configuration 6-place; empty weight (approximate) 1,695 pounds; wing loading 20.5 pounds per square foot; power loading 12.0 pounds per horsepower; fuel capacity 65 gallons; engine 6-cylinder fuel injection; propeller constant-speed 82-inch diameter.

Performance

Maximum speed at sea level 174 miles per hour; cruise speed, 75 percent power at 6,000 feet, 164 miles per hour; cruise range, 75 percent power at 6,000 feet, 650 miles (optimum at 10,000 feet 810 miles); rate of climb at sea level 920 feet per minute; service ceiling 14,800 feet; take-off run over 50-foot obstacle 1,780 feet; landing run over 50-foot obstacle 1,395 feet.

Note: Turbo-System Super Skywagon has increased performance.

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-T25.

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-37A STRIKE AIRCRAFT

Prime Contractor: Cessna Aircraft Company

Remarks

Formerly known as the AT-37D, the A-37A has been delivered to the U.S. Air Force for close air support work. Developed from the T-37B jet trainer, the A-37A is equipped with armor plating, partial self-sealing fuel tanks, wing tip 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. An A-37B version is also being produced and has the same performance as the A-37A.

Specifications

Gross weight 12,000 pounds; length 29 feet 4 inches; wing span 35 feet 9 inches; engines General Electric J-85-GE-17A total thrust 4,800 pounds.

Performance

Maximum speed 415 knots; gross weight take-off distance over 50-foot obstacle 2,650 feet; landing distance over 50-foot obstacle 2,350 feet; rate of climb 6,500 feet per minute; single engine performance after lift-off at gross weights up to 11,700 pounds.

T-41A 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 also has supplied the Army 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.

Specifications

Wing span 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 0-300-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.

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; take-off run over 50-foot obstacle 1,525 feet; landing run over 50-foot obstacle 1,250 feet.

MODELS 401/402

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 39.86 feet; length 33.75 feet; height 11.68 feet; gross weight 6,300 pounds; engines 2 six-cylinder, fuel-injection engines 300 rated horsepower at 2700 revolutions per minute; propellers 3-bladed constant-speed full-feathering 76.5 inches diameter; empty weight (approximate) 3,641 pounds; standard fuel capacity 106 gallons, 143 optional; seating 6–8; baggage allowable 930 pounds; wing loading 32.2 pounds per square foot; power leading 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; normal cruise range 694 miles (100 gallons); maximum cruise range at 25,000 feet 808 miles; rate of climb at sea level (twin engine) 1,610 feet per minute, (single engine) 255 feet per minute; service ceiling (twin) 26,180 feet, (single) 11,700 feet; take-off run over 50-foot obstacle 2,220 feet, landing run over 50-foot obstacle 1,765 feet.

Note: Performance figures given for Model 401 (shown in photo). Performance for Model 402 is identical. Model 402 is utility version that can seat 9 or carry 2,000 pounds of cargo.

MODEL 421

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 39.86 feet; length 33.75 feet; height 11.38 feet; gross weight 6,800 pounds; engines 2 six-cylinder fuel injection geared, 375 horsepower each; propellers 3-bladed constant-speed, full-feathering 90 inch diameter; empty weight (approximate) 4,237 pounds; standard fuel 175 gallons, optional 255 gallons; seating, 6; baggage allowable 930 pounds; wing loading 34.0 pounds per square foot; power loading 9.06 pounds per horsepower; pressurized cabin.

Performance

Maximum speed, 6,800 pounds gross weight at 16,000 feet, 275 miles per hour; cruise speed, 75 percent power at 20,000 feet, 255 miles per hour; at 10,000 feet 233 miles per hour; normal cruise range 955 miles (standard fuel); maximum cruise range at 25,000 feet 1,174 miles; rate of climb at sea level (twin) 1700 feet per minute, (single) 300 feet per minute; service ceiling (twin) 26,000 feet, (single) 13,340 feet; take-off run over 50-foot obstacle 2,516 feet, landing run over 50-foot obstacle (6,500 pounds gross) 2,110 feet.

MODEL 0-1E "BIRD DOG"

Prime Contractor: Cessna Aircraft Company

Remarks

Although currently not in production, the 0-1 is still widely used by both the U.S. Army and Air Force for liaison and observation duties. Formerly known as the L-19, the aircraft is able to operate out of rough, small fields.

Specifications

Wing span 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; stalling speed 54 miles per hour.

MODEL O-2A

Prime Contractor: Cessna Aircraft Company

Remarks

Military version of Cessna's Super Skymaster, the O-2 is being produced in 2 versions. The O-2A is used primarily for forward air control, liaison and observation functions. The O-2B 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

Wing span 38 feet; length 29 feet 9 inches; height 9 feet 4 inches; wing area 201 square feet; engines 2 six-cylinder fuel-injected 210 horsepower (each).

Performance

Similar to commercial Super Skymaster version.

MODEL 230 AND 300 AGWAGON

Prime Contractor: Cessna Aircraft Company

Remarks

The Agwagon aerial application aircraft is being produced by Cessna in two models, the Agwagon 230 with a 230 horsepower engine and standard fixed-pitch prop or optional constant-speed prop, and the Agwagon 300 with a 300 horsepower engine and standard constant-speed prop.

Specifications

Gross weight 3,300 pounds (without dispersal equipment); length 25 feet 3 inches, height 7 feet 4½ inches; wing span 40 feet 4½ inches; hopper capacity 200 gallons, 757 liters; wing loading 16.3 pounds per square foot; power loading 14.3 pounds per horsepower (Model 230) and 11 pounds per horsepower (Model 300); engine Continental 0-470-R (Model 230) and Continental IO-520-D (Model 300).

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, and (300 constant-speed 75 percent power at 6,500 feet) 320 miles; rate of climb at sea level for the three versions: 710, 755, and 940 feet per minute; service ceiling: 13,000 feet, 13,700 feet, and 15,700 feet.

A-3 SKYWARRIOR

Prime Contractor: Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)

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 photo-reconnaissance 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 on October 28, 1952. It is now 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

Wing span 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 more than 2,500 nautical miles. Other data classified.

A-4F AND TA-4F SKYHAWK TRAINER-ATTACK BOMBER

Prime Contractor: Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)

Remarks

Newest versions of the versatile A-4 Skyhawk series of Navy attack bombers are the A-4F and TA-4F, the latter a jet trainer. 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 incorporates the advanced avionics and Pratt & Whitney Aircraft J52-P-8A engine of the trainer into an improved attack bomber. Nosewheel steering and landing spoilers also have been added to the original Skyhawk. Both are produced at Long Beach with final assembly at Palmdale, California. In photo, A-4F.

Specifications (TA-4F)

Wing span 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 600–700 mile per hour class.

B-66 DESTROYER BOMBER

Prime Contractor: Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)

Remarks

Several versions of the B-66 tactical bomber are in service with the Air Force. Produced in bombing and reconnaissance versions, the Destroyer performs at stratospheric or minimum altitudes. The B-66 and RB-66 were built at the Douglas Long Beach plant, and the RB-66C and WB66D 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, in-flight refueling system, and thermal-cyclic de-icing system.

Specifications

Wing span 72 feet 6 inches; length 75 feet 2 inches; height 23 feet 7 inches; gross weight 70,000–78,000 pounds; engines 2 Allison J71 jets; crew of 3, RB-66C, 4; armament 2 20-millimeter tail turret guns electronically operated.

Performance

Speed 600–700 miles per hour. Other data classified.

C-124 GLOBEMASTER

Prime Contractor: Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)

Remarks

The C-124 Globemaster, first flown in November 1949, has been daily flying supply lines reaching practically around the world 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, self-contained ramp and an elevator located amidships permitting loading and unloading at both points. The last C-124 was delivered in May 1955.

Specifications

Wing span 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 R-4360-63A; fuel capacity 11,000 gallons; wing area 2,506 square feet.

Performance

Maximum payload 70,000 pounds; 50,000 pound payload can be delivered 1,000 miles and plane can return to base without refueling.

C-133 HEAVY CARGO TRANSPORT

Prime Contractor: Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)

Remarks

The C-133A and C-133B are capable of transporting any missile in the United States arsenal including intercontinental ballistic missiles. They also can carry virtually all 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 pressurized to maintain a sea level cabin altitude up to 16,000 feet and varying to a 10,000-foot cabin altitude at 35,000 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

Wing span 179 feet 7.86 inches; length 157 feet 6.44 inches; height 48 feet 9 inches; empty weight 120,363 pounds; wing loading 107.0 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 at Military Power at 286,000 pounds gross weight at 8,700 feet; cruise speed 284 knots at approximately 90 percent normal rated power, at altitudes varying 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: Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)

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 R-2800 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 five feet longer to seat up to 102 was designed and designated the DC-6B. This design was the basis of the first commercial air freighter, the DC-6A, and the military C-118 Liftmaster ordered by the Air Force and Navy for cargo, troop transport and medical evacuation purposes. More than 700 DC-6 aircraft of all type were produced. First DC-6 flight was February 15, 1946; first delivery was March 28, 1947.

DC-7 COMMERCIAL TRANSPORT

Prime Contractor: Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)

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. First of the airliners 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 four Wright R-3350 compound engines giving 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, December 20, 1955; certification, May 15, 1956.

DC-8 JET TRANSPORT

Prime Contractor: Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)

Remarks

Four basic models of the DC-8, including 3 new extended fuselage Super Sixty Series versions, are manufactured. Each is also made in a cargo or combination cargo-passenger variation. Series 50 DC-8 and DC-8F models are identical in dimensions to the original Model 10, but have increased capacity to 189 passengers. Super 61, first of the Super Sixty Series versions, has a fuselage extension of 440 inches to a total of 187.4 feet and carries up to 251 passengers. Super 62, an ultra-long-range transport, seats up to 189 passengers in a fuselage extended 80 inches to 157.4 feet and has a six-foot increase in wing span, increased fuel capacity and redesigned engine pylons and ducted fan nacelles. Super 63 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, March 14, 1966; Super 62, August 29, 1966; Super 63, April 10, 1967. Certification all Super Sixty Series models, 1967.

Specifications—(basic DC-8)

Span 142 feet 5 inches; length 150 feet 6 inches; height 42 feet 4 inches; wing area 2,773 square feet; crew 3-5 plus cabin attendants; engines 4 Pratt & Whitney Aircraft JT3D-3 18,000 pounds thrust; design gross weight 318,000 pounds.

Performance

Level flight speed 579 miles per hour; rate of climb 2,380 feet per minute; maximum range 7,090 statute miles.

DC-9 JET TRANSPORT

Prime Contractor: Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)

Remarks

The short-to-medium range DC-9 twin-jet transport is produced in two versions—the Series 10 with a fuselage 104.4 feet in length to accommodate up to 90 passengers, and Series 30 with an extension of 15 feet, seating as many as 115. Convertible passenger-cargo and executive models also are in production. All have Pratt & Whitney Aircraft JT8D ducted fan-jet power plants, mounted on the aft fuselage. All versions are designed to operate from relatively short airfields. Wings of the larger Series 30 have leading edge slats to increase lift on takeoff. Features such as a self-contained boarding ramp and chest-level baggage compartment are of special value for service at airports of limited facilities. First flight of Series 10 February 25, 1965; first delivery September 1965; certification, November 1965. First flight Series 30, August 1, 1966; certification, November 1966.

Specifications

Span 87.4 feet; length 104.4 feet; height 27.4 feet; wing area 925 square feet; crew 2 plus cabin attendants; engines 2 Pratt & Whitney Aircraft JT8D-5 ducted fanjet 12,000 pounds thrust; maximum take-off weight 77,700 pounds.

Performance

Level flight speed 557 miles per hour; rate of climb 2,750 feet per minute; range at optimum cruise speed 1,470 statute miles.

C-9A AEROMEDICAL EVACUATION TRANSPORT

Prime Contractor: Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)

Remarks

On August 31, 1967, the Air Force awarded a $28,700,000 contract to the McDonnell Douglas Corporation's Douglas Aircraft Group for 8 C-9A medium-sized twin-engine jet aircraft to be used for aeromedical evacuation. Essentially an off-the-shelf DC-9 designed for commercial use, the C-9A will be configured to carry 30 litter patients, 40 ambulatory patients or a combination of the two. The C-9A will be built at the Douglas Long Beach facility, and first deliveries to the Military Airlift Command are scheduled to begin in the first quarter of fiscal 1969.

Specifications

See DC-9.

Performance

The C-9A will cruise at approximately 520 miles per hour over a medium range with a maximum patient load.

EC-135N APOLLO RANGE INSTRUMENTED AIRCRAFT

Program Direction: Electronics Systems Division, Air Force Systems Command
Contractors: Douglas Aircraft Modification Division (prime contractor for Apollo Range Instrumented Aircraft Program); 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 will provide a highly mobile communications network which can be quickly shifted 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 onto it and then transmit and receive voice and telemetry communications. Four of the aircraft will also be equipped with optical tracking and photographic equipment. The first EC-135N made its initial flight on September 19, 1966.

F-27J PROPJET TRANSPORT

Prime Contractor: Aircraft Division, Fairchild Hiller Corporation

Remarks

Fairchild Hiller has built 120 F-27 airplanes that are flown by 11 airlines and many corporations. This aircraft, one of the most efficient and economical twin-propjets in service, is now available in a new more powerful version—the F-27J. 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; operates from short runways and unimproved fields.

Specifications

Wing span 95 feet 2 inches; length 77 feet 6 inches; empty weight 21,961 pounds; operational weights: 42,000 take-off, 40,000 landing; engine Rolls-Royce Dart RDa 7/Mark 532-7 2,050 maximum horsepower; fuel capacity 1,364 or 2,063 gallons; propeller Rotol 4-blade constant-speed; wing area 754 square feet.

Performance

Cruise speed 300 miles per hour at 20,000 feet; rate of climb 2,200 feet per minute at sea level; service ceiling 32,700 feet.

FH-227B PROPJET TRANSPORT

Prime Contractor: Aircraft Division, Fairchild Hiller Corporation

Remarks

Fairchild Hiller has introduced the FH-227B, an enlarged and improved version of the F-27. With a 6-foot longer fuselage, the FH-227B 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

Wing span 95 feet 2 inches; length 83 feet; operational weights: 45,500 take-off, 45,000 landing; engine Rolls Royce Dart RDa 7/Mark 532-7 2,050 maximum horsepower; fuel capacity 1,364 or 2,063 gallons; propeller Rotol 4-blade 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

Cruise speed 300 miles per hour at 20,000 feet; rate of climb 2,200 feet per minute at sea level; service ceiling 35,000 feet.

HELI-PORTER

Prime Contractor: Aircraft Division, Fairchild Hiller Corporation

Remarks

Fairchild Hiller is producing 100 units of the Heli-Porter high performance single-engine turbine-powered STOL aircraft for commercial markets. A spectacular performer, it is the first single-engine propjet airplane to be certified in the United States. The Heli-Porter is an all-purpose aircraft capable of operating from extremely small unprepared fields. It features large double doors installed on either or both sides, depending on customer requirements. Interior configuration can be changed by one man in a matter of seconds 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 8 people including the pilot.

Specifications

Wing span 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 140 knots; range 550 nautical miles plus 30-minute fuel reserve; take-off run 320 feet at maximum gross weight on standard day with no wind; landing roll 180 feet (under same conditions); service ceiling at maximum load 28,000 feet.

FH-1100 HELICOPTER

Prime Contractor: Aircraft Division, Fairchild Hiller Corporation

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-C/8.

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.

E4 HELICOPTER (OH-23F)

Prime Contractor: Aircraft Division, Fairchild Hiller Corporation

Remarks

Built to meet the Army's high-altitude, rugged terrain requirements, the OH-23F is a four-place utility helicopter. As a civilian craft, the E4, it is in wide service in forestry work, missile site construction support, executive transportation and off-shore 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.

SL4 HELICOPTER

Prime Contractor: Aircraft Division, Fairchild Hiller Corporation

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 four-place craft, sister ship to the non-supercharged 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.

US/FRG V/STOL ADVANCED TACTICAL FIGHTER

Prime Contractor: EWR Fairchild International

Remarks

Now in systems definition phase as a joint development project of the U.S. and the Federal Republic of Germany, the proposed US/FRG V/STOL fighter is a medium weight aircraft capable of operating conventionally from short airstrips or vertically. The design incorporates variable-sweep wings, plus a new concept of retractable, swing-out lift engines located just forward of the leading edge of the wings. Mounted on arms which swing out from the fuselage, the engines can be tilted to varying degrees from the horizontal to provide vertical lift or extremely short rolling take-off capability with full loads. The 2 lift/cruise engines are mounted at the rear of the fuselage and will have deflected thrust for STOL or vertical operations. The combination of lift and deflected thrust propulsion gives a classic tripod stability throughout take-off and landing. Detailed specifications and performance are classified, but the aircraft is reported to be comparable to the F-105. A decision on building of prototypes was expected by the spring of 1968. The contractor, EWR Fairchild International, is a joint-venture company comprised of members of the U.S. firm Republic Aviation Division of Fairchild Hiller and the German firm EWR Sud. Power plants: Lift cruise engine competition between Pratt & Whitney Aircraft and General Electric; lift engines, joint development between Rolls Royce Ltd. and Allison Division of General Motors.

F-105 THUNDERCHIEF FIGHTER BOMBER

Prime Contractor: Republic Aviation Division, Fairchild Hiller Corporation

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 two models—the single-seat F-105D and the two-place F-105F. The F-105 is in service with the tactical Air Force in the U.S., Europe, and the Far East. Its speed, maneuverability, and aerial firepower qualify it for use in counterair, close support or 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 "work horse" 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 (F-105D) 64 feet 3 inches, (F-105) 69 feet 7 inches; height (F-105D) 19 feet 8 inches, (F-105F) 20 feet 2 inches; 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.

F-102A ALL-WEATHER INTERCEPTOR

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

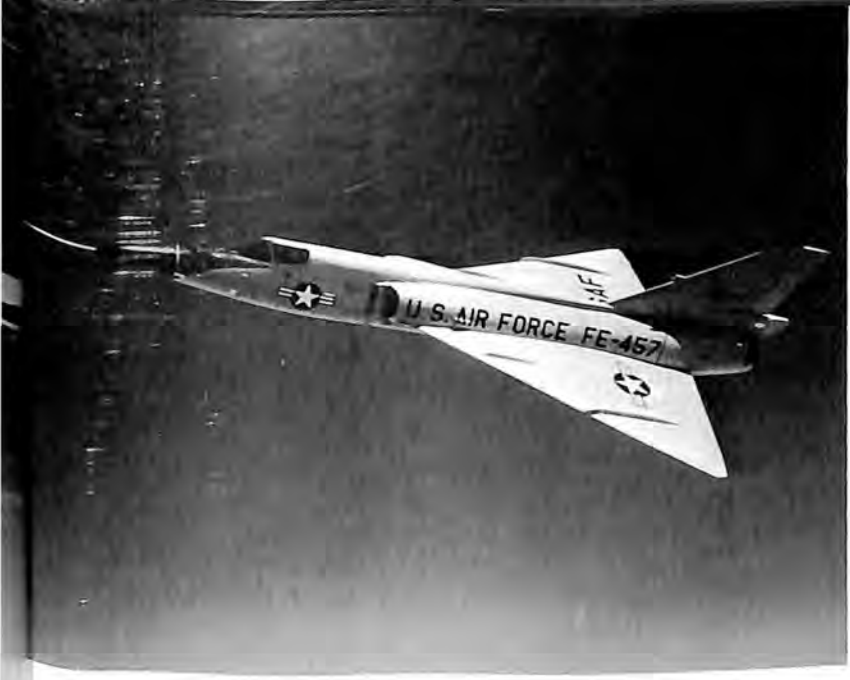
The single-seat F-102A, world's first supersonic all-weather interceptor, is a prime air defense weapon of the Air Force in America, Europe and the Far East. The F-102A carries Hughes Falcon missiles and 2.75 inch folding-fin rockets. The TF-102A combat proficiency trainer is similar to the F-102A except for a wider nose section to accommodate pilot and student in side-by-side seating. First flight of the YF-102 prototype was made October 23, 1953, at Edwards AFB, California. First flight of the YF-102A was on December 20, 1954. First deliveries to the Air Force were made in June 1955.

Specifications

Span 38 feet 1.6 inches, length 68 feet 5 inches; height 21 feet 2.5 inches; engine one Pratt & Whitney Aircraft J57-P-23 turbojet with afterburner; 10,000 pounds 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 Douglas AIR-2A special weapon equipped with a nuclear warhead. The F-106B is the two-seat version of the F-106A with all-weather capabilities and carrying the same armament. First flight of the F-106A was made December 26, 1956, at Edwards Air Force Base, California. First flight of the F-106B was on 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

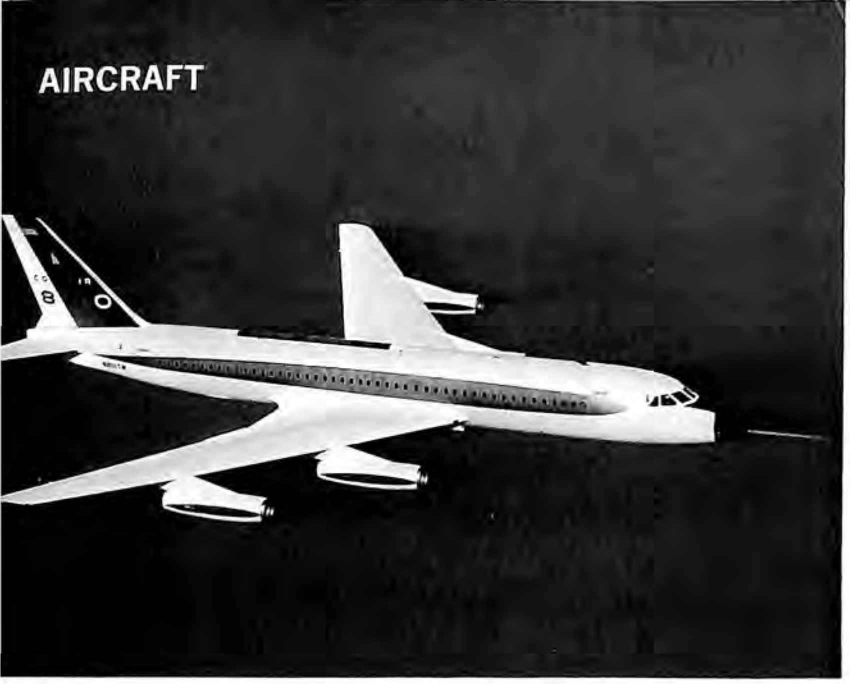
600: Wing span 91 feet 9 inches; length 76 feet 11 inches; height 26 feet 11 inches; passengers 40; 2 Rolls-Royce MK 542-4 turboprops with 3,025 shaft horsepower each; 2 Dowty Rotol 4-bladed 156-inch propellers; empty weight 28,250 pounds; gross weight 46,200 pounds.

640: Wing span 105 feet 4 inches; length 81 feet 5 inches; height 18 feet 2 inches; passengers 44; 2 Rolls-Royce MK 542-4 turboprops with 3,025 shaft horsepower each; 2 Dowty Rotol 4-bladed 156-inch propellers; empty weight 30,540 pounds; gross weight 55,000 pounds.

Performance

600: cruise speed 312 miles per hour at altitude of 10,000 feet at maximum cruise power; rate of climb 1,600 feet per minute; service ceiling 24,000 feet; maximum range 2,280 miles.

640: cruise speed 300 miles per hour at altitude of 10,000 feet at maximum cruise power; rate of climb 1,400 feet per minute; service ceiling 22,500 feet; maximum range 3,225 miles.



CONVAIR 880 AND 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 up to transcontinental flights. Its sister airliner, the Convair 880-M, offers increased range, fuel capacity, 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 will carry 110 persons.

Specifications

Wing span 120 feet; length 129 feet 4 inches; height 36 feet 4 inches; empty weight 84,300 pounds; wing loading 92.95 per square foot; at maximum 880 take-off weight of 184,500 pounds; engines 4 General Electric CJ-805-3 turbojets with 11,200 pounds thrust each, (880-M) 4 General Electric CJ-805-3B turbojets with 11,650 pounds static thrust each.

Performance

Maximum speed 615 miles per hour at maximum cruise thrust at 22,500 feet; cruise speed 556 miles per hour at Mach 0.84 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 41,000 feet airplane altitude; 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 tend otherwise to cling to the trailing edge of the wing and create drag. Some of the Convair 990A's fuel capacity comes from the fact that these speed capsules also serve as fuel tanks.

Specifications

Wing span 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 take-off weight of 239,200 pounds; engines 4 CJ-805-23B aft fan turbojets with 16,050 pounds static thrust each; fuel capacity 15,188 gallons; wing area 2,250 square feet.

Performance

Cruising 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 41,000 feet airplane altitude; range with maximum payload 4,050 miles.

F-111A TACTICAL FIGHTER-BOMBER

Prime Contractor: Fort Worth Division of General Dynamics Corporation

Remarks

The Air Force's newest, fastest and most versatile fighter-bomber, the F-111A is the basic aircraft of the variable-wing F-111 series. The wings of all F-111 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. This capability enables the F-111 to penetrate enemy defenses in any weather, day or night. The aircraft is powered by 2 fanjet engines with afterburners. First flight of a developmental F-111A was made in December 1964; first production aircraft were delivered to the Tactical Air Command in September 1967. Initial production order for 331 F-111As was announced by the Air Force in May 1967.

Specifications

Span, wings extended, 63 feet, wings fully swept, 32 feet; height 17 feet; length 73 feet; engines two Pratt & Whitney Aircraft TF30-P3 afterburning turbofans, each in 20,000-pound-thrust class.

Performance

Speed at altitude Mach 2.5; speed at sea level Mach 1.2; service ceiling 60,000 feet; range transoceanic without refueling; in-flight refueling capability.

F-111B AIR SUPERIORITY FIGHTER

Prime Contractor: Fort Worth Division of General Dynamics Corporation
Principal Subcontractor: Grumman Aircraft Engineering Corporation

Remarks

The U.S. Navy F-111B is a high-performance air superiority fighter for the fleet air defense mission in the 1970s. It will carry the Phoenix Missile System, an extremely sophisticated air-to-air missile. The F-111B provides the high performance needed for effective deployment of this missile. Now in development, the F-111B will be capable of flying at speeds in excess of Mach 2.2, remaining on combat patrol for long periods, and operating at altitudes that permit interception of both low and high altitude aircraft, hundreds of miles from the fleet. The 6 Phoenix missiles which the F-111B will carry have ranges more than twice that of present systems. Operational F-111Bs will land on aircraft carriers at the relatively slow speed of 113 knots, an important factor for safe operation from carriers. First flight of a developmental F-111B was made in May 1965. Initial production order for 24 F-111Bs was announced in May 1967.

Specifications

Span, wings extended, 70 feet, wings fully swept, 34 feet; height 16 feet 8 inches; length 66 feet 9 inches; engines 2 Pratt & Whitney Aircraft TF30-P12 afterburning turbofans; armament, conventional and nuclear, Phoenix Missile System, other air-to-air missiles, and air-to-surface missiles.

Performance

Speed supersonic at sea level, Mach 2.2-plus at altitude; service ceiling 60,000 feet; range transoceanic without refueling; in-flight refueling capability.

RF-111A RECONNAISSANCE AIRCRAFT

Prime Contractor: Fort Worth Division of General Dynamics Corporation

Remarks

The U.S. 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 on the reconnaissance version and optical windows under the weapons-bay area. 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 will have virtually all the capabilities of other modern reconnaissance aircraft, plus all of the additional features and capability of the F-111A, such as added range and endurance. The RF-111A's long-ferry range coupled with short take-off and landing capability will permit 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 scheduled for late 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 thru F models of the B-52. To modernize this part of the strategic bomber force, the FB-111A will capitalize on essentially the same performance capabilities demonstrated by the F-111A. The FB-111A will enhance 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 will have the F-111A fuselage but the longer F-111B wing. The FB-111A's landing gear is strengthened to support heavier payloads of conventional or nuclear weapons, including a new Short Range Attack Missile (SRAM) that delivers a nuclear warhead at supersonic speeds. First flight of a developmental FB-111A was made in July 1967. Initial production order for 64 FB-111As was announced in May 1967.

Specifications

Span, wings extended, 70 feet, wings fully swept, 34 feet; height 17 feet; length 73 feet; engines 2 Pratt & Whitney TF 30-P5 afterburning turbofans; armament, conventional and nuclear, SRAM.

Performance

Speed high subsonic at sea level, Mach 2.2 at altitude; service ceiling 60,000 feet; range transoceanic without refueling; in-flight 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 is equipped with the U.S. Air Force F-111A avionic system. Australia has ordered 24 F-111Cs, 6 of which may be fitted for reconnaissance roles. First flights of the F-111C and deliveries of production aircraft were scheduled for 1968.

Specifications and Performance

F-111C is outwardly identical to FB-111A but has essentially the same performance features as F-111A.

F-111K STRIKE RECONNAISSANCE AIRCRAFT

Prime Contractor: Fort Worth Division of General Dynamics Corporation

Remarks

Great Britain's Royal Air Force F-111K will employ the fuselage and wing of the U.S. Air Force F-111A and the landing gear of the U.S. Air Force FB-111A. The F-111K will carry an advanced avionic system; most of its mission and traffic control equipment will be British-made. Great Britain has ordered 50 F-111Ks. First flight of a developmental F-111K was scheduled for 1968.

Specifications and Performance

F-111K is outwardly identical to and has essentially the same performance features as the F-111A.

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 Strategic Air Command. It is this nation's first-and-only bomber to operate at more than 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 the 305th Bomb Wing, Bunker Hill 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 four General Electric J79 turbojets mounted in pods; engine thrust each 15,600-pound at take-off 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 an hour (Mach 2); service ceiling above 60,000 feet; range intercontinental with refueling.

E-2A HAWKEYE

Prime Contractor: Grumman Aircraft Engineering 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 made October 21, 1960.

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 Aircraft Engineering 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 or navigational problems. Armament includes nuclear depth charges, depth bombs, rockets and homing torpedos.

Specifications

Span 72 feet 7 inches; length 43 feet 6 inches; height 16 feet 7 inches; power plants 2 Wright R-1820 1,525 horsepower engines.

A-6A INTRUDER

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

The A-6A Intruder is a low-altitude, long-range, twin-engine attack aircraft with all-weather or night attack capability. It can be configured to deliver either nuclear or conventional stores and 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 by means of visual displays presented on viewing screens, under zero visibility conditions. In addition, the A-6A employs the Digital Integrated Attack Navigation System (DIANE) 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-tow catapult system. The A-6A is deployed with the Navy and the Marine Corps in Vietnam and is establishing an excellent record.

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

Classified.

EA-6A INTRUDER

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

The EA-6A is the progenitor of a line of aircraft specifically created to monitor electronic emissions and interfere with automatically controlled weaponry. These aircraft are in service with the Marine Corps, first service to fly this type of weapon system. The 2-place EA-6A will 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. Development of a second generation EA-6B craft with much greater capabilities is already under way at Grumman.

Specifications

Span 53 feet; length 55 feet; power plants 2 Pratt & Whitney Aircraft J52-P-8A turbojets 9,300 pounds thrust each.

Performance

Classified.

EA-6B

Prime Contractor: Grumman Aircraft Engineering 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 in order to accommodate 2 additional crew members. Sustained low altitude flight capability combined with spacious crew stations and armor plate protection are additional features of this newest addition to the Intruder family.

Specifications

Span 53 feet; length 59 feet 5 inches; height 16 feet 3 inches; powerplants 2 Pratt & Whitney Aircraft J52-P-8A rated at 9,300 pounds thrust (each).

Performance

Classified.

OV-1 MOHAWK

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

Designed to operate from small, unimproved fields, the Mohawk is used by the Army for observation work. Its bugeye canopy offers exceptional visibility to its two-man crew. Featuring a 55-knot stall speed and short take-off and landing capabilities like the Army's light single-engine aircraft, the Mohawk is able to "live" with the field Army.

Specifications

Span 42 feet; length 41 feet; height 12 feet 8 inches; engines 2 Lycoming T53-L-15 each of 1,100 equivalent shaft horsepower.

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 Aircraft Engineering Corporation

Remarks

Grumman's largest amphibian, the Albatross, is used by the Air Force, Navy and Coast Guard as a general utility aircraft capable of performing as a hospital plane, sea-air rescue, cargo, transport or photographic airplane. Most recent version is the HU-16B, which has greater wing span, 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; power plants 2 Wright R-1820-76 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 Aircraft Engineering Corporation

Remarks

The Grumman Gulfstream I is a twin-engine corporate transport with transcontinental range. The plane carries a 2-man crew and is designed for 10–14 passengers in the executive version or up to 24 passengers in a high-density configuration. The plane has short field flexibility. More than 180 Gulfstream Is have been sold to the nation's leading corporations.

Specifications

Span 78 feet 4 inches; length 64 feet; height 22 feet 9 inches; power plants 2 Rolls Royce Dart Mark 529-8X turboprops rated at 2,190 equivalent shaft horsepower.

Performance

Cruise speed 357 miles per hour; range more than 2,500 miles; service ceiling 39,000 feet.

GULFSTREAM II

Prime Contractor: Grumman Aircraft Engineering 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 10–19 passenger aircraft grosses 56,000 pounds. Gulfstream II also retains the short field flexibility of its predecessor, the turboprop Gulfstream I. First flight was October 1966 and FAA certification was expected late in 1967.

Specifications

Span 68 feet 10 inches; length 79 feet 11 inches; cabin interior 34 feet long, head room 6 feet 1 inch; seating 10–19 normal, up to 30 in high density version; engine 2 Rolls Royce Spey RB-163–25 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 Aircraft Engineering 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 in addition 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 which allows ease of loading operations; it is readily convertible into a personnel carrier.

Specifications

Span 80 feet 7 inches; length 56 feet 6 inches; power plants 2 Allison T56-A-8 engines rated at 4,050 equivalent shaft horsepower each.

Performance

Range 1,300 nautical miles with a 10,000 pound payload.

C-1A TRADER

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

The C-1A Trader is a cargo version of the S-2D/E Tracker and is used extensively as a Carrier Onboard Delivery aircraft. The aircraft features a larger fuselage with 9 rear facing seats or cargo fittings. Other uses for which the C-1A is designed include: instrument trainer, light cargo aircraft, utility or administrative aircraft and carrier qualification trainer. The C-1A Trader is no longer being produced; but it continues to serve alongside its newer brother, the C-2A Greyhound, as an important link between the fleet and its support bases on land.

Specifications

Span 69 feet 8 inches; length 42 feet; height 16 feet 3½ inches; power plants R1820-82 rated at 1,525 horsepower.

Performance

Cruise 150 knots; service ceiling 24,800 feet; range 964 miles.

TC-4C

Prime Contractor: Grumman Aircraft Engineering 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 features 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 train a greater number of bombardier/navigators. In the TC-4C, Intruder training missions can be flown by a pilot and a 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, may observe the same displays as seen by the bombardier/navigator in the simulated cockpit. Students may 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 may also be observed. Each console is also outfitted with navigational readouts.

Specifications

Span 78 feet 4 inches; length 67 feet 10¾ inches; height 23 feet 4 inches; power plants 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 Aircraft Engineering Corporation

Remarks

The TF-9J is a 2-seat version of the F9F-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 U.S. Navy Advanced Jet Training Command capable of transonic speed. Performance, range, and combat capability very closely duplicates those of the F-9J. It is well suited to intermediate and operational jet training, transonic flight indoctrination, carrier operations, instrument and navigation training as well as gunnery and external store delivery training. Even though the Cougar-Trainer is no longer in production, it is still in active service with the Navy and Marine Corps and is being used in Vietnam as a tactical air control aircraft.

Specifications

Span 34 feet 6 inches; length 44 feet 4¼ inches (with refueling boom add 4 feet 4½ inches); height 12 feet 4 inches; power plant 1 Pratt & Whitney J48 rated at 6,250 pounds thrust.

Performance

Mach .87 at 35,000 feet; service ceiling 43,000 feet.

E-1B TRACER

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

The E-1B Tracer is a development of the S-2/C-1 series of aircraft and is distinguished by its large, top of the fuselage mounted radome. Airframe constructions 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 continues in active service on both ASW and attack carriers.

Specifications

Span 72 feet 4 inches; length 72 feet 4 inches; height 16 feet; power plants 2 R-1820-82 rated at 1,525 horsepower.

Performance

Range 875 miles; service ceiling 15,800 feet.

AG-CAT

Prime Contractor: Grumman Aircraft Engineering 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 has a Pratt & Whitney Aircraft 450 horsepower engine, together with stronger construction, increased fuel capacity and higher gross weight.

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, in accordance with its CAM 8, Appendix A, Section 7.1.

Performance

Working speed range 80–100 miles per hour; never-exceed speed 147 miles per hour; rate of climb 1,080 feet per hour.

MODELS 300, 300 LE

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. Newest addition to the Hughes line of helicopters, the Model 300 LE has been designed and equipped especially for law enforcement. Since June 1966, Model 300 LE helicopters have been used in Project Sky Knight, a federally-sponsored crime suppression experiment utilizing helicopters as round-the-clock "aerial patrol cars" in the city of Lakewood, California. 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 feet patrol altitude. Engineering refinements include Quiet Tail Rotor and exhaust muffler (also available now on Model 300) which make all-night patrolling possible without disturbing sleeping citizenry. Model 300 LE is a 2-place aircraft.

TH-55A HELICOPTER TRAINER

Prime Contractor: Hughes Tool Company, Aircraft Division

Remarks

The TH-55A is a 2-place primary helicopter trainer in production for the Army. Hughes had delivered a total of 397 TH-55A helicopters to the Army to date; the company has been awarded contracts to build 396 more by April 1969. Option could bring total to 991 in Army service.

Specifications

Crew 1; main rotor diameter 25 feet 3½ inches; length 28 feet 5 inches; height 8 feet 3 inches; design gross weight 1,600 pounds; useful load 590 pounds; engine Lycoming H10-360-B1A 180 horsepower.

Performance

Maximum speed 75 knots; endurance 2½ hours at 65 knots; hovering ceiling, IGE, 6,400 feet; hovering ceiling, OGE, 4,000 feet.

OH-6A LIGHT OBSERVATION HELICOPTER

Prime Contractor: Hughes Tool Company, Aircraft Division

Remarks

Hughes is now delivering the OH-6A light observation helicopter to the Army under contracts calling for 1,071 aircraft by December 1968. This helicopter set 23 world records for rotorcraft including marks for altitude, speed, and nonstop, non-refueled, cross-country flight (2,215 miles). The OH-6A can carry a 5-man firepower team.

Specifications

Length 30.3 feet; height 8.2 feet; main rotor diameter 26.33 feet; empty weight 1,163 pounds; design gross weight 2,400 pounds; useful load 1,537 pounds at overload gross weight of 2,700 pounds; engine Allison T63 250 shaft horsepower.

Performance

Maximum speed 130 knots; cruise speed 125 knots; range 300-plus nautical miles (including reserves); rate of climb 1,550 feet per minute; endurance more than 3.7 hours (including reserves).

MODELS 500, 500U

Prime Contractor: Hughes Tool Company, Aircraft Division

Remarks

The Hughes 500 executive transport (in photo), luxurious commercial version of the U.S. Army OH-6A, carries 5 people and their luggage. It is a helicopter designed to rival fixed-winged aircraft in executive transportation providing faster point-to-point travel up to 450 miles. The 500 features exceptional performance, luxurious appointments and low maintenance requirements. The companion Model 500U provides maximum utility with its 40-cubic-foot cargo compartment. The compartment's position at the center of gravity of the aircraft eliminates balance problems. Extremely versatile, the 500U may carry up to 950 pounds of internal cargo in the aft compartment; total personnel carrying capability is seven including pilot. Speed, performance, low maintenance, exceptional external and internal cargo lifting capabilities enable the 500U to fulfill many roles in the fields of agriculture, forestry, construction, oil exploration and offshore supply.

HH-43B, HH-43F RESCUE/UTILITY HELICOPTER

Prime Contractor: Kaman Aircraft 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 foreign governments around the world, the Huskie has demonstrated an ability to perform in the 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 military aircraft ever in service.

Specifications

HH-43B powered by Lycoming T53-L-1B and HH-43F by T53-L-11A. Two intermeshing, counter-rotating two-bladed rotors, diameter 47 feet; height 12.6 feet; empty weight 4,469 (B model), 4,620 (F model); gross weight: 5,969 (B model), 6,500 (F model); maximum gross weight: 9,150 (both models).

Performance

Maximum speed 120 miles per hour (both models); cruise speed 110 miles per hour (both models); range 277 statute miles (B model), 504 statute miles (F model); rate of climb 2,000 feet per minute (B model), 1,800 feet per minute (F model); hover OGE 18,000 feet (B model), 16,000 feet (F model); service ceiling 25,000 feet (B model), 23,000 feet (F model).

UH-2A/B UTILITY/RESCUE HELICOPTER

Prime Contractor: Kaman Aircraft Corporation

Remarks

This compact high-speed turbine-powered helicopter is in production for the Navy. 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 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, and there are now over 150 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; overload gross weight 10,200 pounds; engine GE T58-8 with 1,250 shaft horsepower; single 4-blade main rotor 44 feet diameter; 3-blade tail rotor 9.3 feet 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.

UH-2C RESCUE/UTILITY HELICOPTER

Prime Contractor: Kaman Aircraft 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 7,440 pounds; gross weight 9,951 pounds; overload gross weight 11,614 pounds; main rotor, single, 4-bladed, 44 feet diameter; tail rotor, 3-bladed, 9.3 feet diameter; engines 2 General Electric T58-8, 1,250 shaft horsepower each.

Performance

Maximum speed 162 miles per hour; cruise speed 152 miles per hour; normal range 466 miles; ferry range 570 miles; rate of climb, sea level, 1,890 feet per minute; hover ceiling, OGE, 15,900 feet; service ceiling 18,300 feet.

LA-4 AMPHIBIAN

Prime Contractor: Lake Aircraft Corporation

Remarks

The Lake LA-4 is an all-metal mid-wing 4-passenger amphibian aircraft. It has retractable tricycle gear and large flaps, both actuated by an engine-driven hydraulic system. This system is backed up for emergency use by a manually-operated hand pump. The aircraft is powered by the Lycoming 180 horsepower 0-360A1A used in pusher configuration, and 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. This high-performance amphibian is enjoying a wide acceptance on the world market, several having been flown to Europe and to Australia.

Specifications

Wing span 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

Speed 132 miles per hour; stall speed 50 miles per hour; take-off run 650 feet (land), 1,125 feet (water); landing roll 475 feet (land), 600 feet (water); rate of climb 800 feet per minute.

LEAR JET MODEL 24

Prime Contractor: Lear Jet Industries, Inc.

Remarks

Certified in March 1966, as a growth version of the original Lear Jet Model 23, the Model 24 meets Air Transport Category requirements under part 25 of Federal Air Regulations. More than 150 Lear Jets in corporate service by the end of 1967 had accumulated some 130,000 hours of flight—equivalent to 65,000,000 miles of travel. Lear Jets, 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; take-off gross weight 13,000 pounds; pressure differential 8.78 pounds per square inch; engines 2 General Electric CJ610-4.

Performance

Maximum speed 553 miles per hour; stall speed normal landing weight 104 miles per hour; maximum range with 45-minute reserve 1,565 statute miles; cruising altitude 41,000 feet; certified service ceiling 45,000 feet; 1 engine service ceiling at midcruise weight 26,000 feet; rate of climb at sea level 6,350 feet per minute; 2 engine take-off over 35-foot obstacle 3,017 feet; 2 engine landing over 50-foot obstacle 3,307 feet.

LEAR JET MODEL 25

Prime Contractor: Lear Jet Industries, Inc.

Remarks

First flown August 12, 1966, the Model 25 measures 4⅓ feet longer than the Model 24. It carries 8 passengers plus crew of 2. Offering essentially the same high performance statistics as the Model 24, the longer Model 25 provides certain advantages in load-carrying ability, cruising altitude, and other criteria.

Specifications

Span 35 feet 7 inches; length 47 feet 7 inches; height 12 feet 7 inches; wing sweepback 13 degrees; take-off gross weight 15,000 pounds; pressure differential 8.94 pounds per square inch; engines 2 General Electric CJ610-6.

Performance

Maximum speed 553 miles per hour; stall speed normal landing weight 107 miles per hour; maximum range with 45-minute reserve 1,670 statute miles; cruising altitude 41,000 feet; certified service ceiling 45,000 feet; 1 engine service ceiling at midcruise weight 27,500 feet; rate of climb at sea level 5,600 feet per minute; 2 engine take-off over 35-foot obstacle 3,700 feet; 2 engine landing over 50-foot obstacle 3,650 feet.

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-7A Corsair II, which 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 more capability and versatility, the A-7 overall design characteristics were derived from the F-8 Crusader series, but optimized for the attack role. The Corsair II can carry more than twice the load of bombs, or the same bomb load more than 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, with 199 production aircraft to be delivered by early 1968. The A model is equipped with the Pratt and Whitney TF30-P-6 engine. The Navy has contracted for production of 196 B models of the Corsair II, with the more powerful TF30 P-8 engine, to be delivered during 1968/1969. An Air Force version, the D model, and the Navy's updated E will be 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, which is expected to offer a 3–1 improvement in effectiveness of close support missions.

Specifications

Wing span 38.7 feet; length 45.4 feet; height 16.2 feet; engine Pratt & Whitney Aircraft TF30 P-6 (A-7A), TF30 P-8 (A7 B & E), Rolls Royce/Allison TF-41 Spey (A-7D).

Performance

Subsonic.

AIR FORCE A-7D CORSAIR II

Prime Contractor: LTV Aerospace Corporation, a subsidiary of Ling-Temco-Vought, Inc.

Remarks

The Air Force will initially procure 4 wings of the A-7D for tactical use beginning in 1968. Described as capable of carrying and effectively delivering all types of non-nuclear munitions, the Corsair II is an updated version of the Navy-developed A-7A Corsair II to be used in tactical multipurpose attack missions. It is designed to achieve a high level of operational reliability with a minimum of maintenance support. Basic difference between the Air Force A-7 and earlier versions is the avionics suit which gives the aircraft a great improvement over other aircraft in terms of day and night visual and all-weather weapon delivery and precise navigation for the attack mission. Weapon delivery will be improved by a ratio of 3 to 1 over most other aircraft in the inventory with the "electronic brain" equipped avionics package. The first Air Force Corsair II was to be test flown in Dallas in February 1968, and to be operational within Tactical Air Command in 1969. The Air Force version includes an arresting hook for emergency landings or aborted take-offs, an inflight refueling probe and folding wing sections, a gas turbine self-starter, the M-61 Vulcan 20 millimeter cannon capable of firing 6,000 rounds a minute, and 8 store stations on the fuselage and wings.

Specifications

Wing span 39.73 feet; length 46.13 feet; height 16.7 feet; engine Allison/Rolls Royce TF-41 Spey.

Performance

Speed subsonic, more than 650 miles per hour; ferry range more than 2,780 miles, inflight refueling capability.

F-8 CRUSADER

Prime Contractor: LTV Aerospace Corporation, a subsidiary of Ling-Temco-Vought, Inc.

Remarks

Eight versions of the famed F-8 Crusader aircraft are in active service with Navy and Marine Corps squadrons. A ninth, the F-8E (FN) fighter, is operational with 2 French Navy squadrons aboard the carriers Clemenceau and Foch. Models A, B, C, D, and E Crusaders are on active duty as well as the RF-8A photo reconnaissance versions and the RF-8G equipped with wing pylons, ventral fins, a new navigation system, and improved camera stations. A TF-8A 2-seat version is also in service. The newest Crusaders are equipped to carry 4 20-millimeter cannon, Zuni and Sidewinder missiles, and 2 2,000-pound bombs. A remanufacturing program to extend the life of the Crusaders through 1975 is in progress at the Vought Aeronautics Division plant in Dallas; and the first aircraft, formerly an F-8D but redesignated F-8H, was delivered to the Navy August 29, 1967. The firm is re-equipping the Crusaders with new wings with pylons for carrying armament, new landing gear, revisions to the radar and fire control systems and other improvements. After refitting, the D will become the H and the E will be changed to the J. Future conversions will include the A, B and C versions and RF-8As for the Navy and Marine Corps.

Specifications

F-8E span 35 feet 2 inches; length 54 feet 6 inches; height 15 feet 9 inches; engine Pratt & Whitney Aircraft J57-P20A. Other versions equipped with P-4, P-12 and P-16.

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 Ryan Aeronautical Company.

Remarks

The world's largest flying V/STOL aircraft, the tri-service XC-142A is now completing operational flight testing at Edwards Air Force Base, California. Two of the tilt-wing assault transports were delivered to Edwards in July and August, 1965, where a 12-man pilot team from the Air Force, Navy and Army began tests which included high altitude, rough terrain and aircraft carrier operations. Three other aircraft were built, 2 being delivered to the armed services in December 1965 and a fifth delivered in August 1966. Designed to operate from landing areas as small as 350-feet square, the XC-142A will carry 32 fully-equipped combat troops or 8,000 pounds of cargo. With its wing tilted straight up, its 4 T64 turbo-prop engines permit it to make vertical take-offs, 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 first full transition flight on January 11, 1965.

Specifications

Wing span 67 feet 7 inches; length 58 feet; height 26 feet; engines 4 General Electric T64-1; propellers, 15.5 foot Hamilton Standard fiberglass.

Performance

Speed zero to 430 miles an hour.

F-104G SUPER STARFIGHTER

Prime Contractor: Lockheed-California Company

Remarks

Lockheed-California Company's F-104 prototype made its initial flight in February 1954. In January of 1958, the multi-mission fighter-interceptor went into service with the USAF. Starfighters are serving with the USAF's Tactical Air Command and the Air Defense Command. The aviation industry's largest international production program has provided more than 2,200 Super Starfighters for the air arms of 14 free world nations—Germany, Canada, Belgium, The Netherlands, Italy, Japan, Norway, Turkey, Greece, Nationalist China, Pakistan, Denmark, Spain and the United States.

Specifications

Span 21 feet 11 inches; length 54 feet 9 inches; height 13 feet 6 inches; gross weight 28,800 pounds; engine General Electric J79 16,000 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 other free world nations. Steady refinements and new additions kept the P-2 modern and up-to-date through seven models. Although the P-2 is gradually being replaced in the Navy by Lockheed's P-3A Orion, it still bears the insignia of seven other nations, including 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 turbo compounds.

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 ASW systems of the future. Orions have also been purchased by New Zealand and Australia.

Specifications

Span 99 feet 8 inches; length 116 feet 10 inches; height 33 feet 9 inches; gross weight 127,200 pounds; engines 4 Allison T56-14 4,591 shaft horsepower each.

Performance

Speed 413 knots; altitude above 30,000 feet.

SR-71 LONG RANGE STRATEGIC RECONNAISSANCE AIRCRAFT

Prime Contractor: Lockheed-California Company

Remarks

The SR-71 is a United States Air Force long-range advanced strategic reconnaissance aircraft capable of flying above 80,000 feet at 3 times the speed of sound—more than 2,000 miles an hour. The SR-71 made its first flight on December 22, 1964. Operational with the Strategic Air Command at Beale AFB, 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 SR-71 is powered by 2 Pratt & Whitney Aircraft J58 turbojet engines, the first engine to be flight qualified at Mach 3 for the U.S. 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

Companion plane to the SR-71, the YF-12A, formerly designated A-11, is an advanced interceptor for use by the Air Force. It is an all-weather fighter and it is equipped with an automatic navigation system. Powered by 2 Pratt & Whitney Aircraft J58 engines, it has a speed capability of more than 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 Corporation and it is equipped with the Hughes AIM-47A air-to-air guided missile. Other details classified.

T-33A JET TRAINER

Prime Contractor: Lockheed-California Company

Specifications

Span 38 feet 10½ inches; length 37 feet 8½ inches; height 11 feet 8⅓ 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 square foot; 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 AND RC-121 EARLY WARNING AIRCRAFT

Prime Contractor: Lockheed-California Company

Remarks

Derivatives of the Lockheed Constellation series, the WV-2 (Navy) and RC-121 (Air Force) are radar-equipped flying sentinels for long distance early warning missions. Carrying six tons of electronic equipment to high altitudes, the planes were designed as aerial sentries, locating sneak raiders at interception points far away from the nation's borders. High fuel capacity and operational economy of the Wright turbo-compound engines give the airplane 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 same span, length 94 feet 4 inches; height 23 feet 9 inches.

Performance

Endurance of 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-blade 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 PT-6B-6 turboshaft produced by United Aircraft of Canada, Ltd.

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-blade aircraft converted from a "pure" XH-51A helicopter in 1964 with the addition of stub wings and an auxiliary jet engine (mounted on left wing) under an Army-sponsored program. In June 1967, the 4-blade XH-51A compound reached 302 miles per hour, world's fastest known rotorcraft speed. The speed was achieved 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 4500 pounds; engines 1 Pratt & Whitney Aircraft PT-6B-6 turboshaft and 1 Pratt & Whitney Aircraft J60-P-2; wing span 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 the National Aeronautics and Space Administration. It 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 five persons. The XH-51N has the Lockheed-developed rigid-rotor system and retractable landing gear.

Specifications

Fuselage length 33 feet; rotor blade diameter 35 feet; weight 4000 pounds; engine 1 Pratt & Whitney Aircraft PT-6B-9 turboshaft produced by United Aircraft of Canada, Ltd.

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 Agency type certificate. It was the first rigid-rotor helicopter to be certificated by the FAA. It has a wide range 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 take-offs from the deck of a moving destroyer at sea. The 4-blade Model 286 has the Lockheed-developed rigid-rotor system and is equipped with retractable landing gear. It has performed aerobatic-type maneuvers—barrel rolls, loops—to demonstrate stability and control made possible by the rigid-rotor system. The Model 286 helicopters—which have toured the continental U.S. and Hawaii and participated in the 1967 Paris Air Show—are being used extensively as rigid-rotor demonstrato s.

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, Ltd.

Performance

Design speed 176 miles per hour; estimated range 225-plus miles.

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, fall-out, 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 AIRCRAFT

Prime Contractor: Lockheed-California Company

Remarks

The AH-56A Cheyenne, advanced aerial fire support system under development for the U.S. Army Aviation Materiel Command, will fly at nearly twice the speed of current combat helicopters. The winged and rotor-bladed AH-56A, designed to replace armed helicopters used by the Army, was rolled out at Lockheed's Van Nuys, California, plant in the spring of 1967. Following extensive flight-testing, the Cheyenne was scheduled for FAA certification in late 1968 and for Army service evaluation in early 1969. Mission of this rigid-rotor compound aircraft is to escort troop-carrying helicopters in air mobile operations and to provide direct fire support in the combat landing zones. The heavily-armed AH-56A could 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; wing span 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; cruising 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 take-off and landing) 2,900 miles; hover ceiling (OGE—out of ground effects) 10,600 feet.

XV-4B HUMMINGBIRD

Prime Contractor: Lockheed-Georgia Company

Remarks

The XV-4B Hummingbird is a vertical take-off and landing (VTOL) mid-wing monoplane, with provisions for a crew of 2 in a side-by-side seating arrangement. Uniquely, this aircraft is a 6-engine direct and diverted thrust V/STOL configuration which resembles most closely a compact, twin-engine jet observation aircraft. Four of the engines are vertically mounted in the fuselage and are used for lift only, while 2 cruise engines are mounted horizontally in the nacelles, providing normal thrust for conventional flight and lift thrust for hover and transitional flight through thrust diversion by means of diverter valves. Vertical flight, hover, transition, and horizontal flight take place in this manner: With the diverter valves positioned to cause the dual-cruise engine exhaust to flow out the bottom of the airplane, accompanying the thrust from the 4 direct-lift engines, the throttles are advanced and the plane rises vertically. Small jets in the wing tips, nose, and tail are used to direct roll, pitch and yaw, deriving their power from a common engine compressor bleed air system. After obtaining the desired height over adjacent obstacles, the transition to forward flight is accomplished by tilting the nose downward to obtain a horizontal thrust component from the lift and diverted cruise engines.

Specifications

Overall length 33 feet 9.4 inches; wing span 27 feet 1 inch; 6 modified General Electric J85 turbojet engines provide a total of 18,000 pounds thrust.

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 575 mile per hour, 4-engine, multi-mission transport, stressing reliability and safety with double and triple backup systems; it is the only 4-engine executive jet, and the only one equipped with thrust reversers. JetStars are in use around the world, flying 5 chiefs of state and other high government officials, as well as the 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. 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 to a cargo-personnel transport with a 3,500-pound combined payload, or to 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 take-off weight 41,900 pounds; engines 4 Pratt & Whitney Aircraft JT 12A-8s, 3,300 pounds thrust each.

Performance

Maximum speed 575 miles per hour; unrefueled range 2,250 statute miles with 8 passengers; certificated altitude 43,000 feet.

C-130E HERCULES TRANSPORT

Prime Contractor: Lockheed-Georgia Company

Remarks

The C-130E is an advanced version of the C-130A and C-130B, embodying various structural and system modifications. Maximum payload has been increased to 45,000 pounds and this weight can be carried over 2,100 nautical miles. Using an overload take-off weight, the payload can be carried over 3,100 nautical miles. The C-130E is designed for the optional use of externally mounted wing fuel tanks. The use of these external tanks gives this model Hercules true trans-ocean capability. More than 435 of the C-130E models are being produced for the Air Force, the Navy, and foreign countries.

Specifications

Wing span 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 take-off weight 175,000 pounds; maximum take-off weight 155,000 pounds; fuel capacity 9,680 gallons; Engines 4 Allison T56-A-7 propjet 4,050 shaft horsepower each.

Performance

Range with maximum payload, approximately 2,100 nautical miles; high speed cruise 315 knots; take-off run at 155,000-pound gross weight 3,800 feet; landing ground run at design weight 2,120 feet; propellers Hamilton Standard 4 blades, 13.5 feet diameter, full reversing capability.

HC-130H/P HERCULES

Prime Contractor: Lockheed-Georgia Company

Remarks

HC-130H and HC-130P Hercules are in world-wide service with the Aerospace Rescue and Recovery Service (ARRS) of the U.S. Air Force's Military Airlift Command. The HC-103H 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 more than 2,000 miles from its base. The helicopter aerial refueling version is the HC-130P. This version 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 in-flight refueling techniques that not only made these flights possible, but also gave these Air Force rescue helicopters world-wide deployment and rescue capabilities. HC-130P has beefed-up outer wing tank areas, additional back-up 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 with a number of other subsystems for their ARRS missions. These include 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 of the craft to 13,280 gallons. Power plants are 4 Allison T56-A-15 propjets. Propellers are Hamilton Standard 54H60-91, 4-bladed, 13½-foot diameter. In photo, HC-130P refuels Sikorsky HH-3E during 1967 transatlantic flight.

EC-130E HERCULES

Prime Contractor: Lockheed-Georgia Company

Remarks

This new version of the military C-130-E Hercules provides the U.S. 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 operated by the Coast Guard. 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 four 7½-foot cube compartments, or modules, which interlock into a single unit to provide work space, lavatory and galley facilities for 12 persons.

Specifications

Wing span 132.6 feet; overall length 97.7 feet; height 38 feet; maximum payload with maximum fuel 35,926 pounds; maximum gross take-off weight 151,522 pounds; fuel capacity 6,960 gallons; power plants 4 Allison T56A-7 propjet engines.

Performance

The EC-130E has a cruising speed of 300 knots true air speed with normal power, at 148,000 pounds gross take-off weight and 20,000-foot altitude, maximum range is 2,800 nautical miles at long-range cruise, with maximum fuel, 35,926 pounds payload, and 4,260 pounds of reserve fuel.

LOCKHEED-382B HERCULES COMMERCIAL AIRFREIGHTER

Prime Contractor: Lockheed-Georgia Company

Remarks

The Lockheed 382B Hercules is a fully certificated commercial airfreighter. It is in airline service in North America, Africa and Asia. Powered by 4 propjet engines, the Lockheed-382B will carry more than 24 tons of payload nonstop over 2,100 statute miles. At maximum landing weight of 130,000 pounds, normal landing distance is 4,760 feet. Fully pressurized and air-conditioned, the Lockheed-382 is an uncompromised airfreighter designed for both on-line schedule cargo service and for the delivery of large outsize cargo into remote construction, mining, or oil drilling sites. The clear-cube cargo compartment is over 40 feet long, 10 feet wide, and 9 feet high.

Specifications

Wing span 132.6 feet; length 97.7 feet; height 38 feet; cargo floor above ground 3.4 feet; maximum payload over 48,000 pounds; engines 4 Allison 501-D22 turboprop, 4,050 shaft horsepower each; maximum take-off weight 155,000 pounds; maximum landing weight 130,000 pounds; normal crew 3; clear cube volume 4,300 cubic feet; bulk loaded volume 5,000 cubic feet.

Performance

Range with maximum payload 1,850 nautical miles; range with 30,000 pounds payload 3,250 nautical miles; high speed cruise 300 knots.

LOCKHEED-100 HERCULES COMMERCIAL AIRFREIGHTER

Prime Contractor: Lockheed-Georgia Company

Remarks

Lockheed-100s are in service with Delta Air Lines, Alaska Airlines and Airlift International. The Hercules, a propjet commercial air freighter, is capable of revenue payloads up to 45,747 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 with the ramp 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.

Specifications

Length 97.7 feet; height 38 feet; wing span 132.6 feet; maximum take-off weight 155,000 pounds; maximum net payload 45,747 pounds; crew 3; 4 Allison 501-D22 turboprop engines, driving 4-blade Hamilton Standard hydromatic propellers; fuel 50,926 pounds.

Performance

Maximum cruise speed 300 knots; range with maximum payload 1,920 nautical miles; take-off 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.

C-141A 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 will 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 will transport the Minuteman missile, or it will transport 154 troops or 123 paratroopers or 80 litters with 16 ambulatory patients and/or attendants. The StarLifter began squadron duty in 1965, and received its FAA certificate as a commercial freighter in January 1965. It 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 is the first jet to land in the Antarctic.

Specifications

Wing span 159.9 feet; length 145.0 feet; height 39.3 feet; wing sweepback 25 degrees; take-off 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, or sea level cabin up to 21,000 feet.

LOCKHEED-200 COMMERCIAL STARLIFTER

Prime Contractor: Lockheed-Georgia Company

Remarks

The Lockheed Commercial StarLifter, being discussed with airlines of the world, has shown its ability to deliver massive, awkward-to-handle cargo to far-away destinations at fast speeds. In demonstrations for airlines, it has transported a large turbine from Amsterdam to Iran; 2 F-104 jet fighters nonstop from Bonn to Burbank, California; 2 helicopters from Ft. Worth, Texas, to Munich, and huge sections of the Europa rocket from Germany and France to Australia. The Lockheed-200 has a payload of 90,926 pounds, including the loading equipment.

Specifications

Wing span 159.9 feet; length 145.0 feet; height 39.3 feet; wing sweep 25 degrees; take-off weight 323,600 pounds; engines 4 Pratt & Whitney Aircraft JT3D-8A fanjets of 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 7,040 miles; maximum payload range 3,660 miles; cargo compartment and flight station pressurized for cabin altitude of 8,000 feet at 40,000 feet, or sea level up to 21,000 feet.

C-5A GALAXY CARGO/PERSONNEL CARRIER

Prime Contractor: Lockheed-Georgia Company

Remarks

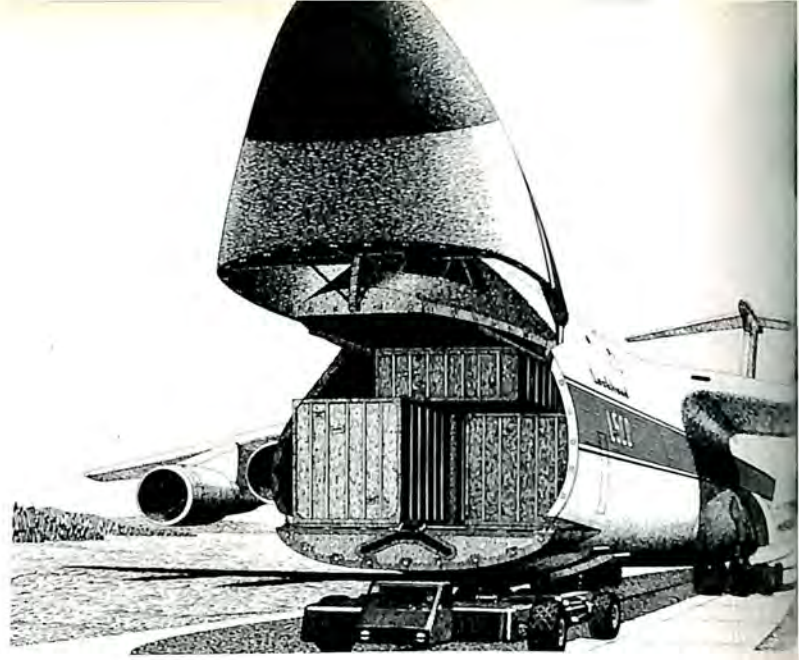
Primary mission of the C-5A Galaxy, which will be the world's largest aircraft, is to provide a significant increase in the Military Airlift Command's ability to airlift all types of combat and support forces. Basic requirements are for very high payload and cargo volume, intercontinental range, support area airfield operations, and air-dropping of troops and equipment. Double-deck design provides cargo compartment 121 feet long between ramps, 19 feet wide, and 13½ feet high. Flight or relief crews, and support personnel for vehicles carried below, ride on upper deck. Prototype roll-out was due in February 1968; first flight in June 1968. Operational deliveries will begin in 1969.

Specifications

Wing span 222.7 feet; length 245.9 feet; height 64.7 feet; wing sweep 25 degrees; gross take-off weight (2.5 g) 728,000 pounds; engines 4 General Electric TF-39 turbofans of 41,000 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.



LOCKHEED-100-20 HERCULES COMMERCIAL AIRFREIGHTER

Prime Contractor: Lockheed-Georgia Company

Remarks

The Lockheed-100-20 Hercules is a "stretched" version of the commercial Hercules now in service with 6 airlines. Lockheed is adding 2 barrel sections to the cargo compartment—one 5 feet long forward of the wing, and the other 3 feet 4 inches aft of the wing. This increases the length of the cargo section by 100 inches. A new engine, the Allison 501-D22A, is expected to increase initial time between overhaul to 4,000 hours and to reduce maintenance and overhaul costs by 30 percent. Cruise speed at 20,000 feet altitude will be 15 miles an hour faster than the present Hercules commercial freighters. The new version airfreighter will reduce direct operating costs 2.3 percent per airplane mile, and 18.6 percent per cube ton mile. The new commercial Hercules was expected to be available in July 1968. A retrofit program is being established whereby commercial Hercules now in airline service can be converted to the longer, faster model.

Specifications

Wing span 132.6 feet; overall length 106 feet; maximum payload 48,500 pounds (with airplane carrying a greater volume of lighter weight freight).

Performance

Take-off distance shortened by 500 feet; hot-day second segment climb limit improved by 11 percent; initial cruise ceiling increased by 2,500 feet; payload cube capacity increased by 698 cubic feet in Lockheed-100-20; increased by 800 cubic feet to 5,300 cubic feet in Lockheed-382B version when stretched.

LOCKHEED 500-114M GALAXY

Prime Contractor: Lockheed-Georgia Company

Remarks

A civil derivation of the USAF C-5A Galaxy, the Lockheed 500-114M has main cargo compartment 13.5 feet high, 19 feet wide, 143 feet long; 2 upper deck compartments 7.8 feet high, totaling 92 feet in length. The main compartment takes 2 rows of containers or pallets on floor, plus one row of containers suspended from ceiling-mounted rails. Alternately, it 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 284,320 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.

Specifications

Wing span 222.7 feet; length 246 feet; height 65.1 feet; gross take-off weight 814,000 pounds; wing sweep at ¼ chord 25 degrees; engines 4 Pratt & Whitney Aircraft turbofans 44,000 pounds thrust; 4-wheel nose landing gear; 4 independent 4-wheel bogie main landing gear.

Performance

Maximum cruise speed 484 knots; long-range cruise speed 440 knots; range with 282,500 pounds of cargo 2,800 nautical miles; direct operating cost at 2,800 nautical miles, maximum cargo, 2.27 cents per ton mile.

MARTIN 4-0-4 AIRLINER

Prime Contractor: Martin Marietta Corporation, Baltimore Divisions

Remarks

The 4-0-4 is an improved version of the earlier Martin 2-0-2. It has a crew of three and carries 40 passengers. Tricycle landing gear and 32-foot-wide, retractable passenger steps facilitate ground operations. One hundred and three 4-0-4s were built between 1951 and 1952.

Specifications

Length 74 feet 7 inches; height 28 feet 5⅜ inches; span 93 feet 3⅜ inches; fuel capacity 1,350 gallons; weight at take-off 44,900 pounds (maximum), landing 43,000 pounds, operating empty 30,701 pounds, design useful load 15,774 pounds; engines 2 Pratt and Whitney Aircraft R-2800 CB16.

Performance

Range 925 miles with 40 passengers and baggage plus 1,000 pounds cargo (total of 8,800 pounds); 2,525 miles maximum engineering range with full fuel, 10,000 feet altitude and 5,694 pound payload; 312 mile per hour level flight high speed at 14,500 feet; 280 mile per hour cruising speed at 18,000 feet; 1,250 feet per minute maximum rate of climb at sea level, maximum take-off gross weight; 29,000 feet service ceiling with engines at normal rated power and 40,000 pounds gross weight.

SP-5B MARLIN PATROL SEAPLANE

Prime Contractor: Martin Marietta Corporation, Baltimore Divisions

Remarks

SP-5B was designed for a crew of eight for anti-submarine warfare missions. The low bow chine (lower than on the P5M-1) permits higher gross take-off weights and lessens the possibility of spray damage to surfaces and propellers, while the long hull afterbody provides increased control during rough-water landings and take-offs. The high T-shaped tail reduces structural weight and aerodynamic drag and eliminates spray damage to horizontal tail surfaces. Hydroflaps on both sides of the hull afterbody act as a brake when opened together, or as a rudder when operated separately. First flight August 1953 and first delivery June 23, 1954. Martin delivered 117 aircraft to the Navy between 1953 and 1960.

Specifications

Length 101.8 feet; overall height 33 feet; hull width 10 feet; span 118 feet; gross weight 76,635; powered by 2 Wright R-3350-32WA engines.

Performance

Range 1,790 nautical miles; maximum speed 250 miles per hour.

B-57 BOMBER

Prime Contractor: Martin Marietta Corporation, Baltimore Divisions

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 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 and the "E" model is a tow-target version. Martin built 403 planes between 1953 and 1959.

Specifications

Span 64 feet (RB-57D span 82 feet); length 65.5 feet; height 15 feet; gross take-off weight 50,000 pounds; tricycle gear; powered by 2 Curtiss-Wright J65 jet engines, each with 7,200 pounds thrust; tactical versions have rotary bomb doors, pylon weapons mounts under the wings and four 20 millimeter cannons or eight .50 calibre machine guns fire from the leading edges of the wings.

Performance

Speed over 600 miles per hour; range more than 2,000 miles; service ceiling over 45,000 feet.

F-4C PHANTOM FIGHTER-BOMBER

Prime Contractor: McDonnell Douglas Corporation

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 semi-submerged under the fuselage; 2 additional Sparrow IIIs or 4 infrared-guided Sidewinders may be carried on wing stations. More than 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 made on May 27, 1963, less than 14 months after McDonnell received contractual go-ahead from the USAF. The first 2 aircraft were delivered on November 20, 1963, and the last of 583 F-4Cs was delivered on May 4, 1966. The F-4D Phantom has augmented the F-4C in the USAF inventory.

Specifications

Length 58 feet; span 38½ feet; wing sweepback 45 degrees; engines 2 GE J79-15 engines, 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

Remarks

The F-4B Phantom is a two-place, twin-jet all-weather fighter built for the U.S. Navy and Marine Corps. The Phantom has the greatest firepower of any Navy fighter. The crew consists of a pilot and a radar intercept officer. The plane is equipped with detection and tracking systems which make it capable of destroying 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 38½ feet; wing sweepback 45 degrees; horizontal stabilizer slopes downward at 23 degrees; boundary layer control; engines 2 GE 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 FIGHTER

Prime Contractor: McDonnell Douglas Corporation

Remarks

The RF-4B is a tactical all-weather multi-sensor 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. The basic changes in the RF-4B from the RF-4C reconnaissance version are: (1) the RF-4B is carrier-suitable, including the smaller wheels used on the Navy version; (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 two camera stations. Cameras in the Air Force version can only be repositioned on the ground. The RF-4B has no armament capability.

Specifications

Length 63 feet; span 38½ feet; wing sweepback 45 degrees; engines 2 J79-GE 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

Remarks

The RF-4C Phantom is a high-performance fighter-type aircraft with an effective, tactical all-weather multi-sensor reconnaissance capability. The Air Force RF-4C incorporates optical, infra-red and electronic sensors necessary to perform 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 in-flight film process and film ejection from the low altitude panoramic camera station. By adding an HF communications transceiver to the electronics 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 infra-red reconnaissance system (IRRS), and an inerted navigation set.

Specifications

Length 63 feet; span 38½ feet; retains air-to-ground nuclear attack capability of other Phantom versions; no conventional weapons; engines 2 GE J79-15 engines. Basically same aircraft as F-4C in service with Air Force. Main difference lies in nose section which contains the 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

Remarks

The Air Force's newest, fastest and highest-flying fighter bomber, the F-4D 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 to deliver 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 took place 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-Robbins AFB, Georgia, later flown to Bitburg, Germany as the forerunner of several squadrons of F-4Ds that are replacing F-105 aircraft stationed there.

F-4E PHANTOM AIR SUPERIORITY FIGHTER

Prime Contractor: McDonnell Douglas Corporation

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-engined, 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 multi-barrel cannon, based on the Gatling-gun concept, is capable of firing shells at a rate of 100 rounds a minute.

F-4J PHANTOM

Prime Contractor: McDonnell Douglas Corporation

Remarks

An advanced version of the Phantom II series, the F-4J was the 6th model to reach production status. It made its first public flight on May 27, 1966, the 8th anniversary of the initial flight of the first airplane of the Phantom II series. Being delivered to both the Navy and the Marine Corps, the F-4J has a higher maximum speed, greater range, higher combat ceiling, shorter take-off distance, lower approach speeds and better air-to-air and air-to-ground combat capabilities than any predecessor Phantom model. Major improvements include a new radar system, a new bombing system, new electronics systems, improved control surfaces and new engines. The 2 General Electric J79-10 engines each produce 17,900 pounds thrust at take-off, 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 earlier B and C models.

F-4K PHANTOM

Prime Contractor: McDonnell Douglas Corporation

Remarks

The F-4K, which made its initial flight on June 28, 1966, is the 8th 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's 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 J79s 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.

F-4M PHANTOM AIR SUPERIORITY FIGHTER

Prime Contractor: McDonnell Douglas Corporation

Remarks

The McDonnell Douglas F-4M Phantom for the 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. Some of the major differences in the F-4M are the use of Rolls-Royce Spey engines, an improved navigation/attack system, a strike camera and an advanced AWG-12 missile control system. In addition, the F-4M has either reconnaissance controls or dual controls in the rear seat, an innovation from U.S. Phantom models. The dual controls permit the F-4M Phantoms 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 version powering the F-4M is the MK-201 equipped with reheat and Plessey gas turbine starter. The 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 take-offs 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, a function of which is to prepare and launch the radar-guided Sparrow III or infrared heat seeking Sidewinder missiles for air-to-air attack. The F-4M is also equipped with the AJ-168 Martel, a new generation air-to-ground precision strike missile.

F-101B VOODOO INTERCEPTOR

Prime Contractor: McDonnell Douglas Corporation

Remarks

The F-101B has the greatest combination of speed and long range of any 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 two-place interceptor; the second crewman is a radar operator. The F-101B operates under all-weather conditions to execute two primary missions: the identification of unknown aircraft and then destruction if they are hostile. There are 15 squadrons of the F-101B Voodoo currently in service with the Air Defense Command and three squadrons now in the inventory of the Royal Canadian Air Force.

Specifications

Length 67½ feet; span 40 feet; height 18 feet; wing and stabilizer swept back at angle of 35 degrees; engines 2 Pratt and Whitney Aircraft J-57.

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

Remarks

The 188E is designed to carry an eight-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 is provided through cross-shaft interconnection of the four engines. The 188E can make steep turns and gear-down landing approaches at airspeeds as low as 50 knots. The Breguet-designed aircraft will be built to U.S. military standards by McDonnell with U.S. tooling; material and equipment with the technical assistance of Breguet.

Specifications

Length 77 feet; span 77 feet; height 31 feet; gross weight 58,400 pounds; payload for 575-mile radius missions 8 tons; troop capacity 55.

Performance

Cruise speed 250 knots; ferry range 3,500-plus miles.

RANGER

Prime Contractor: Mooney Aircraft, Inc.

Remarks

The 4-place retractable gear Ranger features positive control for "wings level" flight attitude. Its 4-cylinder, 180 horsepower engine uses 91/98 octane fuel. The fuel is contained in two 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 or manual gear retraction system is available.

Specifications

Span 35 feet; length 23 feet 2 inches; height 8 feet 4½ 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 ¾ inches; engine 1 Lycoming 0-360-180 horsepower; propeller 74 inches constant speed; fuel capacity 52 gallons.

Performance

Maximum level speed 179 miles per hour; maximum cruising speed at 75 percent power 172 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.

STATESMAN

Prime Contractor: Mooney Aircraft, Inc.

Remarks

The Mooney Statesman offers the economy of a 180 horsepower engine combined with the stretch-out comfort of the Mooney Executive 21. The Statesman, new in 1968, has a restyled instrument panel, improved instrument and interior lighting and an easy operating manual gear retraction system. The new Statesman has all the basic features of the Mooney line such as Positive Control flight stability system, wrap-around wing skins and integral fuel tanks.

MUSTANG

Prime Contractor: Mooney Aircraft, Inc.

Remarks

The Mustang is an advanced single engine business aircraft with pressurized cabin seating 4–5. 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 Mustang will fly above virtually any en route weather. The 310 horsepower engine is turbocharged. The Mustang will fly at speeds up to 250 miles per hour.

Specifications

Span 35 feet; length 26 feet 11 inches; height 9 feet 11 inches; gross weight 3,680 pounds; useful load 1,300 pounds; engine 1 Lycoming T10-541-AIA; usable fuel 92 gallons.

Performance

Maximum level speed 253 miles per hour; maximum recommended cruise 230 miles per hour; stall speed 69 miles per hour; gross weight rate of climb at sea level 1,120 feet per minute; take-off 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: (U.S., Mexico & Canada) Mooney Aircraft, Inc.

Remarks

The Mooney MU-2 is a new 7-place, twin turboprop, executive transport featuring exceptionally high speeds with good short-field capabilities at a practical investment and operating cost. It can cruise at 310 mph and has a 26,500 feet ceiling. Passengers enjoy air conditioned and pressurized comfort. Its two 605 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 level speed 325 miles per hour; maximum cruising speed at 10,000 feet 310 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, Inc.

Remarks

The Mooney Executive 21 combines all the high performance features of the Mark 21 and Super 21 with a longer fuselage allowing more leg room for both front and back seat passengers. It has individually reclining seats and a longer range. The Executive 21 features a one-piece windshield, 3 windows on each side, and a full-length rudder. It has modified wing tips which reduce aileron pressures to provide easier control response.

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 125 pounds; wing loading 15.4 pounds per square foot; power loading 12.9 pounds per horsepower; wing area 167 square feet; tread 9 feet ¾ inch; engine 1 Lycoming IO-360-200 horsepower; propeller 74-inch constant-speed; fuel capacity 64 gallons.

Performance

Maximum level speed 184 miles per hour; maximum cruise speed at 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 minutes reserve; service ceiling 17,900 feet.

MASTER

Prime Contractor: Mooney Aircraft, Inc.

Remarks

The Mooney Master is a 4-place fixed gear aircraft engineered for conversion to retractable gear. It was designed as a practical solution to the need for an airplane which can bridge the gap between the training period requirements of the beginning pilot and those of the pilot who needs the high performance of retractable gear. It is powered with a 4-cylinder, 180 horsepower engine and is available with either a fixed-pitch or constant-speed propeller.

Specifications

Span 35 feet; length 23 feet 2 inches; height 8 feet 4½ inches, gross weight 2,500 pounds, empty weight 1,475 pounds; useful load 1,025 pounds; baggage 120 pounds; wing loading 15.4 pounds per square foot; power loading 14.3 pounds per horsepower; wing area 167 square feet; engine 1 Lycoming 0-360-180 horsepower; fuel capacity 52 gallons.

Performance

Maximum level speed 146 miles per hour at sea level; cruise speed at 75 percent power, 138 miles per hour at 10,000 feet; stall speed 57 miles per hour; rate of climb 740 feet per minute; maximum range 750 miles; service ceiling 13,600 feet.

XB-70A RESEARCH AIRCRAFT

Prime Contractor: Aerospace & Systems Group, North American Rockwell Corporation
Associate Contractor: General Electric Corporation

Remarks

The XB-70A is a high-speed, high altitude 6-jet aircraft currently being flown in research programs at Edwards AFB, California, under NASA management. Originally conceived as an intercontinental bomber, its development began in 1956 following a two-company study competition. In 1963, the decision was made to produce only two 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 goals of Mach 3 (2,000 mph) 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 mid-air collision with one of its chase planes. The 2 XB-70 airplanes have accumulated 112 flights totaling more than 217 hours. Its design features include a canard on the forward fuselage, wing tips that fold downward during high speed flight to increase directional stability, and use of the "compression lift" principle which enables the aircraft to "ride" its own shock waves at high Mach numbers.

Specifications

Span 105 feet; length 185 feet; height 30 feet; weight over 500,000 pounds; engines 6 General Electric YJ-93 in 30,000-pound thrust class; crew pilot and co-pilot.

Performance

Speed 2,000 miles per hour; altitude, over 70,000 feet.

T-39 SABRELINER

Prime Contractor: 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 made in October 1960. Three models were manufactured for military use: the T-39A, with a basic configuration for 4 passengers and crew of 2, and 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 9 passengers and a crew of 2 and the "stretched" Series 60, which carries up to 10 passengers and crew of 2. Both models are equipped with the more powerful Pratt and Whitney Aircraft JT12A-8 engine which develops 3300 pounds of thrust. In photo, Series 60 left, Series 40 right.

Specifications

Span 44.5 feet; length 44 feet; height 16 feet; maximum gross take-off weight 18,650 pounds; capacity 7 passengers, 2 crew (business version); engines 2 Pratt & Whitney Aircraft JT 12A-6A turbojets 3,000 pounds thrust each (military version Pratt & Whitney Aircraft J60-P-3A).

Performance

Speed 560 miles per hour plus; range 2,005 miles; altitude 40,000 feet, certified to 45,000 feet (business version).

X-15 RESEARCH AIRCRAFT

Prime Contractor: Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The X-15 is a special purpose research airplane whose initial development was funded jointly by the Air Force, 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 has made a great many contributions to research, particularly in the hypersonic area, and it has attained speeds of over Mach 6 and altitudes above 350,000 feet. Currently the No. 1 plane is exploring atmospheric density and collecting micrometeorites and is used for a study of the solar spectrum. It is scheduled to continue operations into early 1968. No. 2 aircraft is employed in a program of ultraviolet photography of stars at very high altitudes. Later, it will be modified as a ramjet test bed and will be used in a new program to explore the still untouched flight regime of Mach 6–8. Under current schedules it will continue operations into 1969. No. 3 will be used in experiments with supersonic deceleration devices, energy management studies and horizon definition, with operations extending into mid-1968. Vehicle No. 2 has been fitted with twin droppable external fuel tanks and an ablative coating, both of which are needed to achieve a speed approaching Mach 8.

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 counter-insurgency and limited war operations. It is intended for use by the 3 military services, allied foreign countries and the Military Assistance Program. Its mission capabilities include: observation and reconnaissance, helicopter escort, limited ground attack, gunfire spotting, liaison, transport and training. The LARA can operate from rough clearings, waterways and primitive roads, as well as prepared airfields and small carriers. The OV-10A 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 LW3-B escape system, allowing for 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 a fuselage sponson which contains four fixed 7.62 millimeter machine guns.

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 265 knots; range 1,200 nautical miles; service ceiling 28,000.

RA-5C ATTACK/TACTICAL RECONNAISSANCE VEHICLE

Prime Contractor: Columbus Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The RA-5C is an all-weather, carrier-based reconnaissance aircraft, capable of delivering both conventional and nuclear weapons at high or low altitudes. It is the third model in the Vigilante series, and has a top speed in the Mach 2 range. The RA-5C incorporates design features which give it a greater fuel capacity and improved slow-flight and lateral control characteristics. Stores are carried internally in a linear bomb bay and delivery is by rearward ejection out the tail section. The pilot and reconnaissance/attack navigator occupy tandem cockpits. The Vigilante carries the latest reconnaissance equipment, including frame and panoramic cameras, side-looking radar and passive electronic countermeasures devices, in a detachable fuselage pod. The aircraft and its equipment comprise one half of the Navy's Integrated Operational Intelligence System, which is on most attack carriers.

Specifications

Span 53 feet; length 75 feet; height 20 feet; wing, tail, nose hinged for folding aboard carriers; normal take-off gross weight 65,600 pounds; landing weight 50,000 pounds; engines 2 General Electric J79-8 turbojets, 10,900 pounds thrust each, 17,000 pounds with afterburner; tricycle landing gear.

Performance

Speed Mach 2-plus; range 2,000-plus nautical miles.

T-2A BASIC JET TRAINER

Prime Contractor: Columbus Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The T-2A Buckeye is the standard basic jet trainer of the Navy, 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, which is effective throughout the trainer's flight envelope.

Specifications

Span 36 feet; length 38 feet 8 inches; height 14 feet 9 inches; gross weight 6,893 pounds; engine Westinghouse J34D 3,400 pounds thrust; tricycle landing gear.

Performance

Speed 426 knots; range 790 nautical miles; service ceiling 40,000-plus feet.

T-2B BASIC JET TRAINER

Prime Contractor: Columbus Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

An improved version of the T-2A, the T-2B Buckeye entered production in 1965. It will be 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 two-engine configuration provides the Buckeye with performance and safety characteristics superior to the T-2A. Waist-level engine compartments and equipment bays afford ease of access for ground maintenance and servicing. Fuel is carried in the fuselage, inboard wing leading edges and 100-gallon tanks on each wing tip. Under-wing stores stations permit the attachment of various installations for gunnery practice, bombing or target sleeve towing. The Buckeye's tandem cockpits are equipped with North American-designed rocket escape systems.

Specifications

Span 37 feet 10 inches; length 38 feet 3 inches; height 14 feet 9 inches; take-off gross weight 13,284 pounds; engines 2 Pratt & Whitney Aircraft J60 turbojets 3,000 pounds thrust each; tricycle landing gear.

Performance

Speed 460 knots; range 965 nautical miles; service ceiling 42,000 feet.

F-100 SUPER SABRE

Prime Contractor: Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The F-100 Super Sabre was the first supersonic fighter in the U.S. Air Force Tactical Air Command. The first production model, the F-100A was delivered in October 1953. It was produced in four 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 in-flight 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 a long range nuclear striking power and supersonic air-to-air combat ability. In addition to its bomb armament and four 20 millimeter cannon, 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 pounds thrust class; crew, pilot, except F model, pilot and observer or student.

Performance

Speed more than 800 miles per hour; range more than 1,000 miles; altitude more than 50,000 feet.

AERO COMMANDER-100

Prime Contractor: Commercial Products Group, North American Rockwell Corporation

Remarks

The Aero Commander-100 is a four-place, all metal, high wing tricycle geared monoplane equipped with a Lycoming 0-320-A 150 horsepower engine and a Sensenich M74DM-60V metal propeller. The aircraft has a 44-gallon fuel capacity. The Commander-100 is certified under Civil Air Regulations Part 3 for normal category aircraft.

Specifications

Span 35 feet; length 22 feet 6 inches; height 9 feet 4 inches; empty weight 1,280 pounds; useful weight 970 pounds; gross weight 2,250 pounds; wing loading 12.2 pounds per square foot; power loading 14.7 pounds per horsepower.

Performance

Take-off distance 750 feet; landing distance 390 feet; rate of climb 850 feet per minute; maximum speed 142 miles per hour; cruise speed 128 miles per hour; absolute range 650 statute miles; service ceiling 13,000 feet.

AERO COMMANDER-200

Prime Contractor: Commercial Products Group, North American Rockwell Corporation

Remarks

The Aero Commander-200 is a four-passenger monoplane, all metal, low wing cantilever design with a retractable tricycle landing gear. The aircraft is equipped with a 6-cylinder opposed 10-520-A, 285 horsepower Continental engine and a McCauley constant speed metal propeller. The Commander-200 has an 80-gallon fuel capacity including auxiliary fuel of 40 gallons in outer wing panel tanks.

Specifications

Span 30 feet 6 inches; length 24 feet 4 inches; height 7 feet 4 inches; empty weight 1,940 pounds; useful weight 1,060 pounds; gross weight 3,000 pounds; baggage capacity 200 pounds; wing loading 18.75 pounds per square foot; power loading 10.5 pounds horsepower.

Performance

Take-off distance over 50-foot obstacle 1,200 feet; landing distance over 50-foot obstacle 1,150 feet; rate of climb 1,450 feet per minute; optimum cruise speed 218 miles per hour; range 1,380 statute miles; landing speed 54 miles per hour (full flaps); service ceiling 18,500 feet.

JET COMMANDER

Prime Contractor: Commercial Products Group, North American Rockwell Corporation

Remarks

The Jet Commander is an executive jet capable of carrying 8 passengers and 735 pounds of baggage on a trip of 1,585 miles at speeds above 500 miles per hour.

Specifications

Wing span 43 feet 3.7 inches; length 50 feet 11 inches; height 15 feet 10 inches; empty weight 9,155 pounds; gross weight 16,800 pounds; wing loading 55.39 pounds square feet; power loading 2.9 pounds per pound of thrust; engines two GE CJ-610-1 rated at 2,850 pounds thrust at sea level; fuel capacity (JP-4) 926 gallons; cabin capacity 6–8; cabin pressure at sea level up to 20,000 feet, 7,000 feet at 30,000 feet; certified to operate to 45,000 feet with 9.0 pounds per square inch; at 45,000 feet cabin altitude is 8,000 feet. Useful load 7,240 pounds.

Performance

Maximum speed 568 miles per hour at 35,000 feet; cruise speed 503 miles per hour at 35,000 feet; approach speed at 14,000 pounds, 100 knots; rate of climb 5,000 feet per minute; operational ceiling 45,000 feet; range with 45 minute reserve 1,585 statute miles.

GRAND COMMANDER

Prime Contractor: Commercial Products Group, North American Rockwell Corporation

Specifications

Span 49 feet 6 inches; length 41 feet 3.25 inches; height 14 feet 9 inches; tread 12 feet 11 inches; maximum take-off weight 8,500 pounds; empty weight 5,200 pounds; useful load 3,300 pounds; maximum fuel capacity 223 gallons (285 with auxiliary tank).

Performance

Cruise speed, 70 percent power at 10,000 feet, 244 miles per hour; take-off distance over 50-foot obstacle 1,560 feet; landing distance over 50-foot obstacle 1,360 feet; cruising range with 45 minute fuel reserve 1,565 statute miles; service ceiling 26,500 feet.

Note: The airplane is also available as the Pressurized Grand Commander which has identical specifications and performance with these exceptions: Empty weight 5,700 pounds; useful load 2,800 pounds.

TURBO II COMMANDER

Prime Contractor: Commercial Products Group, North American Rockwell Corporation

Remarks

The Turbo II Commander is a propjet aircraft with all-weather capability that can carry up to 10 occupants.

Specifications

Span 44 feet; length 43 feet 2 inches; height 14 feet 6 inches; tread 12 feet 11 inches; maximum take-off weight 9,400 pounds; empty weight (with std. equipment) 5,783 pounds; useful load 3,667 pounds; maximum fuel capacity 287 gallons; engines 2 Garrett-AiResearch TPE 331-43 with take-off power of 575 shaft horsepower at sea level, fully reversible propellers.

Performance

Cruise speed at 10,000 feet, 280 miles per hour; take-off distance over 50-foot obstacle 1,975 feet; landing over 50-foot obstacle 1,200 feet (w/reverse); range 1,050 statute miles; service ceiling 25,000 feet.

AERO COMMANDER 500U

Prime Contractor: Commercial Products Group, North American Rockwell Corporation

Specifications

Span 49 feet 6 inches; length 35 feet 1¼ inches; height 14 feet 9½ inches; tread 12 feet 11 inches; take-off weight 6,750 pounds; empty weight 4,350 pounds; useful load 2,400 pounds; fuel capacity 156 gallons; engines 2 Lycoming IO-540 290 horsepower each.

Performance

Cruise speed 70 percent power, 10,000 feet, 218 miles per hour; take-off distance over 50-foot obstacle 1,375 feet; landing distance over 50-foot obstacle 1,235 feet; range with 45-minute reserve 1,305 statute miles; service ceiling 21,000 feet.

AG COMMANDER S2D

Prime Contractor: Commercial Products Group, North American Rockwell Corporation

Remarks

The Ag Commander is a highly maneuverable agricultural duster/sprayer with exceptional visibility and safety features. A monoplane with a full cantilever low wing, it is of all-metal construction with the exception of fabric empennage skin surfaces. The cockpit is stressed to over 40 g's and is completely sealed against chemical entry.

Specifications

Span 44 feet 6 inches; length 28 feet 4 inches; height 8 feet 10 inches; tread 8 feet 4 inches; take-off weight 6,000 pounds; empty weight 3,400 pounds; useful load 2,600 pounds; fuel capacity 109 gallons; hopper capacity 300 gallons; engine 1 Pratt & Whitney Aircraft R-1340AN-1 rated at 600 horsepower.

Performance

Cruise speed 140 miles per hour; stall speed (normal) 57 miles per hour; stall speed at gross weight 70 miles per hour; take-off distance 850 feet; landing distance 500 feet; service ceiling 15,000 feet; range with 45-minute reserve at 50 percent power 470 statute miles.

AG COMMANDER A-9, A-9 SUPER

Prime Contractor: Commercial Products Group, North American Rockwell Corporation

Remarks

The Ag Commander A-9 and the Ag Commander A-9 Super are popular aerial application aircraft. With identical airframes, the Ag Commander A-9 and the Ag Commander A-9 Super differ in power and performance.

Specifications

Span 35 feet; length 24 feet; height 8 feet; tread 6 feet 10 inches; gross weight 3,000 pounds; empty weight 1,600 pounds; fuel capacity 40 gallons; hopper capacity (A-9) 170 gallons or 1,400 pounds, (A-9 Super) 210 gallons or 1,600 pounds; engine (A-9) 1 Lycoming 0540-B2B5 rated at 235 horsepower, (A-9 Super) 1 Lycoming 10540-G1C5 rated at 290 horsepower.

Performance

Cruise range (A-9) at 75 percent power 300 statute miles, (A-9 Super) at 50 percent power 300 statute miles; cruise speed at 75 percent power (A-9) 105 miles per hour, (A-9 Super) 115 miles per hour; stall speed at gross weight 48 miles per hour; stall speed usually landed 40 miles per hour; take-off distance at gross (A-9) 600 feet, (A-9 Super) 1,000 feet; landing distance (A-9) 447 feet, (A-9 Super) 800 feet.

AG COMMANDER B1A

Prime Contractor: Commercial Products Group, North American Rockwell Corporation

Remarks

The Ag Commander B1A is a high-performance, highly maneuverable agricultural sprayer/duster aerial application aircraft with removable side-panels and a corrosion-proofed airframe structure. Its fuel tanks located in the wings, the Ag Commander B1A has an all-fiberglas hopper with a toploading door and comes equipped with landing gear and windshield wirecutters as well as a wire deflection cable as part of its wide list of standard features.

Specifications

Span 44 feet; length 30 feet; height 10 feet; tread 9 feet 3 inches; gross weight 4,500 pounds; empty weight 2,700 pounds; fuel capacity 80 gallons; hopper capacity 300 gallons or 2,400 pounds; engine 1 Pratt & Whitney Aircraft 1R-985 rated at 450 horsepower.

Performance

Cruise range at 75 percent power 350 statute miles; cruise speed at 75 percent power 115 miles per hour; working speed 90–100 miles per hour; stall speed at gross weight 61 miles per hour; stall speed as usually landed 45 miles per hour; take-off distance 600 feet; landing distance 400 feet; service ceiling 18,000 feet.

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. By September 1967, 11 Free World nations had received quantities of F-5s, with three other nations programmed to receive the aircraft. Single seat F-5A fighters and twin cockpit F-5B models are produced. Utilizing the same basic design, the F-5B combines the combat capability of the F-5A with training capability. The aircraft is intended for close support of troops, interception, attacks on communications and supply lines and armed reconnaissance missions over enemy territory. It is produced by Northrop's Norair Division.

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 lead 6,200 pounds of air-to-air and air-to-ground weapons, reconnaissance and surveillance equipment and extra fuel; engines 2 General Electric J85-13 turbojets 4,080 pounds thrust each. (GE J85-15 engines with 4,300 pounds thrust each will be used in the Canadian and Dutch versions).

Performance

Speed Mach 1.4-plus; combat ceiling more than 50,000 feet; sea-level rate of climb more than 29,000 feet per minute; range more than 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

A supersonic jet trainer, the T-38 is a twin-jet, low wing monoplane with "coke bottle" fuselage. It is used as an advanced trainer by the Air Force and it has been selected by NASA for astronaut space flight readiness training. More than 800 have been delivered to the USAF. A quantity of T-38s has also been delivered to the German Air Force. It is produced by Northrop's Norair Division.

Specifications

Span 24 feet 3 inches; length 42 feet 2 inches; height 12 feet 11 inches; weight 11,550 pounds; crew 2; engines two General Electric J85-5 turbojets; two independent 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-1A PATHFINDER II

Prime Contractor: Piasecki Aircraft Corporation

Remarks

The 16H-1A is an advanced developmental shaft compound helicopter with one GE T-58-8 turbine of 1,250 shaft horsepower. The 16H-1 predecessor design was developed and tested originally with company funds, then major modifications under contract to the Army led to the 16H-1A and additional advanced ground and flight testing. It is an 8-place 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; wing span 20 feet; main rotor diameter 44 feet; empty weight 4,550 pounds; VTOL gross weight 8,000 pounds; STOL gross weight 10,500 pounds.

Performance

Maximum speed sea level 225 miles per hour; service ceiling 18,700 feet.

16H-3H PATHFINDER EXECUTIVE

Prime Contractor: Piasecki Aircraft Corporation

Remarks

A commercial twin-turbine configuration derived from the advanced developmental 16H-1A shaft compound, the 16H-3H is oriented to the "portal to portal" executive market. It retains much of the tested dynamics of the 16H-1A such as the main 3-bladed rotor, shafting and ring-tail enclosing a 3-bladed controllable pitch propeller. The model will accommodate 7 passengers and a pilot, plus 30 pounds of baggage each in a fully instrumented aircraft for instrument flight operations. Twin-turbine power in the range of 1,250 to 1,460 horsepower is available making this a true twin-engine hot-day, altitude 1,000 feet, aircraft.

Specifications

Fuselage length 37.25 feet; wing span 20 feet; main rotor diameter 44 feet; empty weight 5,000 pounds; VTOL gross weight 8,000 pounds; STOL gross weight 10,500 pounds.

Performance

Maximum speed sea level 235 miles per hour; cruise speed 200 miles per hour; range 350 statute miles with ½ hour fuel reserve.

PA-25 PAWNEE "B"

Prime Contractor: Piper Aircraft Corporation

Remarks

The Pawnee was specifically designed for the safe, efficient, economical dispersal of liquid and solid agricultural chemicals, insecticides and salt; and for ease of maintenance under field conditions. The Pawnee was first introduced in 1959; the present horsepower Pawnee "B" is equipped with a Lycoming 0-540-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.

Specifications

Wing span 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; take-off 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 140

Prime Contractor: Piper Aircraft Corporation

Remarks

The Cherokee 140 is a 2–4 place fixed-gear sport/trainer powered by a Lycoming 0-320-E2A 150 horsepower engine. Since its introduction in 1963 the Cherokee 140 has become one of the most popular aircraft for the fixed-base operator, flying clubs, flight schools, as well as for 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

Wing span 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; take-off run 800 feet; landing roll 535 feet; rate of climb 600 feet per minute; service ceiling 14,300 feet; cruising range 725 miles.

CHEROKEE "C"

Prime Contractor: Piper Aircraft Corporation

Remarks

The Cherokee "C" is the latest version of the Cherokee line of 4-place fixed-gear aircraft which was originally introduced in 1961. The Cherokee "C" is available in a choice of 3 engines: Lycoming O-320-E2A (150 horsepower), Lycoming O-320-D2A (160 horsepower), or the Lycoming O-360-A3A (180 horsepower).

Specifications

Wing span 30 feet; length 23.5 feet; height 7.3 feet; gross weight 2,150 pounds (150), 2,200 (160), 2,400 (180); empty weight 1,210 pounds (150), 1,215 (160), 1,230 (180); wing area 160 square feet; wing loading 13.4 pounds per square foot (150), 13.8 (160), 15.0 (180); power loading 14.3 pounds per horsepower (150), 13.8 (160), 13.3 (180); fuel capacity 50 gallons; propeller all-metal fixed-pitch Sensenich with 74-inch diameter for the 150 and 160, and 76-inch diameter for the 180.

Performance

Top speed 144 miles per hour (150), 146 (160), 152 (180); cruise speed at 75 percent power 135 miles per hour (150), 137 (160), 143 (180); stalling speed 54 miles per hour (150), 55 (160), 57 (180); take-off run 780 feet (150), 740 (160), 720 (180); landing roll 535 feet (150), 550 (160), 600 (180); rate of climb at sea level 690 feet per minute (150), 730 (160), 750 (180); service ceiling 14,900 feet (150), 15,800 (160), 16,400 (180); cruise range at 75 percent power 725 miles (150), 735 (160), 725 (180).

CHEROKEE 235 B

Prime Contractor: Piper Aircraft Corporation

Remarks

The Cherokee 235 B can carry 4 passengers, 200 pounds of luggage, 84 gallons of fuel and still have weight left over. With its Lycoming 0-540-B2B5 235 horsepower engine and its modern low-wing design, the Cherokee 235 B can operate out of even the shortest fields, and then cruise at 156 miles per hour for a range of over 900 miles. The new Cherokee 235B incorporates many new improvements, such as "shock-mounted" cowling, dynafocal engine mounting, increased soundproofing and a new, larger instrument panel that will accommodate even the most professional type of equipment.

Specifications

Wing span 32 feet; length 23.5 feet; height 7.1 feet; gross weight 2,900 pounds; empty weight 1,465 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; take-off run 800 feet; landing roll 680 feet; rate of climb at sea level 825 feet per minute; service ceiling 14,500 feet; cruising 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 or utility and air taxi, it is offered with a choice of horsepower, 6 or 7 place seating and also in seaplane configuration. The 260 horsepower version uses a Lycoming 0-540-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 7th seat optional.

Specifications

Wing span 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, 260 and 300 horsepower versions respectively, 166 and 174 miles per hour; cruise speed at 75 percent power 160 and 168 miles per hour; stall speed, either version, 63 miles per hour; take-off 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

Prime Contractor: Piper Aircraft Corporation

Remarks

Newest of the Cherokee line, the Arrow has a number of features which distinguish it from its companion craft, the Cherokee C. 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

Span 30 feet; length 24.2 feet; height 8 feet; gross weight 2,500 pounds; empty weight 1,380 pounds; wheel tread 10.5 feet; engine Lycoming IO-360, 180 horsepower at 2,700 revolutions per minute.

Performance

Top speed 170 miles per hour; optimum cruising speed 162 miles per hour; stalling speed, flaps and gear down, 61 miles per hour; take-off run 820 feet; landing roll 776 feet; cruising range 75 percent power 857 miles; service ceiling 15,000 feet.

PA-18 SUPER CUB

Prime Contractor: Piper Aircraft Corporation

Remarks

The PA-18 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 and 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, training, patrol, survey, agricultural and general utility work.

Specifications

Wing span 35.3 feet; length 22.5 feet; height 6.7 feet; gross weight 1750 pounds; overload gross weight 2070 pounds; empty weight 930 pounds; wing area 178.5 square feet; wing loading 10.0 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; take-off run 200 feet; landing roll 350 feet; rate of climb at sea level 960 feet per minute; service ceiling 19,000 feet; cruising range at 75 percent power 460 miles.

COMANCHE B

Prime Contractor: Piper Aircraft Corporation

Remarks

The Comanche B is the latest version of the proven Comanche line of airplanes. The new Comanche B has a longer cabin that seats up to 6 people, more luxurious styling, and has 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 B cruises at over 180 miles per hour and has a range of 1,100 miles at 75 percent power.

Specifications

Wing span 35.98 feet; length 25.29 feet; height 7.47 feet; gross weight for take-off 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; take-off run 760 feet; landing roll 655 feet; rate of climb at sea level 1,370 feet per minute; service ceiling 20,000 feet; cruising range at 75 percent power 1,108 miles.

TWIN COMANCHE B

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 B. Powered by 2 Lycoming IO-320-B fuel injection engines developing 160 horsepower each, the Twin Comanche B cruises at over 190 miles per hour at 75 percent power. If even better performance is desired for high altitude, the Turbo Twin Comanche B can cruise at 24,000 feet at 223 miles per hour at 75 percent power. It holds the light twin nonstop distance record.

Specifications

Wing span 35.98 feet; length 25.2 feet; height 8.2 feet; gross weight 3,600 pounds (3,725 pounds for the Turbo); empty weight 2,210 pounds (2,408 pounds for the Turbo); wing area 178 square feet; power loading 11.3 pounds per horsepower; fuel capacity 90 gallons; propeller Hartzell constant-speed full-feathering with 72-inch diameter.

Performance

Top speed 205 miles per hour (240 for Turbo); cruise speed at 75 percent power 194 miles per hour (223 for Turbo); take-off run 950 feet; landing roll 700 feet; rate of climb at sea level 1,460 feet per minute (1,350 at 10,000 feet for Turbo); service ceiling 18,600 feet (Turbo ceiling is 30,000-plus feet); single engine ceiling 7,100 feet (19,000 feet for Turbo); cruising range at 75 percent power 1,270 miles (1,425 miles for Turbo).

AZTEC "C" AND TURBO AZTEC "C"

Prime Contractor: Piper Aircraft Corporation

Remarks

The Aztec "C" is powered by 2 Lycoming fuel-injection IO-540-C4B5 engines developing 250 horsepower each. It cruises at 206 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 "C" is equipped with 2 Lycoming fully modified IO-540-J4A5 engines which increase cruise speed to 236 miles per hour at 24,000 and give the Turbo Aztec "C" a ceiling of over 30,000 feet.

Specifications

Wing span 37 feet; length 30.2 feet; height 10.3 feet; gross weight 5,200 pounds; empty weight 2,933 pounds (3,023 pounds for the Turbo Aztec); wing area 207.56 square feet; fuel capacity 144 gallons; propellers Hartzell constant-speed full-feathering with 77 inch diameter.

Performance

Top speed 216 miles per hour (256 for Turbo); cruise speed at 75 percent power 206 miles per hour (Turbo 236 to 24,000 feet); stall speed 68 miles per hour; take-off run 820 feet; landing roll 860 feet; rate of climb at sea level 1,490 feet per minute (Turbo rate of climb at 10,000 feet 1,390 feet per minute); service ceiling 19,800 (absolute ceiling for Turbo plus 30,000 feet); cruise range at 75 percent power 1,055 miles (1,135 for Turbo); single engine ceiling 6,400 feet (18,500 for Turbo).

PA-31 NAVAJO

Prime Contractor: Piper Aircraft Corporation

Remarks

Piper's entry into the medium twin field is marked by two models of the Navajo, the Turbo Navajo with 310 horsepower turbocharged Lycoming T10-540-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 and 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 the Aztec.

Specifications

Wing span 40.67 feet; length 32.63 feet; height 13 feet; gross weight 6,200 pounds; empty weight 3,603 pounds for Navajo 300 and 3,759 pounds for Turbo Navajo; wing area 229 square feet; fuel capacity 190 gallons; propellers full-feathering constant-speed Hartzells.

Performance

Top speed 224 and 260 miles per hour; cruise speed at 75 percent power 210 miles per hour at 6,400 and 247 at 23,500; stall speed 71 miles per hour; take-off run 1,080 feet and 1,066 feet; landing roll 1,725 feet; rate of climb at sea level Navajo 300 1,440 feet per minute, Turbo Navajo 1,395 feet per minute; service ceiling 20,500 feet and 26,300 feet (absolute ceiling for Turbo Navajo 30,000 feet plus); cruise range at 75 percent power, 1,240 miles for Navajo 300, 1,305 miles for Turbo Navajo; single engine ceiling 5,750 feet and 15,800 feet.

XV-5A V/STOL VERTIFAN

Prime Contractors: Ryan Aeronautical Company and General Electric Company

Remarks

The Ryan XV-5A V/STOL research aircraft, utilizing 5-foot diameter fans submerged in its wings for vertical flight, is powered by 2 General Electric J85 engines. Its speed range includes capabilities of zero speed in hover to more than 400 knots in conventional jet mode. The XV-5A made its first flight on May 25, 1964, and the first complete transition from vertical to forward flight and vertical landing on November 17, 1964. It successfully completed extensive soil erosion hover, landing and take-off tests in early 1966 at Edwards Air Force Base, and later engaged in tests to demonstrate jet strike escort and rescue capabilities. The XV-5A was damaged in October 1966. Program assets were transferred to NASA. The aircraft, redesignated XV-5B, was repaired and is expected to resume flight testing in 1968.

Specifications

Span 29.83 feet; length 44.52 feet; height 14.75 feet; tread 8.39 feet; design gross weight 9,200 pounds; engines 2 General Electric J85; maximum VTOL useful load 4,419 pounds.

Performance

Maximum horizontal speed at sea level 475 knots (Mach .72); transition speed up to 105 knots; stalling speed, flaps down 82 knots; maximum rate of climb 9,500 feet per minute; altitude 40,000 feet; ferry range 650 nautical miles.

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, Army, many foreign countries, and 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), 12–18 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 to carry external loads and a 600-pound capacity hydraulically-operated utility hoist are provided as desired. Automatic stabilization equipment is installed on Navy, Marine, and Army versions of the aircraft and 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 R-1820 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 U.S. 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 U.S. 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, and Italian navies, as well as the Japanese Self Defense Forces. The S-61A, without the antisubmarine warfare gear, has been produced for the Danish Air Force and the Malaysian Air Force. 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 GE 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 28 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 U.S., BEA Helicopters Ltd. in England, Greenlandair in Greenland, and Ansett-ANA in Australia. In addition, S-61Ns have been used for passenger service in both Pakistan and Japan. S-61Ns have been used for construction and oil rig work both here and abroad; they fly crews and supplies to offshore rigs in the Gulf of Mexico and the North Sea. The Canadian Coast Guard uses the S-61N.

Specifications

Empty weight 12,256 pounds; normal gross weight 19,000 pounds; useful load 6,744 pounds; engines 2 GE CT58-140-1 1,400 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 a transport and rescue vehicle, the former called the CH-3E and the latter HH-3E. The HH-3E is equipped with external jettisonable fuel tanks and features a telescopic air-refueling probe for extended flights. Two HH-3Es made the first nonstop transatlantic helicopter flight in 1967, refueling 9 times from New York to Paris. Assigned to the Aerospace Rescue and Recover Service (ARRS), the HH-3E's prime combat mission is the 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. Rapid loading and unloading of the aircraft is provided by a rear ramp and cargo door. Power is supplied by 2 gas turbine engines. The 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 U.S. Coast Guard. It is equipped with sophisticated communications and navigation equipment.

Specifications

Empty weight 14,426 pounds; normal gross weight 19,500 pounds; useful load 5,074 pounds; engines 2 GE T58-5 1,500 horsepower each.

Performance

Maximum speed 165 miles per hour; cruising speed 154 miles per hour; service ceiling 11,700 feet; range (with two tip tanks) 748 miles.

S-62 SEARCH & RESCUE HELICOPTER

Prime Contractor: Sikorsky Aircraft

Remarks

The single-turbine S-62, the 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 Agency for commercial operations. The FAA certificate permits it to carry a pilot, a co-pilot, 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

The first flight of the twin-turbine-powered Sikorsky S-64 Skycrane, a universal transport vehicle with both military and industrial potential, took place May 9, 1962. The S-64 carries a 10-ton payload. First deliveries of the S-64 were made to the West German Ministry of Defense. The U.S. Army purchased 6 in 1964, and has ordered additional quantities. The S-64 is designed to carry its cargoes externally. It has a rear-facing pilot's seat to provide a clear view of the cargo during pick-ups or deliveries. By means of a hoist it can pick up or deposit loads without landing. A lightweight van, for such military uses as a field hospital, command post, and repair shop, or for such civilian applications as a skybus or construction headquarters, can be attached to the Skycrane fuselage. The Skycrane has proved particularly useful for recovering aircraft downed in enemy-held territory and for other heavy-lift duty in combat zones. It has a strong potential for use in ship-to-shore cargo carrying.

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 4,050 horsepower each.

Performance

Cruising 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 U.S. Marine Corps as a heavy assault transport helicopter, the CH-53A. First flight took place October 14, 1964. First delivery to a Marine Corps squadron took place in September 1966. The CH-53A has flown at speeds exceeding 200 miles an hour and has carried loads, both internally and externally, weighing 10 tons. The CH-53A, with a crew of 3, can accommodate 38 troops. It has been used to retrieve other aircraft and deliver equipment and supplies. The HH-53B, a rescue and recovery version produced for the U.S. Air Force, has 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 (CH-53A) 2 GE T64-1 and (HH-53B) 2 GE T64-3, both 3,080 horsepower.

Performance

Cruising speed 172 miles per hour; maximum speed 195 miles per hour; service ceiling 18,550 feet, range 250 miles (or, with auxiliary tanks, 806 miles).

SA-26T CORPORATE AIRCRAFT

Prime Contractor: Swearingen Aircraft

Remarks

The SA-26T or Merlin IIA is an 8–10 place pressurized twin-engine airplane designed for corporate use. It has a cylindrical fuselage with a pressure differential of 5.5 pounds per square inch. The SA-26T is powered by 2 United Aircraft of Canada Ltd. Pratt & Whitney Aircraft PT6A-20 free turbine engines equipped with propeller reversing features and rated at 550 maximum continuous shaft horsepower. The SA-26 made its initial flight on April 12, 1965.

Specifications

Span 45 feet 10½ 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 9,300 pounds; empty weight 5,800 pounds; design landing weight 8,500 pounds.

Performance

Speed at 17,000 feet 270 miles per hour; range at 27,500 feet 1,700 miles; rate of climb at sea level 1,950 feet per minute; service ceiling 30,000 single engine ceiling 12,500 feet; stall speed 86 miles per hour.

WREN-460 STOL AIRPLANE

Prime Contractor: Wren Aircraft Corporation

Remarks

The Wren 360 is a 4-place high-wing single-engine airplane which derives its STOL and slow speed abilities through aerodynamic devices. New Cessna 182 airframes are utilized in the manufacture of the Wren for economy and to assure the user of parts and service availability in most of the free world. The Wren 460 is capable of sustained patrol for up to 11¾ hours at speeds of 45 to 60 miles per hour using less than 35 percent power while maintaining a level flight attitude and maneuverability through the use of slow speed control devices. The prototype Wren 460 first flew in January 1963, and FAA certification was received June 1964.

Specifications

All-metal high-wing fixed-gear; span 36 feet 6 inches; length 27 feet 4 inches; height 8 feet 9 inches, empty weight 1,710 pounds; useful load 1,090 pounds; gross weight 2,800 pounds; fuel capacity 65–84 gallons; engine Continental O-470-R 230 horsepower.

Performance

Maximum speed 160 miles per hour; cruise speed 75 percent power at 6,500 151 miles per hour; take-off 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 872 miles; maximum range 1,150 miles; take-off to clear 50-foot obstacle 605 feet; landing to clear 50-foot obstacle 612 feet.

MINUTEMAN ICBM

Weapon System Integrator: The Boeing Company; technical direction by TRW Systems Group of TRW Inc.

Associate Contractors: Thiokol Chemical Corporation (first-stage engine); Aerojet-General Corporation (second-stage engine); Hercules Incorporated (third-stage engine); Autonetics Division, Aerospace and Systems Group, North American Rockwell Corporation (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 U.S. Air Force's Strategic Air Command. One thousand Minuteman missiles are on strategic alert in 6 wings. The first 5 wings are equipped with Minuteman I missiles, and the sixth wing, centered at Grand Forks, North Dakota, is armed with the larger, more powerful Minuteman II. Minuteman II is also deployed in an extra co-located 50-missile squadron near Malmstrom Air Force Base, Montana. An improvement program in progress, called "Force Modernization," will replace all Minuteman I missiles in the first 5 wings with Minuteman II missiles by 1970. Minuteman is a three-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 two SAC officers, with 10 launch facilities. Minuteman II has a larger second-stage engine, improved guidance system, greater range and payload capabilities, more flexible targeting and increased survivability. Minuteman carries a nuclear warhead. In photo, Minuteman II.

Specifications

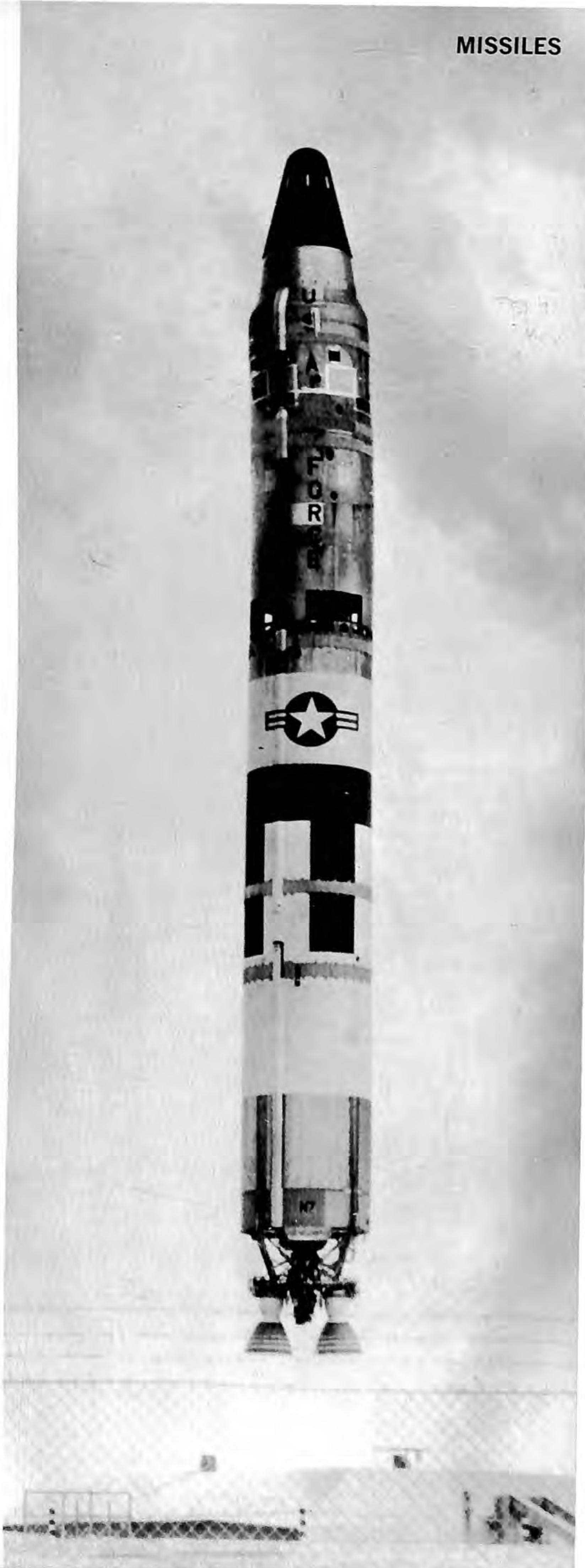
Minuteman I (WS-133A)—Model LGM-30A 54 feet, Model LGM-30B 55.9 feet; weight approximately 65,000 pounds; diameter approximately 6 feet at first-stage interstage.

Minuteman II (WS-133B)—Length 59.8 feet; weight approximately 70,000 pounds.

Performance

Minuteman I—range more than 6,300 nautical miles; speed more than 15,000 miles per hour.

Minuteman II—range more than 7,000 nautical miles; speed more than 15,000 miles per hour.



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); GE Missile and Space Vehicle Division (reentry vehicle); TRW 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.

ATLAS ICBM (SERIES D, E, and F)

Prime Contractor: Convair Division of General Dynamics Corporation
Associate Contractors: Rocketdyne Division, Aerospace and Systems Group, North American Rockwell Corporation (engines); General Electric Company, Burroughs Corp., and American Bosch Arma Corp. (guidance); General Electric Company and Avco Corporation (reentry systems)

Remarks

Developed as the free world's first intercontinental ballistic missile, Atlas served as the backbone of the nation's deterrent force during the late 1950s and early 1960s. Installed at launch sites across the nation under the Air Force policy of concurrence, Atlas missiles and their launch sites were produced in three basic versions, the Series D, Series E, and Series F. Series D missiles were emplaced in "soft," above-ground launch sites. Series E missiles were installed in above-ground "coffin" launch facilities providing greater protection from enemy attack than the Series D emplacements; Series F missiles served as deterrents in underground "silo" launch sites, fully hardened against all but a direct hit. Series D missiles used engines producing 360,000 pounds thrust with radio-inertial guidance systems. Series E and Series F missiles employed uprated engines capable of 390,000 pounds thrust, and used all-inertial guidance systems. Atlas ICBMs in test flights placed reentry vehicles more than 9,000 miles from the launch site, though originally designed for ranges of approximately 6,000 miles. Phased out of the nation's deterrent arsenal during 1965, Atlas missiles are currently being used for flights in the Air Force ABRES (Advanced Ballistic Re-Entry Systems) program, the Nike-Target program and the OV1 satellite program.

POSEIDON 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 (nose cone)

Remarks

The Poseidon C-3 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' 4½ feet, and, at 34 feet, 3 feet longer than the A-3 Polaris. Poseidon 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 A-3 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 submarines with Poseidon C-3 and the remaining 10 with Polaris A-3.

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 (nose cone)

Remarks

Now in production at Lockheed, 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 1,500 nautical miles 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, is being 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 of the FBM submarines. An additional 112 A3s are assigned to the Pacific Fleet.

PERSHING SURFACE-TO-SURFACE WEAPON SYSTEM

Prime Contractor: Martin Marietta Corporation, Orlando

Remarks

Pershing is a two-stage, surface-to-surface ballistic missile which is now operational with Army artillery battalions. It was deployed with the U.S. Seventh Army in Europe in early 1964 and is also in the hands of Federal Republic of Germany Air Force units, within the framework of NATO. Pershing has the longest range and greatest firepower of all weapons in the Army's arsenal. Four-tracked vehicles carry 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. Under a $66 million contract awarded by the Army to Martin Marietta in early 1966, improved ground support equipment is under development. The Pershing Ia system, using the new equipment, will be adapted to wheeled vehicles. Rate of fire and system reliability will be increased, with major system improvements centered in a new programmer-test station and a new erector-launcher. Improved missile components are also being developed.

Specifications

Length 34½ feet; diameter 3.3 feet; weight approximately 10,000 pounds; speed supersonic; trajectory ballistic; propulsion two-stage, solid propellant; guidance inertial; warhead nuclear.

Performance

Range 100–400 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, simple to operate and, with its ease of maintenance and degree of immunity to countermeasures, 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.

REDSTONE SURFACE-TO-SURFACE MISSILE

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 TRW Systems, has made major modifications to a number of Redstones for use in the SPARTA (Special Anti-Missile 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 reentry payloads, the Redstones are assembled and launched at Woomera, Australia. Chrysler also provides the payloads and assists 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; 75,000 pounds thrust.

MACE SURFACE-TO-SURFACE MISSILE

Prime Contractor: Martin Marietta Corporation, Baltimore Divisions
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

An improved version of Matador first launched in 1959, Mace is an all-weather guided missile incorporating enough innovations to justify its classification as an entirely new weapon system. Mace TM-76A is fired from a truck-drawn zero-length launcher; Mace TM-76B, from hardened underground bases.

Specifications

Swept-wing missile; length 44 feet; span 23 feet; diameter 54 inches; guidance Mace A self-contained ATRAN (Automatic Terrain Radar and Navigator) map-matching system; guidance Mace B all-inertial; 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 and Systems Group, North American Rockwell Corporation (propulsion); Whittaker Controls and Guidance (gyroscope); F. M. C. Corporation (vehicles); Hawker Siddeley (lightweight launcher)

Remarks

Lance is a surface-to-surface ballistic missile designed by the Army to provide greater fire support to Army field divisions. It complements division tube artillery and extends the division commander's capability for nuclear and non-nuclear supporting fire. Lance is built by the Michigan Facility of LTV's Missiles and Space Division. It is the first Army missile to use packaged storable liquid propellants. Major components of the missile include a warhead section, a guidance package, fuel tankage and an engine. Major ground support equipment includes a self-propelled launcher, a fully mobile lightweight launcher, the transporter-loader, and the prefire tester and fire pack. Guidance is a simplified inertial unit developed in the Army Missile Command's Guidance and Control Laboratory. Development of an extended Lance (XRL) also has been approved by the Army and the company holds an exploratory development contract from the Navy to determine whether Lance can be used under any type of weather or water conditions as a ship-launched amphibious support weapon.

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 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 and tanks, troops and field fortifications. Shillelagh utilizes a command guidance system, giving it extreme high accuracy against either stationary or moving targets and a high first round "kill" probability. The system includes both the guided missile system and conventional ammunition, both fired from a 152 millimeter combination gun/launcher. Now in production by Aeronutronic at the Army's Lawndale, California, Missile Plant, Shillelagh is used in the compact turret version of the Army's M60 Main Battle Tank. It will also be standard armament on the U.S.-Federal Republic of Germany Main Battle Tank, to be operational in the 1970s. The Army awarded Shillelagh a type standard "A" Classification, the classification given to any Army materiel item determined to be the most advanced and satisfactory item to fill a given Army need. Shillelagh, which is handled in the field with the ease of a conventional round of ammunition, has been tested under extreme environmental conditions ranging from desert heat to arctic cold and high tropical humidity.

DAVY CROCKETT CLOSE SUPPORT MISSILE

Prime Contractor: Army Weapons Command (In-House)

Remarks

A small Army battlefield missile, Davy Crockett is a short range weapon for support of ground troops. It is fired from a bazooka-type launcher carried by 2 men or mounted on a vehicle.

HONEST JOHN SURFACE-TO-SURFACE MISSILE

Prime Contractor: Electronics and Space Division, Emerson Electric Company

Remarks

Honest John is a surface-to-surface missile propelled by a single-stage, solid propellant engine, with spin stabilization provided by small spin rockets. Unguided, it attains a top speed of Mach 1.7. The Honest John is capable of carrying either a nuclear or high-explosive warhead. Honest John is operational.

Specifications

Length 24.8 feet, diameter 30 inches; weight 4,500 pounds.

Performance

Range 12 miles; maximum speed Mach 1.7.

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. It gets its name from the 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 of angle between target course and his weapon. If he keeps the crosshairs centered, signals transmitted through the two-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 now undergoing service testing by the U.S. Army.

SUBROC ANTISUBMARINE MISSILE

Prime Contractor: Goodyear Aerospace Corporation
Subcontractors: Aerospace Systems Division, General Precision Systems 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, formerly the Navy Bureau of Weapons, 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, and conventional launch methods are employed. 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 now operational with the fleet and has performed successfully in a number of firings.

Specifications

Weight approximately 4,000 pounds.

Performance

Classified.

DRAGON MEDIUM ANTITANK ASSAULT WEAPON

Prime Contractor: McDonnell Douglas Corporation

Remarks

In engineering development status, Dragon is a medium antitank assault weapon designed for use by the infantryman. Light enough to be carried by 1 man and shoulder-fired, Dragon has a warhead big enough to knock out most armor and other infantry targets. It will be far superior in range, accuracy and hit probability to the 90-millimeter recoilless rifle it will replace. Weighing about 27 pounds, 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 launches the missile. While he 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).

MARK 46 MOD 1 ANTISUBMARINE TORPEDO

Prime Contractor: Honeywell Inc.
Subcontractors: TRW Inc., Clevite Corp.

Remarks

The Mark 46 Mod 1 antisubmarine warfare torpedo is a liquid-propelled version of the Mark 46. It is in production at Honeywell Ordnance Division, Minneapolis, Minnesota.

MARK 46 ANTISUBMARINE TORPEDO

Prime Contractor: Aerojet-General Corporation
Subcontractor: Bendix Corporation (guidance and control system)

Remarks

The Navy's Mark 46 is a rocket propellant driven, high-speed, deep-running, passive/active acoustic homing antisubmarine torpedo. It is designed to seek, acquire, pursue and destroy conventional and nuclear submarines. The Mark 46 can be launched from aircraft, the torpedo tubes of antisubmarine vessels, from conventional or drone helicopters or by ASROC (antisubmarine rocket). The Mark 46 is now in production at Aerojet's Von Karman Center, Azusa, California.

Specifications

Approximate dimensions: Length 101 inches; diameter 12¾ inches; weight 570 pounds.

ASROC/TERRIER

Prime Contractors: Honeywell Inc. (ASROC) and General Dynamics Corporation (Terrier)

Remarks

The ASROC/Terrier system is a new concept in shipboard weaponry. It combines the ASROC (antisubmarine rocket) and Terrier supersonic guided missile weapons system in an advanced ASROC/Terrier combination aboard a new class of ship. The ASROC has been modified so that it can be fired from a Terrier launcher on the forward deck of the ship. Two Terrier or two ASROC missiles can be alternately mounted on the launcher and fired in rapid succession, although one cannot be on the launcher with the other 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. The first of the new class of ships to be equipped with the system is the USS Belknap (DLG-26).

SPRINT ANTIMISSILE MISSILE

Prime Contractor: Martin Marietta Corporation, Orlando (under contract to Bell Telephone Laboratories, Inc.)

Remarks

The Sprint missile is one of the major components being developed for the Army's Nike-X 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—will be only a matter of seconds. Sprint is designed to be "popped" from its launch cell rather than flown out under its own power. A gas generator placed under the missile will eject it like a dart from a blowgun. The Sprint booster will ignite after the missile is aboveground. At the same time, the missile will pitch over on a trajectory that will take it to the vicinity of the computer-calculated intercept point. Fine adjustments will be 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

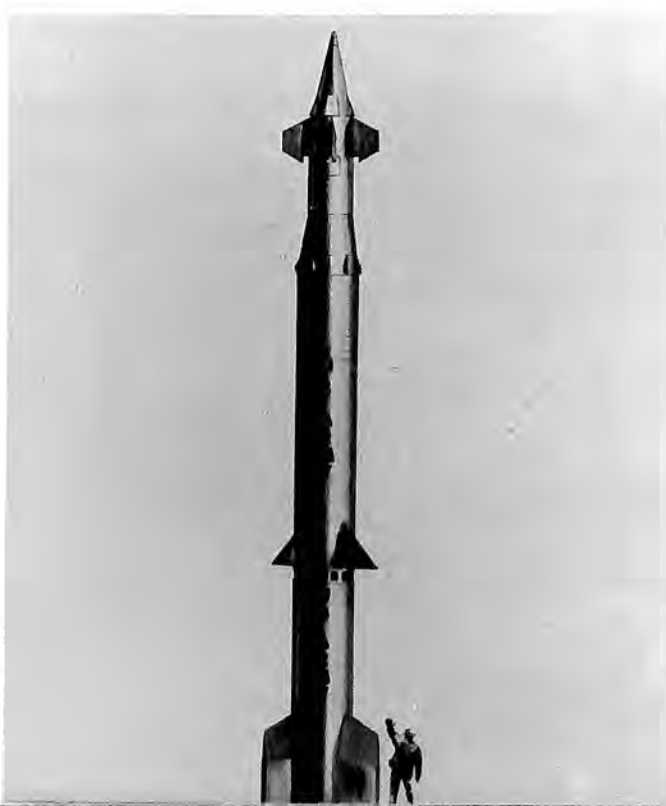
Prime Contractors: Western Electric Company (for complete Nike-X ground and flight system); McDonnell Douglas Corporation (Spartan airframe)

Remarks

Spartan is one of the two missile components of the Nike-X antimissile missile system, which also includes a battery of tracking radars and computers on the ground. Spartan complements the Sprint missile to provide the system with a wide variety of intercept ranges and altitudes, Spartan being the long-range member of the missile team. It is an advanced version of the Zeus missile. Component and motor tests started in 1967.

Specifications

Three stages, all solid-propelled; overall length about 55 feet; basic stage thrust approximately 450,000 pounds.



NIKE HERCULES AIR DEFENSE MISSILE

Prime Contractor: Western Electric Company

Remarks

Nike Hercules is the U.S. primary 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 31½ inches; weight 10,000 pounds at launch; propulsion system 2-stage solid propellant; command guidance; conventional or nuclear warhead.

Performance

Speed supersonic; range more than 75 nautical miles; ceiling in excess of 150,000 feet.

HAWK ANTIAIRCRAFT MISSILE

Prime Contractor: Raytheon Company
Associate Contractors: Aerojet-General Corporation (propulsion); Northrop Corporation (launcher/loader/carrier)

Remarks

Hawk is a surface-to-air antiaircraft missile in operational service with the Army and the Marine Corps. In addition, Hawk is deployed overseas in Europe, Panama and the Far East, and is being 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 antiaircraft 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, Raytheon is developing an improved Hawk.

Specifications

Weight 1,275 pounds; length 198 inches; span 47.4 inches; solid propellant; high explosive warheads.

Performance

Speed supersonic.

TARTAR SHIPBOARD ANTIAIRCRAFT 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 4 other navies of the free world—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 semi-active homing guidance system is made up of several interrelated units so 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.

ADVANCED TERRIER SHIPBOARD ANTIAIRCRAFT MISSILE

Prime Contractor: Pomona Division of General Dynamics Corporation
Associate Contractor: Hercules Incorporated/Allegany (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 antiaircraft 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 Gyroscope Company (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-fire-power defense against air attack. It also has a surface-to-surface capability. It is a two-stage weapon with a solid-fuel rocket booster and 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.

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, will for the first time give the infantryman effective antiaircraft 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 Corporation (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, operating eight bases equipped with from 28 to 56 launch-shelters. Bomarc B incorporates a solid-fuel rocket engine developing some 50,000 pounds of thrust. This engine launches the missile in a vertical position. Just prior to boost burnout at approximately 30,000 feet altitude, 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

Wing span 18 feet 2 inches; overall length 45 feet; height 10 feet 2 inches; fuselage diameter 35 inches; width of the 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.

CHAPARRAL AIR DEFENSE GUIDED MISSILE SYSTEM

Prime Contractor: Aeronutronic Division, Philco-Ford Corporation

Remarks

Chaparral is an adaptation of the Sidewinder IC 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, Chaparral utilizes the Sidewinder IC 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, with awarding of a $6,400,000 initial tooling and production contract to Aeronutronic by the Army. Chaparral can be fired from various types of existing Army vehicles including railroad flat cars, flatbed trucks, flatbed trailers or can be ground mounted. The missiles are aimed by a gunner in a turret mount and automatically guide on the target's heat source after launch. Chaparral, which has completed successful test firings and guided launchings at White Sands Missile Range, New Mexico, and Naval Weapons Center, China Lake, California, has been selected by the Army as one of 2 major weapon 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.

STANDARD SHIPBOARD MISSILE

Prime Contractors: Pomona Division of General Dynamics Corporation (guidance, control and airframe); The Johns Hopkins University Applied Physics Laboratory (consultant to Ordnance System 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 in attaining the performance improvements are maximum reliability and overall economy, all to be achieved with simplified logistics and compatibility with existing Terrier/ Tartar handling and shipboard weapon systems. There are 2 versions of Standard Missile: extended range (ER) and medium range (MR). The principal difference between the 2 is in the propulsion systems. ER has a separable booster 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) and 15 feet (MR); diameter 1 foot.

Performance

Speed, supersonic; range (ER) 35-plus miles, and (MR) 15-plus miles.

SEA SPARROW SURFACE-TO-AIR MISSILE

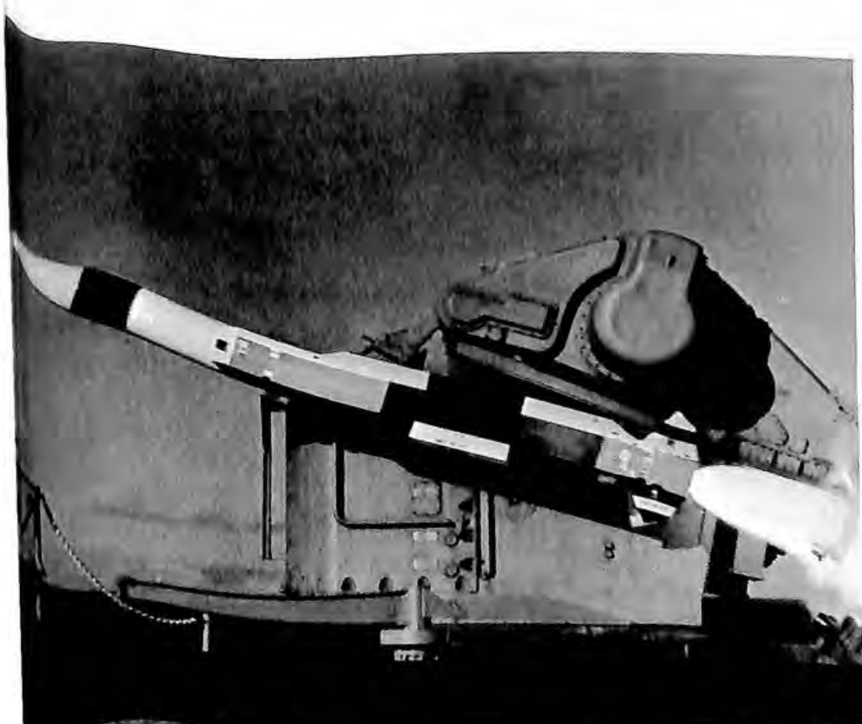
Prime Contractor: Raytheon Company

Remarks

Sea Sparrow (AIM 7E) is under development for use by the Navy and the armed forces of NATO nations as a basic point defense missile system.

Specifications

Length 12 feet; maximum diameter .67 feet; span over fins 3.3 feet; launch weight 400 pounds; guidance semi-active homing radar.



SRAM (SHORT-RANGE ATTACK MISSILE) AGM-69A

Weapon System Integration Contractor: The Boeing Company
Major Subcontractors: Lockheed Propulsion Company; General Precision, Inc.; Litton Industries; Autonetics Division, Aerospace and Systems Group, North American Rockwell Corporation; Sylvania Electronics; and Unidynamics

Remarks

SRAM is a supersonic air-to-ground missile with nuclear capability which will be carried by the FB-111 fighter-bomber. It is adaptable for use on 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 design and development stage.

STANDARD ARM

Prime Contractor: Pomona Division of General Dynamics Corporation

Remarks

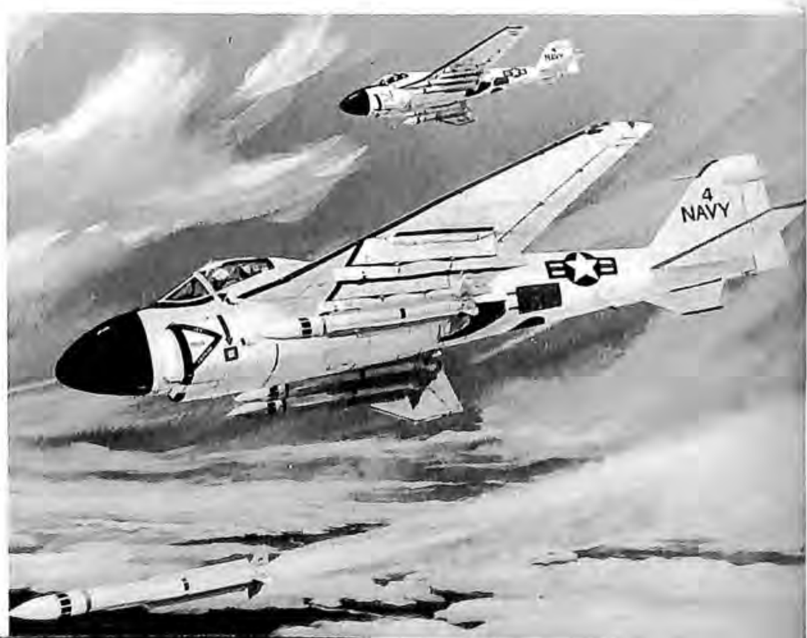
Standard ARM is an air-launched guided missile system. It will be deployed by the U.S. Navy and U.S. Air Force to locate and destroy hostile ground-based radar installations. The system consists of a modified medium range Standard missile delivered by high-performance aircraft equipped for the detection, identification and acquisition of the radar target. Aircraft will include the Navy's A-6, the Air Force's F-105 and F-4. The 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. and Sperry Farragut Company
Subcontractor: Rocketdyne Division, Aerospace and Systems Group, North American Rockwell Corporation (propulsion elements)

Remarks

An air-to-ground missile designed as a countermeasure to enemy radar, Shrike was developed by the Naval Weapons Center, China Lake, California, and 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 USAF 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 with a low unit cost, Shrike is powered by a solid fuel rocket. In photo, Shrike in underwing mount on Navy A-4.

ADM-20C QUAIL

Prime Contractor: 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 J85 (GE) turbojet engine, the missiles are guided by a preprogrammed autopilot. Quail was integrated into the SAC inventory in 1961, declared combat ready, and is standing strategic alert with the B-52.

Specifications

Length 13 feet; span 5½ feet; weight 1,200 pounds.

Performance

Same operating envelope as the B-52.

HOUND DOG (AGM-28) MISSILE

Prime Contractor: Space and Information Systems Division, Aerospace and Systems Group, North American Rockwell Corporation
Principal Subcontractors: Pratt & Whitney Aircraft (J-52 turbojet engines); Autonetics Division, Aerospace and Systems Group, North American Rockwell Corporation (guidance and controls)

Remarks

The AGM-28 Hound Dog (formerly GAM-77) is a B-52-launched air-to-surface strategic missile operated by the USAF Strategic Air Command. Nearly 30 SAC bases throughout the United States are equipped with the double-sonic missile. The B-52 carries two 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 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.

BULLPUP AGM-12B, BULLPUP AGM-12C MISSILES

Prime Contractor: Martin Marietta Corporation, Orlando

Remarks

Extremely accurate and reliable, the Bullpup is launched more than two miles away from surface targets such as airfield installations, trains 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. Martin Marietta design and production reliability permit the missile to be handled as a "round of ammunition" with no prefiring checkout required. Very little ground support is required. The missile can be loaded on aircraft ready for firing in about five minutes using only normal bomb-handling equipment or special ground handling equipment now in production at Orlando. In photo, AGM-12C.

Specifications

Length (AGM-12B) 11 feet, (AGM-12C) 13.6 feet; diameter (AGM-12B) 1 foot; weight (AGM-12B) 571 pounds including warhead, (AGM-12C) 1,785 pounds; (AGM-12B) 250-pound conventional warhead, (AGM-12C) larger conventional warhead; range (AGM-12B) 3–6 miles, (AGM-12C) more than 6 miles; propulsion pre-packaged liquid rocket; guidance radio command, controlled by pilot.

CONDOR AIR-TO-SURFACE MISSILE

Prime Contractor: Columbus Division, Aerospace and Systems Group, North American Rockwell Corporation

Remarks

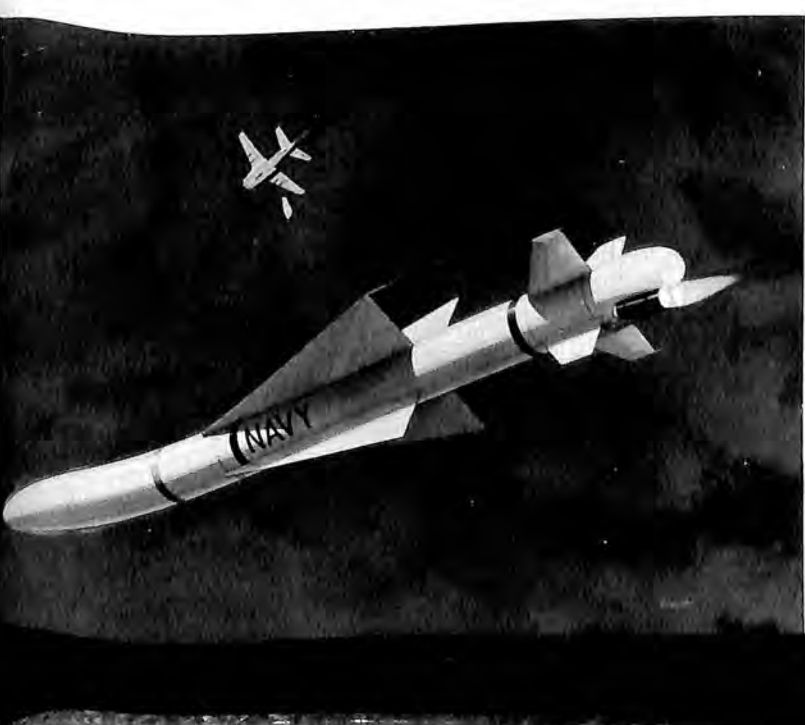
Condor, designated AGM-53A, is a rocket-powered, conventional warhead guided missile designed for use with current and future Navy aircraft. The Condor system relies on closed-circuit television and a command link between missile and airplane for guidance. Condor is adaptable to the armament system in the Navy's A-6A all-weather attack aircraft.

HORNET AIR-TO-SURFACE MISSILE

Prime Contractor: Columbus Division, Aerospace and Systems Group, North American Rockwell Corporation

Remarks

Hornet is a rocket-powered air-to-surface missile system design for use on tactical aircraft. The missile depends on a television guidance system which locks on and automatically guides it to previously identified mobile or stationary targets.



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 strafing 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

Remarks

A guided bomb with a range of several miles, Walleye weighs approximately 1,000 pounds. It is equipped with movable fins for television guidance by the pilot. The missile was developed by the Naval Weapons Center, China Lake, California.

SPARROW AIR-TO-AIR MISSILE

Prime Contractor: Raytheon Company

Remarks

Developed and produced by Raytheon's Missile System Division, Sparrow is a supersonic, radar homing weapon which can be launched from aircraft flying at subsonic or supersonic speeds. The original model became operational with Navy squadrons in 1956; the missile is now being used as primary defensive armament on USAF, Navy and Marine Corps fighters and current models have greater performance capabilities than the original, due to 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. This information is supplied to the computer to generate signals that will enable the pilot to attack targets successfully. The missile is operational with the Royal Airforce F-4 Phantom and in production for the Italian Air Force. An advanced version is under development.

Specifications

Weight 400 pounds; length 12 feet; diameter 8 inches.

Performance

Speed supersonic; all-weather, all-aspect, all-altitude capability.

SIDEWINDER IC AIR-TO-AIR MISSILE

Prime Contractors: Philco-Ford Corporation and Raytheon Company
Associate Contractors: Rocketdyne Division, Aerospace and Systems Group, North American Rockwell Corporation (propulsion); and General Electric Company (guidance)

Remarks

Sidewinder IC (AIM9D) is a second generation version of the Navy's air-to-air missile. A simple aluminum tube powered by a Rocketdyne Mark 18 Mod 1 solid propellant rocket, Sidewinder IC is a rugged, inexpensive weapon used on fighter aircraft. The first missile to destroy enemy aircraft in combat, it has interchangeable infrared and radar heads. AIM9D is operational with the Navy, in production, and scheduled for service in the United Kingdom.

Specifications

Overall length 9.5 feet; maximum diameter .42 feet; span over fins 2.1 feet; launch weight 185 pounds.

Performance

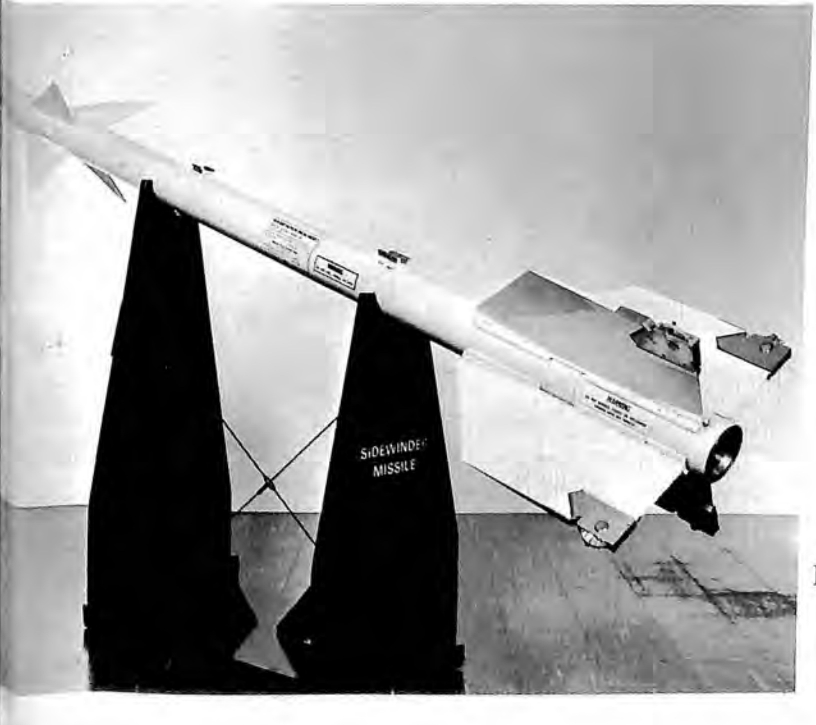
Speed Mach 2.5.

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.



PHOENIX AIR-TO-AIR MISSILE

Prime Contractor: Hughes Aircraft Company
Associate Contractors: Control Data Corporation (computer); Rocketdyne Division, Aerospace and 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 in the F-111B aircraft, the missile is a long-range, high-performance, solid-propelled weapon.

GENIE AIR-TO-AIR ROCKET

Prime Contractor: Missile & Space Systems Division, Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)
Major Subcontractor: Aerojet-General Corporation

Remarks

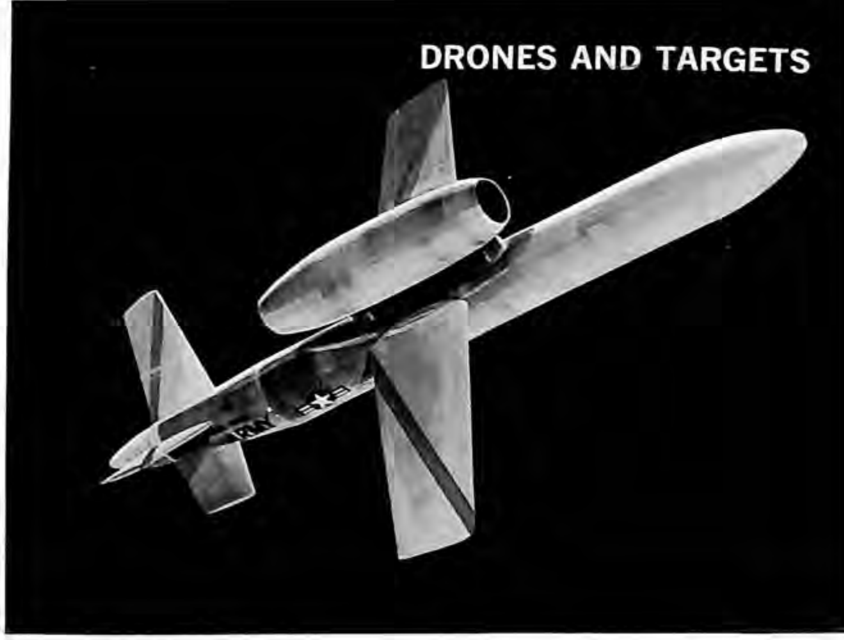
The AIM-2A Genie is an air-to-air rocket with a solid-propellant motor capable of carrying a nuclear warhead. Douglas builds the Genie weapon system for the USAF's Air Defense Command. It is carried on the F-101B Voodoo and the F-106 Delta Dart.

Specifications

Length 9 feet; width 1 foot 5 inches; weight 830 pounds.

Performance

Classified.



MODEL 1025 TARGET DRONE (MQM-39A, MQM61-A)

Prime Contractor: Beech Aircraft Corporation

Remarks

This target missile system is designed principally for programs involving developmental and evaluation testing and personnel training of surface-to-air and/or air-to-air weapon systems. The system features make it ideal as a realistic threat simulation for radar guided weapons. Infrared augmentation can be provided to make it compatible with heat seeking type weapons. Some of the weapon systems the Beech Model 1025 target has been successfully used with are the Hawk, Sparrow, Terrier, Tartar, Sidewinder, Nike-Hercules, Nike-Ajax and Redeye. If desired, the Model 1025 may be used as a tug for towing banner type targets for gunnery practice.

Specifications

Span 155 inches; length 181 inches; diameter 17¾ inches; weight 664 pounds; engine McCullough turbo-supercharged 125 horsepower with Beech constant-speed propeller.

Performance

Maximum speed 305 knots; service ceiling 40,000 feet; endurance 82 minutes on station.

MODEL 1025-TJ TURBOJET TARGET MISSILE

Prime Contractor: Beech Aircraft Corporation

Remarks

This new target missile system provides "out of sight" target for suface-to-air and air-to-air weapons systems. It is a remote-controlled, recoverable target missile, capable of speeds in excess of 400 knots for a duration of over 90 minutes. It was designed for such weapons systems as the Hawk, Nike, Mauler and Redeye. This drone is the turbojet version of both the standard MQM-39A and MQM-61A target drones.

Specifications

Wing span 142.8 inches; length 204 inches; diameter 17.75 inches; weight 999 pounds without launch booster; engine one Continental 321-2 turbojet.

Performance

Maximum speed Mach .8; service ceiling in excess of 40,000 feet; endurance in excess of one hour.

AQM-37A TARGET MISSILE

Prime Contractor: Beech Aircraft Corporation

Remarks

This supersonic missile target 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 does have surface launch capability from shipboard or land-based launcher systems. The target's universal launch capability and high performance uniquely suit it 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 and a tangent ogive nose; engine one 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 and 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 U.S. 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 plexiglass 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 the 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.

QH-50 DASH DRONE HELICOPTERS

Prime Contractor: Gyrodyne Company of America

Remarks

The DASH (Drone Anti-Submarine 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. The D (photo), which has simplified avionics, greatly increased range capability and load carrying capacity as compared with the C, joined the Fleet in 1966. Production was discontinued in 1967.

Specifications (D)

Rotor system coaxial; fuselage length 7 feet 3 inches; height 9 feet 8.5 inches; rotor diameter 20 feet; rotor blades molded fiberglass; weight 1,093 pounds; normal gross weight 2,350 pounds; powerplant 1 T50 BO-12 turboshaft, normal rated power 300 horsepower.

Performance (D)

Maximum speed sea level 80–103 knots; hovering ceiling 10,200 feet; service ceiling 15,700 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 and Systems Group, North American Rockwell Corporation (airframe and guidance/control); Rocketdyne Division of North American Rockwell Corporation (booster rocket)
Associate Contractor: The Marquardt Corporation (ramjet engine)

Remarks

The MQM-42A Redhead/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 high altitudes. It is used primarily for realistic training of crews of the Hawk-type of anti-air warfare batteries of the Army Air Defense System. The Redhead/Roadrunner is capable of simulating 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 solid propellant booster which drops away after burnout, and inflight propulsion is furnished by a top-mounted ramjet engine. The missile body contains 2 Luneberg passive augmentation lenses to enhance tracking by ground radars throughout the mission profile. Recovery is effected by activation of a parachute/retrorocket system housed in the rear equipment section.

Specifications

Length 24.8 feet; diameter 12 inches; gross weight 861 pounds.

Performance

Speed Mach 0.9–2.1; service ceiling 60,000 feet.

NV-105/MQM-74A TARGET DRONE

Prime Contractor: Northrop Corporation

Remarks

A new low-cost variable-speed target drone aircraft, the NV-105/MQM-74A was designed by Northrop Corporation's Ventura Division for Army and 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 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 NV-105/MQM-74A is capable of flying both visual and out-of-sight missions. The Luneberg lens passive radar augmenter providing 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; wing span 66.7 inches; weight 248 pounds empty, 347 pounds fully fueled for flight with provisions for adding 2 25-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 0.5–1.5 hours; recovery by parachute.

SD-1 SURVEILLANCE DRONE

Prime Contractor: Northrop Corporation

Remarks

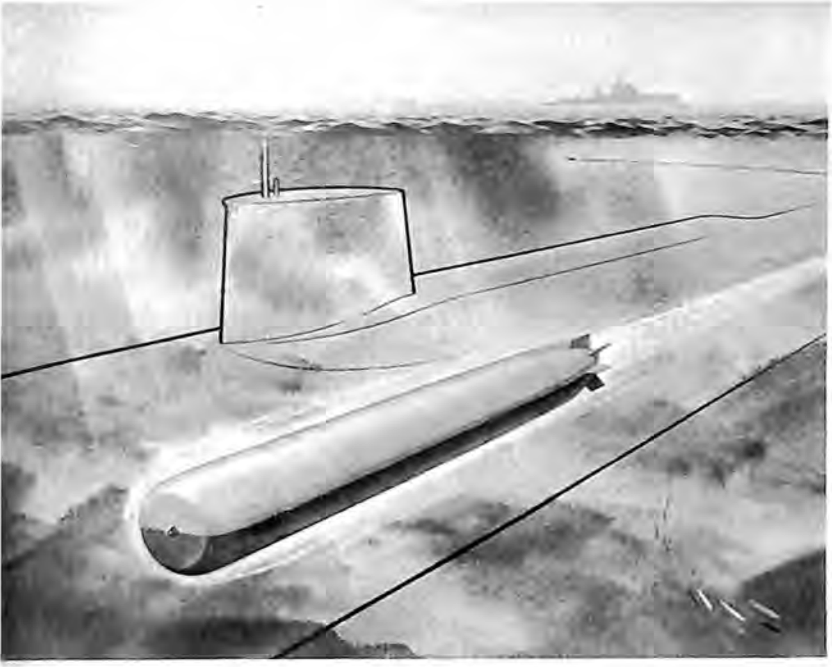
Developed for the Army Signal Corps by Northrop Corporation's Ventura Division, the propeller-driven SD-1 is currently in use by the armed forces of several NATO member countries. The small mobile radio-controlled aircraft travels with Army field units by truck and trailer including ground launcher, tracking and other equipment. It can be set up and launched quickly in rough terrain from a camouflaged position and flown by remote control over enemy installations to provide field commanders with rapid photo reconnaissance. After the aircraft's camera has exposed its film by radio command over the target, it is flown back and recovered by parachute. The camera is removed, the film processed and prints delivered within minutes without risking a pilot and man-carrying aircraft. Sensory equipment other than aerial cameras is optional.

Specifications

Span 11 feet 6 inches; length 12 feet 7 inches; height 2 feet 7 inches; guidance radio control, visual and radar; power plant 2-cycle 4-cylinder air-cooled McCulloch engine.

Performance

Speed 184 miles per hour; endurance 40 minutes; altitude 15,000 feet.



MARK 30 MOBILE ASW TARGET

Prime Contractor: Northrop Corporation

Remarks

Presently under development for the U.S. Naval Ordnance Systems Command by Northrop Corporation's Ventura Division, is the Mark 30 Mobile ASW Target, to be used for antisubmarine warfare training. 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 may be launched either from surface ships or submarines. An acoustic transducer will be towed behind the vehicle itself so that live torpedoes may be exercised against the system without destroying the target vehicle. During an exercise the pre-programmed target will travel at changing speeds, direction, and depth, and is capable of up to 7 hours of operation, depending on the speed required. Upon conclusion of its target run, the vehicle will surface for recovery either by surface ship or helicopter. It will be powered by batteries which drive an electric motor coupled to propeller shafts.

AQM-38 TARGET AIRCRAFT

Prime Contractor: Northrop Corporation

Remarks

An advanced target for surface-to-air and air-to-air weapon training and evaluation, the AQM-38 is a complete flight service package. The drone aircraft are supplied, maintained and operated (flown and tracked) by Northrop Ventura personnel allowing military missile crews a maximum amount of operational training at minimum cost. The AQM-38 is a simple low-cost lightweight target launched from jet fighter aircraft and radio-controlled from the ground. Since 1960 it has been deployed against the Nike Ajax, Hercules and Hawk missiles with high performance at high and low altitudes. Its solid-propellant rocket engine is the key structural component. Aluminum honeycomb wings, plastic nose section and aft fuselage are attached to the steel engine case. Luneberg lens passive radar augmenter provides radar cross-section of large aircraft. Provision is made for proximity or miss distance scorer. Northrop Ventura RPTA-1 is the tracking aid system. The integral flight control package including control vanes, is located in the nose section. Recovery after flight is by 2-stage parachutes.

Specifications

Span 5 feet; length 9 feet 8 inches; height 1 foot 6 inches; fuselage 1 foot diameter; guidance Northrop Ventura autopilot with radio command override; powerplant solid propellant rocket.

Performance

Thrust 100 pounds.

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), Navy (MQM-36), and the Air Force as a target for antiaircraft training. Under its general, international designation, KD2R-5, it is presently being used by 18 free world countries. The standard target for worldwide antiaircraft weapons training for many years, it is available with various operational equipment including a speed-up kit, tow darts, altitude hold device, and an 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 aircooled McCulloch engine.

Performance

Speed 175–207 knots; rate of climb 3,060 feet per minute; ceiling 24,000 feet; flight endurance 60 minutes.

BMTS (BALLISTIC MISSILE TARGET SYSTEM)

Prime Contractor: Raytheon Company
Subcontractor: Aerolab Development Company

Remarks

The Ballistic Missile Target System was developed for the Army as an effective, low cost target system for ballistic missile defense studies. The system consists of a modified mobile Terrier launcher, a control center and a target vehicle. The vehicle is composed of 3 stages, the first a Nike M-5 booster, the second either a Cajun or an Apache rocket motor, depending on desired range. Third stage is the payload, which includes augmentation, telemetry, tracking aids, electronic countermeasures equipment, miss distance indicators or other devices. Range, apogee and velocity can be adjusted to produce a variety of targets. There have been two successful flights of approximately 180 miles, the longest overland flights made with an unguided target missile.

Specifications

Length 13.5 feet; length with booster 25 feet; maximum diameter 16 inches; span of wings, 1st stage 5 feet, 2nd stage 2½ feet; launch weight 2,000 pounds; guidance spin stabilized.

Performance

Speed at burn-out 2,000–6,000 feet per second; range 12 to 175 nautical miles.

BIKINI SURVEILLANCE SYSTEM

Prime Contractor: Republic Aviation Division, Fairchild Hiller Corporation

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 only 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

Wing span 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 80–100 miles per hour; service ceiling 10,000 feet; flight duration 30 minutes.

RYAN FIREBEE JET TARGET DRONE (MQM-34D ARMY)–(BQM-34A NAVY, AIR FORCE).

Prime Contractor: Ryan Aeronautical Company

Remarks

Ryan Firebee jet target drone has been modified for multipurpose use, featuring beefed-up payload capability and Towbee targets that are streamed astern Firebee during weapons exercises. Ryan has delivered more than 3,000 Firebee targets to the military services since 1947. The Firebee/Towbee systems have been used extensively at White Sands in support of research and development studies and at McGregor for Hawk missile exercises.

Specifications

Speed 200–600 knots TAS; altitude 50 to 60,000 feet; endurance up to 100 minutes; range more than 1,200 kilometers; payload up to 1,000 pounds; reliability over 7,500 flights; maintainability, high-quality, interchangeable components; mobility, requires only standard military vehicles.

RYAN SUPERSONIC FIREBEE II JET DRONE (XBQM-34E NAVY)

Prime Contractor: Ryan Aeronautical Company

Remarks

The Ryan supersonic Firebee II, XBQM-34E, under development for the Naval Air Systems Command, started its flight test program in 1967 at Point Mugu, California. The new generation Firebee II performs missions in excess of 60,000 feet at speeds exceeding Mach 1.5 and has 5g maneuverability capabilities. The Continental YJ69-T-6 turbojet engine, a modification of the power plant used in the BQM-34A Firebee, develops 1,840 pounds of static sea level thrust to power the XBQM-34E. Firebee II is designed to carry an external fuel pod under its fuselage. After completion of subsonic missions, the pod is jettisoned for higher performance, supersonic flight. Firebee II carries active and passive augmentation as employed in the subsonic Firebee.

Specifications

Supersonic configuration: empty weight 1,317 pounds, gross weight 1,783.2 pounds, useful load includes 160.8 pounds augmentation equipment and 305.4 pounds internal fuel and oil. Subsonic configuration: empty weight 1,375.3 pounds, gross weight 2,241.5 pounds, useful load includes 160.8 pounds augmentation equipment and 705.4 pounds internal and external fuel and oil.

Performance

Sea level speed Mach 1.1; at 50,000 feet Mach 1.8; above 60,000 feet Mach 1.5; 5g capability at altitudes up to 20,000 feet.

TDU-9B BANDITO

Prime Contractor: UNIVAC Salt Lake City, 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.

SATURN V

Contractors: Marshall Space Flight Center, NASA; assembly, NASA; systems engineering and integration, The Boeing Company; S-IC stage, The Boeing Company; S-II stage, Space Division, Aerospace and Systems Group, North American Rockwell Corporation; S-IVB stage, Douglas Missile & Space Systems Division; propulsion, all stages, Rocketdyne Division, Aerospace and Systems Group, North American Rockwell Corporation

Remarks

The superbooster which will send American astronauts to the moon under NASA's Project Apollo/Saturn V is a three-stage vehicle 364 feet tall which is capable of placing a 250,000 pound payload in earth orbit or sending 95,000 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 1,500,000 pounds of thrust in a single chamber. Five such engines, fueled with kerosene and liquid oxygen, give the first stage a launch output of 7,500,000 pounds to start the 6,100,000 pound vehicle on its journey. The lunar mission profile will begin with launching of the Saturn V space vehicle at Cape Kennedy, Florida, with the first stage reaching full thrust three seconds after ignition. S-IC engine cutoff occurs 150 seconds later, placing about 700 tons of equipment toward a low-earth orbit, 50 miles down range at an altitude of approximately 40 miles and at 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. NASA has contracted with The Boeing Company for the assembling of 13 flight and 2 test first stage vehicles.

S-IC STAGE

Prime Contractor: The Boeing Company

Remarks

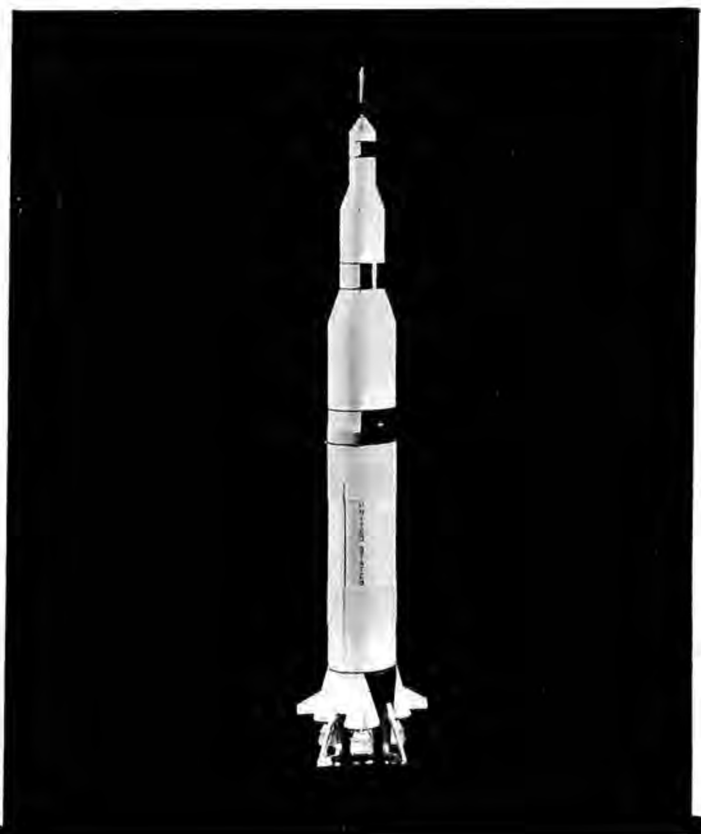
The S-IC is the first stage booster for the Saturn V launch vehicle. Close to 10,000 Boeing employees are working on this largest and most powerful booster stage in the free world at 6 sites in the United States. Most of the major subassembly and vertical assembly tasks are accomplished at NASA's Michoud Assembly Facility in New Orleans. Burning liquid oxygen and kerosene, the S-IC will propel the 3-stage Saturn V and the Apollo spacecraft during the first 2½ 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 are ground test versions. Flight vehicles are now in production.

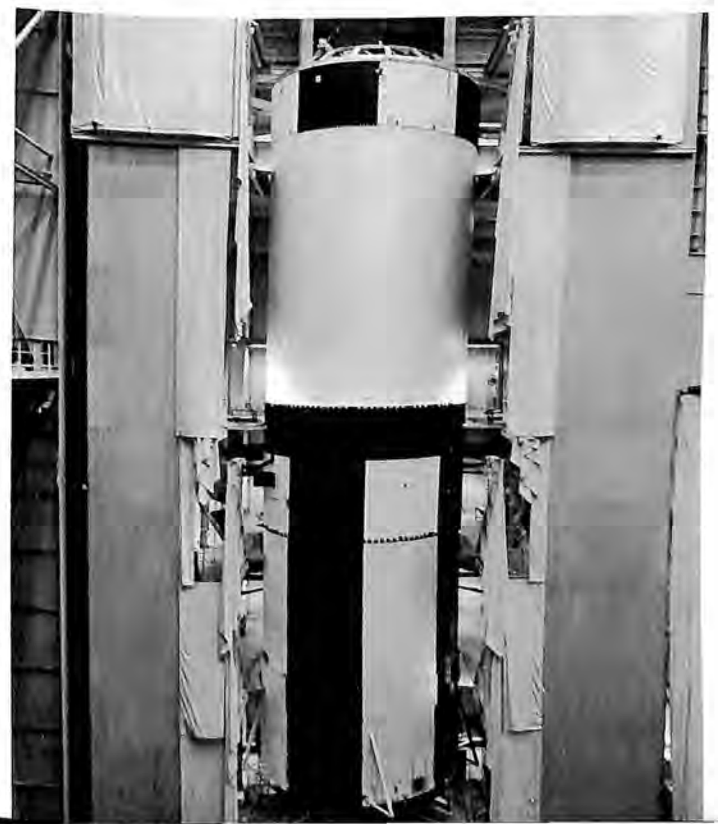
Specifications

Length 138 feet; diameter 33 feet.

Performance

Thrust 7,500,000 pounds, produced by 5 Rocketdyne F-1 engines; lunar voyage firing endurance 150 seconds.





S-II STAGE

Prime Contractor: Space Division, Aerospace and 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 (cryogenic lines); B. H. Hadley (disconnects); W. O. Leonard, Inc. (vent valves); Parker Aircraft Company (hydraulic systems); Solar Division—International Harvester Corporation (cryogenic lines)

Remarks

The S-II is the second stage of NASA's Apollo launch vehicle—the giant Saturn V. Most powerful hydrogen-fueled booster under production, the S-II is destined for Apollo manned lunar missions and will help power 3 Americans 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 200,000 pounds thrust each, the S-II develops a total thrust of 1,000,000 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 81½ feet; diameter, 33 feet; weight, 95,000 pounds empty and 1,037,000 pounds loaded.

Performance

Thrust (combined engines) more than 1,000,000 pounds.

S-IVB STAGE

Prime Contractor: Missile & Space Systems Division, Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)

Remarks

The upper stage of the Saturn V launch vehicle, the S-IVB fires on a lunar voyage after the S-II stage has burned for 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 is also used as the upper stage of the Uprated Saturn I vehicle. Propellant capacity is the same for both versions. 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; diameter 21.7 feet; engine Rocketdyne J-2; propellants liquid oxygen/liquid hydrogen; propellant capacity 230,000 pounds.

Performance

Thrust 200,000 pounds.

UPRATED SATURN I

Contractors: Marshall Space Flight Center, NASA, engineering and systems assembly: first stage (S-IB), Chrysler Corporation Space Division; second stage (S-IVB), Missile & Space Systems Division, Douglas Aircraft Company, McDonnell Douglas Corporation; propulsion first and second stages, Rocketdyne Division, Aerospace and Systems Group, North American Rockwell Corporation

Remarks

The primary mission of the Uprated Saturn I is to launch the Apollo spacecraft into earth orbit for spacecraft testing and development and astronaut training. The 2-stage Uprated Saturn I 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 Douglas SIVB as top stage, in place of the earlier SIV stage. The first 3 of 12 Uprated Saturn Is have been launched successfully.

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) 58.4 feet long, 21.7 feet in diameter.

Performance

The Uprated Saturn I first stage (S-IB) is powered by eight Rocketdyne H-1 engines, each of which produces 200,000 pounds of thrust or a total of 1,600,000 pounds. The second stage (S-IVB) is powered by a single Rocketdyne J-2 engine which generates 200,000 pounds of thrust at altitude. Uprated Saturn I is capable of placing approximately 18 tons in earth orbit and 2.5 tons in lunar orbit.

TITAN III

Program Management: Air Force Systems Command's Space Systems Division of the Space and Missile System Organization (SAMSO)
Major Contractors: Martin Marietta Corporation, Denver Division (systems integration, airframe, flight test); Aerojet-General Corporation (liquid propulsion); AC Electronics Division, General Motors (guidance); United Technology Center (solid propellant boosters); The Ralph M. Parsons Company (launch facilities design and engineering); and Aerospace Corporation (technical direction)

Remarks

Titan III is the nation's heavy-duty military space booster. All propellants are storable for long hold and quick reaction capabilities. Because it utilizes the building-block principle, its weight-lifting capabilities vary from 5,000 to 27,000 pounds into earth orbit, and up to 5,000 on a lunar trajectory. The largest version which has flown to date, Titan III-C (photo), produces a liftoff thrust of 2,400,000 pounds. The Titan III-M configuration has been designated as the Air Force Manned Orbiting Laboratory (MOL) booster.

Specifications

Titan III-C is 127 feet tall with a standard payload fairing; the MOL version will be about 170 feet tall. Diameter of all stages is 10 feet. Weight 1,400,000 pounds.

TITAN III TRANSTAGE

Program Management: Air Force Systems Command's Space Systems Division of the Space and Missile System Organization (SAMSO)
Major Contractors: Martin Marietta Corporation, Denver (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 17 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

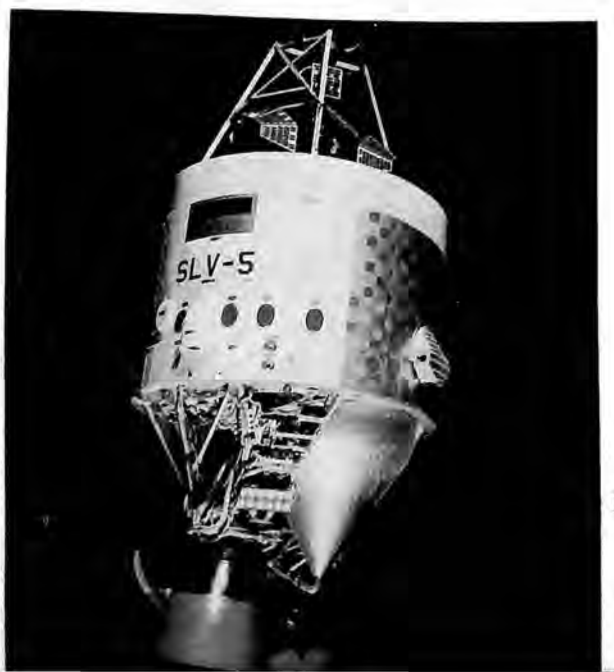
Transtage is 10 feet in diameter; with the standard payload fairing utilized for unmanned missions, it is 33 feet long. Weight, fueled but not including payload, is 28,000 pounds. It is capable of 10 or more starts in space.

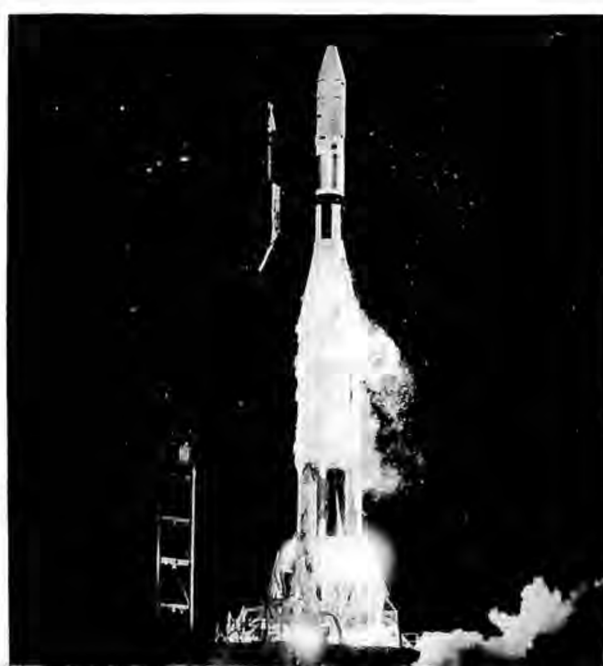
ATLAS SLV-3

Prime Contractor: Convair Division of General Dynamics Corporation
Associate Contractors: Rocketdyne Division, Aerospace and Systems Group, North American Rockwell Corporation; General Electric Company; Acoustica Corporation

Remarks

An uprated version of the reliable and versatile Atlas space launch vehicle, the Atlas SLV-3, is itself now being uprated and identified as the SLV-3A. Fifty-six of the SLV-3s were produced for various National Aeronautics and Space Administration and Air Force missions. Of 52 flown, 50 were successful for an overall booster reliability of 96 percent. These missions included Lunar Orbiter, Orbiting Astronomical Observatory, Orbiting Geophysical Observatory, Gemini Target, Precision Recovery Including Maneuverable Entry, and a variety of special Air Force missions. The last SLV-3 launch, for NASA's Applications Technology Satellite, was scheduled to be launched from the Eastern Test Range, Florida, late in 1967.





SLV-3A AND SLV-3C

Prime Contractor: Convair Division of General Dynamics Corporation
Associate Contractors: Rocketdyne Division, Aerospace and Systems Group, North American Rockwell Corporation; General Electric Company; Acoustica Corporation

Remarks

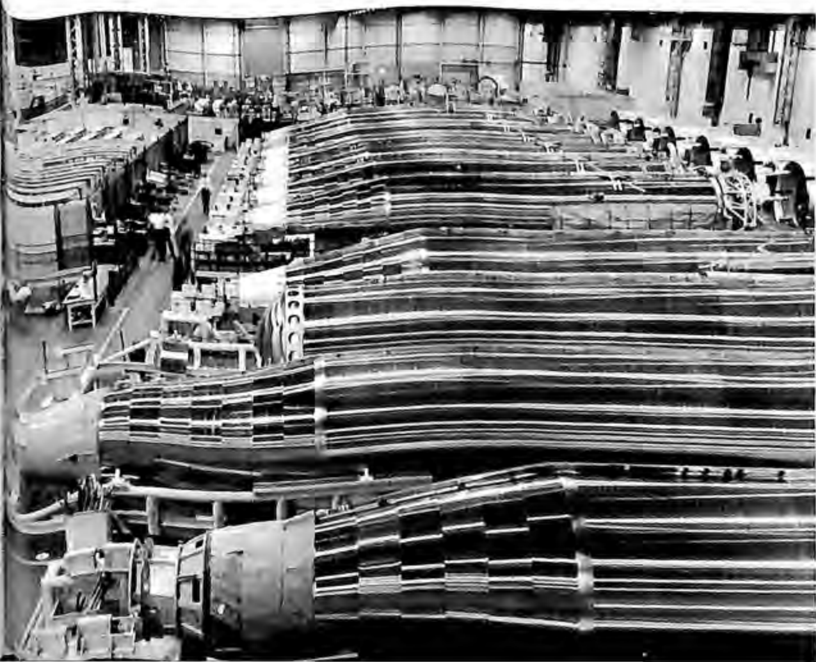
The SLV-3A is an uprated version of the dependable SLV-3 vehicle. Increased performance is achieved by modifying existing systems, thereby retaining the inherent, flight-proven reliability of the SLV-3. The new tank is 117 inches longer, holding about 48,000 pounds more of usable propellants than formerly. 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 is an uprated version of the constant 10-foot diameter LV-3C used to launch Centaur upper stage. The first uprated SLV-3C was flown as Atlas-Centaur 13 for the Surveyor V 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 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 launched from the Eastern Test Range can carry a 2,900-pound payload to escape or a 2,200-pound payload to Venus or Mars. In photo, SLV-3A (foreground) and SLV-3C (second from front).

CENTAUR

Prime Contractor: Convair Division of General Dynamics Corporation
Associate Contractors: Pratt and Whitney Aircraft Division of United Aircraft Corporation (main propulsion system); Honeywell Inc. (all-inertial guidance system); Pesco Products Division of Borg Warner Corporation and General Electric Company (hydrogen boost pumps); Bell Aerospace Corporation (hydrogen peroxide, ullage, and attitude-control system)

Remarks

Now operational, Centaur is a high-energy upper stage currently using an Atlas first stage of similar diameter and construction. Centaur's primary mission is Surveyor, designed to soft-land instruments on the moon prior to manned landings. Centaur is a high-specific impulse vehicle powered by two 15,000-pound-thrust liquid hydrogen and liquid oxygen engines. Centaur is 46 feet long with its nose fairing, and weighs about 37,500 pounds at launch. Centaur weight in orbit is about 5,000 pounds. 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 2,500 pounds to escape with an Atlas first stage, 3,200 pounds using a Titan III-X first stage, and 10,400 pounds to escape atop a Titan III-C booster. Using a Saturn IB in combination with Centaur, 13,500-pound payloads can be boosted to escape velocity.



THOR, LONG TANK THOR

Prime Contractor: Missile and Space Systems Division, Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)
Associate Contractors: Rocketdyne Division, Aerospace and Systems Group, North American Rockwell Corporation (liquid propulsion); Thiokol Chemical Corporation (solid propulsion); Western Electric (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) where the predecessor was conical; total thrust is essentially the same as that for the Thrust Augmented Thor, but Long Tank Thor gets its increased payload from a burn time of 216 seconds compared with 146 for the earlier Thor. In photo, Long Tank Thor at right, standard model left.

Specifications (Long Tank Thor)

Length 70½ 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.

DELTA

Prime Contractor: Missile & Space Systems Division, Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)
Associate Contractors: Aerojet-General Corporation (propulsion system, second stage); Rocketdyne Division, Aerospace and Systems Group, North American Rockwell Corporation (first-stage propulsion); Allegany Ballistics Laboratories (third-stage propellant motor); Western Electric (first and second stage guidance)

Remarks

The Delta launch vehicle is an economical and extremely accurate three-stage vehicle used in launching spacecraft packages on space-probe and earth-orbital missions. Its first stage is a modified Thor rocket. Its first two stages are liquid propellants; a solid propellant is used in the third. With a reliability record of more than 90 percent, Delta has lifted the majority of the nation's scientific and communications satellites, including the Tiros, OSO, Explorer, Telstar, Relay and Syncom payloads. Improved Delta, with larger second stage, was introduced in 1965.

Specifications (DSV-3C model, the standard Delta)

Length 93 feet 2 inches; 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). Improved Delta has 92-foot length, 149,606-pound weight.

Performance

Payload 875 pounds in a 500-nautical-mile circular orbit.

THRUST AUGMENTED DELTA

Prime Contractor: Missile & Space Systems Division, Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)
Associate Contractors: Aerojet-General Corporation (second stage propulsion); Rocketdyne Division, Aerospace and 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 has launched the Syncom C satellite that relayed on-the-spot television pictures of the Olympic Games from Japan to the U.S. and the Communication 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.

THRUST AUGMENTED IMPROVED DELTA

Prime Contractor: Missile & Space Systems Division, Douglas Aircraft Company (A Component Company of McDonnell Douglas Corporation)
Associate Contractors: Aerojet-General Corporation (second stage propulsion); Rocketdyne Division, Aerospace and Systems Group, North American Rockwell Corporation (first stage propulsion); Thiokol Chemical Corporation (strap-on propulsion)
Subcontractor: United Technology Center, Division of United Aircraft Corporation (third stage propulsion)

Remarks

The Thrust Augmented Improved Delta (TAID), introduced in 1965, is an advanced version of earlier Delta models, incorporating features and performance that meet the demand of current and future space progress requirements. Adaptable either as a 2-stage or 3-stage vehicle, the TAID can carry a wide range of spacecraft, including communications satellites, specialized scientific capsules, navigation, meteorological, experimental and other types of payloads into near earth orbits, moon orbits or on into deep space. The TAID, both as a 2-stage or a 3-stage vehicle, 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; liftoff weight (with solid boosters) 149,461 pounds; thrust 333,000 pounds (first stage), 7,900 pounds (second stage), 5,650 pounds (third stage).

Performance

Payload 1,120 pounds in a 500-nautical-mile circular orbit.

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

The Scout is a 4-stage, solid-fueled rocket developed to provide the United States with a reliable, versatile and 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 and Space Company
Associate Contractors: Bell Aerosystems (primary and secondary power plants); Honeywell Inc. (guidance)

Remarks

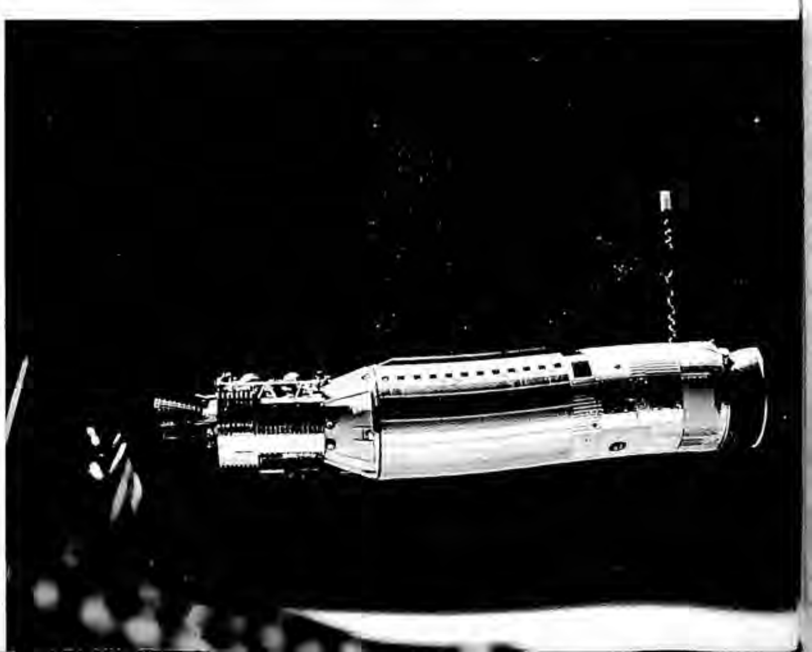
One of the real workhorses of U. S. space exploration, Agena is an upper stage which is also employed as a spacecraft, the whole vehicle going into orbit. Agena played a key role in manned space flight; it was the target vehicle for rendezvous and docking maneuvers in NASA's Gemini project. Agena has a main rocket engine capable of multiple re-starts 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 and Orbiting Astronomical Observatory. In photo, Gemini Standard Agena with astronauts Schirra and Stafford.

Specifications

Length 19–40 feet depending on version; Gemini version 25 feet; diameter 5 feet; all-inertial guidance.

Performance

Thor/Agena 1,500-plus pounds in earth orbit; 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 & Co. (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 is readily adapted for use on the complete range of standard launch vehicles. Its general assignment will be to place small- and medium-size payloads into 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. Four 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 U.S. Army Corps of Engineers by the 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 (SESP) 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. Several studies have indicated the feasibility of using Burner II as an upper stage for NASA deep space probes.

ATHENA REENTRY TEST VEHICLE

Prime Contractor: Atlantic Research Missile Systems Division
Associate Contractors: Propulsion: Thiokol Chemical Corporation, 1st stage; Thiokol & Hercules Incorporated, 2nd stage; Aerojet-General Corporation, 3rd stage; Hercules Incorporated, 4th stage; Atlantic Research, spin rockets; Hercules, boost-assist motors and retro motors.

Remarks

The Athena reentry vehicle, conceived to simulate the reentry evironment of intercontinental ballistic missiles, 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 this country's first inland range for the overland test of multi-stage 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 on White Sands, New Mexico, some 470 miles downrange. The Army's highly instrumented range had monitored 85 flights by the end of August 1967, in a program of 149 launchings scheduled through 1969. The program is under the direction of the Space & Missile Systems Organization (SAMSO), Air Force Systems Command.

Specifications

Four stages, all solid propelled; overall length 50 feet; diameter 31 inches; weight 16,000 pounds at launch; unguided boost, mid-course correction.

Performance

Speed in excess of 15,000 miles per hour at reentry; range more than 470 miles; ceiling in excess of 1,000,000 feet. Is successfully yielding high degree of reentry space physics data and sub-scale systems test data.

APOLLO

Prime Contractor: North American Rockwell Corporation's Space Division

Major Subcontractors: Aerojet-General Corporation (service module propulsion engine); Aeronca Manufacturing Company (honeycomb panels); Avco Corporation (ablative heat shield); Beech Aircraft Corporation (super critical gas storage system); Bell Aerosystems 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 Victory Company (main communications antenna systems); Electro-Optical Systems, Inc., Micro Systems, Inc. subsidiary (temperature and pressure transducer instrumentation); Garrett Corporation, AiResearch Manufacturing Division (environmental control system); General Motors Corporation (fuel and oxidizer tanks); General Precision, Inc. (mission simulator trainer); General Time Corporation (central timing system); Honeywell (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 Corporation (reaction control motors service module); Northrop Corporation (earth landing system); Remanco, Inc. (rocket engine test set); Sciaky Bros., Inc. (tooling, welding and machinery); Simmonds Precision Products (propellant gaging 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, Aerospace Electrical Division (static inverter conversion unit); Webber Aircraft (spacecraft couches).

Remarks

Project Apollo is the United States' program to place Americans on the moon for scientific exploration and safe return to earth. The Apollo program is directed by the National Aeronautics and Space Administration. Technical management of the Apollo Spacecraft is under NASA's Manned Spacecraft Center, Houston, Texas. The Apollo spacecraft comprises 3 separable major parts called "modules" which are fastened together in tandem. North American Rockwell's Space Division is producing the Apollo spacecraft Command and Service Modules. The Lunar Module is being built by Grumman Aircraft Engineering Corporation. The Command Module is the Apollo spacecraft's control center for the moon flight. It provides combination living, working and leisure time quarters for the 3-man crew. The Command Module consists of 2 shells—an inner crew compartment and an outer heat shield. Ablative materials are applied to the outer structure after it has been assembled and fit-checked to the crew compartment.

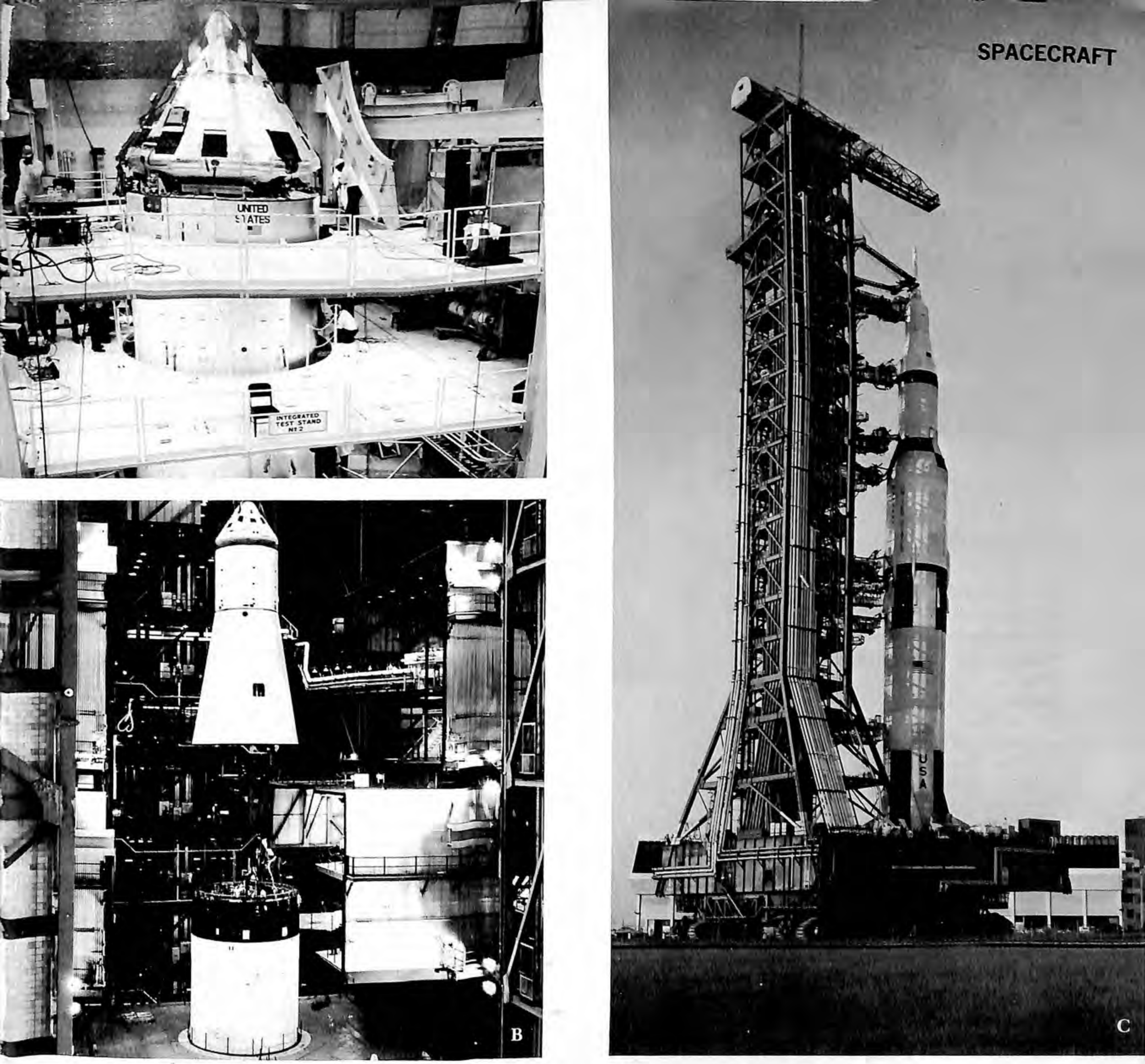
The Service Module houses the main propulsion motor and its propellants for return from the moon and for midcourse corrections. It contains the electrical system, reaction control engines and part of the environmental control system. Propellants and various sytems are housed in pie-shaped sections surrounding the main engine. Attached to the Command Module during the flight to the moon, the Service Module is jettisoned prior to earth reentry.

Command Module Specifications

Shape conical; height 12 feet; diameter (at the base) 13 feet; launch weight 13,500 pounds (approx.); outer structure: stainless steel honeycomb bonded between stainless steel alloy sheets; inner compartment; primarily aluminum honeycomb bonded between aluminum alloy sheets; insulation: a two-layer microquartz fiber insulation separates the walls of the inner and outer structures; environment: shirt-sleeve temperature of about 75 degrees, and 100 percent oxygen.

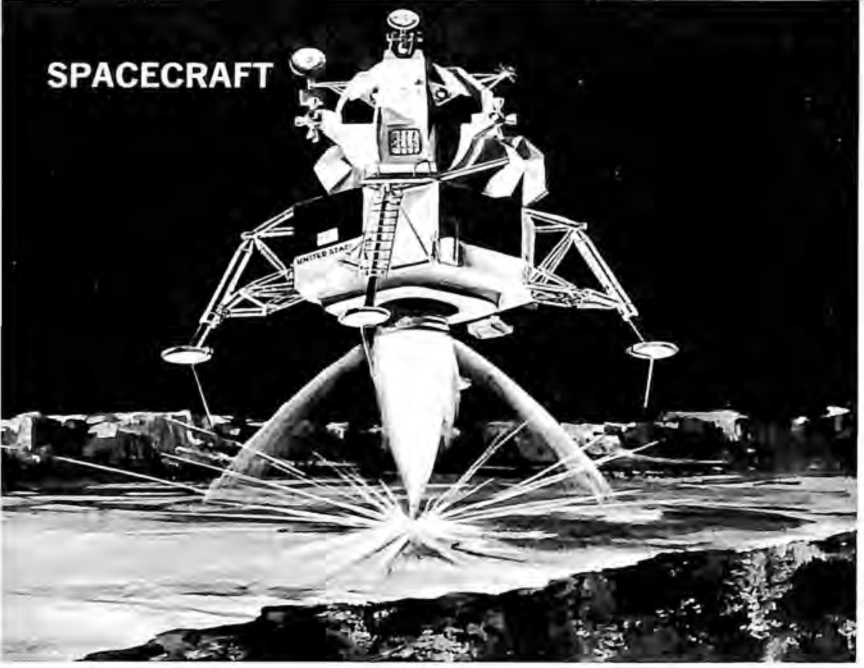
Service Module Specifications

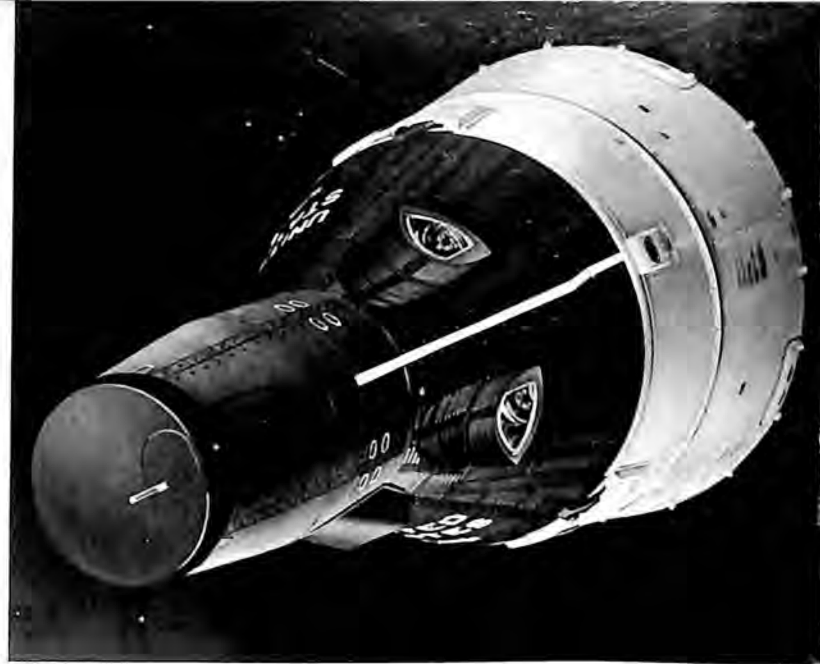
Shape cylindrical; height 22 feet (including engine); diameter 13 feet; construction: mostly aluminum alloy; the outside skin is honeycomb bonded between aluminum sheets; launch weight 50,000 pounds (approx.).



APOLLO 4. NASA's Apollo program got its greatest impetus to date from a "textbook" mission designated Apollo 4. The flight marked the introduction of the Saturn V launch vehicle and also provided the first deep space tests of the Apollo spacecraft. Highlight of the flight was a spacecraft reentry at lunar return velocity, an important test of the heat shield. Photos show mission preliminaries: A, the Command and Service Modules, mated to the Lunar Module Adapter, undergo checkout; B, spacecraft and adapter are mated to the S-IVB third stage; C, the complete Saturn V/Apollo "stack" is transported from assembly building to Pad 39A.

SPACECRAFT





LUNAR MODULE

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

The Lunar Module is a 2-stage vehicle to be used by Project 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 without any aerodynamic considerations imposed upon its structural design, LM lands by use of a main descent engine which is throttleable and capable of developing 10,600 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 either in the automated mode, utilizing a landing radar as the sensing device and a computer to update engine thrust, or can be controlled by the astronauts completely, or in conjunction with the vehicle's automated devices. Its landing gear consists of 4 padded legs. The lower portion of the legs telescopes into the upper portion, crushing a honeycomb structure designed to absorb the energy of the landing impact. When LM is ready to return to the Command Module its 3,500 pounds thrust ascent engine carries the ascent stage into lunar orbit, leaving the descent stage parked on the lunar surface.

Specifications

Height 21 feet; width 19 feet; weight more than 15 earth tons.

GEMINI

Prime Contractor: McDonnell Astronautics Company, McDonnell Douglas Corporation
Associate Contractors: Honeywell Incorporated (guidance); Westinghouse Electric Company (rendezvous radar); International Business Machines Corporation (computer); AiResearch Division, The Garrett Corporation (environmental control system); Beech Aircraft Corporation (propellant loading systems); Rocketdyne Division, Aerospace and Systems Group, North American Rockwell Corporation (spacecraft propulsion); General Electric Company (fuel cell)

Remarks

Gemini is a 2-man spacecraft designed for long-duration space physiological studies and development of rendezvous and docking techniques. Gemini's environmental control system is capable of sustaining 2 astronauts for 2 weeks. The spacecraft has 2 sections, a reentry module housing the astronauts and an adapter section for equipment. The reentry module is 11 feet tall, the adapter unit 7½ feet tall. Spacecraft launch weight is approximately 7,000 pounds. On-board thrusters permit maneuvering for rendezvous and docking missions. McDonnell built 13 flight-rated spacecraft; 12 of them were used (10 manned) in NASA's 1964–66 Project Gemini. The spacecraft was scheduled for further use, in a modified version, in the USAF's Manned Orbiting Laboratory project.

MANNED ORBITING LABORATORY

Major Contractors: General Electric Company (experiment integration); McDonnell Douglas Missile & Space Systems Division (laboratory module); McDonnell Astronautics Company (Gemini B spacecraft)

Remarks

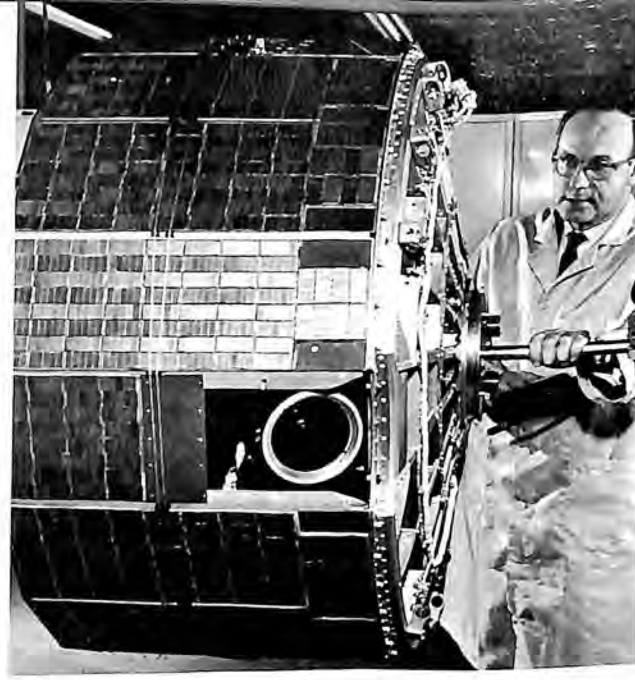
The U.S. Air Force Manned Orbiting Laboratory (MOL) program is the largest Department of Defense space program. Its objectives are to learn more about what man is able to do in space and how that ability relates to defense requirements; to develop technology and equipment which will help advance manned and unmanned space flight; and to experiment with this technology and equipment. The program was begun August 25, 1965. Initial work has been completed and the program is now in the engineering development phase. The baseline configuration has been established, consisting of the Gemini B, a 41-foot laboratory vehicle, and the Titan III booster. First flight by a 2-man crew is planned for 1970. The MOL crews will be launched into orbit inside a Gemini B spacecraft. A modified version of the vehicle used in the NASA Gemini Program, the booster, designated Titan III-M, is an uprated Titan III-C. It will use a pair of 7-segment, solid rocket strap-on motors in place of the 5-segment motors used on the Titan III-C. In orbit, the pilots will transfer into the Laboratory through a hatch in the Gemini B heat shield and a pressurized tunnel. The laboratory is designed to allow them to work in a "shirt-sleeve" environment, without space suits, for up to 30 days. For return to earth, they will go back into the Gemini B, detach it from the laboratory and reenter the atmosphere for an ocean landing and recovery. The laboratory itself will burn up upon reentry. A considerable amount of NASA-developed capabilities will be used in the MOL program.

BIOSATELLITE

Prime Contractor: General Electric Company, Re-Entry Systems Department
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. The National Aeronautics and Space Administration's Ames Research Center selected General Electric to develop and build the Biosatellite vehicles. The Biosatellite 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. Advanced missions of 21 and 30 days are planned. All payloads will be recovered. Payload weights range from 940 to 1,500 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 re-entry. Initial 3-day flight was made in December 1966, but payload was not recovered. A second 2-day flight in September 1967 was highly successful; payload was recovered by USAF air snatch.



NIMBUS

Prime Contractor: NASA, Goddard Space Flight Center
Major Subcontractor: General Electric Company, Missile and Space Division, Spacecraft Department
Associate Contractors: Aracon Geophysical Division, Allied Research Associates, Inc.; California Computer Products, Inc.; Collins Radio Company; Control Data Corporation; General Electronics Labs, Inc.; Hughes Aircraft Company; ITT; Lockheed Electronics Company; RCA; Raymond Engineering Laboratory, Inc.; Texas Instruments, Inc.

Remarks

Nimbus is a second generation research and development weather satellite developed by the National Aeronautics and Space Administration Goddard Space Flight Center. The windmill shaped spacecraft is approximately 10 feet tall and 11 feet wide and is capable of carrying a wide range of meteorological, geophysical and other scientific payloads. Nimbus I was launched into orbit on August 28, 1964, and exceeded all expectations both as a research vehicle and as a storm tracker. Nimbus II, an advanced version of the first Nimbus, was orbited on May 15, 1966, and has established a record lifetime for an earth orbiting spacecraft. Nimbus III, a further improved version, weighing some 1,350 pounds (500 pounds more than the first Nimbus), will carry 2 SNAP 19 radioisotope thermal generators for electric power in addition to its normal solar power supply. All Nimbus spacecraft are earth oriented and stabilized in all 3 axes. The Thor Agena booster is used to launch the Nimbus spacecraft into polar orbit.

TIROS

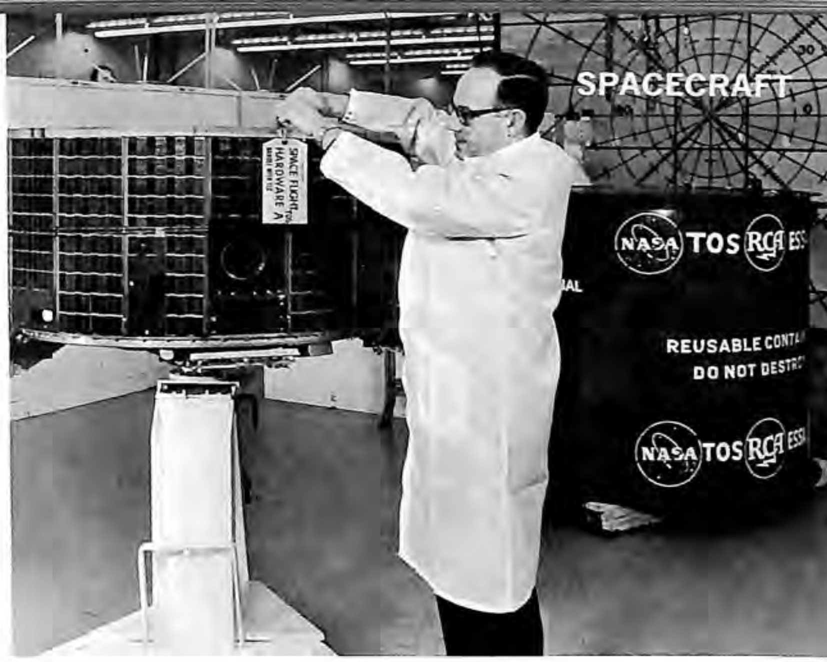
Prime Contractor: Radio Corporation of America, Defense Electronic Products, Astro-Electronics Division

Remarks

One of the most successful of all U.S. space programs, Tiros is a meteorological satellite designed to provide weather forecasters with complete information on which to base predictions. Equipped with TV cameras and infrared equipment, Tiros takes photos of the earth's cloud cover and relays them to earth stations for Weather Bureau analysis. Newest version is the Tiros "wheel," which can be maneuvered to roll in orbit like a drum rolling downhill; its 2 TV cameras are positioned radially so that with each half turn of the wheel either camera will look down at earth.

Specifications

Diameter 42 inches; weight approximately 300 pounds.



TIROS M

Prime Contractor: Radio Corporation of America, 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 will be in 1969, with the initial operational spacecraft, identified as an Improved TOS (ITOS), slated for 1970. One TIROS M will carry both Automatic Picture Transmission (APT) systems for direct readout of local weather pictures and Advanced Vidicon Camera Systems (AVCS) to give scientists global coverage. A stable platform that will keep its sensors always pointed toward earth, TIROS M will also carry high resolution infrared radiometers for nightime views of cloud cover plus 2 secondary sensors, a flat-plate radiometer and a solar proton monitor. Basically, TIROS M and ITOS will enable one satellite to 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

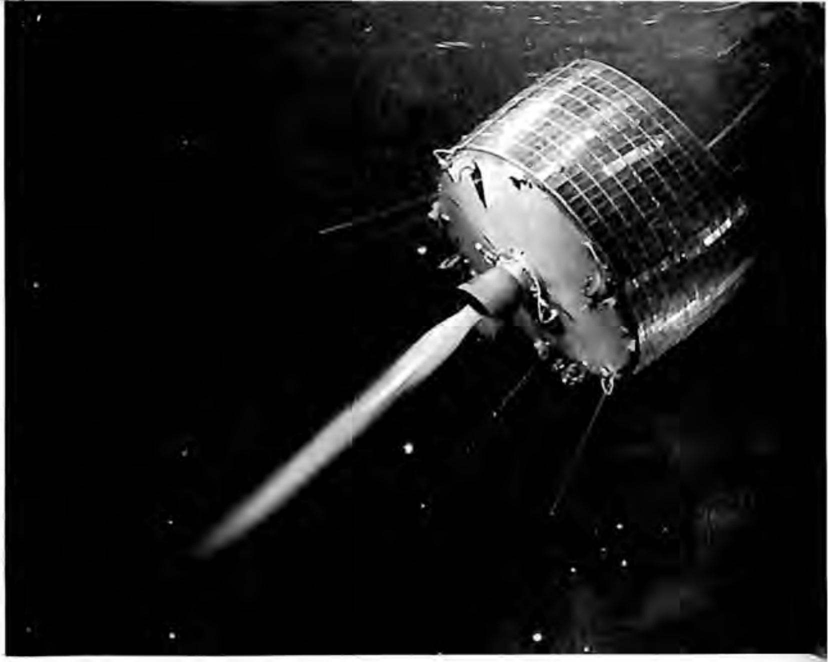
Prime Contractor: Radio Corporation of America, Defense Electronic Products, Astro-Electronics Division

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 successfully launched 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; it also operates in a wheel mode. ESSA 4 (APT), ESSA 5 (AVCS) and ESSA 6 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 diameter, 22.5 inches high; weight 325 pounds.



EARLY BIRD

Prime Contractor: Hughes Aircraft Company

Remarks

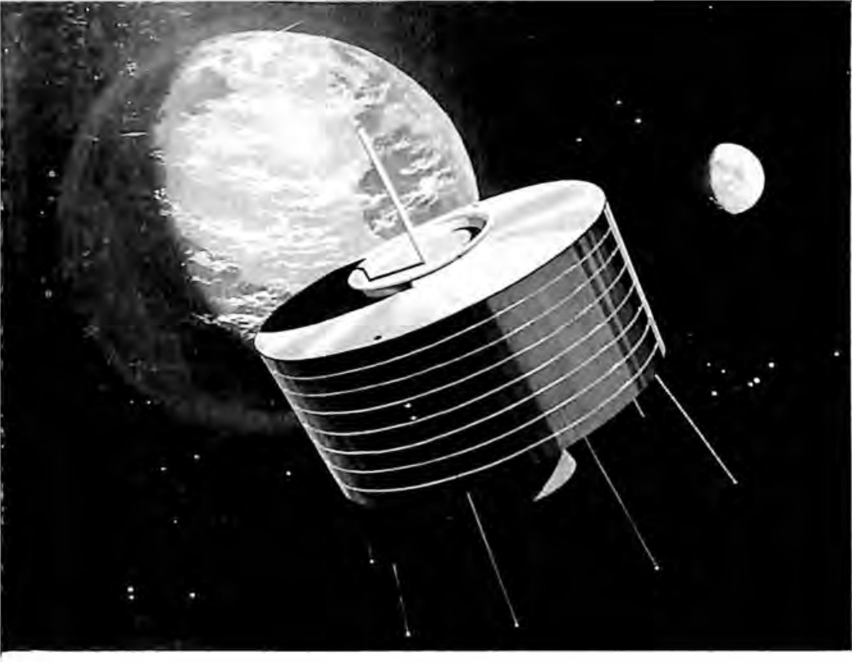
A synchronous communications satellite, Early Bird was launched April 6, 1965, by the U.S. Communications Satellite Corporation as agent for a world consortium of more than 40 participating nations. The satellite was injected into a synchronous orbit 22,300 miles above the equator over the Atlantic Ocean. The 85-pound spacecraft has capacity for 240 two-way telephone channels or simultaneous two-way television between Europe and North America on a 24-hour basis. It can also handle teletype and facsimile at the same time it carries telephone conversations. Power is supplied by some 6,000 solar cells. The satellite is a later version of the NASA-Hughes Syncom.

SYNCOM

Prime Contractor: Hughes Aircraft Company

Remarks

A second-generation active-repeater communications satellite, Syncom is a synchronous orbiting spacecraft, one whose orbital speed just matches 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, more than a third of the earth can be "seen," so three such spacecraft can form a TV-telephone network providing 24-hour service. Syncom I, launched February 14, 1963, was unsuccessful. Syncom II, launched July 26, 1963, was completely successful and was the first spacecraft to achieve synchronous orbit. Syncom III, launched August 19, 1964, was placed in stationary orbit over the International Date Line and it relayed the Olympic Games to the U.S. from Japan.



INTELSAT II

Prime Contractor: Hughes Aircraft Company

Remarks

Intelsat II is a new communications satellite designed to provide the first regular transpacific communications by satellite and at the same time to provide communications support for the Apollo program. Hughes is building 4 spacecraft under an $11,700,000 contract awarded by Communications Satellite Corporation, which acts as manager for the 54-nation International Telecommunications Satellite Consortium. Intelsat II is twice the size and weight of Hughes' Early Bird and it has 3 times the power. Where Early Bird's antenna concentrated its beam in a narrow band between Europe and the United States, Intelsat II offers broader antenna coverage over a wider global area and the ability to carry multiple conversations among ground stations simultaneously. Three of the satellites are now in commercial service, 2 over the Pacific and one over the Atlantic.

Specifications

Diameter 56 inches; height 26 inches.

INTELSAT III

Prime Contractor: TRW Systems Group of TRW Inc. for Communications Satellite Corporation (COMSAT)
International Participants: Contraves AG, Switzerland; Engins MATRA SA, France; Entwicklungsring Nord (ERNO), West Germany; Hawker Siddeley Dynamics, Ltd. (HSD); ITT Federal Laboratories, United States; Mitsubishi Electric Corporation (MEC), Japan; Société Anonyme de Telecommunications (SAT), France; Sylvania Electronic Systems, United States; Lockheed Aircraft Corporation, United States.

Remarks

Intelsat III will be the first wholly commercial communications satellite system to operate on a global scale. TRW will build 6 flight spacecraft for initial operational use in 1968. Each satellite will handle a minimum of 1200 2-way voice channels, or 4 high-quality television channels. The spin-stabilized spacecraft will be positioned at synchronous orbit (22,300 miles) over the Pacific, Atlantic and Indian oceans, as required. They are 56 inches in diameter, 37 inches high and weigh about 250 pounds, not including the apogee motor.

INITIAL DEFENSE COMMUNICATIONS SATELLITE PROGRAM (IDCSP)

Prime Contractor: Space and Re-Entry Systems Division, Philco-Ford Corporation

Remarks

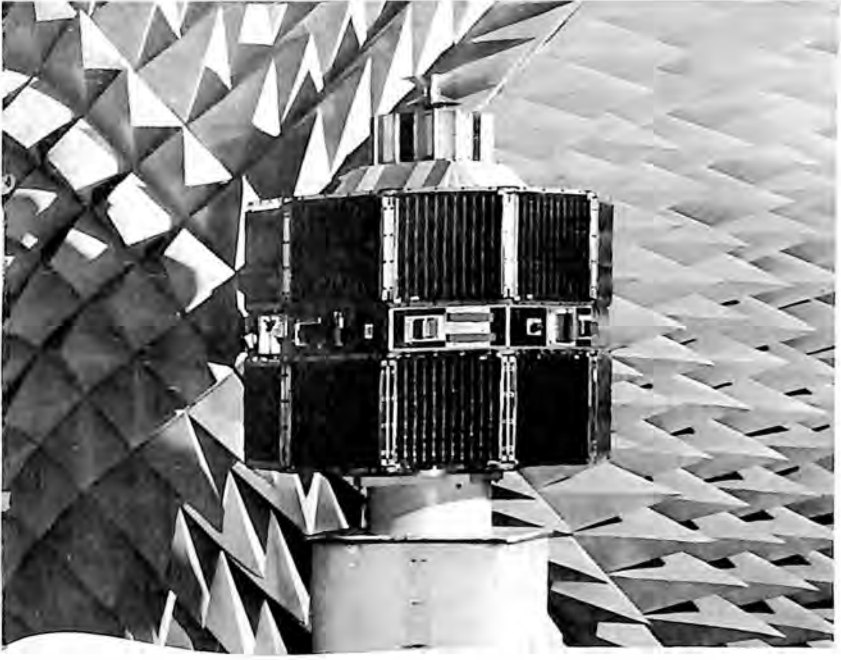
In late October 1964, Philco-Ford Corporation was assigned prime contractor responsibilities to design, develop and assemble both the satellites and the miltiple-launch dispensers for the Initial Defense Communications Satellite Program (IDCSP). Under the overall direction of the Defense Communications 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 III-C rocket launched 7 IDCSP 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.

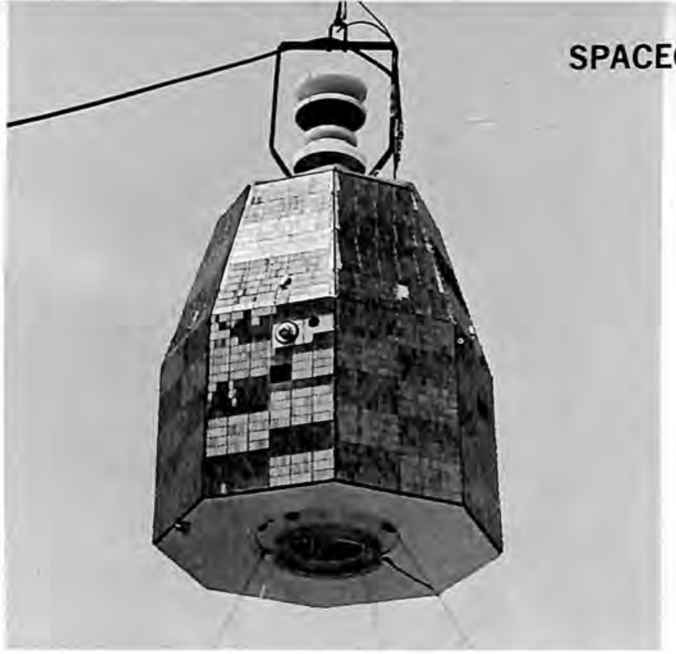
TACTICAL COMSAT

Prime Contractor: Hughes Aircraft Company

Remarks

As part of an Air Force program aimed at eventual development of a military tactical communications system to complement the IDCSP system now in operation, Hughes is building the largest experimental comsat ever constructed. The satellite features a unique antenna array extending from the top of the drum-shaped spacecraft. The 5-element antenna array consists of UHF antennas, each nearly 8 feet long. Beneath them (photo) are 2 microwave horns. At the extreme top is a bi-conical horn used for telemetry and command. The satellite will be spin-stabilized, with the solar panels rotating while the antennas and inner structure remain in a fixed position.





LINCOLN EXPERIMENTAL SATELLITES (LES)

Prime Contractor: Massachusetts Institute of Technology Lincoln Laboratory

Remarks

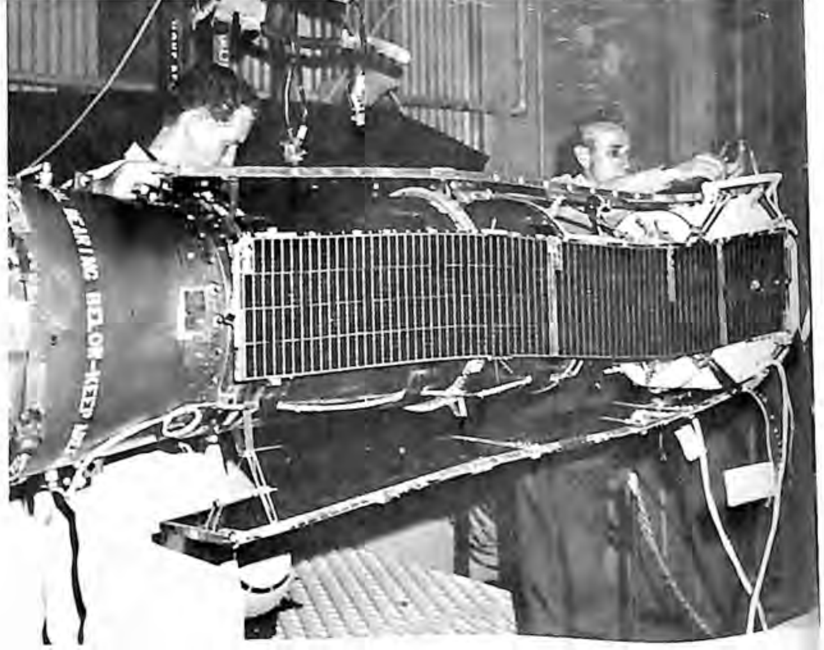
The LES (Lincoln Experimental Satellite) spacecraft are designed and built by the M.I.T. Lincoln Laboratory in Lexington, Massachusetts, as part of the Laboratory's Air Force-sponsored program in space communications, to test realistically, in orbit, new devices and techniques being developed for possible use in satellite communication systems. LES-5, the latest in the series, launched July 1, 1967, is designed primarily to aid in the development of a tactical satellite communication (TACSATCOM) system for the Department of Defense. It has been used for the first communications by satellite among Army, Navy, and Air Force units, including aircraft in flight, submarines and surface vessels, and a variety of ground terminals. LES-5 is the first communication satellite to operate entirely in the government-allocated UHF-band (225–400 MHz), and it carries the first UHF-band satellite antenna system that generates circularly polarized radio signals, to minimize fading and communication drop-outs and to allow a surface terminal to use a very small, simple antenna such as a whip or stub monopole. LES-3, a UHF-band radio signal generator launched in December 1965, helped to establish design criteria for LES-5. LES-1, -2, and -4 (photo), also launched in 1965, operated at X-band (approximately 8,000 MHz) and successfully tested a number of important new devices and techniques, including the first all-solid-state communication satellite transmitters and the first "electronically despun" (earth-sensing and antenna-beam-switching) systems to increase the effective radiated power from the satellite.

RELAY

Prime Contractor: Radio Corporation of America

Remarks

Relay is a communications satellite of the active-repeater type, in which signals from one ground station are picked up and rebroadcast to another station by the satellite's internal equipment. A NASA project, Relay is a 172-pound, spin-stabilized spacecraft boosted by a Delta launch vehicle. The first Relay satellite was launched December 13, 1962, and it remained operational for more than 2 years. Relay 2, launched January 21, 1964, was used in thousands of tests and experiments and in some 40 public demonstrations through September 1965.



TELSTAR

Prime Contractor: American Telephone and Telegraph Company, management by Bell Telephone Laboratories

Remarks

The first active-repeater communications satellite, Telstar demonstrated the feasibility of transmitting television images, telephone, telegraph and radio messages on a global basis. Launched by a Delta booster, Telstar first went into orbit on July 10, 1962. Telstar II was orbited on May 7, 1963. Both satellites were highly successful. NASA provided launch vehicles and tracking facilities on a reimbursable basis.

EROS (EARTH RESOURCES OBSERVATION SATELLITE)

Program Direction: Department of the Interior and National Aeronautics and Space Administration

Remarks

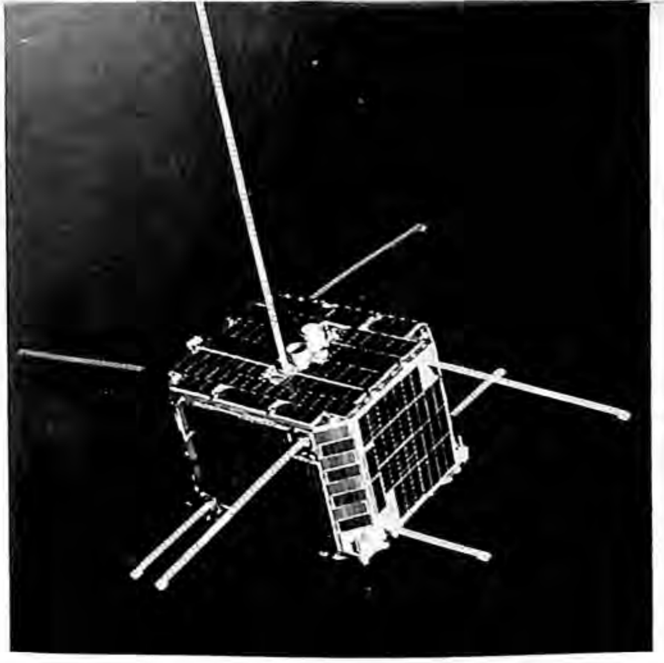
The Department of the Interior has announced Project EROS aimed at gathering facts about the earth's natural resources by means of instrumented spacecraft. Late in 1967 the project had not been approved for hardware status. Radio Corporation of America reported that it was feasible to build an EROS satellite that could be operational by 1969 for launch into a 300-mile, near-polar, synchronous orbit to permit continuous observation of the United States (or the world) under constantly favorable illumination conditions.

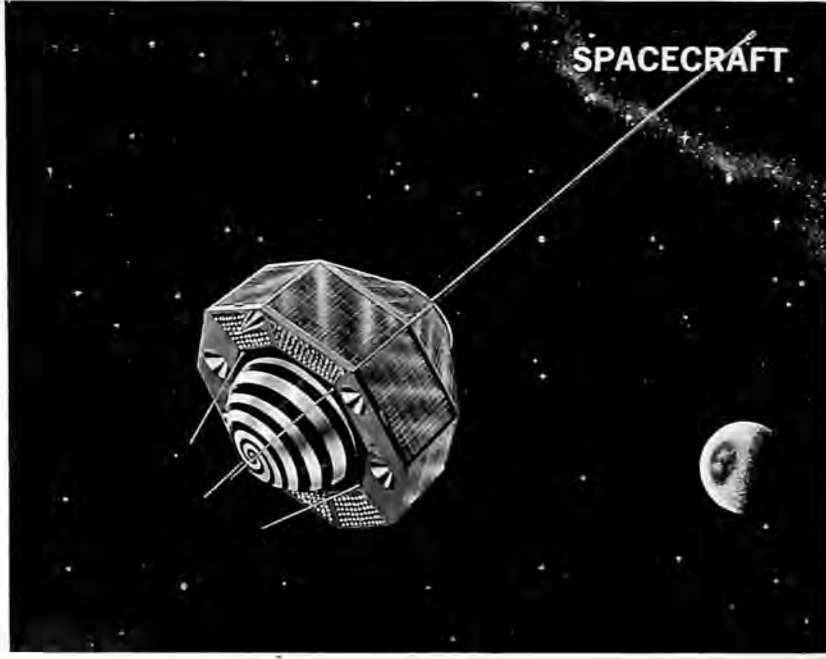
U.S. NAVY NAVIGATION SATELLITE (TRANSIT) (OSCAR)

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory
Associate Contractor: Radio Corporation of America—Moorestown

Remarks

In July 1964, the Navy put into operational service a system of navigational satellites for precision position determination of Polaris missile submarines and surface vessels. The system consists of 4 satellites, each weighing less than 100 pounds, in near-circular orbits at 600 miles altitude. The satellites, once known as Transit, are launched by the Scout booster. A number of operational navigation satellites (known as Oscar) have been launched to enhance the Navy's world-wide all-weather navigation system being used operationally by the fleet (in photo, OSCAR 09, launched by a 4-stage Scout May 19, 1966). The satellite is an octagonal prism, 18 inches across and 10 inches high with 4 blades of solar cells, 66 inches long and 10 inches wide. The 144-pound satellite carries 2 transmitters for telemetering, doppler signals and memory read-out. All of the OSCAR spacecraft employ electromagnetic and gravity gradient stabilization systems. Each also has a memory system for storing advance orbital data. Pulse signals in the memory system provide the satellites with a digital clock. Launched into polar orbits, at a general inclination of 90 degrees to the equator, the Oscar satellites circle the Earth at altitudes from 450 to 600 miles. RCA—Moorestown is responsible for manufacture of operational satellites.





GEODETIC SECOR SATELLITE SURVEYOR

Prime Contractor: Cubic Corporation

Remarks

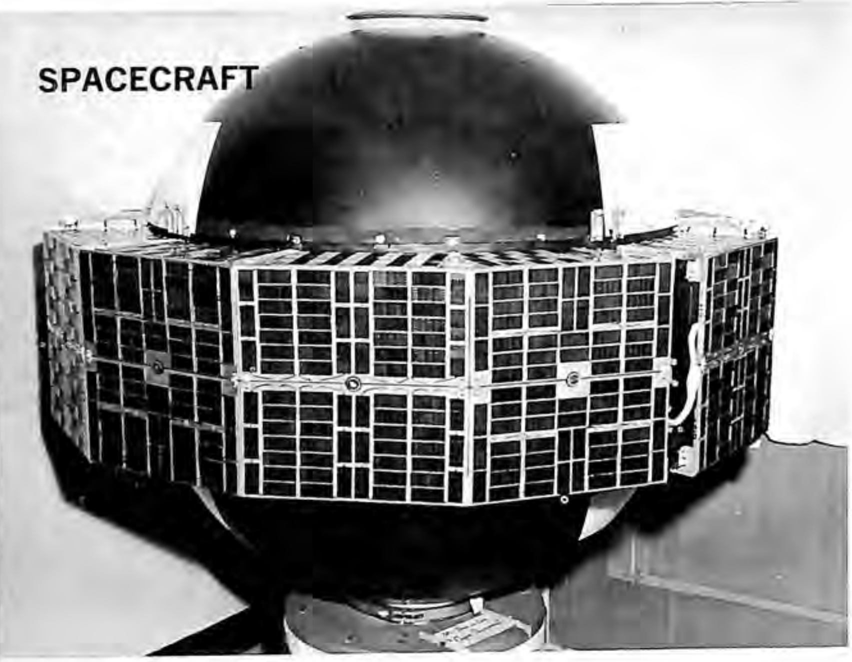
Geodetic SECOR (Sequential Collation of Range) is an all-weather geodetic survey system which has been in operational use for 3 years establishing a global survey network. It uses the successive positions of artificial satellites in space to determine locations on the earth's surface with exactness over 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 time is fixed by the measured ranges from the 3 known stations. Using these 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 presently being developed to replace these units. The present satellite has a volume of one cubic foot, weighs approximately 39 pounds and contains a transponder, a telemetry system to monitor temperature and operating voltages, and a power unit comprised of solar panels and batteries.

GEOS-A

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

The primary objective of GEOS-A is to provide global geodetic measurements for determining the positions of fiducial control points on the Earth to an accuracy of 10 meters in an Earth center of mass coordinate system, and to determine the structure of the Earth's gravity field to 5 parts in 10^8. GEOS-A is a 385-pound 52-inch top-shaped satellite. It was launched by the improved Delta rocket. It has an array of 5 geodetic systems—flashing light beacons, radio doppler transmitters, a radio range system, a combined range and range rate system, and a laser reflector. Primary power for the instrumentation is obtained from solar cells that cover most of the exterior of the satellite. The program is directed by NASA's Goddard Space Flight Center. In January 1967, a failure in the satellite's command system rendered several geodetic systems inoperable. Radio doppler measurements and the passive laser reflector experiment were expected to continue indefinitely, however.



ANNA I-B

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

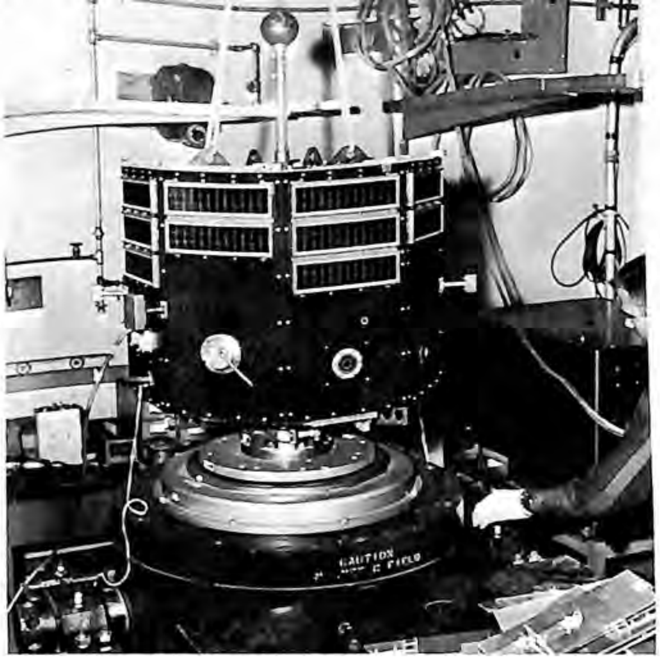
ANNA is a geodetic research satellite with primary missions of measuring the strength and direction of the Earth's gravitational field, locating the center of the Earth's mass and marking off positions on the Earth. ANNA weighs 350 pounds, is 36 inches in diameter and is powered by a band of solar cells around its equator supported by nickel cadmium batteries. A broad band spiral antenna is painted on the sphere, and the instrument tray is centrally mounted on the inside. Named for Army, Navy, Air Force and NASA, its sponsors, ANNA was launched October 31, 1962. The satellite contained optical, radio ranging and radio doppler instrumentation. The optical system is a high intensity optical beacon activated by programmed command to set off a series of 5 light flashes 5.6 seconds apart. These are photographed by ground stations. The Navy doppler frequency system is also still operable on command. Despite deterioration of the satellite's solar cells by the artificial radiation belt, ANNA has provided a large amount of geodetic information and permitted highly accurate positioning of tracking stations relative to the center of the Earth. Findings of the Air Force flashing light and the Navy doppler frequency measurement systems agreed to accuracies of 20 meters or better. The Army's radio-ranging system ceased operation in orbit too early to yield comparative data.

NUCLEAR DETECTION SATELLITES (VELA)

Prime Contractor: TRW Systems Group of TRW Inc.

Remarks

The 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 the 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 launch, with further improvements to the payload, was scheduled for 1968.



EXPLORER SERIES

Program Direction: National Aeronautics and Space Administration

Remarks

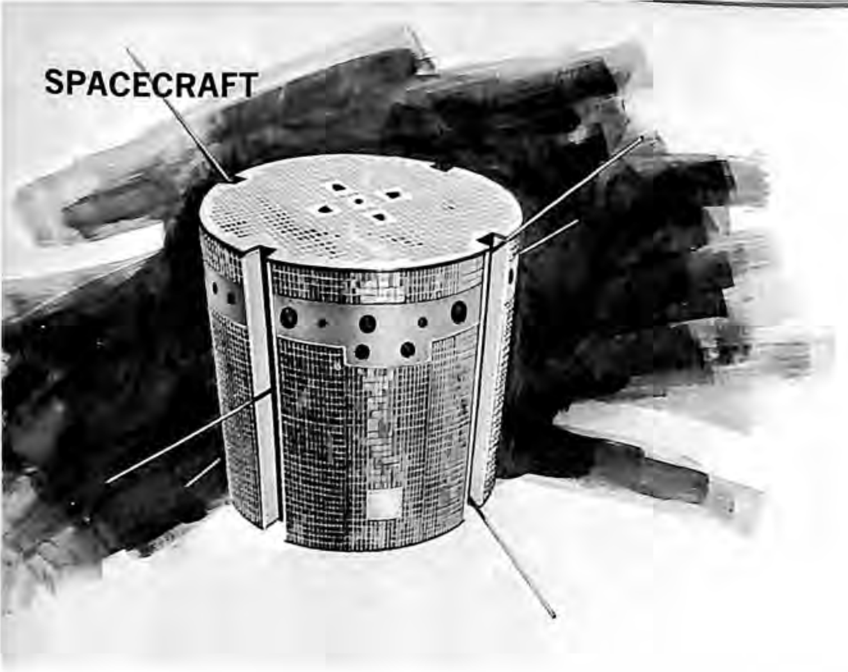
Explorer is not a specific spacecraft but a code name given a series of satellites of different configurations and with varying payloads and assignments. In photo is Explorer XXXI, Direct Measurement Explorer, launched with Canadian Alouette II on November 28, 1965, on a Thor-Agena rocket from Vandenberg Air Force Base, California. The double-launch project known as ISIS-X was the first in a new cooperative NASA-Canadian Defense Research Board program for international Satellites for Ionospheric Studies. Explorer XXXI is in orbit with an apogee less than a mile more than Alouette's and with a perigee of less than a mile lower. The orbits are some 1,850 miles high at apogee and 310 at perigee. Explorer XXXI was built for the NASA Goddard Space Flight Center, Greenbelt, Maryland, by the Applied Physics Laboratory of The Johns Hopkins University. Eight ionospheric measurement experiments sample the environment both forward and after the satellite's path. Explorer XXXI is 30 inches across the top and is 25 inches high. A spherical mass spectrometer protrudes 21 inches above the top surface, making the total height 46 inches. The satellite is powered by solar cells which cover about 15 percent of the spacecraft's surface. Explorers XXXIV and XXXV were launched during 1967.

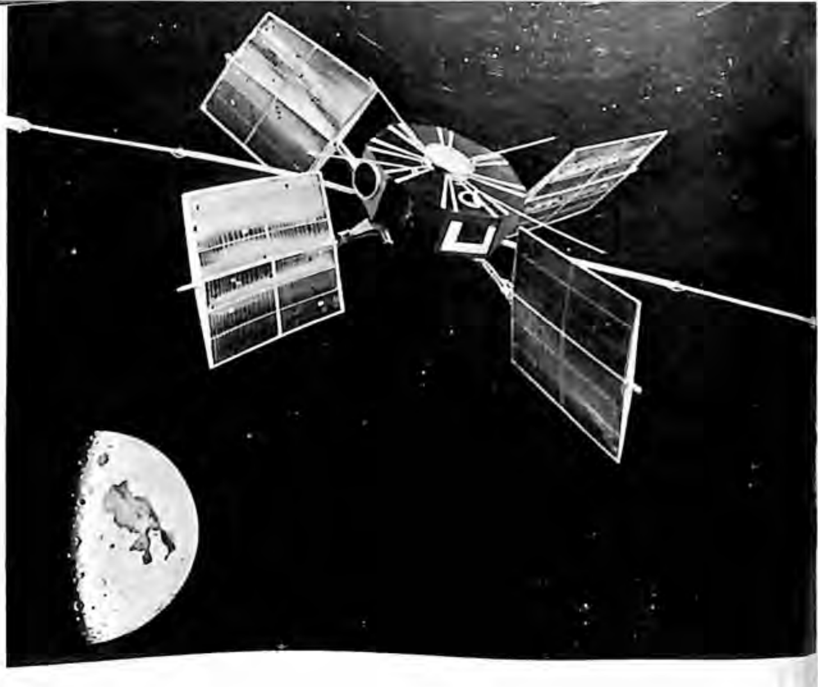
APPLICATIONS TECHNOLOGY SATELLITE

Prime Contractor: Hughes Aircraft Company

Remarks

The Applications Technology Satellite is a spacecraft whose mission is to improve other satellites, specifically to enhance the ability of existing and future satellites to provide weather, and communications data and air/sea navigation aids. Three types of missions are planned for ATS: a 6,000-mile earth orbit to experiment with the gravity gradient stabilization system; 2 synchronous (22,300-mile) orbits for meteorological, communications and navigation investigation; and 2 synchronous orbits using the gravity gradient system to make engineering and technological studies. The ATS is a barrel-shaped spacecraft weighing about 700 pounds; those equipped for gravity gradient experiments will carry 100-foot booms that can be extended like a tight-rope walker's balancing poles to stabilize the spacecraft. The program is managed by NASA's Goddard Space Flight Center. Three ATS satellites have been launched and 2 more are to be orbited in 1968.





OWL

Prime Contractor: Rice University

Remarks

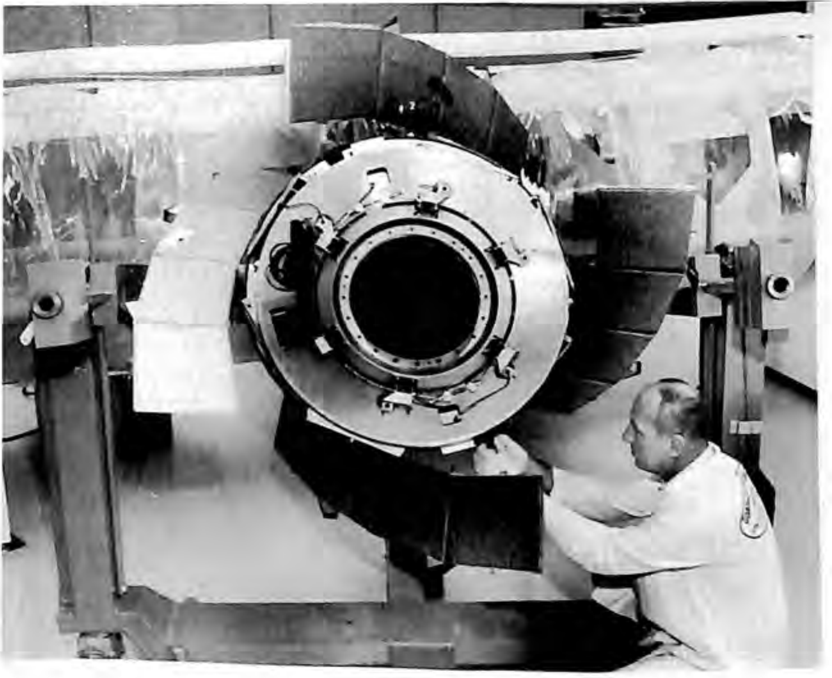
Latest addition to the Explorer series, Owl is designed to investigate a variety of low and high latitude phenomena and to make particularly powerful studies of auroral phenomena. Rice University is building 2 spacecraft, scheduled for late 1968 launch by Scout boosters. The satellites will be put into similar but not identical orbits at a high inclination with nominal altitudes of 500 and 600 nautical miles and with coincident but antiparallel lines of nodes. The 2 flight units (Rice is also building a flight-worthy spare and prototypes of selected subsystems) are identical except that a large permanent magnet is in opposite directions. Each satellite has a flight weight of about 155 pounds; cylindrical, it has a height of 33 inches and a diameter of about 30 inches. Power is obtained by 9,000 solar cells distributed on all sides.

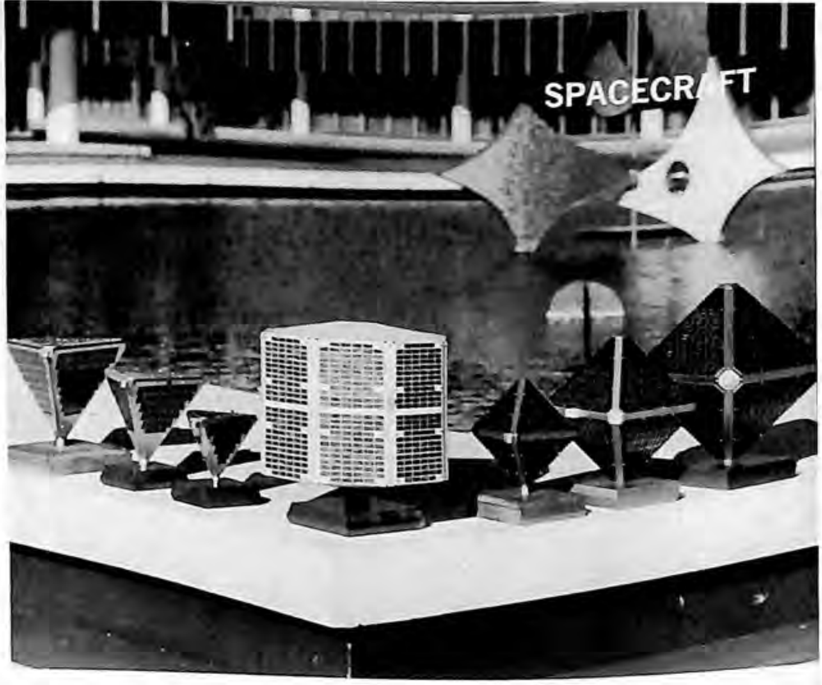
ANCHORED IMP SATELLITE

Prime Contractor: Westinghouse Electric Corporation, Defense and Space Center

Remarks

The Westinghouse Aerospace Division, under contract to National Aeronautics and Space Administration's Goddard Space Flight Center, engaged in the system design, integration, assembly and launch support for Anchored Interplanetary Monitoring Platform-E Satellite, officially designated Explorer XXXV by National Aeronautics and Space Administration. It was launched on July 19, 1967, with the primary objectives of investigation of interplanetary plasma and the interplanetary magnetic field out to and at the lunar distance, in either a captured lunar orbit or a geocentric orbit of the earth. In the geocentric orbit, the apogee will be near or beyond the lunar distance. In a lunar orbit, additional objectives include obtaining data on dust distribution, lunar gravitational field, ionosphere, magnetic field, and radiation environment around the moon. AIMP-E will also study spatial and temporal relationships of geophysical and interplanetary phenomena presently being studied by several other National Aeronautics and Space Administration satellites. The investigation in the vicinity of the moon provides for measurements of the characteristics of the interplanetary dust distribution, solar and galactic cosmic rays, as well as a study of the magnetohydrodynamic wake of the earth in the interplanetary medium at the lunar distances.





RADIO ASTRONOMY EXPLORER

Program Direction: NASA/Goddard Space Flight Center

Remarks

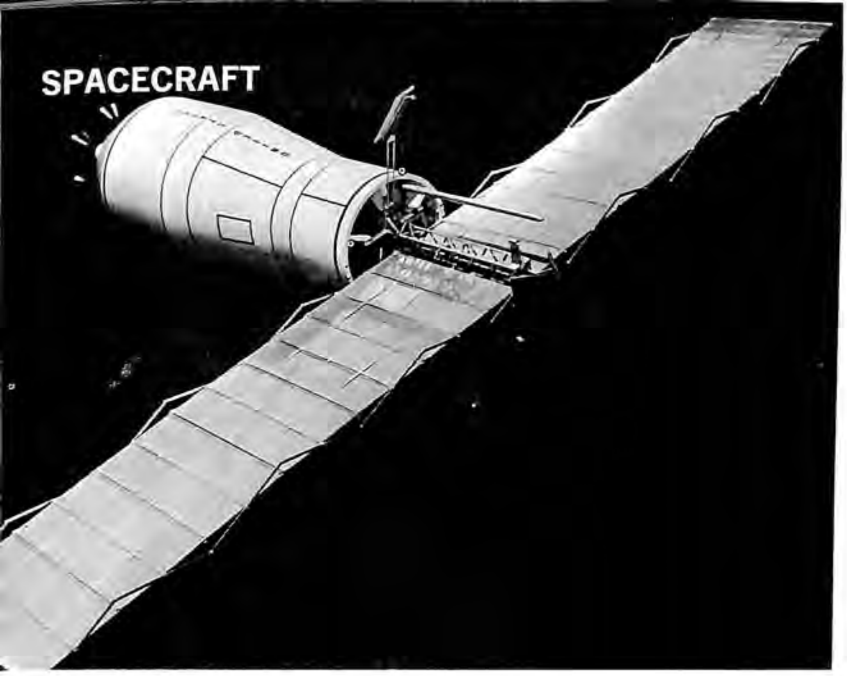
The Radio Astronomy Explorer will investigate low frequency (long wave-length) radio emissions from the sun and its planets as well as galactic and extra-galactic sources. The spacecraft will weigh about 420 pounds. It will be equipped with a dipole antenna (120 feet from tip to tip) and 2 V-shaped antennas. These antennas consist of 4 750-foot long elements which form a large "X" with the spacecraft in the center. The V-shaped antennas will also provide gravity gradient stabilization. The RAE program, as planned, calls for a series of 4 spacecraft with the first scheduled for launch in early 1968. Two missions (RAE-A and B) have been approved and payloads for them have been selected. Missions RAE-C, and D are not yet approved. RAE-A and B are intended for a circular orbit with an altitude of 3,600 miles. Inclination of the orbit to the equator will be 58 degrees retrograde and the orbital period will be 3-5/6 hours.

ENVIRONMENTAL RESEARCH SATELLITES

Prime Contractor: TRW Systems Group of TRW Inc.

Remarks

The Environmental Research Satellites were especially designed for piggyback launching from large primary mission vehicles. Ranging in weight from 1.5 to 100 pounds, and carrying from 1 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. A unique feature of the system is its capability to function without a battery. The key to this advantage is the design which permits solar cells, fastened to all exterior surfaces of the vehicle, to maintain constant exposure of about 15 percent of the sun. The ERS is a small satellite, measuring in one version only 6.5 inches on a side and weighing 1.5 pounds; the larger version weighs 100 pounds and is a 20-inch cylinder. Some 12 satellites have been launched since 1962 for a variety of missions and sponsors. The 8-sided version has been designated the OV-5 and has become a part of a program conducted by the Air Force Office of Aerospace Research.



PEGASUS

Prime Contractor: Space and Electronics Systems Division, Fairchild Hiller Corporation

Remarks

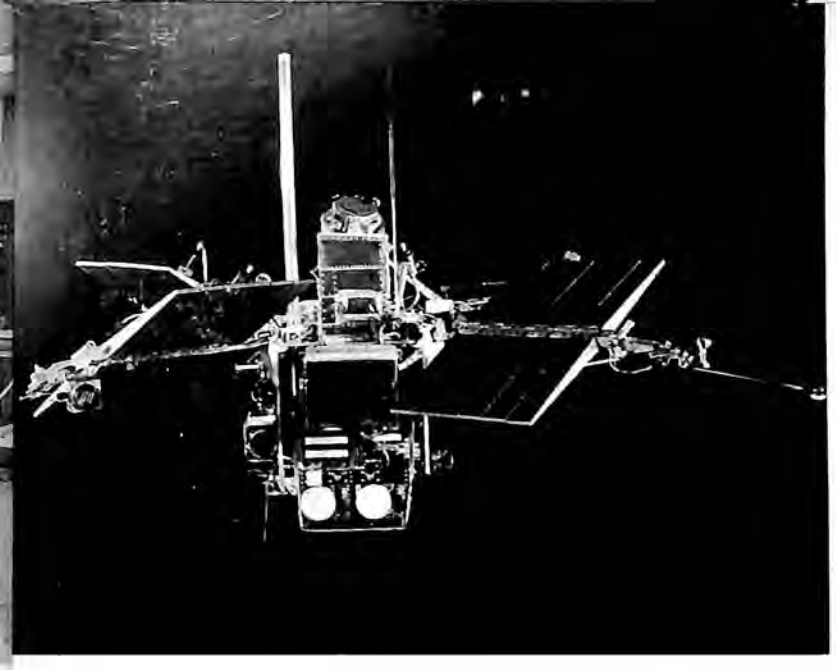
The mission of Pegasus, the Meteoroid Technology Satellite, was to define the magnitude and direction of medium size meteoroids in the near earth space environment. Three Pegasus spacecraft were sent into varying orbits, 300 to 500 miles high, transmitting meteoroid detection information on a daily basis to the FHC operated Satellite Control Center at Cape Kennedy. The spacecraft weighed 3,200 pounds, with a deployed wing 96 feet long and 14 feet high. Its 416 capacitor detectors of varying thickness provided over 2,000 square feet of area designed to count meteoroid hits for at least one year in space. It contained a solar cell powered battery power system, detection system, data processing and storage, real time and stored data transmission system, and temperature sensing and control and attitude sensing systems. The 3 spacecraft, launched in 1965, are still operational and returning useful data; they represent the largest rigid deployable space structures developed.

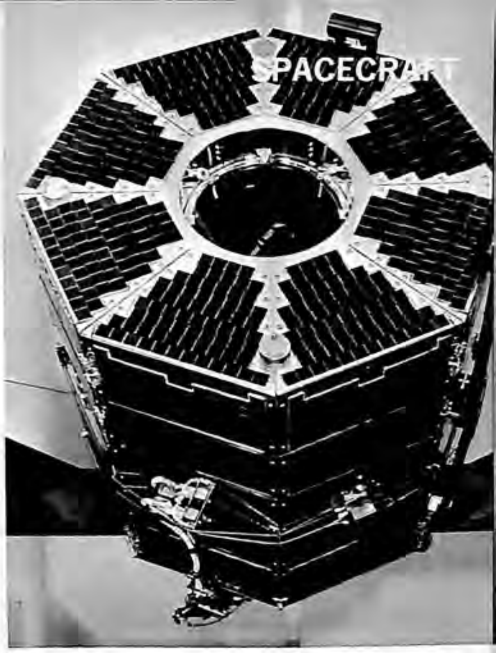
OV1 (AEROSPACE RESEARCH SATELLITE)

Prime Contractor: Convair Division of General Dynamics Corporation
Associate Contractor: Allegany Ballistics Laboratory (propulsion system)

Remarks

The OV1, formerly called SATAR, was designed to carry a variety of scientific experiments into orbit in a special pod on the Atlas booster when the lift capability of the Atlas is not fully utilized by other experiments, thus providing an economical satellite with "bonus" experiments. The OV1 has its own propulsion system which is fired after the satellite is ejected from the booster vehicle. The OV1 remains inside the Atlas-retained structure during the Atlas flight to protect it from aerodynamics loading and heating. The space vehicle coasts for about 8 minutes in space as preprogrammed attitude control maneuvers are performed on command of the propulsion module guidance system to position it for firing of its solid-fueled motor. OV1 can be launched singly on the side of Atlas or in dual pods on the booster nose. Once in space, it can perform near-circular or highly elliptical earth orbits, high altitude probes or high velocity reentry missions. Each OV1 can carry an 80-pound payload. Total weight on the Atlas is 2,455 pounds for the dual pod load. The satellite is 54.6 inches long and 27 inches in diameter. Contracting agency is the USAF's Office of Aerospace Research.





OV2 SATELLITE

Prime Contractor: Northrop Corporation

Remarks

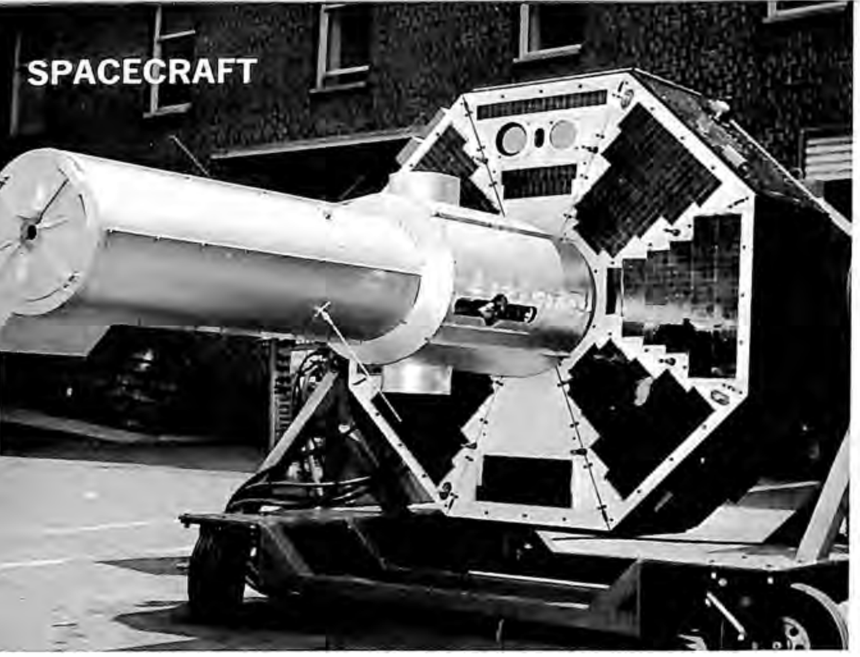
The OV2-5 is a low cost, near-earth space research satellite, scheduled to be launched late in 1967. Northrop Systems Laboratories developed and produced the OV2 satellites for the USAF Office of Aerospace Research. The satellite is a secondary payload for the Titan III-C test flights. Three of the satellites were designed by Northrop, each with diverse applications. The first 2 OV2 satellites failed to orbit, due to Titan transtage malfunction. Northrop designs, fabricates, integrates, assembles and tests the OV2 vehicles for the Air Force. On-board experimentation is provided by Air Force Cambridge Research Laboratories (AFCRL), Air Force Weapons Laboratory (AFWL), and the Air Force Space Systems Division, Aerospace Corporation (SSD/Aerospace). Most subsystem equipment used on the OV2 spacecraft has been demonstrated on previous programs and is readily available for other experiment applications. The spacecraft series is powered by solar energy collected by 4 paddles which extend when the vehicle is in orbit. Span of the basic satellite with paddles extended is approximately 12 feet.

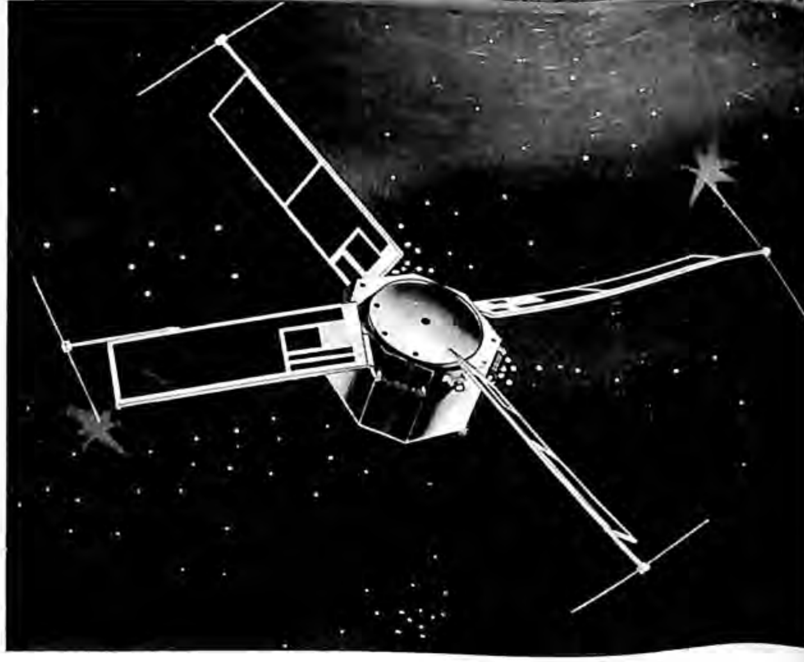
GENERAL UTILITY SATELLITE (OV3)

Prime Contractor: Aerojet-General Corporation (Space-General Plant)

Remarks

The General Utility Satellite was built for the Air Force as part of the OV3 satellite series. Four of the spacecraft were launched during 1967 and all were successful. The satellites were Scout-boosted, 3 from the Western Test Range, one from Wallops Island, Virginia. Apogees ranged from 800 to 3,000 nautical miles and perigees down to 180 nautical miles. The spacecraft is a right octagonal cylinder measuring 29 by 29 inches and weighing from 151 to 171 pounds. Solar cells supply power, with a cell volume of 540 square inches for experiments and 9,000 square inches for support subsystems.





DODGE (DEPARTMENT OF DEFENSE GRAVITY EXPERIMENT)

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

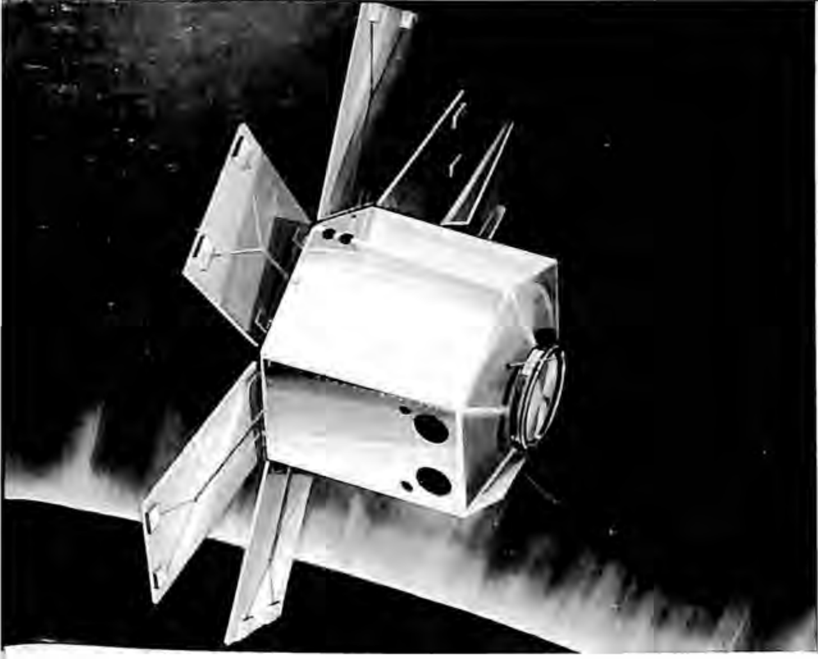
The Navy's 430-pound DODGE satellite, whose primary mission is to explore gravity gradient stabilization at near synchronous altitude, was launched successfully from Cape Kennedy July 1, 1967, aboard a Titan III-C rocket. DODGE carries 10 booms that can be radio commanded to extend or retract along 3 different axes. Data from in-orbit experiments are expected to provide fundamental constants for use in controlling future high-altitude spacecraft. DODGE also carries a number of commandable magnetic damping devices and 2 television cameras to determine satellite alignment. One of the cameras is also expected to provide the first color pictures of the full Earth. One month after launch the satellite had been successfully stabilized and the television cameras were working as expected.

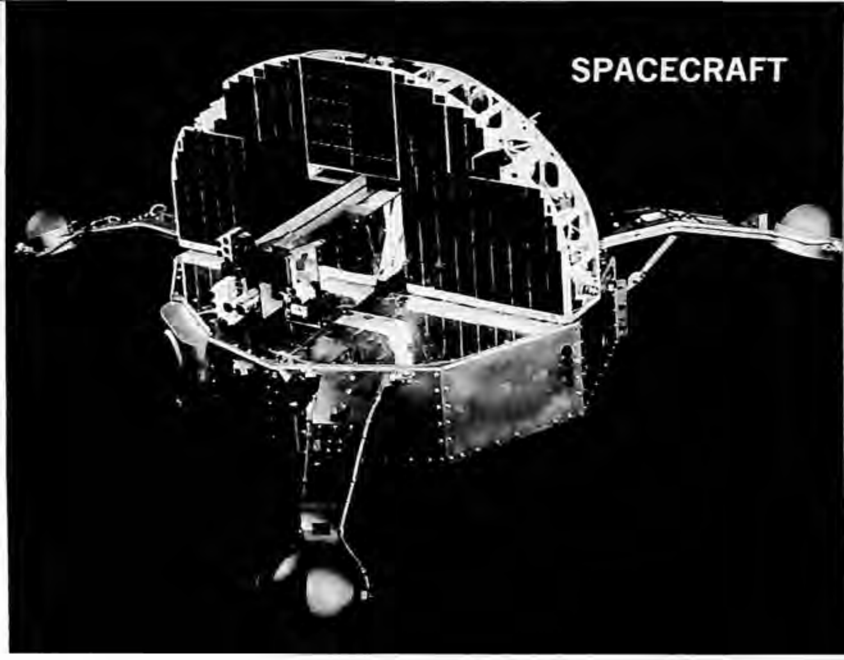
SATELLITE 1963 38C

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

The missions of Satellite 1963 38C are to measure omnidirectional flux of protons and electrons at various energy levels, radiation effects on transistors, and the effectiveness of thermal coatings. The satellite was launched together with a classified Department of Defense spacecraft on September 28, 1963. Its orbit is apogee 1120 kilometers (609 nautical miles), perigee 1070 kilometers (582 nautical miles), inclination 88.9 degrees. The satellite weighs 137 pounds; its body is in the shape of an 18 inch x 10 inch octagonal prism. It is powered by four solar blades and transmits on 136, 162, and 324 mcs. The spacecraft was built for the Bureau of Naval Weapons. In 1967 it was still sending usable data from all systems.





ORBITAL SCANNER

Prime Contractor: Honeywell Inc.
Subcontractors: RCA (communications and data handling); Lockheed Missiles and Space Company (radiometer); Control Data Corporation (attitude determination); Gulton Industries Inc. (onboard power); Spectrolab Division of Textron Electronics Inc. (solar panels); Allied Research-Mellonics (data reduction and analysis)

Remarks

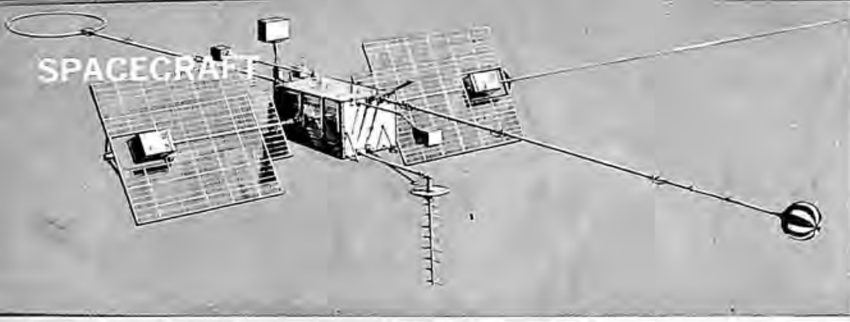
Orbital Scanner is an automated research satellite proposed to map a new artificial horizon on a global basis for use as a more stable reference by future spacecraft guidance, navigation and pointing systems. The present reference point, the earth's limb, may not provide the accuracies necessary to conduct all the precision pointing experiments required in future communications, weather, earth resources observation, reconnaissance and astronomy missions. So preliminary design has begun on spacecraft to map a stable band of infrared energy that exists 25–40 miles high in the earth's atmosphere. The satellite would take readings during the early 1970s from a near-polar orbit over a year's period to assure complete data in all seasonal conditions.

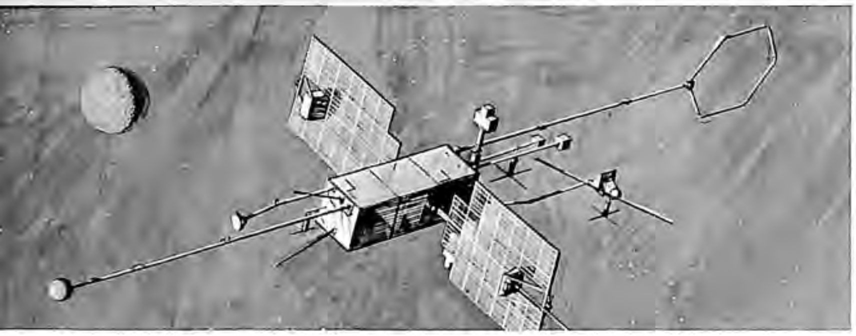
ORBITING SOLAR OBSERVATORIES

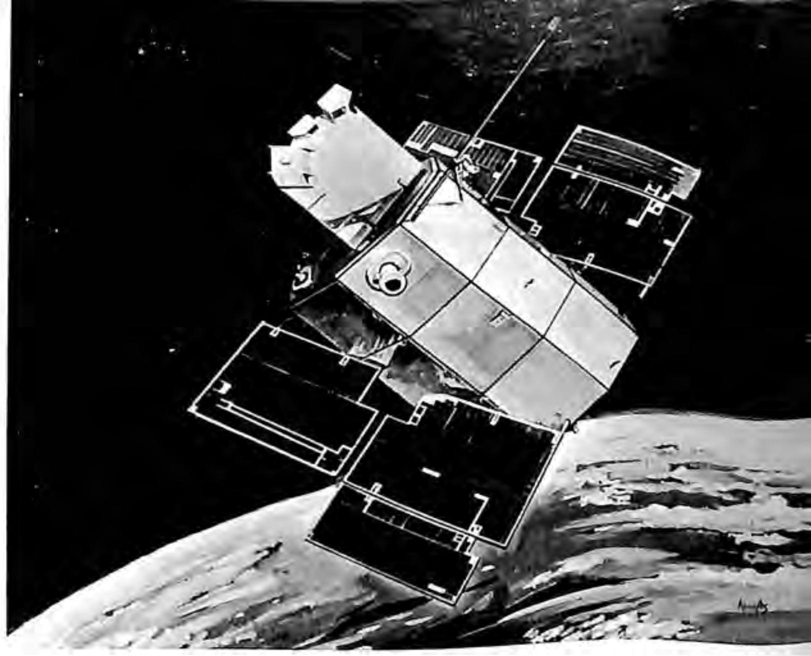
Prime Contractor: Ball Brothers Research Corporation

Remarks

The 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 extra-solar 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 wheel scan the sun every 2 seconds and those in the sail point continuously at the sun. The OSO is placed in orbit 350 miles above earth by a Delta booster and circles the earth every 96 minutes. Each spacecraft weighs from 450 to 620 pounds (including experiments) and carries up to 9 experiments. Each of the 3 successful OSOs exceeded its 6-month design specification. OSO I, launched March 7, 1962, was in operation nearly 18 months; OSO II, launched February 3, 1965, nearly 9 months; and OSO III (photo), launched March 8, 1967, and OSO IV, launched October 18, 1967, continued to send back scientific data through year-end.







ORBITING GEOPHYSICAL OBSERVATORY

Prime Contractor: TRW Systems Group of TRW Inc.

Remarks

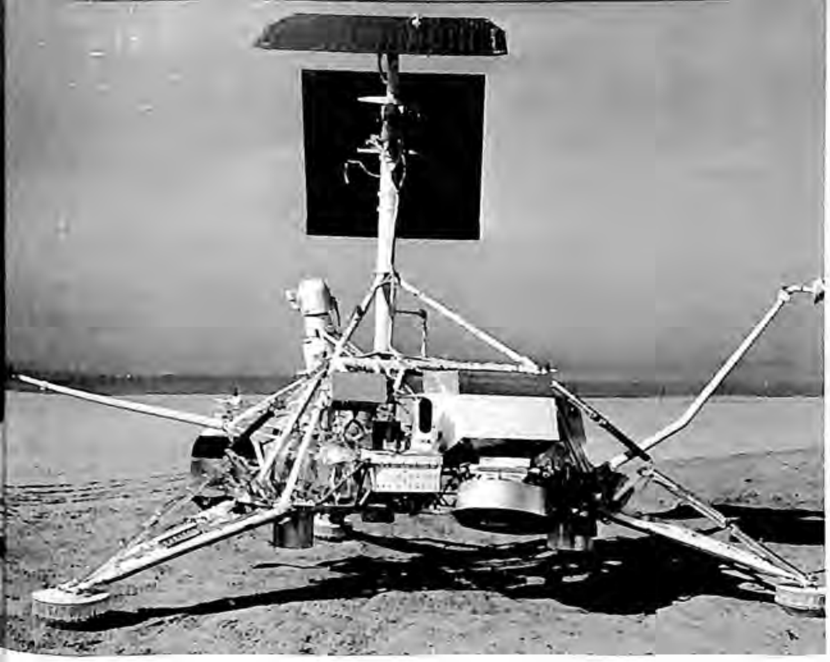
The Orbiting Geophysical Observatory is a large standardized spacecraft capable of carrying approximately 20 different scientific experiments, yet utilizing the identical structure and basic spacecraft systems irrespective of mission. The program has 2 objectives: to conduct large numbers of experiments for making scientific and technological measurements within the earth's atmosphere, the magnetosphere and cislunar space for 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 separated from 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. Four OGOs have been launched and 2 more are planned.

ORBITING ASTRONOMICAL OBSERVATORY

Prime Contractor: Grumman Aircraft Engineering Corporation
Associate Contractors: Westinghouse Electric Company (electronic components); General Electric Company (stabilization and control); Kollsman Instrument Corporation (star trackers); International Business Machines Corporation (data processer); Hughes Aircraft Company and Avco Corporation (communications equipment)

Remarks

NASA's Orbiting Astronomical Observatory is a large (4,000 pounds) earth-orbiting satellite capable of lifting a number of telescopes above the earth's atmosphere, which obscures cosmic radiations of interest to astronomers. Solar paddles provide 1,000 watts maximum of power. OAO will be launched by Atlas-Centaur. Three flights are planned, the first of which took place in April 1966. A second launch was scheduled for 1968.



SURVEYOR

Prime Contractor: Jet Propulsion Laboratory, California Institute of Technology
Associate Contractors: Hughes Aircraft Company (development and manufacture of spacecraft); General Dynamics/Astronautics (prime contractor to Lewis Research Center for launch vehicle system)

Remarks

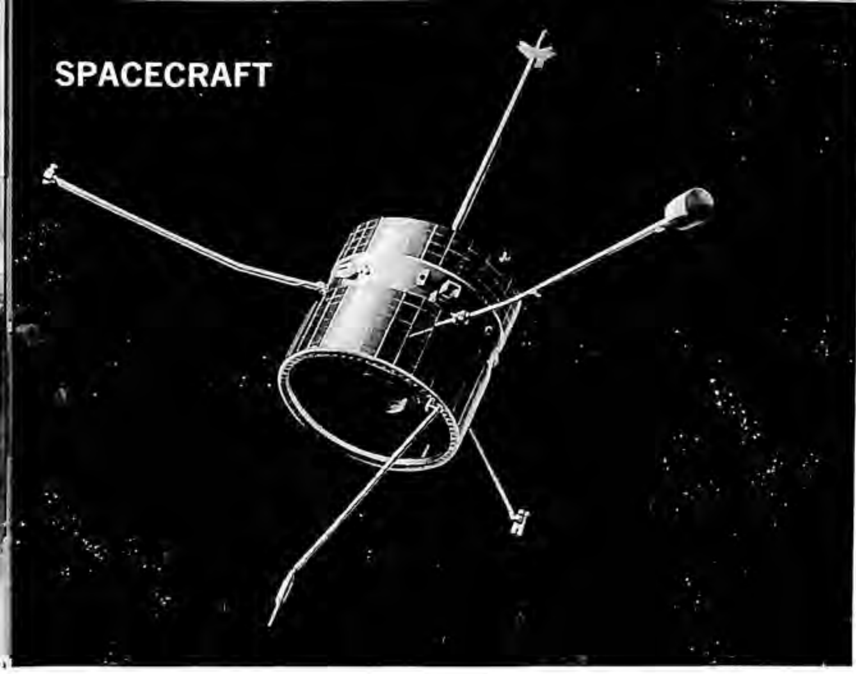
Surveyor is an unmanned, instrumented spacecraft for use in the National Aeronautics and Space Administration program for conducting scientific exploration of the moon and for developing equipment and techniques for soft landing of scientific payloads on the lunar surface. The initial test flights include a survey television system, touchdown instrumentation and diagnostic telemetry for the recovery of engineering data during the launching, in-flight and landing phases. Subsequent missions will carry scientific payloads consisting of alpha particle scattering and surface sampler experiments to extend knowledge of the lunar surface and to verify the suitability of sites for the Apollo spacecraft landings. The initial Surveyors weigh 2,150 pounds. Surveyor I, launched May 30, 1966, successfully softlanded and returned 11,150 pictures of the lunar surface. Surveyor II was unsuccessful. Surveyors III, V and VI successfully softlanded, performed surface sampler experiments and photography. Surveyor IV failed seconds before touchdown. The one remaining Surveyor was slated for 1968 launch.

LUNAR ORBITER

Prime Contractor: The Boeing Company
Major Subcontractors: Eastman Kodak (photographic system); Radio Corporation of America (electrical power and communications equipment)

Remarks

In less than one year 5 Lunar Orbiter spacecraft were launched on successful photographic missions to the moon. Mission I began August 10, 1966, and Mission V began August 1, 1967. The first 2 missions were site search missions to locate possible landing sites for Project Apollo astronauts. The third flight was a site confirmation mission to verify that the sites selected were satisfactory. Eight candidate Apollo landing sites have been selected from the information provided by Orbiters I, II, III and Surveyor I. The final 2 flights in the program essentially were scientific missions, although Orbiter V obtained additional photos of 5 Apollo landing zones plus some westerly oblique pictures which show the view the astronaut will see as he swings around the moon on his way to lunar touchdown. Orbiter IV photographed 99 percent of the moon's front face and Orbiter V completed photography on the far side. Lunar atlases and reference maps will be made of the entire moon —in greater precision and detail than is possible for earth. Lunar Orbiter photos have shown that the moon has a long and complicated history of volcanic activity and have revealed areas on the moon never before seen such as the lunar poles and vertical views of the moon's Eastern and Western limbs. The Boeing Company contracted to build 8 Lunar Orbiters (3 of them ground test vehicles) for NASA's Langley Research Center, responsible for systems management. Boeing also teamed with Langley Research Center to operate the spacecraft during each mission. The Orbiter program is under the overall direction of NASA's Office of Space Science and Applications.



PIONEER

Prime Contractor: TRW Systems Group of TRW Inc.

Remarks

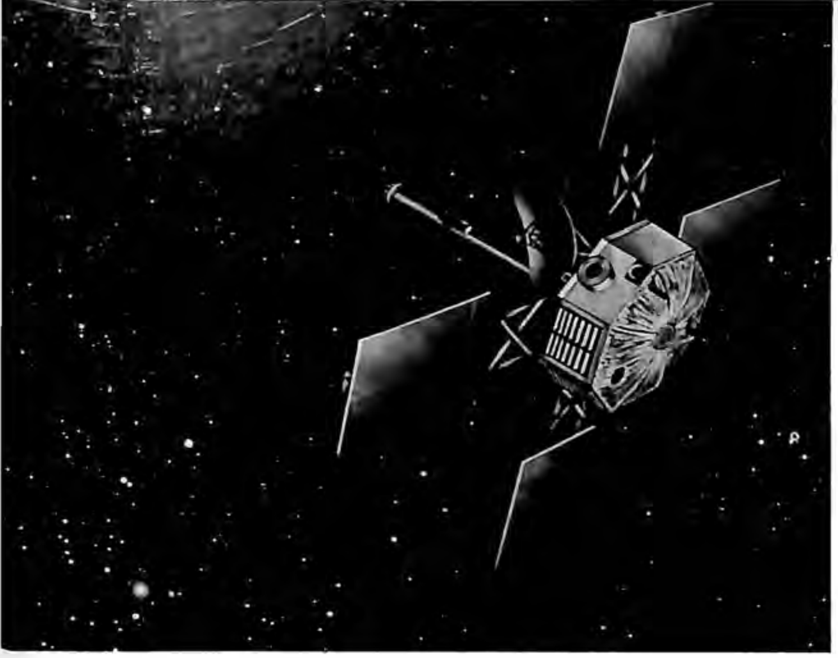
Pioneer is an interplanetary spacecraft designed to operate in solar orbit and send data on interplanetary magnetic fields, radio propagation effects of the sun, plasma spectrometry, ionization levels and solar, high-energy and medium-energy particles. Pioneer is cylindrical, 35 inches long and 37 inches 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 base of the spacecraft. A nitrogen gas jet attitude control system, with input from four 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 earth. Pioneer 7, launched August 17, 1966, will attain an orbit more than 13,000,000 miles further from the sun than earth. Both spacecraft are performing exceptionally well and returning vast amounts of valuable data on the solar environment. Three more Pioneers remain on the launch schedule.

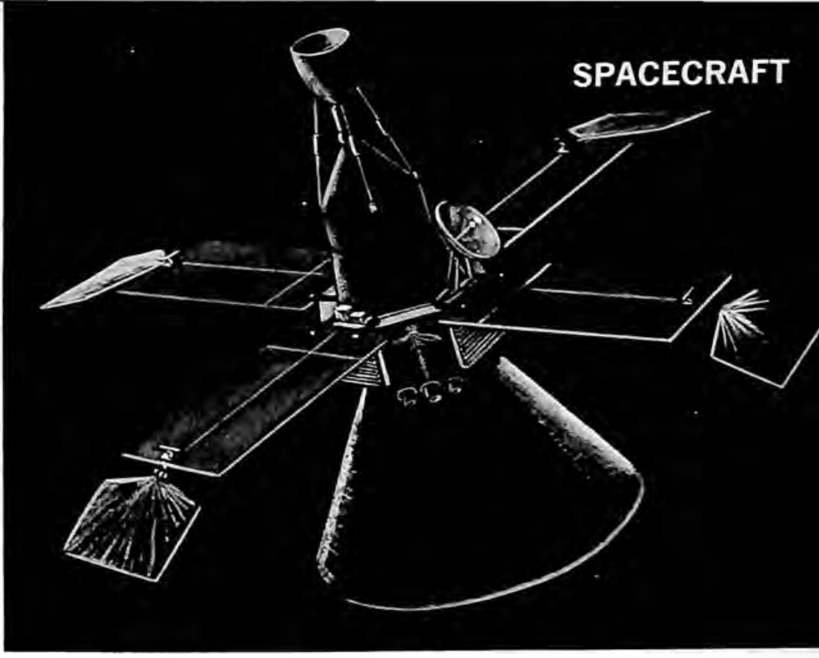
MARINER IV

Prime Contractor: Jet Propulsion Laboratory, California Institute of Technology
Associate Contractors: General Dynamics/Astronautics and Lockheed Missiles and Space Company (prime contractors to Lewis Research Center for launch vehicle systems)

Remarks

Mariner IV was an unmanned, instrumented spacecraft for use in the National Aeronautics and Space Administration program in conducting scientific observations of the planet Mars, for developing equipment and techniques for carrying out planetary explorations, and for making scientific measurements of the interplanetary environment. The spacecraft weighed 575 pounds and in its flight-deployed configuration extended 22 feet across the solar panels and stood 9 feet high from base to antenna tip. The spacecraft was launched by an Atlas-Agena vehicle system and passed within 6,118 miles of Mars in mid-July 1965, following a 228-day flight. Closeup pictures of the Martian surface were successfully transmitted to earth over a distance of 150 million miles. Two years later, after traveling 1.3 billion miles in solar orbit, Mariner IV was again put to work. Still transmitting, it supplied radiation data in August 1967, teaming with Mariner V and an Earth station to provide simultaneous measurements at 3 widely separated points.





MARINER V

Prime Contractor: Jet Propulsion Laboratory, California Institute of Technology

Remarks

Mariner V is an unmanned instrumented spacecraft for use in NASA's planetary exploration program. The spacecraft weighs approximately 575 pounds and in its flight—deployed configuration extends 22 feet across the solar panels and stands 9 feet high from base to the tip of the omni-antenna mast. On-board equipment includes a mid-course propulsion guidance system, a central control and sequencer system, solar panels and battery, attitude control system utilizing sun and star sensors and instruments for making planetary and interplanetary measurements of fields and particles and for studies of the Venusian atmosphere. The spacecraft, a modified flight spare from the Mars mission in 1964–65, was launched by an Atlas-Agena D on June 14, 1967, and it made a fly-by of Venus on October 19, 1967.

VOYAGER

Program Direction: National Aeronautics and Space Administration

Remarks

Voyager is an instrumented space vehicle for use in the National Aeronautics and Space Administration program in conducting experiments on the surface of, and in orbit about, the planet Mars in the '70s in order to obtain information on the existence and nature of extraterrestrial life, the atmospheric, surface and body characteristics of the planet, and the planetary environment. Each space vehicle will probably consist of an orbiting flight spacecraft carrying a capsule designed for landing on the Martian surface. The spacecraft will also provide the capsule with services such as power, timing and sequencing, telemetry, and command during the transit portion of the missions and may also serve as a communications relay. The capsule will be designed for entry into the Martian atmosphere, descent to the surface, impact survival, and surface lifetimes of as much as 6 months and will contain the power, guidance, control, communications, and data handling systems necessary to complete its mission. The Voyagers are expected to be launched by vehicles of the Saturn class. In photo, one concept of Voyager, which has not yet been designed. Budgetary difficulties in 1967 postponed start of the hardware program and first flight date was uncertain.

SV-5D PRIME (PRECISION RECOVERY INCLUDING MANEUVERING ENTRY)

Prime Contractor: Martin Marietta Corporation, Baltimore

Remarks

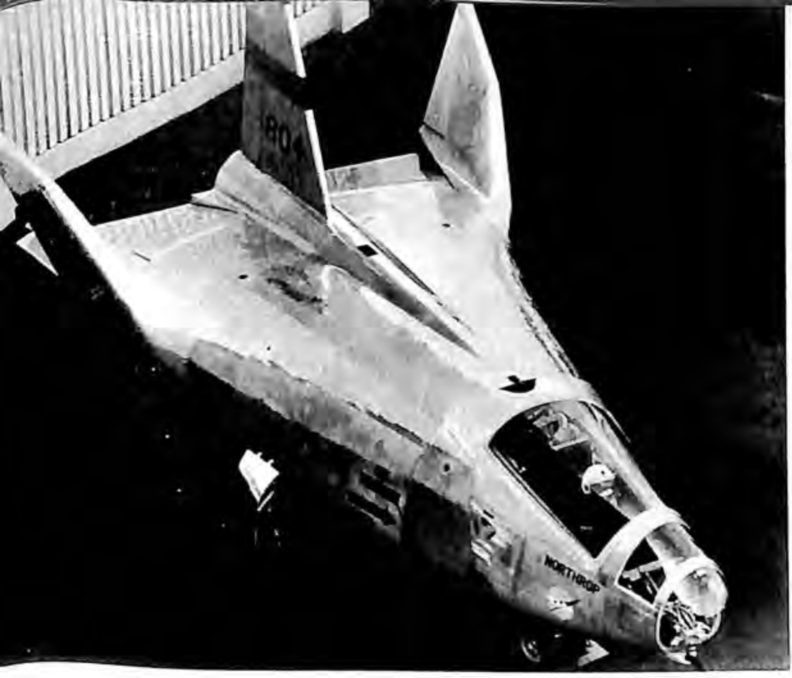
PRIME was a lifting body class vehicle, a wingless, V-shaped spacecraft with a flat bottom, rounded top and vertical tail fins. The PRIME vehicles, of conventional aluminum aircraft structure, were covered with a Martin Marietta developed ablative heat shield material which is mounted in a special honeycomb base. Two movable flaps on the underside of the tail provide control in pitch and roll axes during atmospheric flight, and reaction jets are used in space. The vehicles were built for the Air Force Space Systems Division for hypersonic, maneuvering flight tests following launch from Vandenberg AFB by Atlas SLV-3 standard launch vehicles. Parachute recovery of the PRIME spacecraft took place once it slowed to approximately Mach 2. The program was concluded in 1967, all mission objectives having been met in 3 flights. PRIME was a portion of a broader USAF program called START (Spacecraft Recovery and Advanced Reentry Tests).

X-24A PILOT (PILOTED LOWSPEED TEST)

Prime Contractor: Martin Marietta Corporation, Baltimore

Remarks

The X-24A is a one-man version of the SV-5 configuration. Rocket powered, it will explore flight characteristics of lifting bodies at supersonic speeds of Mach 2 down to normal jet landing speeds. Flight plans call for it to be carried aloft to 45,000 feet under the wing of a B-52 where it will be released to rocket up to 100,000 feet before maneuvering to a landing at Edwards AFB, California. Power will be supplied by the Thiokol XLR-11 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, 13 feet wide and weighs about 5,000 pounds unfueled. X-24A flights will begin where PRIME ended, completing the technology necessary to develop manned maneuvering reentry spacecraft.



HL-10 LIFTING BODY VEHICLE

Prime Contractor: Northrop Corporation

Remarks

The HL-10 was built by Northrop's Norair Division under contract to NASA and was configured at the Langley Research Center at Hampton, Virginia. It is an experimental wingless lifting body designed for high altitude flights within the earth's atmosphere. The HL-10 varies from the first Northrop-built M2-F2 lifting body vehicle in that it is flat on the bottom, whereas the M2-F2 vehicle is flat on the top. 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 successfully flown in late 1966 and has been equipped with a rocket engine for future powered flights.

Specifications

Length 22 feet 2 inches; width 15 feet 1 inch; height 11 feet 5 inches; minimum weight 5,265 pounds; maximum weight 8,000 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, and 2 rudder surfaces can be controlled to vary the base drag.

Performance

Glide to landing approximately 3.5 minutes; flare for landing performed at an altitude of 1,000 feet, speed 200–300 knots; landing speed 140 to 210 knots; landing rockets (optional use) 1,000 pounds thrust for 12 seconds.

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 produced by Northrop's Norair Division under contract to NASA to accomplish 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 original M2 configuration design was created by NASA at the Ames Research Center at California. The basic lifting body is a half-cone altered by blunting the nose and adding tail fins. The M2-F2 was successfully dropped from a special pylon attachment on the wing of a B-52 bomber, flying at 45,000 feet, and piloted to a conventional airplane-type landing at Edwards, California, on July 12, 1966. Several successful flights have been made since that date.

Specifications

Length 22 feet 2 inches; width 9 feet 7 inches; height 8 feet 10 inches; minimum weight 4,600 pounds; maximum weight 8,000 pounds; controls—1 pair thick rudders; 1 pair of 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.

AP12V AIRBORNE HYDRAULIC PUMP

Prime Contractor: Aerospace Division, Abex Corporation

Remarks

Originally developed for the USAF/Navy F-111, the Abex AP12V series hydraulic pump is of simplified design, the axial piston arrangement eliminating universal joints. Direct oil entry permits longer periods of operation at low inlet pressure. All thrust loaded parts are pressure lubricated for reduced friction and increased life. With a maximum displacement of 2 cubic inches per revolution, the pump delivers 47 gallons per minute at 5,800 revolutions per minute. Growth potential of the series design is 65.5 gallons per minute at 8,000 revolutions per minute. The heart of the pump is a revolving cylinder barrel that holds 9 pistons. By means of a hold-down plate and hydraulically balanced shoes, the pistons are supported on an inclined cam plate which causes them to reciprocate as the barrel revolves. The holddown plate insures positive stroking of the pistons during the suction stroke. Approximate weight of the unit is 17 pounds.

SNAP-8 NUCLEAR ELECTRICAL POWER GENERATING SYSTEM

Prime Contractor: Aerojet-General Corporation

Remarks

The SNAP-8 system, under development for NASA's Lewis Research Center, converts nuclear reactor heat into electrical power for large manned space stations, lunar bases and deep space probes of the future. 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 for the spacecraft. In photo, technicians examine one-quarter scale model.

R-182

ANESTHESIOLOGY PATIENT SIMULATOR

Prime Contractor: Aerojet-General Corporation

Remarks

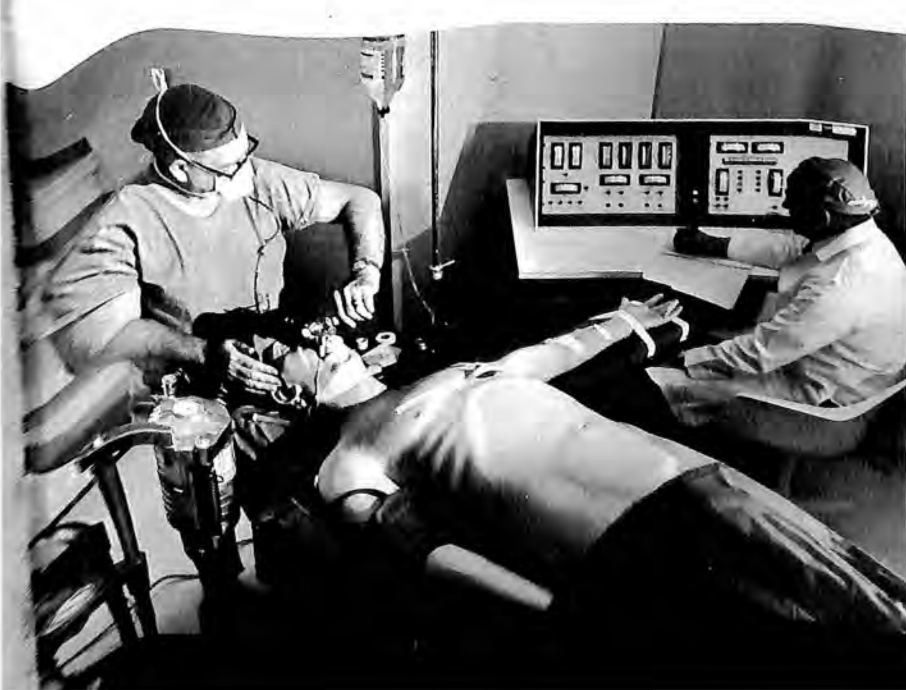
Computer-controlled manikin (known as Sim One) realistically simulates human symptoms and reactions during anesthesiology. Programmed magnetic systems enable the full-size manikin to blink its eyes, twitch muscles, have respiration and pulse and reproduce realistic response to anesthetics and drugs. The system was developed by Aerojet-General and the University of Southern California's School of Medicine. Most complex medical teaching tool ever devised, it is used in training doctors in anesthesiology, drastically cuts time required for training.

REVERSE OSMOSIS WATER PURIFICATION

Prime Contractor: Aerojet-General Corporation

Remarks

Using a Reverse Osmosis water purification technique employing a semi-permeable cellulose acetate membrane which cleanses water impurities, Aerojet-General has produced a number of 10,000 gallon-per-day portable plants that are now in use. The success of these and other larger Aerojet plants is expected to lead to larger systems with capacities of 250,000 gallons per day and more.



MINUTEMAN INTERCONNECTING CABLE ASSEMBLY

Prime Contractor: Amphenol Space & Missile Systems, Amphenol Connector Division, Amphenol Corporation (Subcontractor to Autonetics Division of North American Rockwell Corporation)

Remarks

This specially designed cable system has been developed for the new generation Minuteman ICBM. The cable system is used to interconnect various electronic, electrical, and engine control assemblies of the missile system. The main consideration given to system design was increased missile range and protection against hazardous environments. These considerations resulted in an increase in shielding protection throughout the entire cable system by the employment of continuous braided shielding of specific density and unique connector adapter shells. In the interest of minimum weight, conventional protective covering was replaced by continuous monofilament braided overjacket. The fabrication techniques utilized are extremely sophisticated in order to assure conformance of the cable assembly to rigid, close mechanical tolerance requirements. The interstage connector is employed for connection between the overall system in which it is used and other system electrical and electronic subsystems and system assemblies. The connector is designed to disconnect under pyrotechnic impulse resulting in a zero force separation. The cable assembly and its interconnecting devices are designed to meet the extreme physical environments of launch and outer space and the effects of hazardous environments employed as weapon systems countermeasures.

URIPS (UNDERSEA RADIOISOTOPE POWER SUPPLY)

Prime Contractor: Aerojet-General Corporation, San Ramon Plant

Remarks

URIPS is a radioisotope powered electrical generator designed by Aerojet for long duration underseas power applications. It will supply one-watt power (three to 28 volts regulated AC or DC) continuously for 5 years in sea or fresh water to depths of 20,000 feet. Some of the applications for which it is suited are to power navigational aids and markers, scientific equipment and fixed underwater networks and as a battery trickler for special duty cycles and high peak power.

RESISTOJET SPACECRAFT CONTROL SYSTEM

Prime Contractor: Avco Corporation, Space Systems Division

Remarks

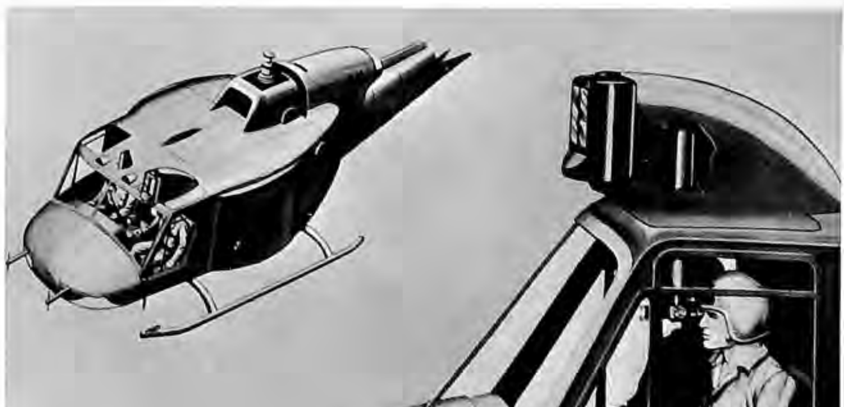
The Resistojet spacecraft control system was developed for the National Aeronautics and Space Administration for attitude and orbit control of stable-platform satellites. Two experimental models have been tested on NASA/Goddard Space Flight Center's Applications Technology Satellites B and C, launched December 1966 and November 1967. The Resistojet on the ATS-C was used to change the spin-rate of the satellite in orbit. The ATS-B and C Resistojets measure 12 inches in length, 4 inches in diameter and weigh about 7½ pounds when fueled with 0.5 pounds of liquid ammonia. The ATS-C Resistojet's two 1-inch, electrically heated thrustors powered by solar energy, can be operated independently at 400 and 34-micropounds thrust. The propulsion unit has a total impulse capability of 750 pound/seconds, corresponding to a specific impulse of 150 seconds. The first operational Resistojet system will be utilized on the ATS-D and E to maintain these gravity-gradient stabilized spacecrafts on station. The thrust level of these station-keeping systems will be 10 micropounds and will be fueled with 3 pounds of liquid ammonia for 3 years operation. A Resistojet system developed for NASA/Lewis Research Center, capable of 3-axis attitude control and multi-directional station-keeping, has a 60-pound ammonia storage capability.

STABILIZED OPTICAL TRACKING DEVICE

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The Stabilized Optical Tracking Device (SOTD) is a new sighting device which will enable helicopter gunners to pinpoint and assess suspect targets quickly and easily. Bell Aerosystems is developing a demonstration model for the Army, designed for use in the Bell UH-1 Iroquois helicopter. The sight provides means for acquisition and tracking of targets by the co-pilot/gunner of a high-speed, highly maneuverable helicopter using manual control. The line of sight is inertially stabilized, virtually isolated from vibration and free from any detectable blurring of the target. This type of stabilization permits use of high magnification optics to aid in the tracking of distant and moving targets. Bell's design makes it possible to have an infrared tracking or laser range finder system, or both, added to the SOTD. In photo, SOTD as mounted on a helicopter.



LIGHTWEIGHT TROPOSCATTER RADIO

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

Developed under contract from the U.S. Air Force's Rome Air Development Center, the Bell troposcatter is one of several systems being considered to augment or replace existing troposcatter terminals which weigh at least 4 times as much and use far more power. The device can transmit 12 voices simultaneously, or 28,000 "bits" of computer data per second, with an error rate of less than one per 100,000. It achieves its high reliability by combining sequential use of 8 different frequencies with a unique coding system.

Specifications

Weight, with aluminum tripod, less than 500 pounds. Parabolic antenna 10 feet high by 10 feet across. Power supplied by a 2.2 kilowatt generator. Transmitter signal radiated with 200 watts of power.

LUNAR LANDING TRAINING VEHICLE

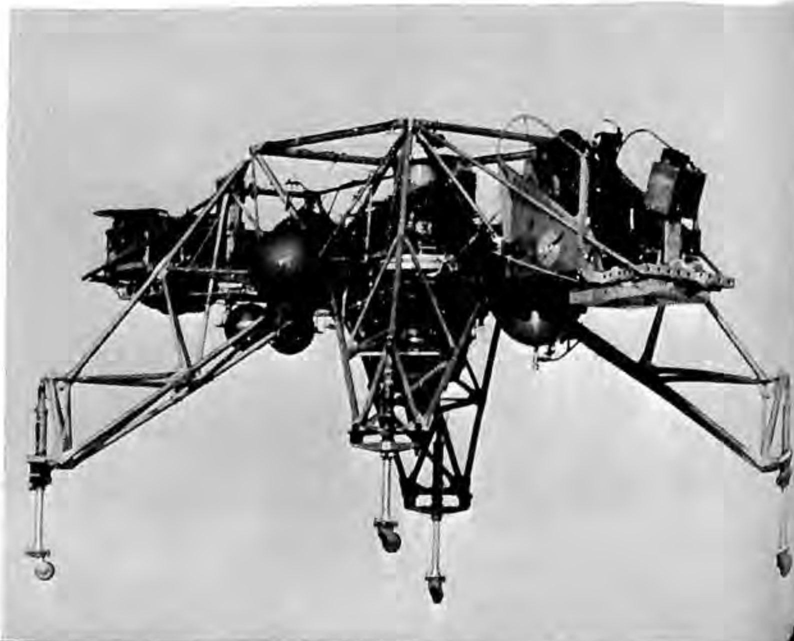
Prime Contractor: Textron's Bell Aerosystems Company

Remarks

A space trainer rather than a flyable spacecraft, the Lunar Landing Training Vehicle was designed and built by Bell Aerosystems for the National Aeronautics and Space Administration. It is a non-aerodynamic VTOL craft being flown at the NASA Flight Research Center, Edwards, California, to train astronauts in lunar landing techniques here on earth. With this vehicle, a pilot can simulate in earth environment, actual approach, hover and touchdown procedures required on the moon. A variable stability autopilot enables the pilot to achieve the same reactions and sensations as if he were operating in a lunar environment. The LLTV is designed so various sections can be removed and replaced by actual hardware of the Apollo Lunar Module. Two LLTVs were delivered to NASA in mid-April, 1964. NASA Test Pilot Joseph A. Walker made the first free flight at Edwards on October 30, 1964. NASA has contracted for delivery of 3 additional LLTVs.

Specifications

Height 10 feet, 6 inches; 4 truss legs spread 13 feet, 4 inches; power plants single gimballed, vertically-mounted General Electric CF700-2V axial flow aft fan engine (4,200 pounds thrust), eight 500-pound thrust hydrogen peroxide lift rockets, 16 reaction control hydrogen peroxide rockets. Gross take-off weight 3,710 pounds.



JET BELT

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

A jet-powered version of the Bell Rocket Belt, the Jet Belt is being developed under a contract from the U.S. Army and the Advanced Research Projects Agency. The system uses a turbojet power plant mounted vertically on the back of a corset assembly around the operator's lower back and hips. Engine exhaust is channeled equally through 2 nozzles pointed downward at the operator's shoulder level to provide the thrust. Bell has patented the invention and carried the project through the mock-up stage. The Jet Belt will have a far greater range and altitude than the Rocket Belt.

DUAL-PURPOSE MANEUVERING UNIT

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The Dual-purpose Maneuvering Unit (DMU) is a double-duty device which can be operated in space by an astronaut (as in photo, left) or remotely controlled from a parent vehicle (photo, right). Bell Aerosystems is developing the small, rocket-powered maneuvering spacecraft for the Research and Technology Division of Air Force Systems Command for possible use in support of future manned spacecraft operating in earth orbit. Incorporated in the DMU are a television camera, stabilization and control systems, propulsion systems, life support equipment, communications and radar as required by the operating mode. Should a mission call for it, a spaceman could don the DMU and help assemble a space station in space, repair a space vehicle or perform other tasks. For unmanned missions, the DMU could be guided remotely, by means of its TV camera and radio signals, for such tasks as inspection of satellites or assistance in docking and transfer of space equipment.

STABILIZED PLATFORM SYSTEM FOR SATURN ROCKET

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 its components are made of beryllium, thereby affording considerable weight saving as well as greatly improved stability over a wide range of temperatures.

INERTIAL GUIDANCE SYSTEM FOR PERSHING MISSILE

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

The inertial guidance system for the Army's Pershing selective range artillery missile contains 3 gyros and 3 accelerometers which provide directional references for hitting a target the size of a football field from a distance of several hundred miles. The actual spinning parts of the gyros are sealed-in miniature cylinders (2 inches long and 1 inch in diameter) which, in turn, are "floated" in an outer cylinder, leaving an airspace of just a few thousandths of an inch at all points. Microscopic, bell-shaped air jets in the outer cylinder "float" the gyros on an air cushion —with no metal-to-metal contacts except for pin-point electrical contacts at each end of the gyro cylinders. Contours of gyro components are checked optically for flatness to within 11.5 millionths of an inch. The self-contained, jam-proof guidance system contains a computer that "stores" target information, compares it with flight attitude and acceleration data provided by the gyro system, and aims the missile in flight. It cuts off the rocket engine at the exact point, and the missile becomes an atomic-age "howitzer shell" of fantastic range. The precision of the system is matched by its ability to perform in flight, and there has never been a recorded in-flight malfunction of the guidance system.

PENDULOUS INTEGRATING GYRO ACCELEROMETER FOR MINUTEMAN MISSILE

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

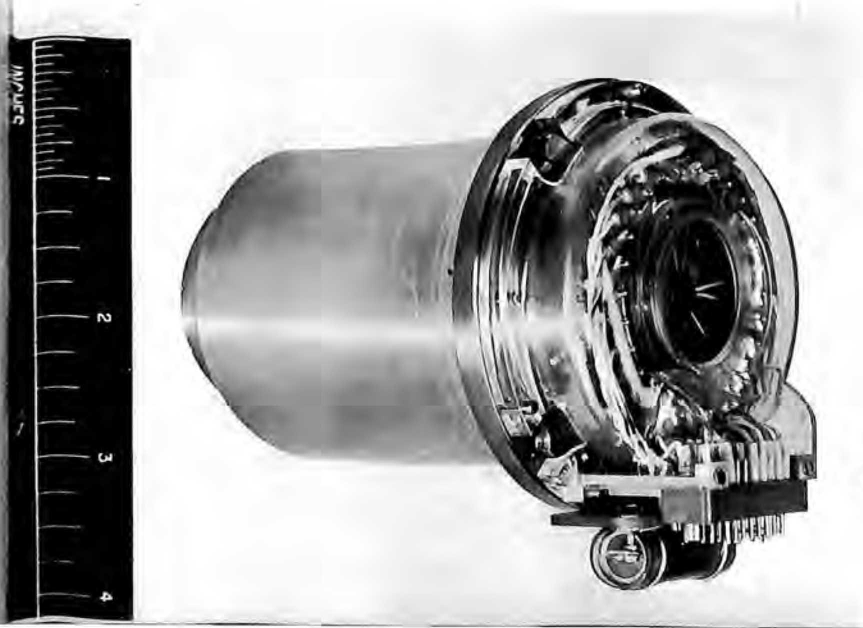
The Bendix 16 PIGA Pendulous Integrating Gyro Accelerometers are the key acceleration-sensing elements in USAF's improved Minuteman ICBM guidance system. The 16 PIGA provides one of the most accurate velocity-measuring devices in production, precisely measuring accelerations in sensitivities as small as mill-minus g to as large as 30 g's. It is a sensitive, liquid-floated, single-degree-of-freedom gyro instrument rugged enough to operate in vibrational and thermal environments of any application where precise velocity information is required. An outstanding feature of the unit is the low threshold level of the gimbal rotation, resulting from floating the gyro gimbal in viscous fluid of the same density as the average density of the gimbal and maintaining proper gaps between rotating and stationary assemblies. The structural material is beryllium. The weight is approximately one pound, 2 ounces; the size is 2½ inches in diameter by 4 inches long. The size of a large percentage of the miniature parts incorporated in the unit are precise to within 50 millionths of an inch or better. An advanced configuration, now in production, incorporates a gas, spin-axis bearing that greatly increases the predicted life.

RANGE INDICATOR FOR LUNAR MODULE

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

The Lunar Module (LM) range indicator will provide LM astronauts with altitude and rate-of-altitude change information during descent from NASA's Apollo Command and Service modules to the lunar surface. During the return ascent and rendezvous with Apollo spacecraft, it will display 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 Contractor: The Bendix Corporation, Navigation & Control Division; and The Boeing Company, Commercial Airplane Division

Remarks

The Precision Approach and Landing System, which in 1965 won Federal Aviation Agency approval to permit large commercial jet aircraft to make fully automatic landing, and later, approval for use in Category II conditions, makes extensive use of transistorized equipment and microelectronics. A complete system for automatic landings is comprised of an improved autopilot coupler (which locks the aircraft's autopilot to the instrument landing system beam at the airport) and amplifier computer, two radio altimeters, monitored flare computer, standby gyro-horizon and 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 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 into the autopilot, provide precise lateral and airspeed control. Operation of all components are constantly monitored during final approach, and should there be any error, the monitor disconnects the autopilot in trim, ready for pilot take-over.

MICROVISION

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

Microvision, an all-weather landing aid that outlines an airport runway in a manner similar to the way a pilot would see it in a normal clear-weather night landing, has been installed by the Federal Aviation Agency at its research center in Atlantic City, New Jersey. Microwave radio signals—beamed to the plane from both sides of the landing strip—puts an electronic image or "picture" of the runway on a semi-transparent 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 one-microsecond pulses approximately 400 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.

1. APPROACH CONTROL PANEL
2. APPROACH PROGRESS DISPLAY
3. LOW RANGE RADIO ALTIMETER No.1
4. AUTOPILOT & AUTOTHROTTLE WARNING LIGHTS
5. AIRSPEED IND. (AUTOTHROTTLE CONTROL)
6. LOW RANGE RADIO ALTIMETER No.2

VERTICAL SCALE FLIGHT INDICATORS

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

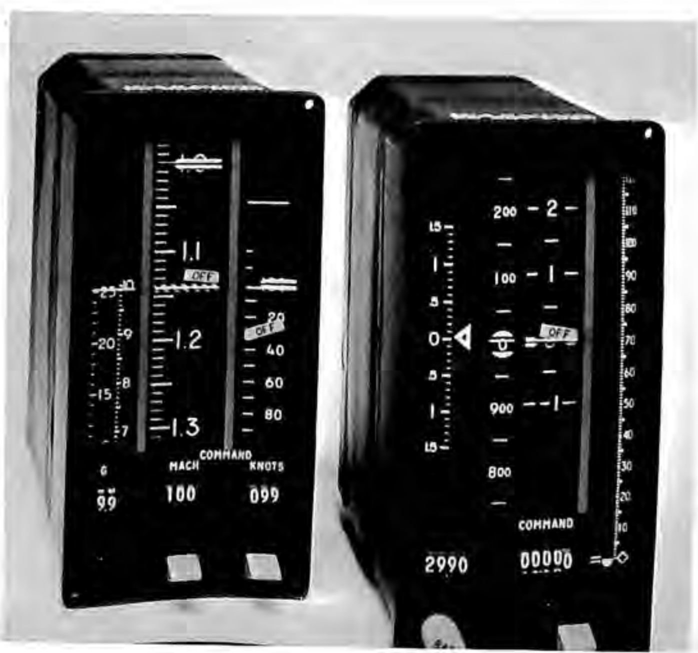
Vertical Scale Flight Indicators for the F-111 use moving tapes, command indices and a common reference line to display vital flight parameters at a glance. Familiarization time is quick and displays during flight are rapidly and precisely interpreted by the pilot. The indicators, which receive inputs from a central data computer and a source of command data in the form of synchro or potentiometer signals, present information such as vertical speed, mach number, indicated airspeed, and maximum safe speed. Indicator tapes provide greatly improved scale factors for better readability. Scale limits are not restricted to 360 degrees, and yet require less panel space and fewer components than round dial indicators. The new reference-line concept of the vertical scale instruments eliminates the often tedious and less accurate method of reading round dials with pointers. Command information is set either manually or remotely from a ground station via data link. When all commands are executed, a continuous horizontal bar appears across the indicator grouping, instantly showing the pilot that the aircraft is correctly performing the necessary tasks.

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 air speed, 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 whole computer relatively immune to position and acceleration errors. Consequently, the computer provides precision outputs of fine sensitivity, particularly required at high altitudes. The computer is flexible in design, reliable, easily maintained, and 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. The air data system is the same—except for a few internal differences due to mission requirements—on USAF's F-111A and FB-111 and USN's F-111B.



PB-60 AUTOMATIC FLIGHT CONTROL SYSTEM

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

The Bendix PB-60 is one of the most advanced automatic flight control systems (AFCS) to meet fully the requirements for stability, precision, accuracy, and automatic landing for a variety of aircraft. It has been approved for use on aircraft ranging from USAF's C-141 transport to the Jet Commander and Fan Jet Falcon. It is equally applicable to private, business, and executive aircraft, as well as to jet and turboprop transports in commercial and military operations. PB-60 engineering and design permits the installation of identical components in different aircraft through adjustment provisions for system gains and the function grouping of electronic units and modules. Convenient front connectors facilitate trouble shooting, while front panel adjustments enable shop calibration of black boxes that accommodate the differences among aircraft types. Such features as all-transistor circuitry, channelized design, and fail-safe control switching exemplify the latest state-of-the-art in the PB60 system.

BANC-660 NAVIGATION COMPUTER SYSTEM

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

The BANC-660 Navigation Computer System provides continuous automatic dead reckoning in latitude and longitude coordinates, computes the precise great circle course and distance to either of 2 destinations, and solves wind magnitude and direction, independent of ground-based aids and free of any outside interferences. Designated as AN/ASN-66 for military use, the system incorporates 3 computers —Present Position, Course and Distance, and Wind Memory—in 2 compact units: the Computer Amplifier and the Computer Control. The units are completely modular and provide for integral self-testing. Electrical outputs of bearing, distance, and ground track are compatible with standard Bearing-Distance-Heading indicators or Horizontal Situation Indicators. Twelve other outputs of navigational data are provided, in addition to the displays of present position and computed wind. The Wind Memory Computer Section provides for 3 modes of operation that are automatically actuated, as required: Doppler, Wind Memory and Air Mass. The console-mounted computer control unit is divided into 6 subassemblies, all mounted within a dust-tight cover. The modules are easily removable from the chassis frame. The compact computer amplifier unit houses 6 electromechanical modules, removable for easy servicing, and the system's electronic circuitry. The electronics include a plug-in power supply at the rear wall of the amplifier unit, and the 8 printed circuit cards, also readily removable. All system primary power is applied to the computer amplifier.

ATTITUDE DIRECTOR INDICATOR FOR C-5A

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

A new Attitude Director Indicator (ADI) having dual display capability has been designed for commercial and military aircraft. The ADI's initial application is on the USAF/Lockheed C-5A heavy logistics transport. The indicator provides a pilot with either a precise bullseye 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 thereby eliminates head motion and hurried eye refocusing from the instrument panel to the real world, reducing fatigue since it allows 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, enroute 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: the pilot's display, a 3-axis adjustable mount, an electronic assembly package and a control panel.

AIRCRAFT WEAPONS RELEASE SYSTEM

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

The Bendix Aircraft Weapons Release System enables the pilot to program the automatic release of stores from aircraft weapons stations in the quantity, mode, and drop interval he selects. The system is compatible with a maximum of 9 weapons stations in any aircraft that utilizes standard squib-actuated racks or that utilizes fire pulses delivered direct to the station. It is used in conjunction with existing armament systems, including station select and weapon release-switches. Solid-state electronics assures high reliability and low power consumption at minimum weight and volume. Modular circuitry permits maximum adaptability to specific aircraft and integration with existing systems. A cockpit-mounted controller and a remotely located programmer comprise the basic system, and a stores inventory display is available as optional equipment. The system is used on the U.S. Navy's A-4 and A-7 and USAF's F-100 aircraft. A dual-control version will be used in the U.S. Army's AH-56A helicopter. Advanced concept testers for testing entire weapons systems at a single point and automatic tape control testers have been developed to check the Aircraft Weapons Release System.

STANDARD NAVIGATION COMPUTER

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

The Standard Navigation Computer System (SNC) developed for the U.S. Army uses a compact, lightweight and low-cost packaging concept. The SNC presents a continuously moving map display of the vehicle's position relative to a rigidly defined terrain. The system thus permits immediate and precise visual correlation of actual course and prescribed ground track, independent of external aids and free of any outside interference. The system was designed specifically for helicopter and light, fixed-wing aircraft. In cockpits where limited panel space prohibits installation, the 5-pound unit can be strapped to and rest upon the pilot's upper leg.

RECORDER DATA PACKAGE

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

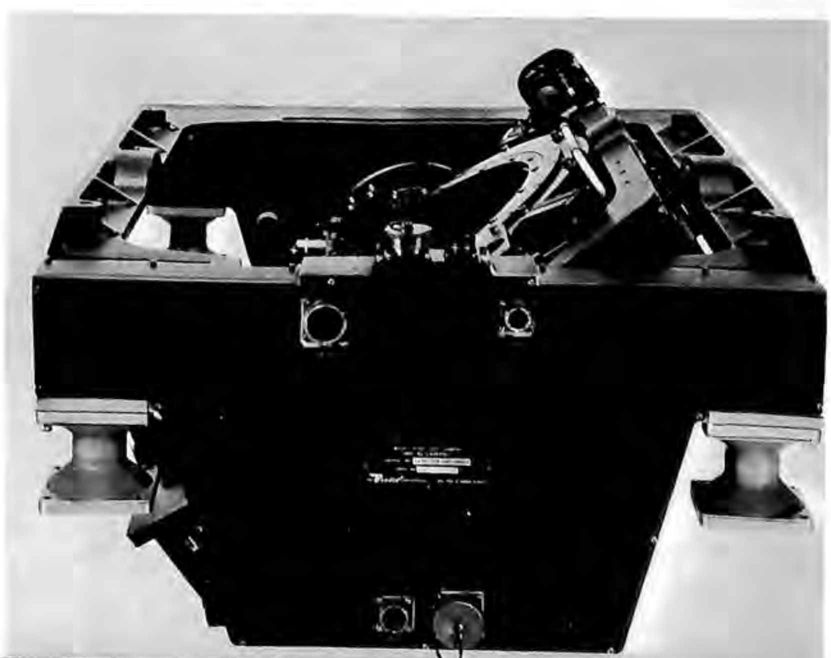
Designed for the Air Force, the recorder data package records the performance of subsystems in ballistic missile reentry vehicles. The purpose of the package currently in production is to record data on the performance of arming and fusing systems under environmental stresses—launch, in-flight and reentry. Upon recovery from the landing area, the magnetic tape in the recorder data package is removed and the results analyzed. This recorder data package represents a significant step forward in the field of reentry vehicle reliability analysis. Information received not only supplies factual operating data but also provides a means of verifying and improving techniques used in a variety of associated reliability analysis and testing programs. Since future requirements for the recorder may contain specifications for increased capacity, such as provisions for recording reentry-vehicle separation data, vibration parameters, and 3-axis attitude information, means to accommodate these extra possible tasks in the same-size package are now being studied.

BENDIX CAMERA MOUNT

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

Designed and developed for aircraft applications, the Bendix camera mount supports and maintains aerial cameras in a vertical attitude under dynamic flight conditions. This highly stable platform isolates cameras from the aircraft's vibration and angular motions on all three axes. Electronically self-contained, the mount requires no electronic chassis while its solid state electronics assures trouble-free operation. Designed to accommodate a wide range of cameras, it has possible application to both military and commercial installations.



AN/GSM-133 PROGRAMMER COMPARATOR

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

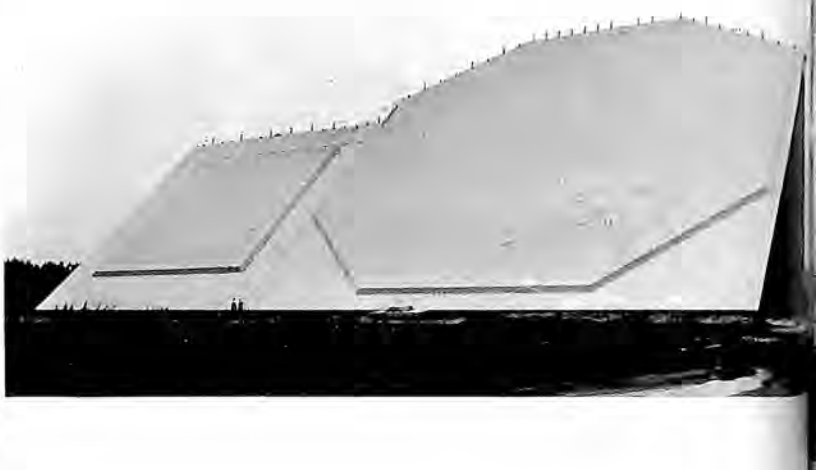
The AN/GSM-133 is an automatic, versatile, programmable testing system that will, for the first time, provide consistent automatic checking of avionic systems for aircraft, missiles and space vehicles at all levels from factory and depot to flight line and on-site maintenance. This second generation programmer-comparator incorporates micrologic techniques that reduce its size by 30 percent and weight by 50 percent over current models. It can be transported either by air or overland. 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 and 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, as well as providing all of 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/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 the Eglin Air Force Base, Florida, will become a major element of the United States aerospace surveillance and warning system. The building housing the space track radar is 13 stories high and more than 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. 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 up 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. The development has been under the sponsorship of the Electronic Systems Division but will be operated by the Air Defense Command.



AN/TRC-111 RADIO REPEATER SET

Prime Contractor: The Bendix Corporation, Communications Division

Remarks

This transportable communications system is used by the U.S. Army Electronics Command as a dual terminal with a spare radio or a repeater with spare radio in the 4400–5000 MHz range when handling signals from 48 channel cables CX-4245 in 48 or 96 channel groups. The system is shelter mounted and is intended for the following modes of operation: (a) 48 channel PCM radio repeater, full duplex, in a line-of-sight radio relay system (nominal 30 mile hops); (b) 48 channel PCM cable system to radio system transition repeater; (c) same as (a) except 96 channels; (d) dual 48 channel PCM cable system to radio system transition repeater; (e) 48 channel PCM radio terminal (split) in conjunction with telephone terminal AN/TCC-62 or AN/TCC-63; (f) 96 channel PCM radio terminal (split) in conjunction with telephone terminal AN/TCC-62 or AN/TCC-63; (g) dual 48 channel PCM radio terminal (split) in conjunction with telephone terminal AN/TCC-62 or AN/TCC-63; (h) a dual 96 channel PCM radio terminal (split) in conjunction with telephone terminal AN/TCC-63; (i) a system operating as in (a), (b), (c), or (d) wherein the third radio is operated as a separate terminal fed from up to 2 additional 48 channel cables.

AN/PRC-72 RADIO SET

Prime Contractor: The Bendix Corporation, Communications Division

Remarks

Combining the best features of previous radios plus the experience gained in Southeast Asia, the Bendix Communications Division has developed for the Air Force a light and very flexible manpack radio set available for forward air control in tactical situations. Conceived to bridge the inter-service communications gap, this radio set, designated the AN/PRC-72, provides absolute operational flexibility. Combined in one compact open frame rucksack are 4 self contained and independently operating radio sets that cover the high, very-high, and ultra-high frequencies in AM, FM, and single sideband modes. The radios can be used independently, or in combinations for repeater service, etc. 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 delivered developmental models to the Air Force.

AN/APX-72 TRANSPONDER

Prime Contractor: The Bendix Corporation, Communications Division

Remarks

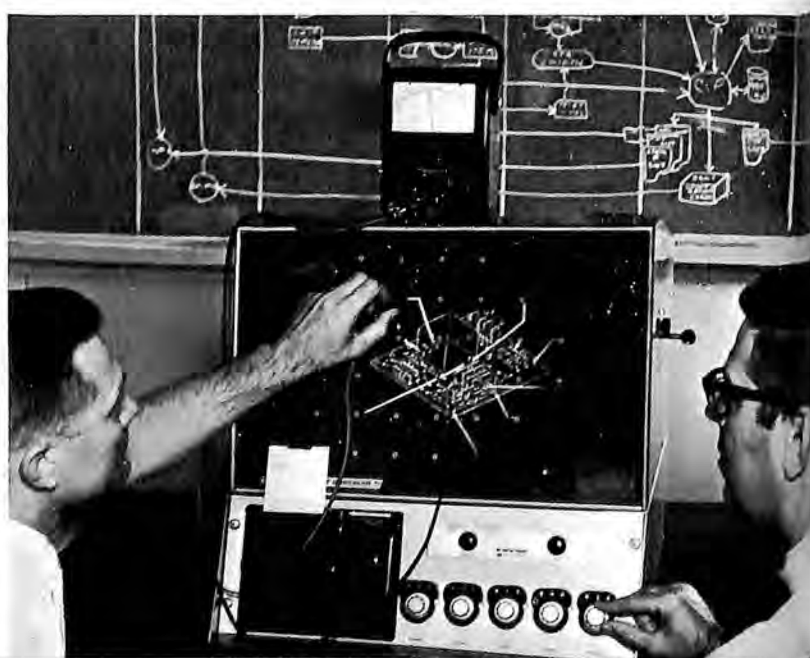
This new IFF Transponder represents the first tri-service procurement for equipment of this nature. The Naval Air Systems Command is the procurement agency, purchasing for all 3 services. The APX-72 is a universal transponder suitable for use in light Army aircraft as well as in high performance Navy and Air Force aircraft. The transponder represents the latest design in airborne IFF transponders and is fully compatible with all DOD directives and AIMS requirements. It features major design advances, increased reliability, reduced maintenance, and offers a replacement for all transponders in both Class I and II environments, and modified Class II (95 degrees Centigrade continuous operation). Present plans are to use this transponder as standard equipment in all new aircraft configurations and for retrofitting existing aircraft.

SAVAC

Prime Contractor: Chrysler Corporation Space Division

Remarks

SAVAC is an electronic problem simulator being used by the Air Force to simplify training of technical personnel who man the complex electronic, electric or mechanical circuitry used in today's missile and fire control systems, radar equipment and automated devices. SAVAC stands for Simulates, Analyzes, Visualizes, Activated Circuitry. A 35 millimeter slide projects circuit diagrams onto the screen of SAVAC, which resembles a television set. Punch cards, fed into the unit, are used to create malfunctions or problems in the projected circuit. The system allows students to work on malfunctioning circuits and to learn intricacies of complex systems without using the actual equipment which is often expensive and highly sensitive. SAVAC units range in size from a table model to a 78-inch high floor demonstrator which can be used for group training. The units are assembled at Chrysler Space Division's Florida Operations Plant near Cape Kennedy, Florida.



FM MINIATURE RECORDER

Prime Contractor: Cook Electric Company

Remarks

Cook Electric Company's Tech-Center Division has developed an FM version of a unique miniature magnetic recorder for industrial and military applications. The FM advance is a variation of the biomedical recorder developed by Cook for NASA's Gemini program (2 of the units were used successfully on each Gemini flight). The smallest ever developed for long operation, the FM recorder is 9 inches long, 6.8 inches wide, and 1.7 inches deep and weighs less than 5 pounds with a full tape load. The biomedical units receive and record on 7 channels simultaneously, 6 recording physiological data, the 7th a channel of time. Prior to the recorder advance, spot check telemetry to ground stations had been the only method for obtaining data on orbiting astronauts. Purpose of the FM variation is twofold. An FM recorder will facilitate higher accuracy data and easier transcription on standard data processing equipment, and better serve industrial applications. The FM version will feature 7 channels and record time of up to 140 hours, depending on signal frequency response requirements.

MOVING TARGET RADAR FIRE CONTROL

Prime Contractor: Electronics and Space Division, Emerson Electric Company

Remarks

The radar fire control subsystem is based on the Emerson Moving Target Detection System (MOTARDES) and is designed for use on the UH-1 Iroquois helicopter to direct the fire of the Emerson produced M-21 helicopter armament subsystem. The Moving Target Radar Fire Control System may also be adapted to other Emerson armament systems to extend weapon effectiveness and day-night assault capability against enemy personnel and vehicular targets obscured in heavy foliage. The 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 continually searched 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. The copilot expands the display as the target is approached and positions a cursor over the target indication to perform the gunlaying action.

GENERAL PURPOSE AUTOMATIC TEST SYSTEM (GPATS)

Prime Contractor: Electronics and Space Division, Emerson Electric Company

Remarks

The General Purpose Automatic Test System (GPATS) consists of a central programmer-controller mated with functional building blocks (i.e. programmable stimulus generators, response monitors, switching units, simulated loads, and power supplies) which can be interconnected in many hundreds of ways to perform desired test programs on any given system. A Universal Decoder Memory Unit (UDMU) is included as an integral part of each building block to provide a common interface and capability for standard decoding and memory of programmed information. GPATS has an inherent self-test and verification capability and is easily adaptable to a computer for multi-station control and time-sharing for improved cost effectiveness. Approximately 95 percent of the present GPATS hardware is reusable, based on studies of avionics systems in inventory or defined for operational use through 1980. GPATS is operational at 4 USAF Air Materiel Areas (SAAMA, WRAMA, SMAMA, OCAMA) for depot maintenance of avionics, and a fifth system is now in production for avionics maintenance at Ogden AMA.

XM-28 ARMAMENT SYSTEM

Prime Contractor: Electronics and Space Division, Emerson Electric Company

Remarks

The XM-28 is an advanced flexible armament system scheduled for installation in the Bell AH-1G HueyCobra helicopter. The system consists of a power operated turret, sighting station, fire control subsystem, and ammunition storage and synchronized feed systems for 7.62 millimeter and 40 millimeter ammunition. Weapon interchangeability for combinations of 2 7.62 millimeter high rate of fire, multibarrel GAU-2B/A machine guns, 2 XM-129 grenade launchers, or one of each, permits the field commander to select the weapon combination best suited for the intended mission. The system is readily adaptable to other military helicopters. Turret diameter is 28 inches, turret weight 112 pounds.

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 1970 time period. 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, non-interference basis. Integrated circuits, thin film techniques, and advanced packaging concepts are used to minimize weight and volume.

AN/TPS-50

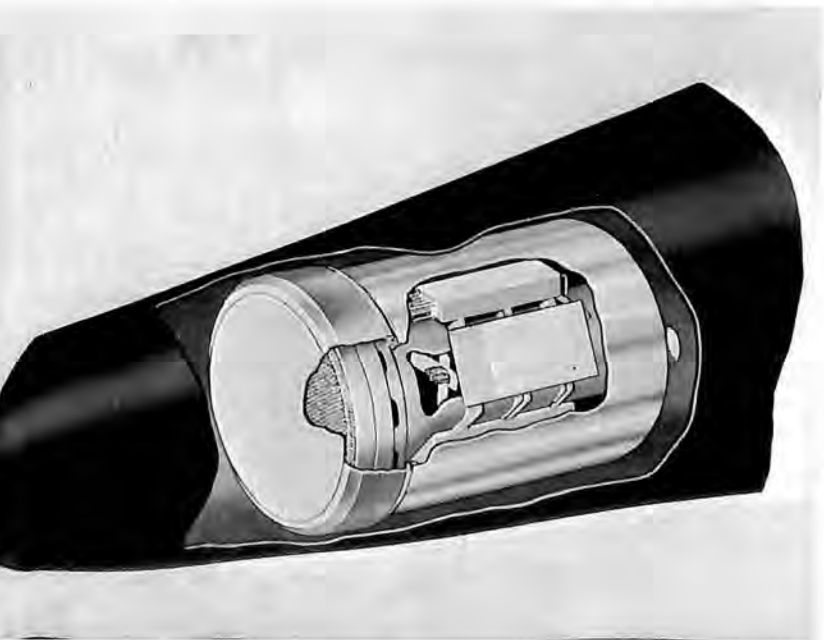
Prime Contractor: Electronics and Space Division, Emerson Electric Company

Remarks

AN/TPS-50 is a lightweight, low cost, man-transportable radar developed by Emerson Electric under contract to Rome Air Development Center for standby prepositioned radar sites, back-up surveillance after bomb attack on prime radars, counter-insurgency applications, tactical air defense and aircraft control. The system is transportable in 7 backpacks, and 30 minutes assembly time is standard for day or night operations with a 6-man crew. The system is vertically assembled using an add-on-component technique while balancing the system with leveling guy wires. Scanning is motor driven and manual. Polarization diversity (linear and circular) permits operation in rainfall. Antenna is operable in winds to 40 miles per hour. Simplified IFF is included to serve as a navigation aid. MTI circuits are incorporated to detect low-flying aircraft and provide alert for air defense missiles and gun systems.

Specifications

Range 50 nautical miles; altitude coverage 20,000 feet; weight 200 pounds.



AN/APM-277 TEST SET

Prime Contractor: Electronics and Space Division, Emerson Electric Company

Remarks

The AN/APM-277 Test Set is a highly mobile system that can be used on the flight line, in hangars, or on shipboard for dynamic testing of aircraft radar systems. The system consists of a mobile, microwave anechoic chamber complete with movable "near-field" target test antennas, electronic circuitry and a remote control unit that permits one-man operation of the entire test set-up and test program. Self-test is an inherent feature of the system. The tester rapidly determines mission readiness in all modes of operation without need for any physical connection to the system under test, simulates free-space with minimum distortion, and boresights to one milliradian or less. Stable operation in a 40-knot wind has been demonstrated. Versions of the system are operational with F-104 and F-105 aircraft. The system is readily adaptable to such aircraft as the Mirage III, F-4, and F-111 and others.

AUTOMATIC PICTURE TRANSMISSION GROUND STATION—PHOTORECORDER

Prime Contractor: Fairchild Hiller Corporation, Space and Electronics Systems Division

Remarks

The Automatic Picture Transmission (APT) Ground Station receives, records and provides terrestrial pictures including the cloud cover as transmitted by weather satellites for interpretation by meteorologists. More than 50 stations are now in service throughout the world, reproducing weather pictures sent by the APT Systems aboard Nimbus and TOS satellites. A new Photorecorder that provides a photographic print instead of the electrolytic-type facsimile recording has been developed (in photo) for use with the APT Ground Stations and other applications. The Photorecorder provides high quality rapidly processed prints on 9-inch wide photographic paper. A high resolution cathode-ray tube is used to generate a line scan, which is imaged on the paper feed and rapid processor, and an 8-inch wide print is produced within 20 seconds after completion of the paper exposure. The rapid processor is integral with the printer and does not require dark-room operation. In addition to the APT mode, switch selected alternate operating modes provide printing of DRIR and WEFAX photographs in all commonly used scan rates and indices of cooperation.

AUXILIARY DATA ANNOTATION SYSTEM

Prime Contractor: Fairchild Hiller Corporation, Space and Electronics Systems Division

Remarks

The Auxiliary Data Annotation System (ADAS) provides mission-pertinent data annotation capability to airborne reconnaissance photo cameras. Pertinent flight information, such as time, latitude, longitude, speed, barometric and radar altitude, heading, pitch, roll, drift, date, sortie number, detachment, radar mode, correlation counter, sensor/station identification and taking unit identification can automatically be marked on the sensor film. Fairchild Hiller has produced the following ADAS equipment: AN/ASQ-90 for RF 4 B/C, AN/ASQ-92 for the AN/USQ-28 in KC-135, AN/ASQ-94 for FR-101, and the MAS-1 (in photo) for FR-104G. Each of these sets has been designed for full compliance with MIL-STD-782, but can be modified to provide an alternate mode of operation in which it will record data in any one of the following forms: MIL-STD-782, alpha-numeric, or alternating forms. Information is recorded on film by means of a cathode ray tube contained in each Recording Head Assembly. A Fixed Programmer Card which provides a means of changing the fixed data (date, sortie number, etc.), is inserted prior to flight. An earlier alphanumeric ADAS system was designed for the AN/USD-5 Reconnaissance Drone.

AN/SPQ-10 FIRE CONTROL METEOROLOGICAL TRACKING SYSTEM

Prime Contractor: Fairchild Hiller Corporation, Space and Electronics Systems Division

Remarks

Fairchild Hiller is engaged in improving the AN/SPQ-10 Fire Control Meteorological Tracking System for the Coast Guard. These modifications will provide the system with the added capability of determining wind speed and direction as a function of altitude. Without degrading the fire control function of the system, the shipboard facility will be capable of automatic tracking of a meteorologicial balloon, providing wind velocity profiles with respect to the true horizontal place by correcting for roll, pitch and yaw influences on measurements. Modifications will include: replacement of the transmitter with that used in the AN/UMQ-7 Meteorological Data Sounding Set, addition of a new tunnel-diodeamplifier front end to the existing receiver, addition of the displays from the AN/TPS-41 Mobile Weather Radar modified to permit the range unit to operate over a 300,000 yard range, and addition of a digital computer (18 microsecond add time, 60 microsecond multiply time) which accepts ship's roll, pitch, heading and speed in addition to radar elevation angle, azimuth angle and slant range. The computer calculates absolute direction, velocity, azimuth, elevation and altitude of the target. Computer output includes a Nixie tube display and punched tape for direct printed readout and teletype transmission.

CODE MATRIX FILM READER

Prime Contractor: Fairchild Hiller Corporation, Space and Electronics Systems Division

Remarks

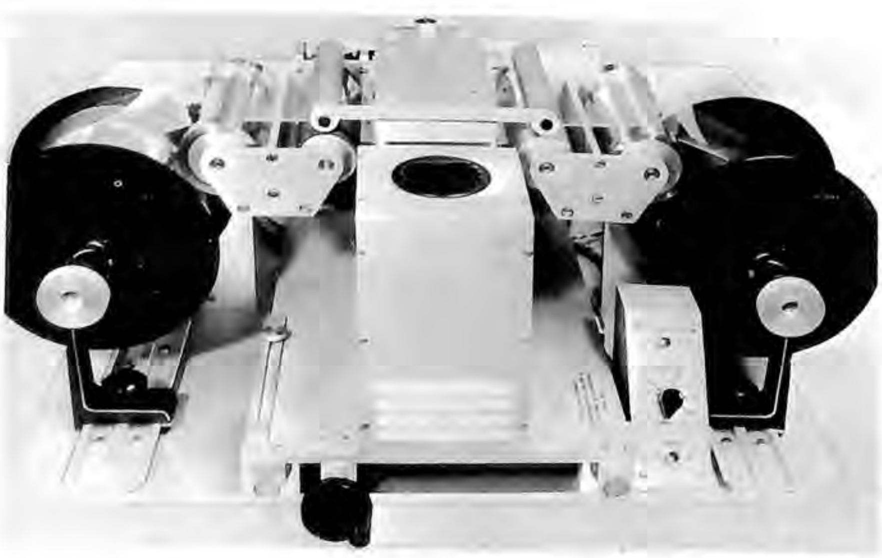
The advanced Code Matrix Film Reader developed by Fairchild Hiller will be employed with the existing viewing equipment in a photo-interpretation facility to retrieve automatically the desired frame by controlling reconnaissance film position. The "Tactical Intelligence Processing and Interpretation" system (TIPI) will also utilize this reader. The reader also will permit conversion of data into alpha-numeric form with a provision to direct outputs for hard-copy print-out, for on-line film titling, or for on-line general-purpose computation. The reader (in photoreader without the electronics subsystem) uses a single line of photo-sensitive diodes to detect film images. Employed with ADAS-annotated film, the MIL-STD-782 code blocks are read and the diode (analog) outputs are converted to digital form and stored. A sensing circuit, associated with the reader head, detects when a code block is being read. Sufficient time is allowed for the whole block to enter a memory section. It is then scanned and the digital expression reidentified as "dots" with each assigned to a proper location within a second memory carrying the code block format. From this second memory, the code block is transferred to numeric displays, printers or a computer buffer. With code block spacings of 5 inches or greater, the reader can handle film rates up to 40 inches per second in either direction; at minimum MIL-spec spacing of 0.7 inches edge to edge, a film rate up to 3 inches per second is possible.

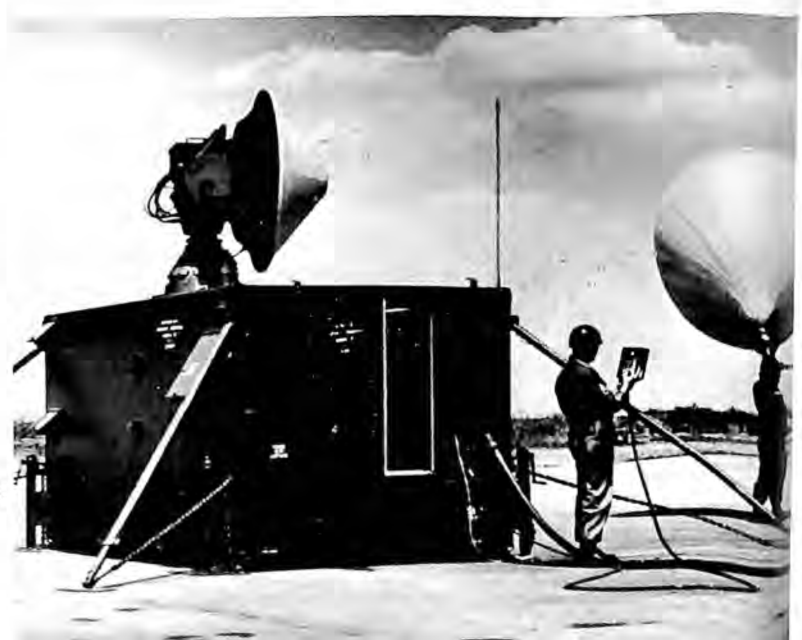
METEOROLOGICAL DATA SYSTEM

Prime Contractor: Fairchild Hiller Corporation, Space and Electronics Systems Division

Remarks

The Meteorological Data System developed by the Space and Electronics Systems Division is a lightweight transportable system designed for set-up and operation within 30 minutes. Its primary function is to provide up-to-the-minute meteorological data to Army artillery units by sounding the atmosphere to an altitude of approximately 100,000 feet. It also supplies meteorological information including nuclear fallout and sound ranging to the Air Weather Service and NATO. The Meteorological Data Sounding Set (AN/UMQ-7) includes the Automatic Atmospheric Sounding Set (AN/TMQ-19) and the Atmospheric Meteorological Probes (AN/AMQ-22 and AN/AMQ-23), in addition to ancillary items such as the power generator, hydrogen generator and the balloon or rocket launcher. The AN/TMQ-19 Automatic Atmospheric Sounding Set (in photo) has the capability of accurately tracking and receiving data transmitted from airborne balloon and rocket probes. High accuracy and rapid data processing and reliability are the outstanding features of this system. The first system was delivered to the Army in September, 1965. It is 12 feet long, 7 feet wide and weighs 5,000 pounds including the mobile shelter in which it is housed.





DEPLOYABLE SOLAR ARRAYS

Prime Contractor: Fairchild Hiller Corporation, Space and Electronics Systems Division

Remarks

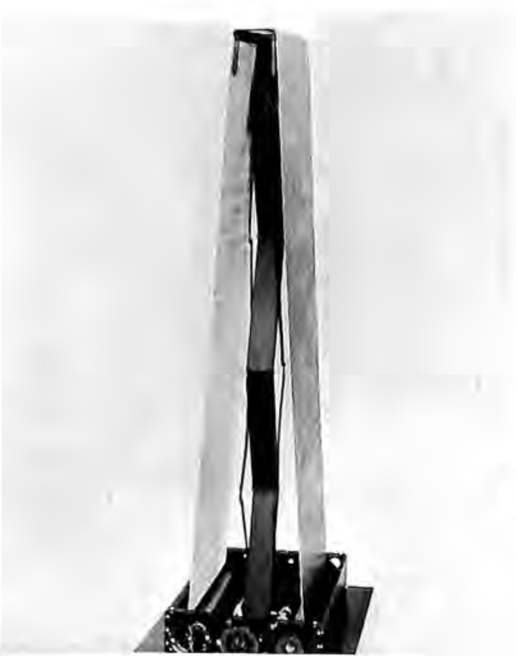
Fairchild Hiller has conducted a series of development programs involving flexible deployable solar arrays over the past several years. The most recent program was performed for NASA-GSFC under contract NAS5–9658. During Phase I of this project, a "proof-of principle" model was designed, fabricated, and tested. The design consisted of 2 flexible parallel arrays, mounted on synchronized rollers and deployed outward from a spinning body. The area of each substrate was 8 square feet. Stabilization of the substrate was accomplished by an extendible scissors linkage between the arrays. Total weight of the 16 square feet of packaged solar cells is approximately 13½ pounds. An analysis of the deployment, launch, solar radiation, and induced stresses was also completed. During Phase II of the program, a 2.16 foot wide by 8.20 foot long flexible array system was developed and tested. The total area of the double panel is 35.5 square feet. The array uses silicon solar cells which are mounted on 2 flexible, back-to-back substrates and are interconnected by a flexible connector. The arrays are deployed from a pair of synchronized rollers using spring energy and are supported in the deployed configuration by a mechanical linkage. The packaged array will fit within a 1.3 cubic foot package and the weight, including mechanism, array, springs, etc., is 29 pounds.

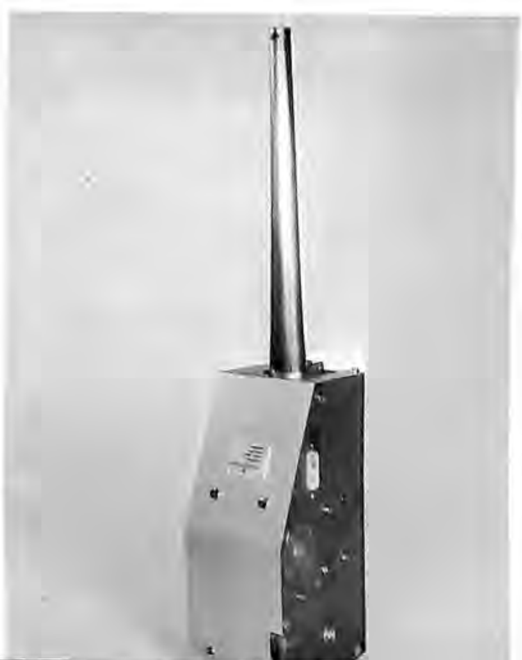
TUBULAR EXTENDIBLE ELEMENTS (TEE)

Prime Contractor: Fairchild Hiller Corporation, Space and Electronics Systems Division

Remarks

Fairchild Hiller has developed and is producing for a wide range of applications Tubular Extendible Element (TEE) devices and systems. Fairchild Hiller TEE's are thin, metal ribbons which are rolled into tubes (along their longitudinal axes) and heat-treated to give them a "memory." The tubes are then opened, flattened into tape again, and wound on a spool. When unwound, they automatically reconstruct themselves into tubes. Motorized systems can extend the tubes in lengths ranging up to thousands of feet. TEE's can be stored in a small space and can also be extended to great lengths (and then be retracted into their original form); they can operate reliably in any kind of environment and require no maintenance. TEE's are used as dipole antennas for satellites and sounding rockets; as gravity gradient attitude control rods; and as instrumentation extension systems. Recently, they have been put to use as extremely long antennas in radio astronomy and electric field measurement satellites. In addition to diameter and material variations, hybrid Tee's can be manufactured with electrical insulative coatings, dielectric joints and in-line antenna termination networks. Tee's are also manufactured with open section seams (overlapped and underlapped) or with torque resisting interlocked seams. TEE solar flux windows and thermal control coating can also be provided. Fairchild Hiller is providing 4 750-foot antenna sections and 3 350-foot libration damper boom sections for the Radio Astronomy Explorer (RAE) Satellite.





AN/TPS-41 MOBILE RADAR WEATHER SYSTEM

Prime Contractor: Fairchild Hiller Corporation, Space and Electronics Systems Division

Remarks

The Mobile Radar Weather System provides 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. The MWR display system consists of three visual indicators—horizontal or vertical cross section area of precipitation and echo return to measure precipitation rate. The first set was delivered to the Army Electronics Laboratories in July 1965. Total weight of this wheeled system is less than 3,500 pounds. The equipment has been designed so that it can be set up in less than 20 minutes on a self-supporting basis. A 40-foot high antenna support pedestal to be used with the AN/TPS-41 is being developed under a separate contract. The new antenna system can be erected or disassembled in less than one hour by a crew of 5 men. The erected structure is capable of withstanding 60-mile-per-hour winds, and will allow unobstructed operation in locations where the radar performance could otherwise be impaired by trees or other obstructions. Fairchild Hiller is also developing under contract the next generation equipment, the AN/TPS-4 (XE-2).

RECORDER, SIGNAL DATA

Prime Contractor: Fairchild Hiller Corporation, Space and Electronics Systems Division

Remarks

The Recorder, Signal Data RO 321/A, previously designated as the Airborne Central Data Tape Recorder (ACDTR), was developed for the Air Force by the Space and Electronics Systems Division, to work with the Auxiliary Data Annotation System for reduction of data interpretation time, automatically, following reconnaissance missions. The complete mission profile can be stored on a single half-inch, one-mil, 7-track magnetic tape to permit preliminary ground analysis while awaiting sensor film processing. The recorder permits photo interpreters to immediately program an updated plot of the missions as performed to identify deviations from the preflight planned observation path, to identify specific sensor coverage, and to compile detailed ELINT maps for the surveyed area. When employed with ADAS, the recorder is comprised of a synchronized magnetic-tape transport and a microelectronic special-purpose computer subsystem. At least 2 hours of continuous mission data can be recorded in a format compatible with an IBM-729 IV reader. Data are recorded at 556 bits per inch on the 7-track, ½-inch tape. Four tracks carry mission data, 1 track ADAS parity, and 1 track tape parity. The 7th track serves as a spare. Recording of both system parities serves as a useful cross-check later in processing the stored data by digital computer.

MOBILAB

Prime Contractor: Fairchild Hiller Corporation, Space and Electronics Systems Division

Remarks

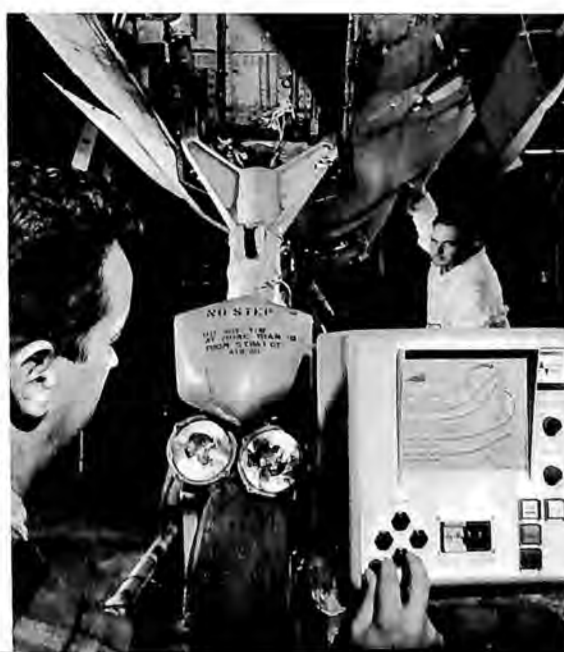
Mobilab, designed and built for the Air Force, is a mobile film processing laboratory which reduces time between acquisition and interpretation of aerial reconnaissance film. In operation, the Mobilab meets the reconnaissance aircraft upon return from its mission. The magazines or cassetts with exposed film are unloaded from the aircraft into the Mobilab darkroom, where technicians remove the film and put it in the EH-68 Bimat processors, returning the empty magazines to the aircraft immediately. Six EH-68 Processors, using the Eastman Kodak Bimat process, automatically develop and fix the film while the Mobilab is in transit. Both a positive and a negative are produced, exhibiting the high quality and definition required for reconnaissance purposes. For flash reporting, a roll of positive film can be produced with only 5 minutes of processing time. Mobilab is completely self-sufficient, i.e., fully mobile self-propelled, has air conditioning, heating, power, and 2-way radio. It is air transportable in a C-130 (2 per aircraft) and/or C-141 aircraft.

MICRO-VUE

Prime Contractor: Fairchild Hiller Corporation, Republic Aviation Division

Remarks

The MICRO-VUE Information System, developed by Republic Aviation Division for commercial and military applications, stores, retrieves, and displays large quantities of text and picture information. It stores the data on laminated photographic 4 by 5 inch film chips that hold up to 9,800 frames of technical data in a 99-by-99 matrix. For information retrieval, solid state electronic digital loops provide random access to any frame on the hi-density micro image chip. The operator simply dials in the frame number, pushes a button, and the frame is automatically found and displayed on a screen. The film chips on which the hi-ratio reduction micro-photographic data are stored are produced using readily available equipment and films. A page of information can be reduced to 1/350th of its original size. Consequently, a single chip can hold a 75-foot-by-75-foot city map or chart of a utility distribution system. Access to a particular frame is usually made automatically, by indexing with a thumbwheel. With an optional slew switch, the operator can view a continuous strip, constituting a 99-page foldout of such data as wiring diagrams, logic flow diagrams, or wave form patterns. Transfer from one point on the matrix to another typically takes a tenth of a second. An optional Auto-Chip Loader can expand the stored data to approximately 200,000 frames with random access at a maximum of 30 seconds.



A/M32C-10 GROUND AIR CONDITIONER

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

The Stratos Model GEA50-1 Ground Air Conditioner (A/M32C-10) is a mobile, compact unit that was designed to deliver cooling or heating air to personnel, cargo, and electronic compartments in military aircraft during ground servicing and checkout. The conditioned air is delivered directly into the air-duct system of the aircraft. Discharge temperatures ranging from 47 to 200 degrees Fahrenheit can be selected and are regulated through a simple and reliable control system. The unit receives its source of energy, turbine bleed air, from an external gas turbine compressor such as the A/M32A60 or the A/MA-1A. The GEA50-1 consists of an air cycle machine, a heat exchanger, a moisture separator, manually operated valves, ducting, undercarriage, and wheels. All the controls required to regulate discharge airflow, temperature, and relief pressure are mounted on the instrument panel. Gages on the panel display pack discharge airflow, temperature, back pressure, backpressure relief valve setting, and air cycle machine oil-pump pressure. The unit is used to service F-4 and F-105 aircraft. Over 200 units are in service in the USAF.

COMPACT MILITARY AIR CONDITIONERS

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

Under the sponsorship of the U.S. Army's Engineering Research and Development Laboratories, Stratos has developed a family of vapor cycle air conditioners for the military needs of the 1970s. Designed to meet the most rigid requirements of Army vehicles, vans and shelters, the air conditioners are offered in 11 different models in the 9,000 to 60,000 British Thermal Units per hour range, with 60 cycle and 400 cycle power available on all units. All models are of a compact low silhouette design, completely self-contained and readily adaptable to any installation requirement. In photo, the 18,000 BTU/hour unit.

747 AIR TURBINE DRIVE

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

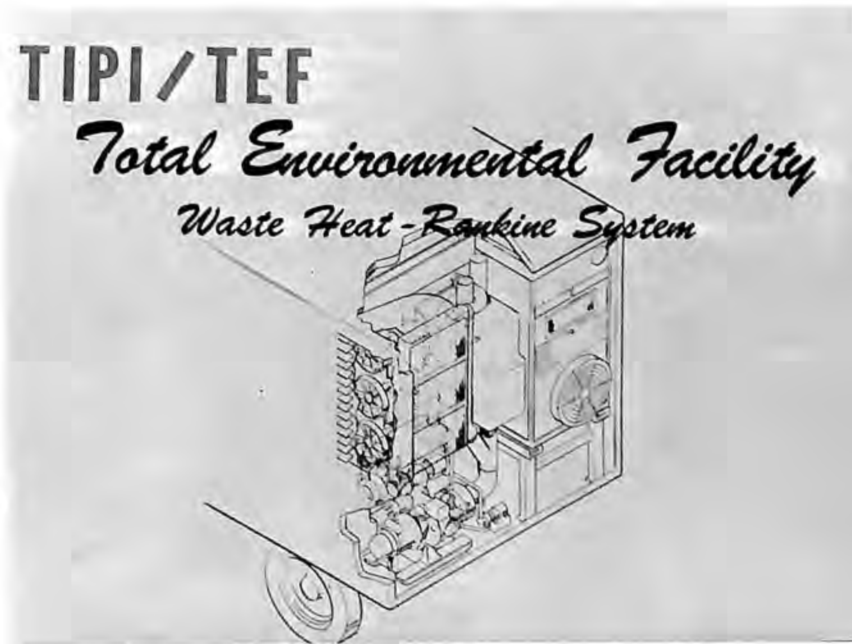
In development at Stratos is the air turbine drive for the Boeing 747. The TP85-1 air turbine will be utilized to drive a hydraulic pump that will furnish, under high load conditions, auxiliary boost power for selected control functions of the aircraft. In addition, the air turbine driven pumps will provide continuous system hydraulic power in case of a malfunction of the engine driven pumps. Nominally rated at 85 horsepower, the Stratos turbine utilizes the bleed air of the jet engine for operating power. There will be 4 turbine drives per aircraft. The TP85-1 control circuits are pneumatic and operate on the primary supply air course. They require no quiescent flow, which minimizes contamination. They are protected by water separators, filters and ⅜ inch minimum diameter lines to preclude any contamination and freezing. Additionally, 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 one 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 will house 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-foot by 8-foot by 8-foot shelter is a gas turbine-generator set with a 50 kilowatt capacity and an environmental control system that will be powered by utilizing the gas turbine exhaust gases that usually are 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. Consequently, the system efficiency increases to a point where 50 kilowatts of usable refined electrical power is developed at the same fuel consumption rate as a 30 kilowatt set requires without the waste heat recovery feature. The net result is substantial fuel savings (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 and Processing and Interpretation System), a tri-service sponsored reconnaissance program.



APOLLO ENVIRONMENTAL CONTROL SYSTEM

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Division, Los Angeles

Remarks

The Apollo environmental control system (ECS) provides a controlled environment for 3 astronauts for up to 14 days. For normal conditions, this environment includes a pressurized cabin, a 100 percent oxygen atmosphere, and a temperature of about 75 degrees. For emergency use the system includes a pressurized suit circuit. The ECS provides fresh oxygen and hot and cold potable water, removes carbon dioxide and odors, dissipates heat from the cabin and from operating electronic equipment, and removes waste water and solids from the gas stream. Primary oxygen for breathing, pressurization, and ventilation is stored cryogenically in the service module. Oxygen tanks in the command module serve crewmen after the separation of the 2 modules before reentry. The system has provisions for supplying oxygen servicing to portable life support systems used by crewmen. Primary cooling is accomplished by means of an intermediate heat transport fluid which absorbs heat and dissipates this heat through a space radiator. A supplementary water boiler-type heat exchanger cooling system is used during launch, reentry and emergency phases. The system is designed so that minimum amount of crew time is needed for its normal operation.

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. Here it becomes desirable to pressurize the cabin for passenger comfort. Cabin pressurization 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 the turbocharger, a compressor discharge pressure sensing controller, turbine bypass "wastegate" 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 7 Cessna models, 2 Beech and 2 Piper models. The Bell 47G-3B and Hiller E4 helicopters also incorporate the unit. Cessna, Mooney and Beech also have models incorporating the combined engine and cabin turbocharging system.

MUST (MEDICAL UNIT SELF-CONTAINED TRANSPORTABLE)

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Company of Arizona

Remarks

Under sponsorship of the U.S. Army Medical Service, The Garrett Corporation's AiResearch Manufacturing Company of Phoenix, Arizona, in 1963 undertook the development of a revolutionary military field hospital, designated MUST (Medical Unit Self-contained Transportable). The basic features of this new concept in military field hospital facilities include mobility, short setup time, high reliability and efficiency, controlled environment, and the capability of maintaining all-weather operation. The basic MUST system is made up of only 3 elements: an inflatable 20 by 52 foot ward-type unit; a 12 foot long, 7 foot wide, 8 foot high rigid panel expandable (12 by 18 feet) unit that serves a variety of shelter needs such as for surgery, laboratory, supply, and pharmacy; and a sound attenuated, weatherproof utility element, 72 inches wide, 108 inches long, and 86 inches high, equipped with an AiResearch gas turbine that supplies all power requirements of the MUST complex. All are helicopter transportable. The MUST elements may be used together in combinations as small as 1 ward or surgery and utility element, up to a full 400-bed U.S. Army field hospital. One utility element provides power for the equivalent of 4 inflatable elements or 6 expandable elements, plus 1 additional expandable element having heavy power needs (such as for X-ray facilities) at the temperature extremes of minus 65 degrees or plus 140 degrees Fahrenheit. MUST hospitals are now in operation in Vietnam in active support of combat forces.

GRAVITY GRADIENT SYSTEMS

Prime Contractor: General Electric Company, Missile and Space Division, Spacecraft Department

Remarks

Gravity gradient satellite stabilization systems have been extensively developed by General Electric. These systems use the natural gravitational field surrounding the earth to make a satellite constantly point to earth. They are lightweight, use little or no power for operation, and have very few parts. They have virtually unlimited life and can be designed for both 2- and 3-axis stabilization. A General Electric system has stabilized a Naval Research Laboratory satellite since its launch in January 1964. Two other Naval Research Laboratory satellites using General Electric systems have been orbiting since March 1965. General Electric has developed 2 Gravity Gradient Test Satellites for the Air Force, one of which was launched June 16, 1966, from Cape Kennedy by a Titan III-C booster along with 7 communications satellites. The Company has also provided gravity gradient systems for NASA's GEOS and Applications Technology Satellites.

CONTINUOUS NONEQUILIBRIUM MHD POWER GENERATOR

Prime Contractor: General Electric Company, Space Sciences Laboratory

Remarks

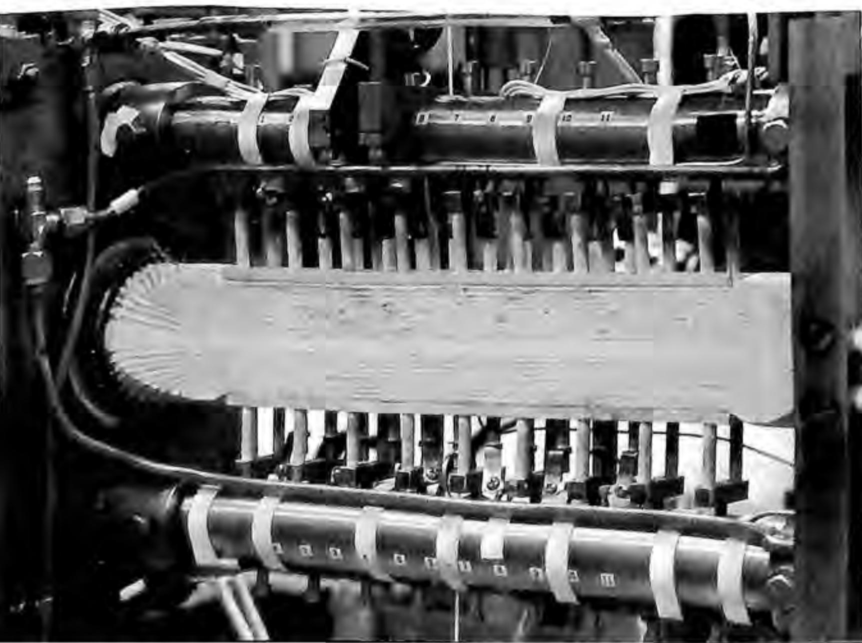
A magnetohydrodynamic generator was continuously operated without high heating, for the first time, in a series of basic experiments at the GE Space Sciences Laboratory. The Department of Defense and GE cosponsored the work under the Independent Research & Development Program. Steady electric power of 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 equilbrium 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 really 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 a high reliability because of the complete absence of moving mechanical parts and is thus strongly attractive for long-term space nuclear power applications, either for electric propulsion, communications, or planet-based needs. In photo, test section of MHD facility, with 11 electrode pairs.

BLOOD FLOW IN ARTIFICIAL HEARTS

Prime Contractor: General Electric Company, Space Sciences Laboratory

Remarks

Artificial hearts may be brought closer to everyday reality by techniques applied from space research. Under contract from the National Heart Institute, researchers at the GE Space Sciences Laboratory are teaming up with medical experts of Philadelphia's University City Science Center. The research comes under the National Heart Institute's Artificial Heart Program which is striving to develop totally implantable artificial hearts and artificial booster heart devices and make them generally available as soon as possible. The Institute is a member of the National Institutes of Health of the U.S. Public Health Service in the Department of Health, Education, and Welfare. A major problem in the development of artificial hearts, valves, and other devices to assist circulation has been clotting and the destruction of blood cells. The Institute has recognized that, while foreign materials used in the prosthetic devices clearly have an important bearing on the clotting and blood cell destruction, much of the difficulty seems to lie in the patterns of blood flow in and around the devices. The theoretical portions of the blood flow problem will be carried out at GE, while the related experiments will be performed in associate laboratories of the Science Center. The program will seek fundamental data to use in designing prosthetic devices in contact with flowing blood. In photo, surgeon holds artificial human heart valve, a product of GE Silicone Products Department.



SNAP-27

Prime Contractor: General Electric Company, Missile and Space Division
Principal Subcontractors: 3M Company (thermopile) and Solar Division of International Harvester Company (beryllium fabrication)

Remarks

The SNAP-27 is a plutonium-238 fueled power supply being developed under contract to the Atomic Energy Commission. The complete system weighs 38 pounds and produces a minimum of 64 watts (DC) at a nominal 16 volts. It will be the power source for the Apollo Lunar Surface Experiment Package (ALSEP) being developed for the NASA Manned Spacecraft Center. This package will be transported to the lunar surface within the scientific equipment bay of the Lunar Module (LM). The fuel capsule will be 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 event of an aborted mission. After landing, the fuel capsule will be removed from the cask and inserted into the generator by one of the astronauts. The ALSEP will then be 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. Two prototype systems have been delivered and delivery of the first flight systems was expected by year-end 1967.

JET AIRCRAFT ENGINE IGNITION SYSTEMS

Prime Contractor: General Laboratory Associates, Inc.

Remarks

GLA has supplied capacitor discharge ignition devices for both military and commercial jet aircraft engines. A typical example of a system employing several products manufactured by GLA is pictured below. This TF30P8 Engine Ignition System is used on the F-111A and B programs and features an engine driven alternator, low voltage interconnecting leads, engine exciters, high voltage leads, and an instrumentation harness. Customized designs for similar equipment on the VSX and UTT aircraft programs are under active development. Commercial programs which utilize GLA ignition devices include the Boeing 707/720, Douglas DC-8/DC-9, Convair 880/990 and the Lockheed Electra II aircraft. Military programs include Lockheed C-130/141, Boeing B-52/KC-197, Sikorsky Skycrane and Lockheed RB-33.

ROCKET ENGINE IGNITION SYSTEMS

Prime Contractor: General Laboratory Associates, Inc.

Remarks

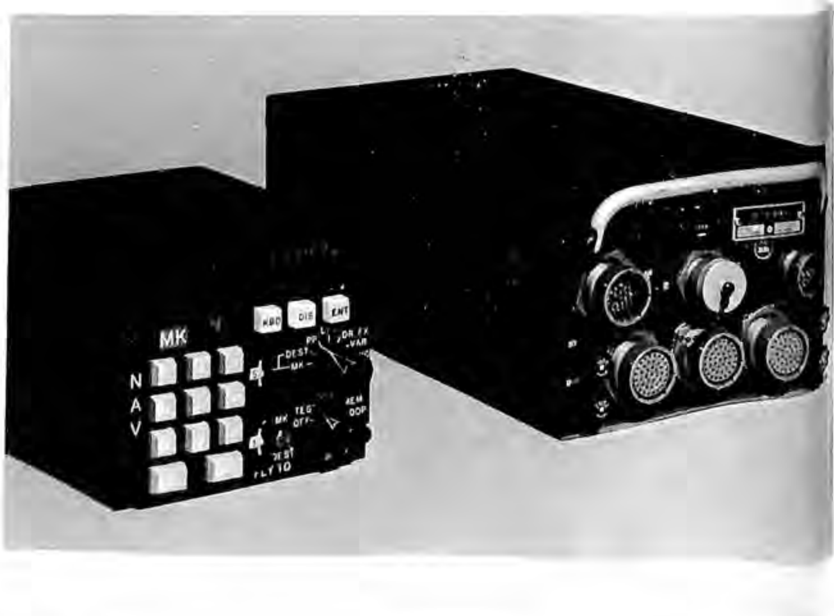
GLA has established a solid position in the design and manufacture of liquid rocket ignition systems through its activities on the Saturn and Centaur programs. Pictured here is a hermetically sealed ignition system for the Pratt & Whitney Aircraft RL-10 LOX hydrogen engine. Successful RL-10 engine restarts in outer space have contributed to the success of the Surveyor probes and have demonstrated the dependable performance and reliability of this ignition system. Important design features of this system include an operating temperature range from minus 160 to plus 165 degrees Fahrenheit (however, units have been tested down to minus 320 degrees Fahrenheit), a sensing device for constant monitoring of the hermetic seal of the system (including a provision for telemetering this information back to earth on space flights), a spark indicator and a fuel cooled igniter.

MICRO-MINAC DIGITAL COMPUTERS

Prime Contractor: General Precision Systems Inc. (Subsidiary of General Precision Equipment Corporation), Kearfott Systems Division, Kearfott Group

Remarks

A significant advancement in the development of small, lightweight, low-cost navigational computers, MICRO-MINAC replaces an earlier analog computer without affecting associated system equipment or cabling. Consisting of a programmable solid-state computer element together with a separate MINAC control/display unit, this airborne computer set has a number of desirable capabilities built into it to enhance its use in tactical missions. The computer segment contains synchro-to-digital converters, digital-to-analog converters, a digital processor, and a power supply. It accepts true air speed, drift angle, ground speed, and magnetic heading inputs from Doppler radar, a magnetic compass, and an air-speed sensor to provide relative ground track, relative bearing to destination, and distance-to-go outputs to a Bearing-Distance-Heading Indicator (BDHI). Doppler-mode-computed present position, wind direction and velocity, together with marked target coordinates are selected by the operator for readout on the computer set's accompanying Control/Display panel. All computer outputs can be made available to other devices.



PERSHING SELF-CONTAINED HYDRAULIC ACTUATION SYSTEM

Prime Contractor: General Precision Systems Inc. (Subsidiary of General Precision Equipment Corporation), Kearfott Products Division, Kearfott Group

Remarks

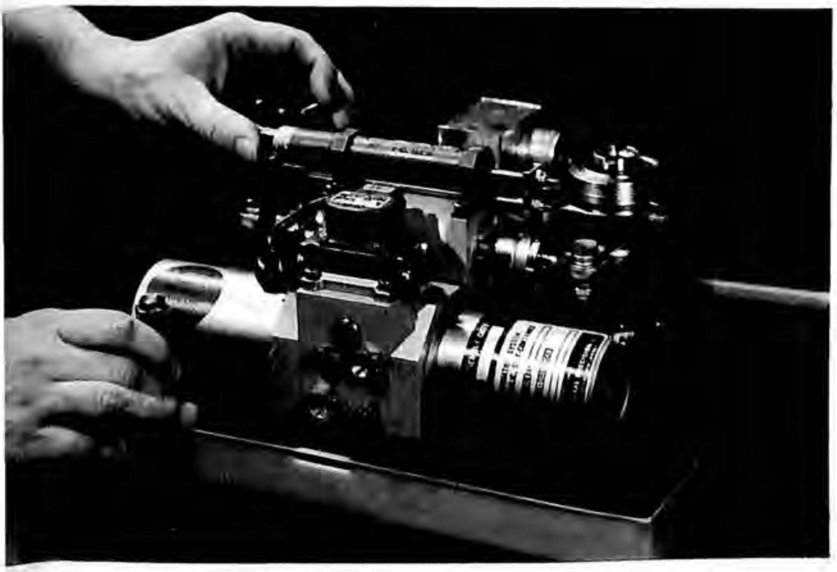
This system is based on General Precision's Modular Hydraulic Control System technology. It has been designed for use on the Pershing surface-to-surface missile and over 1,000 units have been flown without any reported failures. The system controls jet and air vanes on the Pershing missile. It has made a central hydraulic supply and external plumbing unnecessary. Completely sealed against contamination, this lightweight system needs no hydraulic support equipment at the launch site. These modules may be removed simply by disconnecting 3 cables and unfastening 4 mounting bolts. This has the distinct advantage because individual packages can readily be removed for maintenance and replaced by a ready spare.

PROPELLANT QUANTITY INDICATOR

Prime Contractor: General Precision Systems Inc. (Subsidiary of General Precision Equipment Corporation), Kearfott Products Division, Kearfott Group

Remarks

The Propellant Quantity Indicator was developed for use on the Lunar Module Display Subsystem. Consisting of segmented electroluminescent panels, its readouts display numbers in response to excitation of particular segments. Even under the very bright ambient light conditions of space, both displays can be easily read because of high display contrast. Relative fuel and oxidizer tank quantities are simultaneously displayed by the Propellant Quantity Indicator. Two identical data processing channels are used. The associated electronics and the EL Displays were supplied by General Precision Systems Inc.



GYRO COMPASS ATTITUDE REFERENCE SET (GARS)

Prime Contractor: General Precision Systems Inc. (Subsidiary of General Precision Equipment Corporation), Kearfott Systems Division, Kearfott Group

Remarks

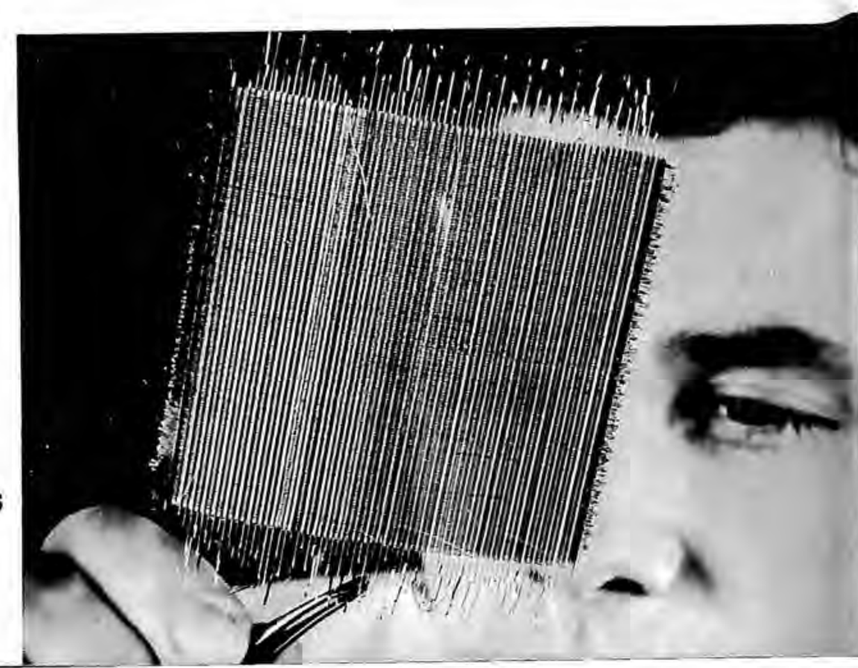
The GARS subsystem is a light, relatively inexpensive Doppler-damped, Schuler-tuned, local-vertical attitude and heading reference set. It can perform both ground-based and in-air gyrocompassing. Designed for use with a Doppler radar navigation set, the GARS subsystem accurately measures aircraft heading and attitude. Because of its airborne gyrocompassing capability, no time-consuming pre-flight alignment procedures are required. This makes it attractive for use in carrier-based aircraft, particularly for scramble missions. In association, the Doppler and GARS equipment provide aircraft velocity data. By combining the long-term accuracy of Doppler velocity measurements with the high short-term accuracy of inertially-derived velocity data, the over-all system provides very accurate and instantaneous velocity outputs. Such Doppler-damped inertial velocity data are smoothed and do not contain the high-frequency noise content associated with the Doppler signal alone. The AN/ASN-57 is a 3-gimbal, limited-attitude version of the GARS subsystem suitable for patrol aircraft and helicopters. The other version is a 4-gimbal, all-attitude set (AN/ASN-58), ideally suited for land-based or carrier-based fighter and fighter-bomber aircraft. Gyroflex gyros and special low-cost accelerometers are the vital components of both types. Special features of the set, common to both versions, are: compactness, light weight, low cost, short ready time capability, high accuracy and provisions for self test.

WOVEN PLATED WIRE MEMORY

Prime Contractor: General Precision Systems Inc. (Subsidiary of General Precision Equipment Corporation), Librascope Group

Remarks

Librascope Woven Plated Wire Memory is a new-generation magnetic memory for aerospace computer, telemetry, and other applications. It is automatically woven on a loom. In aerospace computers, Woven Plated Wire Memory provides operational speeds in the low-nanosecond range, low-power consumption, nondestructive readout, and significant space savings. The memory, already ordered for many space programs, is available in four functional organizations: (1) linear select; (2) coincident select; (3) read-only, electrically alterable; and (4) read-only, permanently woven.



MICRON MENSURATION STAGE

Prime Contractor: General Precision Systems Inc. (Subsidiary of General Precision Equipment Corporation), Link Group

Remarks

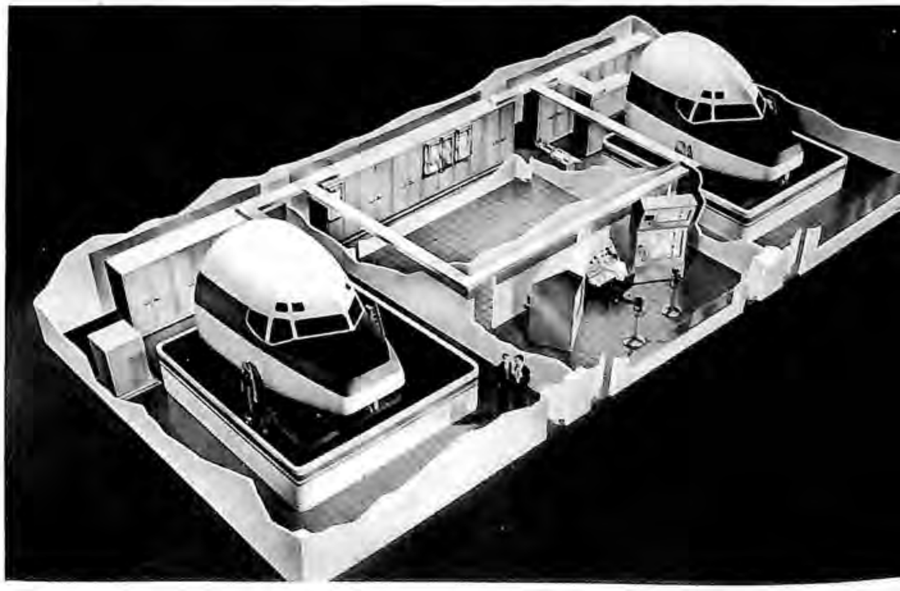
The Micron Mensuration Stage, developed by Link Group under contract with the Rome Air Development Center, Griffiss Air Force Base, New York, provides positioning and measurement to micron accuracy. The stage's accuracy is mainly attributed to an air-floated translation principle that virtually eliminates some of the factors which reduce accuracy in conventional systems—stiction, friction and wear. More accurate than conventional lead-screw systems, the compact Micron Mensuration Stage has a variety of applications in fields which require the utmost in precision positioning and measurement. In a typical application, measurements are provided in a format that is compatible with an associated digital computer programmed to perform data reduction tasks based on the measurements. The system's X-Y motion stages are designed so that they can be coupled with a variety of metering and drive systems, making an extremely precise translation system that is applicable to many fields. These include: integrated circuit manufacturing, photogrammetry, and chemical and medical research. Made of lightweight material, the air-floated translation system preserves the features of an air bearing. By virtually eliminating wear, the original calibrated accuracy of the comparator can be maintained throughout the life of the system. A unique drive minimizes the adverse effects of gear backlash. Other important improvements over conventional systems include simplified design, greater tolerance to machining, and ease of maintenance. The unit is both portable and rugged.

DUAL COCKPIT FLIGHT SIMULATOR

Prime Contractor: General Precision Systems Inc. (Subsidiary of General Precision Equipment Corporation), Link Group

Remarks

The Link dual cockpit flight simulator is the most advanced training complex of its kind to be put to use by the airlines. As of September 1, 1967, 10 airlines either had or had ordered 13 systems similar to the Pan American World Airways installation shown. Each cockpit in a system can simulate a different aircraft, a Douglas DC-9 and Boeing 707, for instance. The flight decks are exact replicas of those in the aircraft. The speed, capacity and advanced electronic design of the system's computer, a Link GP-4, enables the crew of each cockpit to fly an independent training mission. For example, one crew can land at JFK while the other is taking off at Dulles or anywhere in the world. If the simulators are flown in the same area, crews can communicate with each other just as they would in actual flight. The motion systems pitch and roll the flight cabins and simulate rough air conditions. Pre-stall buffeting, high-mach buffet, and engine compressor stall are simulated. The crews are even subjected to the sensations of taxiing on rough runways. Sounds emitted by a plane's engine, slipstream, air conditioning, and pressurization effects, and even the screech of tires at touchdown, are reproduced in each cabin. The simulators' radio-aids recorders plot both cross-country ground tracks and final approaches. The radio-aids systems include altitude deviation recorders which indicate how closely each student-pilot follows his glide slope during an instrument landing approach. The pilots can tune in on any of approximately 500 radio navigational aids that have been programmed into the computer. The students receive and respond to aural signals and instrument indications as they would in the aircraft. The indications apply to VOR, DME, ILS, or LF beacons, whichever the pilot selects.



AUTOMATIC MICROFILM APERTURE CARD UPDATING SYSTEM

Prime Contractor: General Precision Systems Inc. (Subsidiary of General Precision Equipment Corporation), Link Group

Remarks

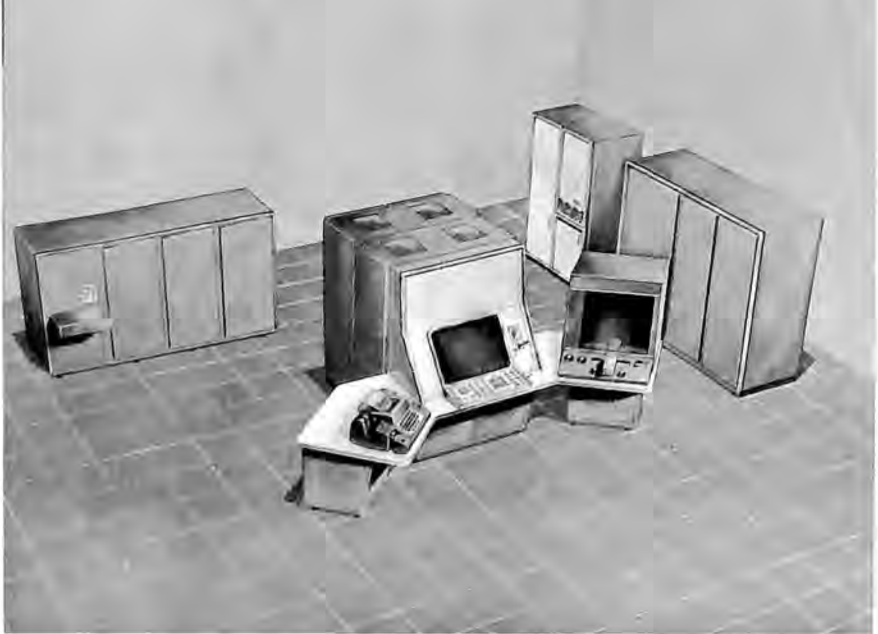
Link developed the Automatic Microfilm Aperture Card Updating System (AMACUS) under contract with the U.S. Army Weapons Command, Rock Island, Illinois. The system allows an operator to add to and to correct technical drawings and data sheets that are stored on microfilm aperture cards. The revisions 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 is 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 and keyboard. His revisions directly modify the digitally stored information on the drum and the new data is 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. A new aperture card is automatically processed and a second generation microfilm document card is then available.

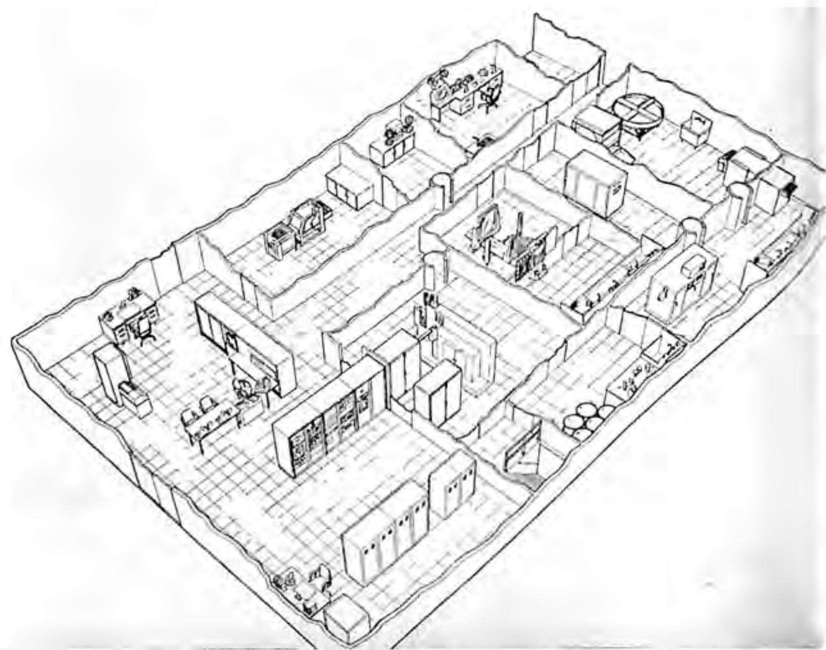
SPACECRAFT TELEVISION GROUND DATA HANDLING SYSTEM

Prime Contractor: General Precision Systems Inc. (Subsidiary of General Precision Equipment Corporation), Link Group

Remarks

The Spacecraft Television Ground Data Handling System (SCTV/GDHS) is one of the most unique systems ever developed to support deep space exploration. The system, designed and produced by Link for use in NASA projects directed by the Jet Propulsion Laboratory, photographs television images and telemetry data transmitted by a spacecraft on 70 millimeter film. Every Surveyor picture has been recorded by the SCTV/GDHS. Television signals received by the system are converted into pictures and are recorded on 70 millimeter film through the use of a high precision CRT flying spot scanner. Telemetry data, received after the picture, is in a signal format. As the data arrives, it is converted by a computer into a human readable format (letters and numbers). All information—data in signal format, data in readable format and the picture—are recorded on film at exactly the same instant. The SCTV/GDHS also converts television pictures received in 200- or 600-line formats to a 525-line format in real time. This allows the pictures to be broadcast over closed circuit and commercial television so that the general public may see them at the same time as JPL scientists. The process of converting telemetry data and exposing the picture and data to film is completed on earth in less than 4 seconds after the information has been transmitted by the spacecraft.





FLIGHT SUIT PRESSURE REGULATOR

Prime Contractor: Vāp-Air Division, Vapor Corporation (Subsidiary of General Precision Equipment Corporation)

Remarks

Vāp-Air has developed a pressure regulator controlling low pressure bleed air to the pilots and co-pilots' flight suits on 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 1/10 pounds per square inch over a flow range of 2 to 28 cfm and at inlet pressures varying from 5 to 80 psig.

ANTI-ICE AND RAIN REMOVAL VALVE

Prime Contractor: Vāp-Air Division, Vapor Corporation (Subsidiary of General Precision Equipment Corporation)

Remarks

Vāp-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, 3.75 inches wide and weighs 2.54 pounds.

SERVO AMPLIFIER

Prime Contractor: Vāp-Air Division, Vapor Corporation (Subsidiary of General Precision Equipment Corporation)

Remarks

Vāp-Air has developed a servo amplifier which drives a hydraulic servo valve that positions the engine inlet geometry of the Phantom II fighter. The ramp is programmed to control the air flow to the power plant by changing the inlet area and positioning the shock area in the duct. The amplifier receives a signal from the Central Air Data Computer in relation to the aircraft's speed. Features include zero dead band, fast response, linearity and stability to provide the frequency response and minimum phase shift required. The amplifier weighs just over a pound and occupies a volume of 2.8 inches by 2.8 inches by 2.4 inches.

LIGHT WEIGHT PNEUMATIC DE-ICING SYSTEM, ELECTRICAL PROPELLER DE-ICING SYSTEM

Prime Contractor: B. F. Goodrich Aerospace and Defense Products

Remarks

The B.F. Goodrich Light Weight Pneumatic De-Icing System gives in-flight protection from the hazards of ice formations on wing and empennage leading edges. It can be put into operation instantly by "flip of the switch" convenience and will operate continuously, if necessary. Engine-driven air pumps give dependable source of energy for De-Icer operation. Spanwise tubes built into the light weight, reinforced rubber "boots" are automatically cycled for inflation and deflation, thus cracking the ice and shedding it into the air stream. 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 light weight Pneumatic and Electrical Propeller De-Icers are available for most popular twin-engine general aircraft. Installation of the systems can be made 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, 35 to 60 pounds; Electrical Prop De-Icers, 11 to 13.5 pounds.

SPACE VEHICLE MOTION SIMULATOR

Prime Contractor: Honeywell Inc.
Subcontractors: Beech Aircraft Corporation (platform); Professional Instruments Inc. (bearing)

Remarks

A massive platform designed to simulate the flight dynamics of future spacecraft on earth has been installed at the Manned Spacecraft Center of the National Aeronautics and Space Administration (NASA) in Houston, Texas. The simulator, standing 15 feet high, spanning 12½ feet in diameter, and weighing nearly 4 tons, "floats" virtually friction-free on a thin cushion of pressurized air surrounding a 17-inch stainless steel bearing. Reaction jets mounted on the tips of 8 4-foot booms protruding like spokes from a wheel "fly" the simulator, controlling its motion in roll, pitch and yaw. A controller operates the vehicle electronically from a dial-filled console in an adjacent room, which also displays the air-bearing table's attitude. The platform enables NASA engineers to develop and verify advanced guidance and control concepts for manned spacecraft to be used in future earth-orbital and lunar missions. The characteristics of different spacecraft can be duplicated by varying the inertial weights on the platform.

HELMET SIGHT SYSTEM

Prime Contractor: Honeywell Inc.

Remarks

The Honeywell helmet sight system permits the pilot of a helicopter or aircraft to acquire a ground target without interfering with his primary task of flying the aircraft. The system is in development 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 an Air Force camera direction experiment. In addition to armament and reconnaissance applications, the system is suited for target reacquisition, bomb drop computing, navigation updating, team attack and offset attack missions. The helmet-mounted eyepiece eliminates the pilot's need for a hand-held sight, while an electro-optical 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.

FLUIDIC CONTROLS FOR JET ENGINES

Prime Contractor: Honeywell Inc.

Remarks

Fluidic (no-moving-part) systems for control of aircraft turbine engines and other aerospace applications are in development to provide more reliable performance than conventional hydromechanical controls. Fluidic techniques permit direct measurement of turbine inlet temperature instead of relying on predetermined fuel flow schedules to prevent over-temperature or unstable surges. Reliability is inherent, since the systems have no moving parts, while weight and cost is low. Fluidic devices can withstand severe environments, need no isolation and operate conveniently off compressor discharge air from the engine. Also under development for the Air Force's Aero Propulsion Laboratory are supersonic inlet controls to "swallow" the shock wave at the narrowest point of the inlet duct. Feasibility of controlling a lift-jet engine for VTOL flight has been demonstrated on a test stand using 2 J-85 engines. The accompanying photo shows a fluidic analog speed sensor being checked out on the shaft of a test engine.

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 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 a lightweight Manpack sending/receiver radio system that offers 16,000 individual voice channels and can operate effectively even in dense jungle. The solid state Manpack is a single sideband radio only 18 inches high, 12 inches wide and 3¾ inches thick. Its 2–12 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. The 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 more than 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.

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 4/10 of a 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-sweep-wing aircraft—the F-111D tactical fighter and FB-111 strategic bomber. Each aircraft uses 2 4 Pi computers, one for navigation, the other for weapons delivery; the Navy's EA-6B electronic warfare aircraft, in an electronic system to process and correlate enemy radar data; and the Navy's Target Identification and Acquisition System, an airborne system used with the standard anti-radiation missile. 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.

AUTOMATIC COMPUTER-CONTROLLED FILM READER/RECORDER SYSTEM

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

An automatic, computer-controlled Film Reader/Recorder has been developed by IBM Federal Systems Division for data handling, data compaction, and other applications involving large volumes of photographic information. The system utilizes a cathode ray tube scanner controlled directly by a digital computer. Rather than generating a normal TV type raster, the beam is directed to a particular spot on the film under computer program control. In this way, only areas of interest are digitized. A course scan can be generated to locate the areas of interest, if they are not known. In addition, the computer can control the intensity, for both reading and recording purposes. The reader has a full field of 4096 by 4096 positions and can encode 64 gray levels. This permits the program to look for changes in relative gray levels as significant events, rather than relying on a "black-white" decision imposed by a clipping level. Because of these features, the reader can digitize and recreate a 35 millimeter photograph, with little or no loss of information. The equipment can read a frame of cinetheodolite film in 2 or 3 seconds. IBM expects to add programmed Input/Output overlap and use improved reading algorithms to achieve a speed of better than 1 frame per second. In addition to data compaction, the Reader/Recorder can relieve human operators from the boring job of measurement or counting anything that is highly repetitive and requires accuracy. A great deal of imagery falls into this class.

RD-281 MILITARIZED DISK FILE

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

IBM's RD-281 is a militarized disk storage system capable of storing up to 200,000,000 bits of information. This storage capacity is achieved in 50 megabit increments by using factory—or field—installable disk-drive units. It can locate and retrieve specifically desired material within 185 milliseconds (.185 seconds) at random. The system is compact, highly reliable and extremely rugged. It is designed for use with tactical military computers in severe environments where highest reliability is essential, even under rigors of wide temperature ranges, shock, vibration, humidity, corrosion and radio frequency interference. The RD-281 is the first disk mass memory capable of being integrated with a wide range of military data processors without costly redesign or design-from-scratch efforts. It has proven itself in service for both the U.S. Navy and the Royal Canadian Navy. RD-281 is based on the commercial IBM 1311, which was militarized and altered using the corporation's new Military Solid Logic Technology (MSLT). Overall responsibility for marketing, engineering and construction of the Mil File rests with the Federal Systems Division's Federal Systems Center in Gaithersburg, Maryland.

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 Uprated Saturn I 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, checkout and launch support. IBM also builds the on-board computer and the data adaptor. 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 checkout. Under blockhouse control, the onboard 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.

DACOR (DATA CORRECTION) FORWARD ERROR CONTROL SYSTEM

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

IBM Federal Systems Division's Engineering Laboratory has developed a communications device called DACOR (DAta CORrection) that promises to greatly advance means of controlling errors in digital data transmissions. The device applies advanced polynominal coding techniques—complex algebraic formulas—for encoding and decoding to provide error correction capability. Information is encoded before transmission in a way that allows it to be decoded at the receiver into its proper form, even if errors have occurred during transmission. Thus, information sent by a data source which becomes garbled during transmission does not have to be retransmitted. The equipment has broad communications applications. While other methods of error control—error detection and error detection and retransmission—provide no means for correcting transmission errors at reception, forward error correction provides for transmitting information with no delay in the data source, and with only a fixed, fraction-of-a-second decoding delay. The DACOR system has a special decoding capability in its receiver called adaptive decoding which allows the decoder to determine whether clustered errors or random errors have occurred in an incorrect message and to adapt its correction process to the type of error pattern that is present. The type of error patterns to be corrected are decided beforehand and a code is chosen to distinguish these patterns. When a message is received without the proper code structure the decoder determines which error pattern has occurred.

OPERATIONAL DATA LOGGER SYSTEM

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

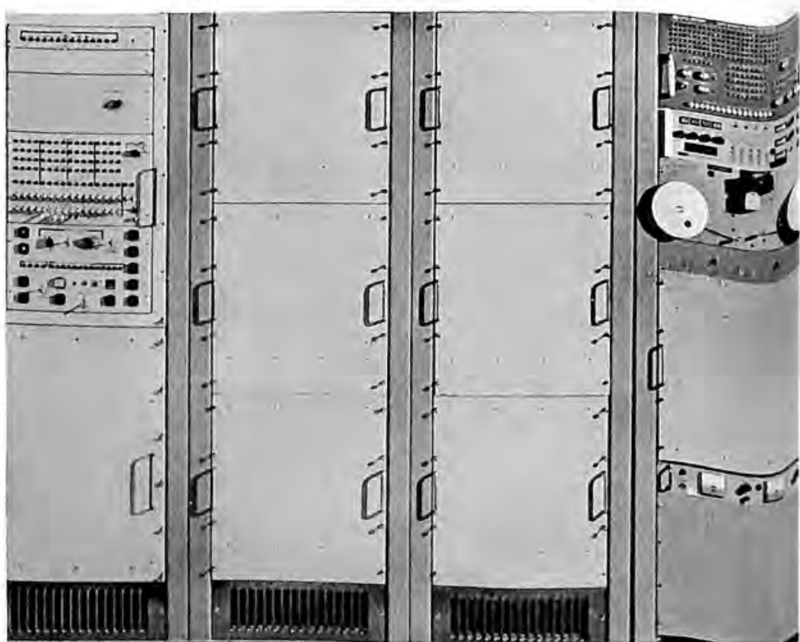
The Operational Data Logger (ODL) system was developed for NASA's Goddard Space Flight Center at Greenbelt, Maryland. It records and plays back high-speed data transmissions between the Goddard Real Time System computers and communications processor computers. The ODL consists of 2 units: the Data Logger Unit (DLU), a specially designed data handling device for the ODL and the interface to the computers; and Dual IBM 2402 Model 4 Phase Encoded Dual Tape Drives. The DLU records and plays back data from any one of 9 computer channel interfaces. Data is transferred in serial mode, formatted in variable message lengths, at rates of 40.8 or 81.6 kilobits a second. Selection of computer channel interface is controlled at the DLU or at a remote operators' console. Data messages transferred between the computer systems and the ODL are buffered and reformatted in the DLU. An 8,000, 18 bits per word memory is contained in the DLU. It stores data blocks to be written on or read from the dual tape drive units. The DLU contains logic for generation of control data and interface signals to operate the tape drives. When the tape reel capacity is exceeded in the first tape drive, the second automatically takes over to permit continuous recording and playback of data. Each tape reel can store up to 100 minutes of data transmission, at 40.8 kilobits per second.

ADAPTIVE MICROPROGRAMMED CONTROL SYSTEMS

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

IBM Adaptive Microprogrammed Control Systems (AMCS) are designed to do a wide variety of control functions; for example, telemetry data preprocessing; communications processing; display driving, signal processing; and data acquisition and feedback control. AMCS consist of standard equipment modules. They can be assembled for numerous control applications without being redesigned and redeveloped. That flexibility is made possible by microprograms written for each application. High data throughput rates, repetitive processing, real-time on-line operation and multiple sources of input and output data characterize control applications readily microprogrammed for AMCS. AMCS handles a 16-bit data flow with storage controls and a simple arithmetic unit controlled by a microprogram. Storage is expandable depending on application requirements. There are 5 major units in the system: the data flow, a set of electronic gates and registers that regulate the flow of data between memory and other AMCS units; the main storage, with a 1.0 microsecond read-write cycle time and a capacity for up to 64,000 words of 16 bits each; the multiplex bus, which addresses up to 256 external devices and allows parallel transfer of 16 bits; the function unit, which performs the particular functions required of the system; and the read-only storage, where the microprogram controlling the system is stored.



DME RADIAL GROUND SPEED INDICATOR

Prime Contractor: ITT Avionics, a Division of International Telephone and Telegraph Corporation

Remarks

The AIN-150A DME Radial Ground Speed Indicator designed by ITT Avionics Division continuously displays a jet aircraft's ground speed, time and distance to destination. The instrument is being developed in accordance with specifications established by United Air Lines, which ordered the instrument for its fleet of Boeing 737 twin-jet aircraft, scheduled to be operational in 1968. The indicator reduces crew workload and requires no additional space on the instrument panel because it replaces the conventional DME (distance measuring equipment) indicator which displays nautical miles from a Vortac, Tacan or DME ground beacon. ITT Avionics' new instrument eliminates wind-computation errors and the need for slide-rule computation of the aircraft's estimated time of arrival. The indicator enables pilots to determine their best cruising altitude by monitoring the instrument for an increase or decrease in ground speed at different altitudes. The indicator can be installed in a few minutes on any aircraft equipped to accommodate an ARINC-type DME or military-type Tacan without changes in the aircraft wiring. The indicator presents no additional load to the DME or Tacan equipment over that required for a standard DME indicator.

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 on Grand Canary Island, Canary Islands, and was built by ITT Defense Communications Division for Compania Telefonica Nacional de Espana, the national telephone company of Spain. Under a leasing agreement with the National Aeronautics and Space Administration the terminal is providing high-quality telephone and teletype communication services in conjunction with spacecraft missions. The terminal features dual automatic-tracking 42-foot-diameter antennas, ultra low-noise receiving equipment and high-power transmitters. The terminal is scheduled to send and receive tracking-network communications via the Intelsat II series satellite for the Apollo lunar exploration mission.

PRECISION DIGITAL TACAN TRANSCEIVER

Prime Contractor: ITT Avionics, a Division of International Telephone and Telegraph Corporation

Remarks

Microelectronic precision digital Tacan (tactical air navigation) transceiver AN/ARN-74(V) designed and developed by ITT Avionics Division uses solid-state digital circuitry wherever possible and is virtually free of moving mechanical parts. Distinct advantages ensuing from the design are increased destination-searching time, high accuracy, self-test and automatic fault detection. ITT Avionics has been awarded a multi-million dollar contract by the Air Force to build AN/ARN-74(V) Tacan sets for the F-111 aircraft.

PORTABLE AUTOMATIC CALIBRATION TRACKER

Prime Contractor: ITTFL-Aerospace, a Division of International Telephone and Telegraph Corporation

Remarks

The Portable Automatic Calibration Tracker (PACT) system was developed for the National Aeronautics and Space Administration's Goddard Space Flight Center to calibrate Space Tracking and Data Acquisition Network (STADAN) antennas. The system comprises an electro-optical sensor and X-Y mount assembly, and subsystems for mount control, data processing, display and printout. 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 STAD-AN antenna facilitates calibration of antenna pointing angles. Manual control is exercised during target acquisition; after the target has been acquired the system tracks automatically.

AN/SPS-48 3-DIMENSIONAL RADAR

Prime Contractor: ITT Gilfillan Inc., International Telephone and Telegraph Corporation

Remarks

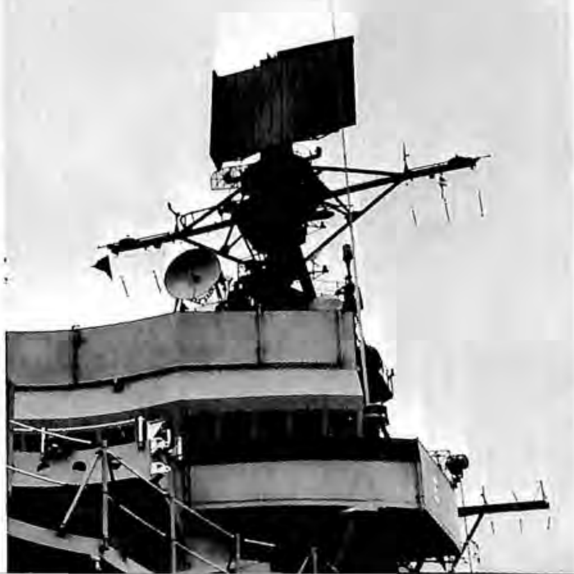
The AN/SPS-48 is a long-range 3-dimensional search radar designed for shipboard use. Operating as an air defense and target designation radar, the system uses techniques of frequency scanning and multiple pencil beam radiation to provide long-range detection, high data rate and full volumetric coverage. The radar was specifically developed by ITT Gilfillan for U.S. Navy guided missile destroyers, frigates, cruisers, attack carriers and amphibious force flagships.

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 is used to keep the pilots on optimum courseline and glidepath to touchdown. The Quadradar provides 360 degrees 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

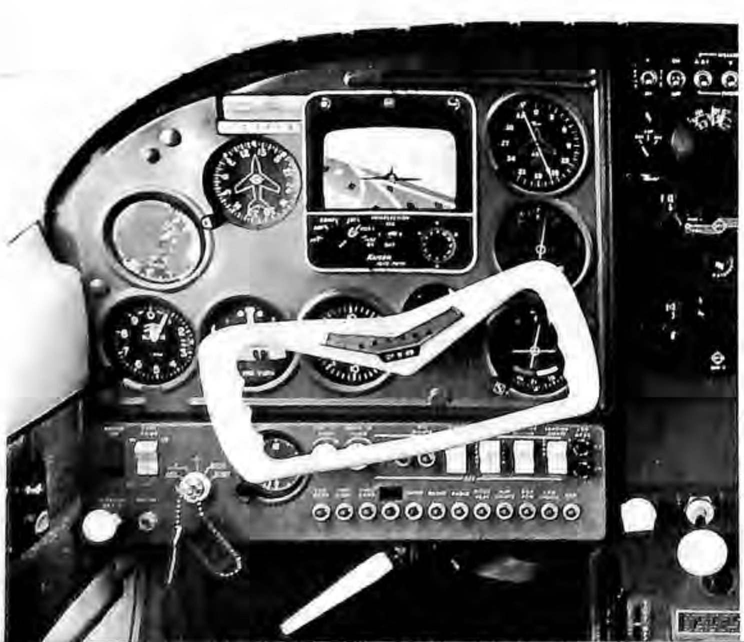
Kaiser Aerospace & Electronics Corporation has developed a revolutionary new aircraft instrumentation system for light aircraft named the Kaiser Flite-Path Display. It is an electronic system that integrates data from many of the currently-used standard instruments and converts it into a TV picture that 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, 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 the pilot feels he is moving over the earth below. In a turn, the symbols move 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, gyro compass and an altitude sensor.

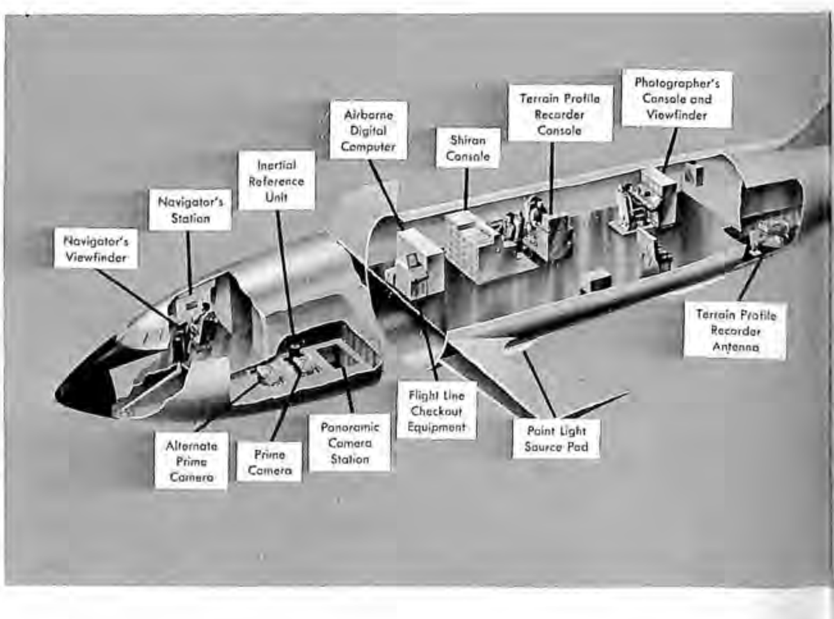
AN/USQ-28 AERIAL SURVEYING AND MAPPING SYSTEM

Prime Contractor: Kollsman Instrument Corporation

Remarks

The AN/USQ-28 is the first of a new class of advanced airborne electronic photography systems that completely integrates aerial surveying and photomapping techniques with computer control. The system includes mapping cameras of advanced design which, with their support equipment, are located 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 amidships and aft in the aircraft. These subsystems are integrated to provide the fastest and most accurate means available to obtain raw geodetic and photomapping data. The AN/USQ-28 system is capable of mapping 30,000 to 40,000 square miles a day and 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, and will be installed in Boeing RC-135A transport/reconnaissance aircraft. Kollsman has delivered a prototype system and 3 production models. Flight testing at Boeing and the first phase of Category II at Wright-Patterson AFB have been completed. The second phase of Category II is under way at Forbes AFB, Kansas, home of the 1370th Photo Mapping Wing.





CENTRAL AIR DATA COMPUTER SYSTEM

Prime Contractor: Kollsman Instrument Corporation

Remarks

The Air Data Computer, in production for the Boeing 737, was developed to meet the requirements of commercial jet transports for an accurate, modular computing system. It operates with proven electro-mechanical and pneumatic computing elements. The design of the system is completely modular in construction to provide maximum configuration flexibility. The design of the basic computer is not affected by the configuration selected to meet the individual airline requirements. The basic computation provides the autopilot with altitude and airspeed from pneumatic inputs of static pressure and total pressure. Information modules can be converted to provide altitude, altitude hold and altitude rate outputs to panel indicators, autopilots, cabin pressurization systems and the automatic altitude reporting system. The computer can also be converted to provide airspeed and airspeed hold outputs. The addition of a Mach module and other conversions will provide Mach number outputs, static source error correction of altitude and airspeed, and the generation and transmission of true airspeed, saturated air temperature, Mach trim signals and other values. The computations are performed with Kollsman transducers that use basic altitude and airspeed mechanisms. The system is mechanically calibrated to eliminate any possibility of changes in accuracy or repeatability caused by aging or temperature changes.

VERTICAL SCALE FLIGHT INSTRUMENT SYSTEM

Prime Contractor: Kollsman Instrument Corporation

Remarks

The Vertical Scale Flight Instrument Systems produced for the Air Force C-141 StarLifter, include altitude and vertical speed indicators, airspeed-mach number indicators, angle of attack indicators and related electronic components. These provide input information which is presented as direct readings on graduated moving tapes. The tapes are read relative to a common center reference line, instead of the conventional circular dial instrument presentation. The vertical scale design presents altitude, vertical speed, air speed, Mach number, angle of attack, command functions and barometric pressure on a single horizontal reference line, allowing the pilot to read them at a glance and make interpretations much more swiftly. Another advantageous feature of the new design is the use of larger numerals, which heretofore has been prohibited by the restricted area of dial-type indicators. Use of tape also allows more intermediate graduations and, in some instances, nonlinear graduations for even higher accuracy. Command parameter functions can easily be displayed by vertical scale indicators, eliminating the need to retain such values mentally. The command marker is positioned to the desired value on the moving tape scale and "rides" the scale to the center reference line. For most aircraft parameters, this action allows the pilot to fly the command marker to the center reference line. Setting of a command parameter can be done either from a front panel slewing switch or automatically by an external command signal, depending upon the position of an internal mode relay.

GODDARD EXPERIMENT PACKAGE

Prime Contractor: Kollsman Instrument Corporation

Remarks

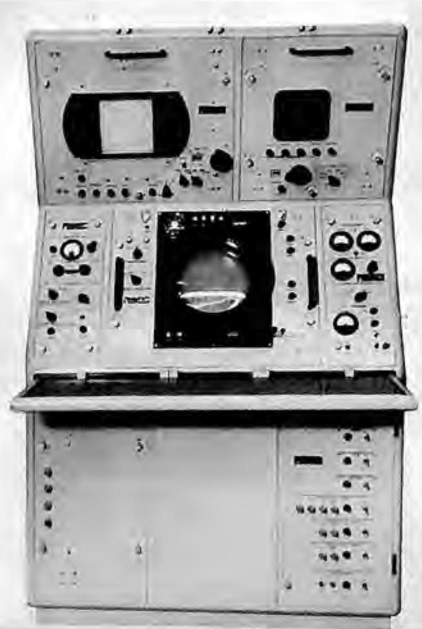
The Goddard Experiment Package is a scientific experiment for the second Orbiting Astronomical Observatory. The Experiment Package consists of a 38-inch spectrophotometric telescope and its associated electromechanical control and data handling equipment. The mission of the GEP is to measure the ultraviolet radiation intensity of many selected stars. Star data that is acquired is arranged by the GEP into a form acceptable to the OAO Spacecraft. The spacecraft stores the data and, upon interrogation from a ground station, transmits the data to the ground station. In addition to data transmission, the spacecraft provides a stable platform that can be commanded to orient the experiment as required, supplies power to the experiment, and provides a system for radio communication with the experiment. The telescope, the spectrometer, the mechanism, the detectors, the fine guidance and associated equipment are all contained on or within the optical structure. This assemblage is 40 inches in diameter and 112 inches in length and weighs 860 pounds. The data accumulators, the digital status-data circuits, and the control electronics are all contained within the Digital Bay Rack. This assembly is housed in Bay E4 of the spacecraft. Its volume is approximately 1 cubic foot and it weighs 40 pounds. A second external unit, the Analog Bay Rack, is housed in Bay E5 of the spacecraft. It is approximately 1 cubic foot in size and weighs 55 pounds.

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 5450–5650 MHZ, power 250 kilowatts (pulse), receiver noise figure 9.5 decibels maximum. The operating console (shown) is the heart of the Radar Meteorological Set and 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 U.S. Air Force to be used as an integral part of the 433L Weather Observation and Forecasting System.



TELEMETRY STATION

Prime Contractor: Lear Siegler, Inc., Electronic Instrumentation Division

Remarks

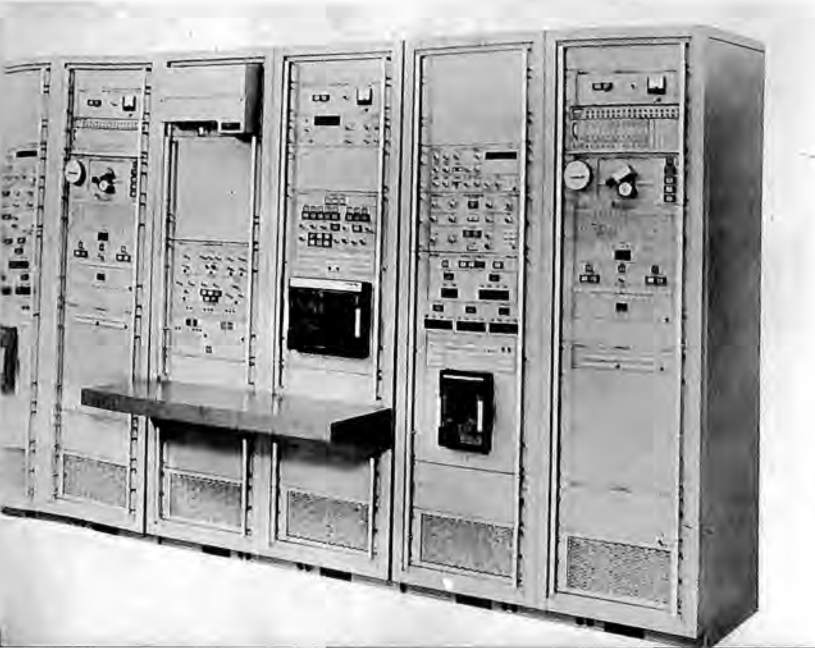
The typical station consists of 4 TDM Type I Stations, 2 TDM Type III Stations, one Test Station for checking out the Type I and Type III Stations, one TDM Type II Station with related TDM Test Unit, Digital-to-Analog Conversion System, Data Correction Unit, Computer Formatter, and Analog and Digital Displays such as bargraphs, oscillographs, and pen recorders. The TDM Stations receive input signals from the receivers and tape recorders, and arrange the resulting data in a common language format. The common language format consists basically of the data words in parallel broadside form, identification codes for the words, and related sync information. This common language output is applied to the Digital-to-Analog Conversion System for subsequent visual display, and to the Data Correction unit prior to being formatted on the computer tape by the Computer Formatter. The Type I Stations, the Type III Stations and the Test Station, all of which are manufactured by LSI/EID, form a complete operational decommutation system. Each Type I Station is capable of receiving PCM, PAM, PDM, or FM data. A centralized core memory contained in the Type I Stations permits rapid changing of the station logic configurations for handling different input formats. The Type II Stations accept PAM, PDM, or FM data with format programming. The operational readiness of the 4 Type I and 2 Type III Stations is easily and automatically evaluated by the single Test Station. Complete diagnostic routines are generated to check all critical parameters of each Station under test.

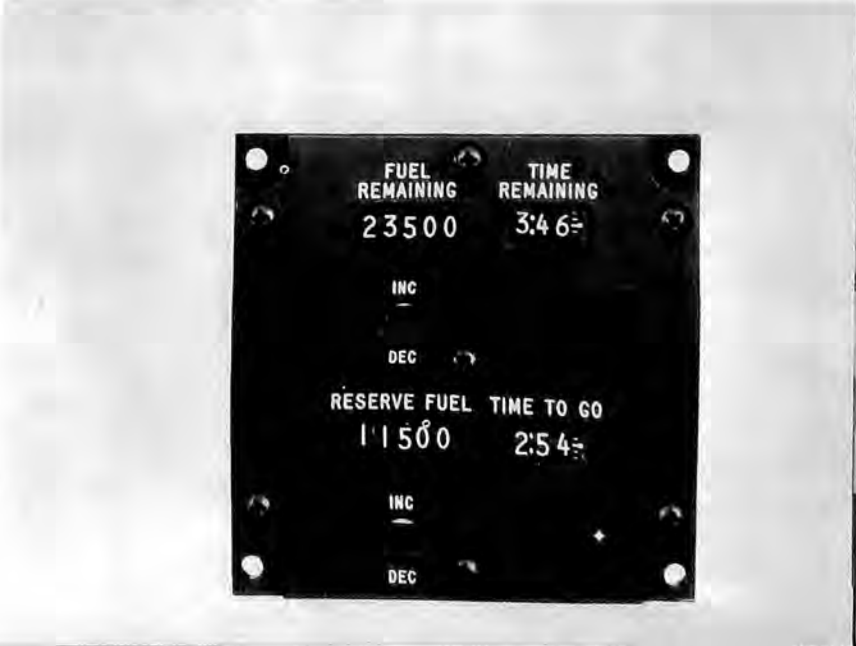
FUEL COMPUTER

Prime Contractor: Lear Siegler, Inc., Instrument Division

Remarks

LSI's Model 6355A Fuel Computer has been developed under contract to the Aeronautical Systems Division, Wright-Patterson AFB, Ohio. The Fuel Computer accepts fuel flow input signals and computes fuel remaining and flight time remaining. With the Fuel Computer in his panel, the pilot gets continuous, direct reading assessments of his fuel and time situation. A warning light comes on at 3 minutes from break off. Then he's told when to go home by a flashing "Bingo Fuel" light. Freed of critical mental calculations under stress, pilot capability is extended appreciably. Fuel remaining is continuously computed from concurrent rates of flow, accurately, within one percent. Time remaining and time to go are real-time computations precise within plus or minus 10 seconds. The conventional fuel quantity indicating system is constantly monitored by the computer and the pilot warned when discrepancies exceed plus or minus 6 percent. The Fuel Computer was designed primarily for aircraft with high fuel consumption, such as high performance tactical fighter bombers with afterburners.



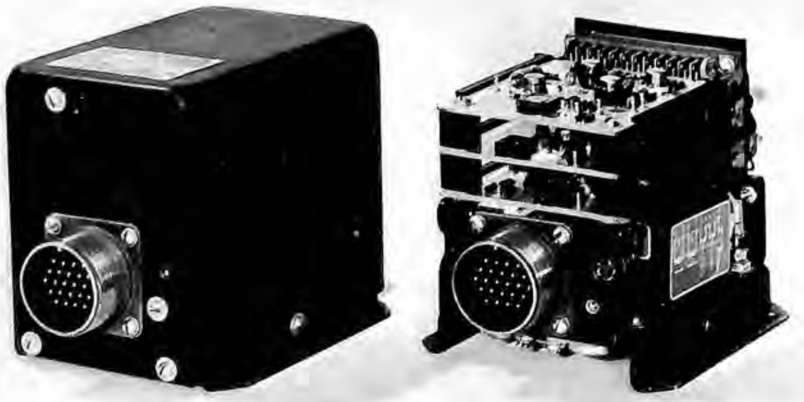


DC CONTROL PANEL

Prime Contractor: Lear Siegler, Inc., Power Equipment Division

Remarks

This DC Control Panel makes unusual use of integrated circuits and incorporates all features possible for a 28 volt DC system in 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 overvoltage 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 predecessor. The unit is 9 pounds lighter, substantially smaller, can regulate over 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.



VARIABLE SPEED CONSTANT FREQUENCY SYSTEM (VSCF)

Prime Contractor: Lear Siegler, Inc., Power Equipment Division

Remarks

The Variable Speed Constant Frequency (VSCF) system is a new electrical generating system which eliminates the hydromechanical constant-speed drive and directly reduces operating costs substantially as compared to advance design CSDs presently in operation. The VSCF system is composed of 4 components in standard ARINC packages. The frequency converter control unit and filter (shown) are completely solid state leaving the generator's rotor as the only moving (rotating) component. The type of generator used in the VSCF system is an oil-cooled brushless rotating rectifier machine with a rated line-to-line voltage at 162 to 184 volts or 324 to 368 volts, depending on whether a low voltage or high voltage system is selected for the aircraft installation. The type of system selected is primarily dependent upon the length of the generator feeders to the frequency converter. The frequency converter is the heart of the VSCF system. It receives the various frequencies and electronically changes them to a selected single frequency which can be precisely slaved to any reference, such as a crystal oscillator. The LSI VSCF system offers many technological advantages over constant-speed drive systems. The relatively few moving parts help increase reliability and lower operating costs. The use of integrated circuits results in smaller and lighter components. Frequent inspections are not required and a lower skill level is required for maintenance, due to this simplicity of the electrical design. By the nature of the components, VSCF also demonstrates flexibility in packaging of equipment.

ASTRONAUT MANEUVERING UNIT

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.

Remarks

The Astronaut Maneuvering Unit is a back pack 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 or move equipment. The AMU equips the pressure-suited astronaut with a complete propulsion system for maneuvering, an automatic stabilization system, 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. Scheduled for flight in the Gemini program as part of Air Force Experiment D-12, its use was prevented on the Gemini 9 flight when the extravehicular astronaut's helmet visor fogged before he could don the pack. The experiment was cancelled on Gemini 12 when extravehicular difficulties encountered during the Gemini 10 flight (not involving the AMU) indicated a need to return to more basic EVA experimentation. Studies are continuing toward possible use of the AMU or similar units on future space flights.

SPACE ENVIRONMENT SIMULATOR

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.

Remarks

This cylindrical simulator, 12 feet in diameter and 11 feet deep, permits testing of space equipment and vehicles at extreme heat and cold to simulate actual space flight. It can simulate orbital altitude up to 200 miles, space thermal radiation levels, solar radiation, intensity and spectral distribution and orbital motion relative to the "sun." Gemini and Apollo astronauts' space suits have been tested in this simulator under heat and cold conditions. Liquid nitrogen flowed through coils permits tests at as low as minus 320 degrees Fahrenheit. Twenty xenon-mercury high-pressure lamps of 2,500 watts each permit solar simulation temperatures.

MANEUVERING WORK PLATFORM AND SPACE TAXI

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.

Remarks

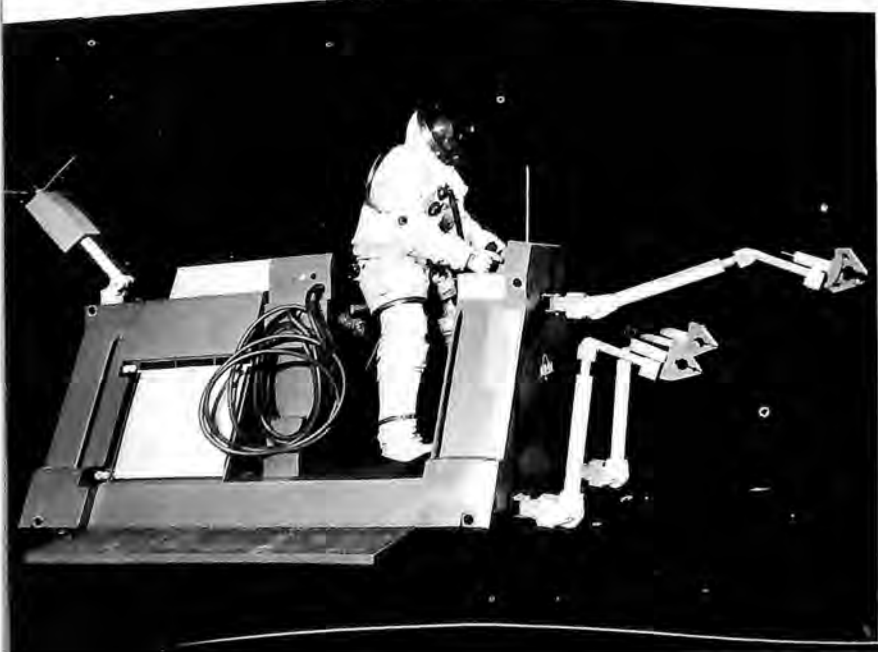
Two advanced extravehicular units, which could operate from a spacecraft to perform construction, maintenance, and servicing tasks at orbital worksites, have been designed by LTV Aerospace Corporation's Missiles and Space Division. The company performed conceptual design work and constructed full-scale mockups under contract to NASA's Marshall Space Flight Center. The Maneuvering Work Platform (shown) or MWP 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 extendable docking and anchoring grapplers. The Space Taxi is completely enclosed, permitting "shirtsleeve" environment, and has remotely-controlled manipulators in addition to anchoring grapplers. Each vehicle has its own propulsion system, automatic stabilization system, power supply, life support system, communications, displays and other equipment to operate independent of the parent spacecraft. The basic work platform is designed to carry some 215 pounds of hand tools, maintenance equipment, diagnostic equipment and spares onboard, 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 onboard, plus some 800 pounds of expendables mounted externally. Each would be propelled and maneuvered by 24 hydrazine-powered jets. The work platform can be extended to accept a variety of modules, including a variable geometry cargo frame which can be assembled in space without tools from interchangeable aluminum tubing sections.

AGIL I AND AGIL II

Prime Contractor: LTV Electrosystems, Inc., A Subsidiary of Ling-Temco-Vought, Inc.

Remarks

The Airborne General Illumination Light set (AGIL) was developed and produced for the Air Force by LTV Electrosystems, Inc., Greenville, Texas. Mounted in a C-123 aircraft, the original system contained 28 long arc xenon lamps and was capable of lighting a circle 2 miles in diameter to 4 times the brilliance of a full moon from an altitude of 12,000 feet. Later developments include both an improved 28-lamp system and a portable 3-lamp unit, completely self-contained, which can be operated from a helicopter. Either system is adaptable to a variety of airborne vehicles and can provide continuous lighting for as long a time as may be required.



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, Inc., 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 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.

MANNED AEROSPACE FLIGHT SIMULATOR

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.

Remarks

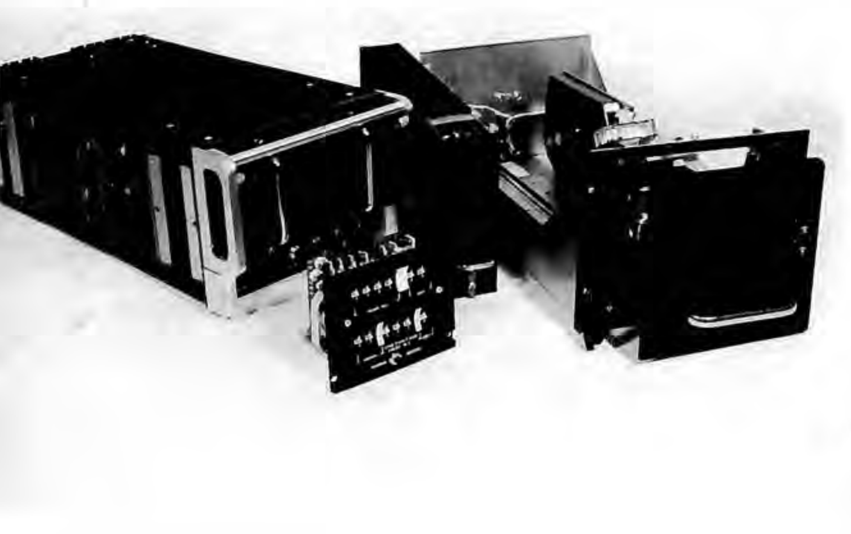
The manned aerospace flight simulator enables an astronaut to make realistic orbital, lunar and interplanetary "flights," view the movement of his vehicle in "space" and experience problems and stresses like those an actual space vehicle would encounter—all while remaining safely on earth. Developed by LTV Aerospace Corp., the simulator has been employed by the U.S. astronauts to practice abort lunar landings and other space missions. Together with its computer facility, the simulator represents a value of more than $2,000,000. The simulator consists of a single-place gondola with a complete set of working controls, instruments and visual aids tied into a huge bank of computers, making possible all types of aerospace missions. The simulator is mounted on a pivoted yoke permitting pitch, yaw and roll movements. Surrounding the gondola is a 20-foot fiberglass sphere on which projections of earth, lunar and star field views can be seen. A larger Dynamic Crew Procedures Simulator based on the flight simulator's design was developed by the company for the Manned Spacecraft Center at Houston. The latter has a 40-foot-diameter projection sphere and accommodates a full-scale Apollo capsule.

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 in 1966. 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 is transmitted by teletype to the airline's overhaul base at Kansas City, Missouri, where rapid computer analysis and printout permits quick and accurate diagnosis of maintenance requirements.



EJECTABLE RECORDING SYSTEM

Prime Contractor: Lockheed Aircraft Service Company

Remarks

Lockheed Aircraft Service Company has installed the Lockheed Ejectable Recording System in the Military Airlift Command fleet of 42 C-133 aircraft. The system retains a 15-hour, continuous record of critical aircraft engine and system operations. A 4-channel voice recorder also retains a 30-minute closed loop tape record of all cockpit area and pilot to crew conversation. A crash position indicator beacon, also housed in a single airborne recorder package, signals location of the aircraft in event of an accident. The airborne recorder package slides into the tail of the C-133 transport aircraft as a small file drawer slides into a filing cabinet. The recording system will withstand fire and shock associated with a land accident. In the event of accident over water, it is automatically ejected from the aircraft upon submersion. The recorder package floats and its beacon serves as a homing target for recovery.

VISUAL APPROACH PATH INDICATOR

Prime Contractor: Lockheed Industrial Products

Remarks

Lockheed Industrial Products in Atlanta is the manufacturing facility for the Lockheed-Georgia Company in certain fields of ground support equipment for its aircraft and for 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 tri-colored beam of amber, green and red, the pilot can tell his relative angle of approach to the air strip by straight-line sight. Amber means he is too high, red too low, and the green light is the safety zone for a smooth and safe landing.

Specifications

Weight 35 pounds, unit size 21 by 21 inches, 7½ 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 kilowatts per hour. Cast aluminum dome protects against ground equipment.

Performance

Visibility 12 miles at night.

RADA (RANDOM ACCESS DISCRETE ADDRESS)

Prime Contractor: Martin Marietta Corporation, Orlando

Remarks

In advanced status, RADA is a project directed toward phase development of a dial telephone system with the mobility of the vehicular radio in battlefield communications. Under project management of Army Materiel Command, RADA is envisioned as being able to handle voice, teletype, facsimile, and data transmission within an Army combat division without use of heavy, fixed, switching centers or the time-consuming and dangerous laying of wire during battle. RADA would provide for priority service among selected subscribers, conference calls, and area warning. It would provide complete privacy of communication between sender and receiver. Intended to be extremely portable and adaptable to all military vehicles, RADA is a radio system in which simultaneous transmissions could occur within a common frequency band without mutual interference. The subscriber set (photo), which has the features of a portable touch-tone telephone automatically selects an available frequency within the allotted band and broadcasts the address of the called party. Distant subscribers are reached automatically through range extension units.

LUNAR MISSION SIMULATOR

Prime Contractor: Martin Marietta Corporation, Baltimore

Remarks

The lunar mission simulator is designed to accurately forecast pilot performance and reliability for Apollo space missions and other missions of equal or longer duration having similar tasks. Under a NASA study contract, real-time, simulated flights were "flown" by 3-man crews from the Air Force's Aerospace Research Pilots School, Edwards AFB, California. Each crew spent 7 days on the simulated round trip to the moon following 5 weeks of classroom work, physical conditioning and simulator training. The Apollo mission was chosen for the studies because it represented a system already well defined and requiring a variety of tasks to be performed by the pilots. Major elements of the simulator include a full-scale Apollo spacecraft, incorporating much the same configuration and instrumentation of the spacecraft that will be used in the Apollo lunar landing program. Adding realism to the simulator are visual out-the-window displays for the benefit of the space pilots, including a huge shell-like parabolic screen measuring 24 feet in diameter. It envelops the Apollo spacecraft in a field of some 2,300 major stars and constellations projected on its surface. The screen also is used to project a view of the moon's surface in the lunar landing phase of the missions. Included in the simulator complex is an extensive group of analog computers, flight control and monitoring decks, utilizing closed circuit TV and other communications equipment in the spacecraft. Data collection equipment provides a continuous transmission of over 550 channels of flight data, all of it used to help fly the missions and collect information on the pilot's performance.

SNAP-9A RADIOISOTOPE THERMOELECTRIC GENERATOR

Prime Contractor: Martin Marietta Corporation, Baltimore

Remarks

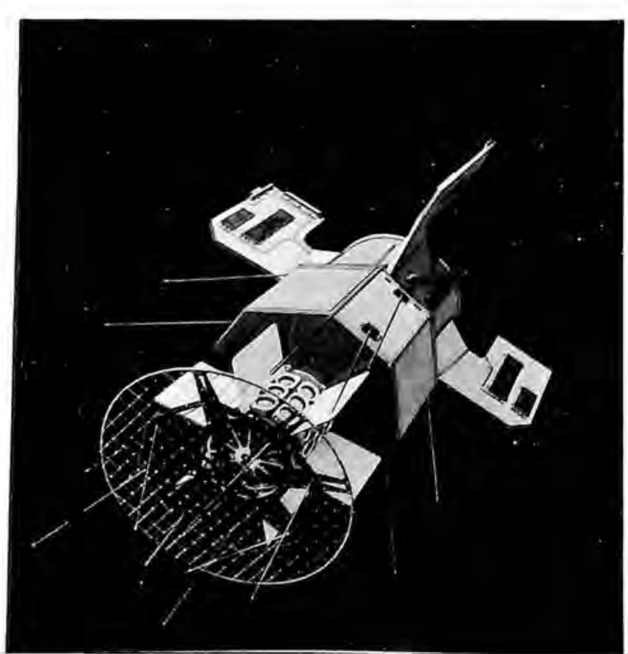
Two SNAP-9A radioisotope thermoelectric generators are in orbit aboard Navy navigation satellites (in photo, SNAP-9A is finned cylinder). The one launched in September 1963, was the first all-nuclear power system to be used on a satellite. The second is part of a 3-satellite navigational system for fleet units. It is the only one in the system to be atom-powered. The others are powered by solar cells.

Specifications

Finned cylinder shape, 20 inches in diameter, 9½ inches high; SNAP-9A fueled with plutonium-238, 25 pounds.

Method of Operation

The generator has no moving parts. The spontaneous decay of the plutonium generates heat in the containment block surrounding it. The heat is transformed directly into electrical energy by a series of thermoelectric elements.



BIRDiE (BATTERY INTEGRATION AND RADAR DISPLAY EQUIPMENT)

Prime Contractor: Martin Marietta Corporation, Orlando

Remarks

BIRDiE is an electronic, semi-automatic 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.

R-241

MINUTEMAN LAUNCH FACILITY SHOCK ISOLATORS

Prime Contractor: Menasco Manufacturing Company

Remarks

The Minuteman Launch Control Center and Launch Control Equipment Building are isolated from ground shock by means of pendulum-mounted liquid-spring shock isolators. This system is designed to isolate the relatively fragile launch control hardware and operating personnel from the destructive ground shocks that accompany nearby enemy weapon bursts. The shock isolators are designed to exhibit dual spring rate characteristics and include integral damping means for enhanced stability. Also included in the units is an electrical position stabilizing system, monitoring instrumentation and servicing elements. The liquid spring isolators offer a minimum volume installation envelope when compared to equivalent pneumatic or mechanical springs. They require negligible maintenance, and can accommodate a wide variation in static load.

Specifications

Envelope 17 inches diameter by 166 inches length (static model); weight 1,375 pounds.

Performance

Spring rate 350 pounds per inch for 31.75 inches; total stroke 45 inches; damping coefficient variable.

P-3 ORION LANDING GEAR SYSTEM

Prime Contractor: Menasco Manufacturing Company

Remarks

The P-3 Orion Landing Gear System is made up of 2 dual-wheeled retractable main landing gears and a dual-wheeled retractable nose gear. The nose gear is supplied with a sealed rack and pinion hydraulic steering motor and control valve. Both the main and nose gear make use of a folding drag brace and locking jury strut linkage system. Also included on all gears is a ground sensing linkage interlock system to prevent inadvertent retraction of the gears during ground handling operations. Other items in the landing gear system include sensing switches, wheels, brakes, lights, and required hydraulic lines and electrical bridles.

Specifications

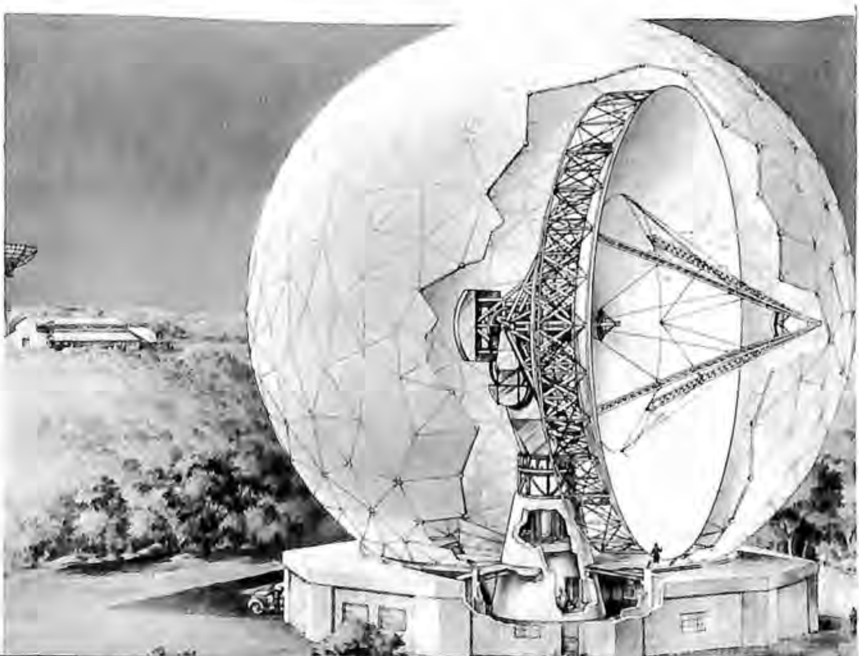
Envelope; main landing gear length (trunnions to ground) 72 inches, width between trunnions 41 inches; nose landing gear length (trunnions to ground) 58 inches, width between trunnions 34 inches; weights—main landing gear 1,400 pounds, nose landing gear 500 pounds, total per aircraft 3,300 pounds.

HAYSTACK 120-FOOT MICROWAVE ANTENNA SYSTEM

Prime Contractor: North American Rockwell Corporation

Remarks

The Haystack is the first of a new generation of ultra-powerful antenna systems whose purpose is to pioneer the development of techniques and equipment for high-capacity satellite relay systems for world-wide communications. Built by North American for the Air Force Systems Command, it is operated by scientists of MIT's Lincoln Laboratory at a hilltop site near Tyngsboro, Massachusetts. The 680-ton apparatus is the most precise steerable instrument of its kind. Enclosed in a 150-foot high fiberglass and aluminum geodesic radome, the giant antenna is a radio telescope of unprecedented high resolution and sensitivity. It can also be used as a very long range tracking and measuring radar, enabling scientists to accurately locate a pea-sized object a thousand miles out in space. Its 100,000 watt transmitter can be used to communicate with space probes at a distance of 100,000,000 miles. The Haystack facility became operational in 1965.



MINUTEMAN II GUIDANCE AND CONTROL SYSTEM

Prime Contractor: Autonetics Division, Aerospace and Systems Group, North American Rockwell Corporation

Remarks

Microelectronics is the key to major technical improvements being incorporated in the Air Force's new Minuteman II ICBM. The new equipment being furnished by the Autonetics Division, associate contractor for guidance, flight control and ground checkout 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, functional capability, greater reliability and reduced size and weight; 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 electro-hydraulic 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 pre-flight operational deployment, the computer performs regular checks and reports on missile flight readiness.

POLARIS SHIP'S INERTIAL NAVIGATION SYSTEMS (SINS)

Prime Contractor: Autonetics Division, Aerospace and Systems Group, North American Rockwell Corporation

Remarks

Ship's Inertial Navigation Systems (SINS) enable Navy Polaris submarines to navigate submerged for long periods of time and to fix precisely their missile-launching positions. This self-contained system basically consists 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 force and those being built in the United Kingdom for the Royal Navy. As Polaris submarines return for overhaul, their early-model SINS are being replaced with improved versions. The Navy's last 12 Polaris submarines and those for the British Royal Navy are equipped with 2 Mk-2 Mod-3 SINS. 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 and USS Ranger) and 2 range tracking ships—the USS Twin Falls Victory in the Eastern Test Range, and the USNS Range Tracker in the Western Test Range.

REINS (RADAR EQUIPPED INERTIAL NAVIGATION SYSTEM) AUTOMATIC BOMBING NAVIGATION SYSTEM (AN-ASB-12)

Prime Contractor: Autonetics Division, Aerospace and Systems Group, North American Rockwell Corporation

Remarks

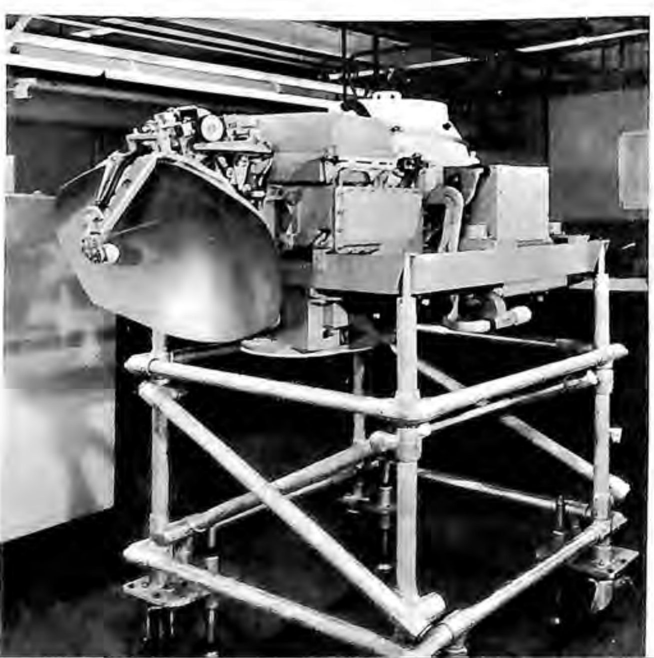
The AN-ASB-12 REINS provides the North American-built Navy Vigilante carrier-based attack bomber with precision guidance, all-weather terrain avoidance for low-altitude missions, air-to-ground ranging, and contour and ground mapping capabilities. REINS target identification and automatic navigation free the aircraft's pilot and navigator-bombardier for concentration on the critical attack phases of the mission. The system includes an inertial autonavigator, digital computer, analog bombing computer, radar, television, wide-angle display projector and tie-in equipment. Eastman Kodak Company and General Dynamics/Electronics, respectively, produced and supplied the system's closed-loop TV and radar. Other Autonetics' systems integrated into the Vigilante include automatic flight control electronics and the shipboard automatic checkout equipment to monitor performance and perform preflight, line and shop maintenance. Released for design in 1959, the first REINS engineering model was produced 14 months later. The first Navy squadrons of REINS-equipped A-5 Vigilantes were operationally deployed in February 1963.

F-105/R14A MULTIMODE, MONOPULSE RADAR

Prime Contractor: Autonetics Division, Aerospace and Systems Group, North American Rockwell Corporation

Remarks

Under subcontract from Republic Aviation Division, the Autonetics Division of North American Rockwell Corporation, has produced the R14A multimode, monopulse radar system now operationally deployed in F-105 Thunderchief fighter-bombers of the Air Force's Tactical Air Command. Integrated with missile-launching and air-data computers, bombing and gun-firing systems, an optical sight and a stable platform, the R14A radar makes the F-105 one of the most versatile of USAF aircraft. It performs all radar functions on both low and high level missions and gives the F-105 capability for air-to-air search and automatic tracking, ground mapping, terrain avoidance, contour mapping and air-to-ground ranging. Autonetics has delivered almost 800 of these radar systems.



HOUND DOG GUIDANCE AND CONTROL SYSTEMS

Prime Contractor: Autonetics Division, Aerospace and Systems Group, North American Rockwell Corporation

Remarks

Inertial guidance and flight control systems produced by Autonetics Division automatically guide the air-launched, operational Hound Dog air-to-ground missile (AGM-28A/B) on a pre-selected path to its target, including evasive action en route. Basic mission of the Hound Dog is to increase the capabilities of the Strategic Air Command's intercontinental B-52 manned bomber. Launched from the high-flying B-52, the Hound Dog can fly low-level to escape radar, or high up at supersonic speeds to avoid ground fire. It can fly a dog-leg evasive course to confuse enemy defenses, then dive to its target to explode at any programmed time. Finally, the Hound Dog can act as a front runner for the B-52 or deal its own blow on a primary target hundreds of miles from its airborne launch point. Hound Dog's G&C system allows new cruise altitudes or new targets to be programmed after the B-52 is airborne, so that target, launch point, trajectory, flight pattern or burst height can be changed as needed. Also, the Hound Dog's guidance system can supplement the B-52 bomber's navigation equipment.

ALOTS AIRBORNE LIGHTWEIGHT OPTICAL TRACKING SYSTEM

Prime Contractor: Northrop Corporation

Remarks

Operational at the Eastern Test Range, the Northrop Airborne Lightweight Optical Tracking System (ALOTS) was designed to provide precision photographic coverage of missiles during the early launch, stage separation and reentry phases of flight. ALOTS is operated at an altitude of 40,000 feet to eliminate interference from cloud cover and other atmospheric conditions which frequently inhibit ground based camera systems. The Nortronics-developed ALOTS system can photograph and resolve a 12-foot target at a distance of 200 miles. The heart of ALOTS, an integrated automatic tracking and photographic system, was installed by Lockheed Aircraft Service in an external pod and mounted on the cargo door of a KC-135A (in photo). ALOTS was developed by Northrop's Nortronics Division.

TEST EVALUATION AND MONITORING SYSTEM

Prime Contractor: Northrop Corporation

Remarks

The Navy's new Knox-class destroyer escorts, which were scheduled for sea duty in 1968, will have the fleet's fastest troubleshooter—an automatic check-out system that will continually monitor sonar gear, fire-control radar, and search radars, all crucial systems for combat. The Test Evaluation and Monitoring System (TEAMS), developed and produced by Northrop Corporation's Nortronics Division, will make a checkout of the 4 sonar and radar sets aboard the ASW ships in just 1½ minutes. Northrop Nortronics has a contract to supply 26 TEAMS for the 26 destroyer escorts scheduled to join the fleet in the next three years. TEAMS is capable of monitoring up to 10 major systems on the 4,100-ton ships, but will be 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.

AIRBORNE COMPUTERS

Prime Contractor: Northrop Corporation

Remarks

With orders for more than 200 airborne computers, Northrop is today one of the largest producers of such equipment in the United States. Northrop's diversified family of low cost digital computers can be tailored to meet specific needs. In 1967 Northrop's Nortronics Division achieved many accomplishments in the specialized computer field, including: (1) contract for airborne computers for the C-5A inertial-Doppler navigation system; (2) contract for computers for the C-5A Malfunction Analysis And Recording (MADAR) system; (3) completion of acceptance tests for the NDC-1050A computer conducted by the Air Force at Holloman AFB, New Mexico, and the start of its integration into an Air Force inertial navigation system for flight tests; (4) introduction of NDC-1051 for aerospace uses; weighs less than 30 pounds with all the computational capability of large data processing machines; (5) successful computer performance in series of flight tests on the Northrop "suitcase navigator." Photo, the 56 integrated circuit assemblies in the Nortronics NDC-1051's conductively-cooled logic section.

C-5A INERTIAL NAVIGATION SYSTEM

Prime Contractor: Northrop Corporation

Remarks

The U.S. Air Force C-5A, the world's largest aircraft, will be the first cargo plane to use both inertial and Doppler navigation systems. Northrop Corporation's Nortronics Division is developing the inertial-Doppler system under a contract awarded by Lockheed-Georgia, a division of Lockheed Aircraft Corporation. Accuracy of the system will be better than one nautical mile per hour. Without the use of preflight ground equipment, the system will need 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.

MODEL-100 FILM VIEWER

Prime Contractor: Northrop Corporation

Remarks

A film viewer which magnifies images up to 70 times is being produced by Northrop's Nortronics Division for precision interpretation and evaluation of film. The Model-100 uses the Northrop 50-to-1 zoom lens for continuous variable magnification between the 3 to 70 times ranges and provides closeup study of any part of any frame. It can be used for reconnaissance imagery analysis, field map evaluation and preparation, oceanographic aerial data evaluations, and photointerpretation training. Data on film rolls of all types and up to 1,000 feet long, between 70 millimeters and 9½ inches wide can be accepted. Film speeds in scanning mode can be controlled to less than 1/10 inch per second movement, and speeds in the fast mode of up to 480 inches per second are possible. A 2,000 watt tungsten filament lamp source and zoom condenser lenses keep the lens pupil completely filled throughout the magnification range. Viewing screen is 30 by 30 inches with directional characteristics. The one-cabinet unit is 8 feet long, 3 feet wide and 6 feet high. The dynamic range zoom lense features only one moving part.

INTEGRAL WEIGHT AND BALANCE SYSTEM

Prime Contractor: Pneumo Dynamics Corporation, National Water Lift Company Division

Remarks

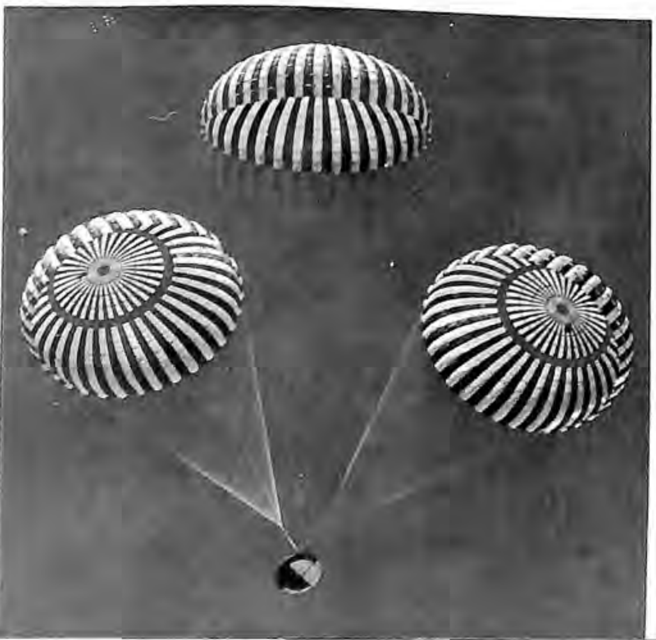
The Integral Weight and Balance System, designated A/A32H-8, is an electronic system which provides an instantaneous visual reading of an airplane's gross weight and center of gravity during loading. Commonly known as STOW (System for Take-Off Weight), the system is presently being installed in all Lockheed C-130 Hercules cargo airplanes in the U.S. Air Force. STOW consists of strain gauge sensing elements mounted in the airplane landing gear and a solid state electronic computer/display. During the loading process the change in deflection of the strain gauge sensors results in changing electrical signals which are fed to a computer mounted in a suitable position in the airplane. Within the computer, the sensor signals are amplified and summed to derive an analog voltage for gross weight. The gross weight analog signal, along with the signal from the nose gear sensor, are applied to the center of gravity computing channel within the computer. The resultant signal, together with the gross weight signal are converted to a decimal format by the indicators. Thus, by merely pressing a button the loadmaster can obtain an immediate reading of gross weight and center of gravity. STOW is a guarantee against inadvertent overload, wasteful underload, and dangerous center of gravity conditions. The availability of accurate weight information during loading permits better center of gravity control resulting in better airplane performance with attendant reduction in fuel consumption. Turn-around time is greatly reduced by quick determination of weight and balance. The STOW system is accurate to within one percent under all normal operating conditions.

APOLLO EARTH LANDING SYSTEM

Prime Contractor: Northrop Corporation

Remarks

The Apollo landing system is being requalified. Certain components have been redesigned as a result of an increase in weight of the Apollo Command Module from 11,000 to 13,000 pounds. Parachutes used in the system are now 2 16-foot diameter drogue stabilization chutes, 3 ringslot 7-foot diameter pilot chutes, and 3 ringsail-type main descent chutes each having a canopy diameter of 83.5 feet. Major improvement to the system is utilization of the larger drogues and a 2-step reefing method for the descent chutes. At 25,000 feet, a barometric pressure switch fires a charge to jettison the apex heat shield covering the parachute compartment. Two seconds later, the 2 drogue chutes are mortar deployed for stabilization and deceleration. At about 10,000 feet, the 3 7-foot pilot chutes are deployed, also by mortar, and each pulls out its respective main chute. Landing speed is approximately 28 feet per second with 3 parachutes functioning, 37 feet per second with 2.



SATURN GROUND COMPUTER SYSTEM

Prime Contractor: Radio Corporation of America, Defense Electronic Products, West Coast Division

Remarks

The Saturn Ground Computer System is an on-line, real-time computer system utilized to perform automatic checkout 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 very well-suited to meet NASA requirements for increased automatic control, flexibility, checkout 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. 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 checkouts 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 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 comes in analog form and goes thru scaling, multiplexing and conversion to digital form when the computer operates upon it. Output data is converted from digital back to analog format with amplification and priority assigned.

ELECTRONIC SWITCHING SYSTEM

Prime Contractor: Radio Corporation of America, Defense Electronic Products, West Coast Division

Remarks

An Electronic Switching System replaces electromechanical switching centers for communication purposes with the use of the electronic computer. This permits "on-line, real-time, full-time" storage and forward type message switching system, utilizing modern electronic components and computer switching techniques to transmit a massive flow of information between widely distributed geographical locations. Two major systems are United Air Lines and RCA Communications AIRCON. These systems provide a communications network consisting of standard teletypewriter circuits and machines to provide an accurate, reliable and efficient message switching system. The system is "on-line" in the sense that messages from field station, teletypewriter sending machines are transmitted directly to the switching center. It is "real-time" in that the switching center immediately processes the received messages and performs required functions to forward them to addressed stations, and it is "full-time" in the sense that it operates 24 hours a day, 7 days per week. To accomplish message switching, the computer routes and interprets messages by electronically reading control characters within the message. The arrangement of messages in comprehensive formats directs the electronic computer's handling of the message from inception to delivery. Basic features are automatic timesharing of all programmed switching functions; each function is performed by priority on a demand basis; automatic smoothing of traffic peaks without comprising line utilization; automatic initiation of on-line selfcheck during low traffic periods. Basic elements are: storage, concentrator, line counter, line scanner, expandor, input/output relays and processor interface.

LUNAR MODULE SYSTEMS

Prime Contractor: Radio Corporation of America

Remarks

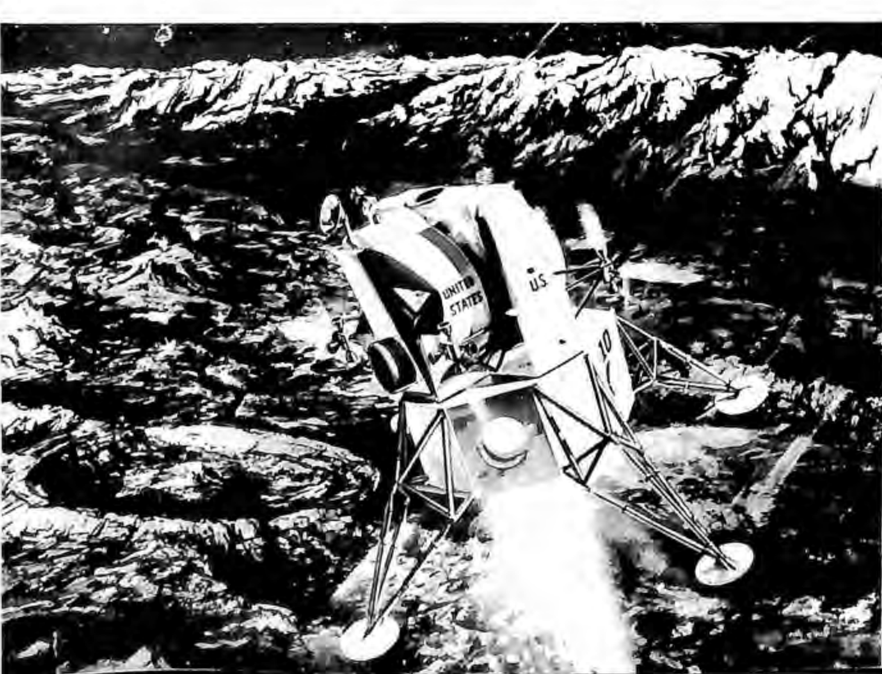
RCA has multiple systems responsibilities in connection with NASA's Lunar Module, shown descending to the moon after separation from the Apollo spacecraft. RCA provides the DECA (Descent Engine Control Assembly) which regulates the engine thrust over a wide range from a maximum of 10,500 pounds, the amount of thrust, and its direction, determining the rate at which 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 provides communications equipment between the LM, the earth monitoring stations and the third astronaut in the Apollo; the company is also supplying a lunar walkie-talkie 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 home trip.

REAL TIME TELEMETRY DATA SYSTEM

Prime Contractor: Radio Corporation of America, 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 collecting and assessing 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 being planned for tracking ships. The system allows mission directors to program in advance of the flight the data desired from a spacecraft or missile. The information is then transmitted from the far-flung stations to the central station in real time in uniform digital form that can be stored, retransmitted and modified by computer. This will eliminate the need to station at these remote areas medical, engineering and other specialists to monitor and interpret incoming data from space vehicles.



AN/FPS-16 PRECISION INSTRUMENTATION RADAR

Prime Contractor: Radio Corporation of America, Defense Electronic Products, Missile & Surface Radar Division

Remarks

First used in downrange missile tracking as early as 1957, the AN/FPS-16 radar is part of the national space tracking network. The AN/FPS-16 and its air transportable version, AN/MPS-25 are C-band radars that can acquire and automatically track passive or active targets with velocities up to 10,000 yards per second. Equipped with a 12-foot dish antenna, the system provides range data to an accuracy of 7 yards at 500 nautical miles. The radars also provide a means of evaluating target performance by supplying precise target position information in the form of digital, synchro and potentiometer data to local or remote computers, visual displays, plotting boards and data recorders.

AN/TSQ-47 AIR TRAFFIC CONTROL SYSTEM

Prime Contractor: Radio Corporation of America, Defense Electronics Products, Aerospace Systems Division

Remarks

The AN/TSQ-47 is a complete package including terminal area navigation, traffic control, instrument landing and communication facilities, transportable in 3 C-130s and put into operation within a matter of a few hours. The system consists of 6 units, each packaged in a separate shelter: the AN/TPS-35 Surveillance Radar, which offers 2-dimensional coverage at distances up to 275 miles; the AN/TRN-17 Tacan navigation station (built by International Telephone and Telegraph Corporation); the AN/TPN-14 Precision Approach Radar; the AN/TSW-5 radar approach and traffic control center; the AN/TSW-8 control tower for active runway and VFR approach operations (in photo); and the AN/TSC-23 communications van, supplied by Adler Electronics. Units of the system are being transitioned into the operational inventory of the Air Force Communications Service.

AN/TRC-97 TROPOSPHERIC SCATTER RADIO RELAY EQUIPMENT

Prime Contractor: Radio Corporation of America, Defense Electronic Products, 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, and 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. Built for the USMC, over 100 AN/TRC-97s are in use in Vietnam. Additional units are being produced for the Air Force 407L system.

SHF TACTICAL SATELLITE COMMUNICATIONS TERMINALS

Prime Contractor: Radio Corporation of America, Defense Electronic Products, Communications Systems Division

Remarks

The SHF TACSATCOM Terminals will provide extremely reliable tactical communications, together with high mobility for battlefield and airborne applications. The present tactical communications are by HF, VHF, and UHF radio plus microwave radio relay and troposcatter systems—techniques which suffer from combinations of low propagation reliability, limited range, and severe size and weight penalties. In addition to avoiding these constraints, the SHF TACSATCOM 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 ultra-stable 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. Deliveries were scheduled to begin in mid-1968. The tactical stations will be tested with an experimental earth-synchronous satellite by all three branches of the military.

LAND COMBAT SUPPORT SYSTEM

Prime Contractor: Radio Corporation of America, Defense Electronic Products, Aerospace Systems Division

Remarks

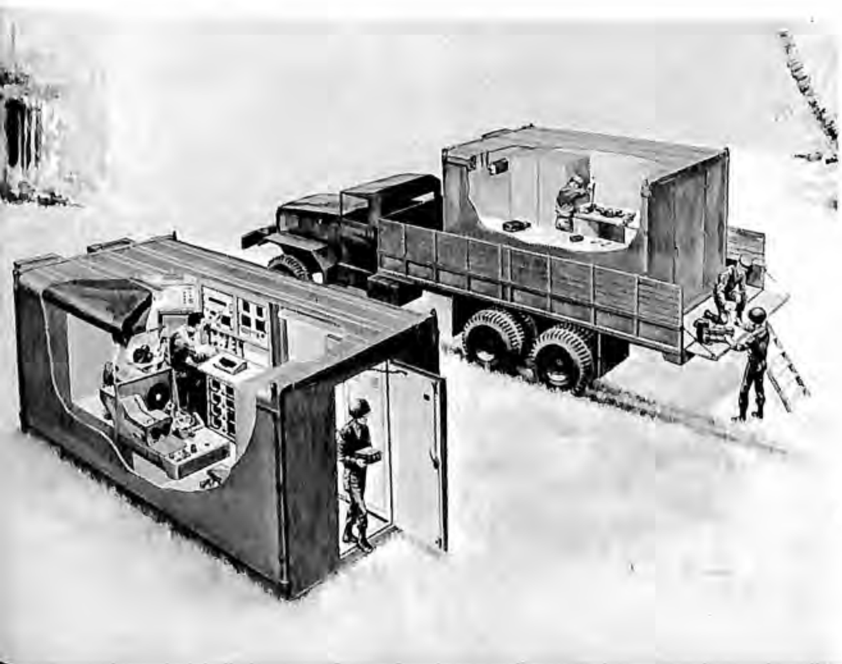
The Land Combat Support System, or LCSS, is a new automatic test set developed by RCA for the Army Missile Command. Electronics and Eletrooptical assemblies from the Shillelagh, Lance and TOW guided missile weapon systems will be maintained in the field with this equipment. LCSS incorporates a number of advanced features, such as integrated circuits and automated test of electrooptics. It is designed for use in the field by Army technicians to perform acceptance tests and to diagnose malfunctions, thus insuring that the weapons for which it is designed will remain at optimum operational readiness.

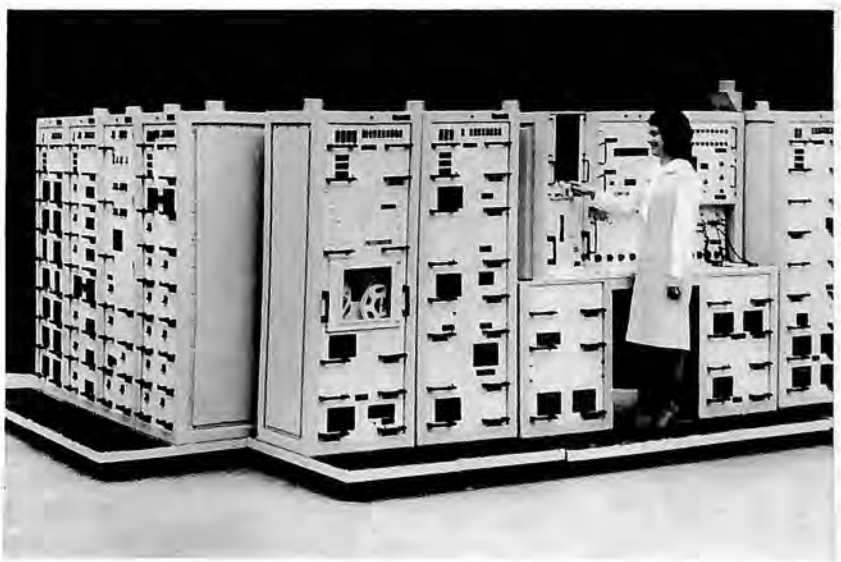
DIMATE

Prime Contractor: Radio Corporation of America, Defense Electronic Products, Aerospace Systems Division

Remarks

DIMATE, developed for the Army Electronics Command and installed at the Tobyhanna and Sacramento Army Depots, is an acronym for Depot Installed Maintenance Automatic Test Equipment. Designed to check out and fault-isolate communications equipment for which the Electronics Command has maintenance responsibility, DIMATE is computer-controlled, operated by test programs on magnetic or perforated paper tape. The equipment racks contain the controls and display, stimulus, measurement switching and power supply subsystems.





MULTISYSTEM TEST EQUIPMENT

Prime Contractor: Radio Corporation of America, Defense Electronic Products, Aerospace Systems Division

Remarks

The Multisystem Test Equipment, built by RCA's Aerospace Systems Division, is designed to check out and monitor the electronic assemblies of existing and future Army missile systems. MTE contains measurement and stimuli subsystems controlled by a digital computer. All test programming information and operator instructions are stored on magnetic tape. To test a particular assembly, the operator connects it to MTE (photo) and leaves the rest to the system. Test results, on a Go, No-Go basis, plus operator instructions for any needed adjustments or repairs, are automatically printed out and displayed.

CAPRI

Prime Contractor: Radio Corporation of America, Defense Electronic Products, Missile & Surface Radar Division

Remarks

RCA, designer and developer of precision instrumentation radar systems, is producing a new radar concept called CAPRI—Compact, All-Purpose Range Instrument. Developed to meet present and future requirements for versatility, reliability and maintainability, the solid-state CAPRI offers high quality with precision determined by the antenna pedestal selected. The user is able to select only as much capability as he requires to fulfill present missions and can expand the systems for future requirements as well. This flexible and compact radar is designed to locate, track and aid in recovery of space vehicles. It also has capability for range safety use and for tracking space vehicles. Because CAPRI uses solid state and integrated circuit design it is extremely compact and requires far less space and power than conventional systems. It is easily adaptable for installation on board ship, in a trailer, or in a small, one-story building. It can be equipped with a number of pedestal configurations at the option of the user. In photo, CAPRI console.

AVQ-46 WEATHER RADAR SYSTEM FOR LIGHT AIRCRAFT

Prime Contractor: Radio Corporation of America, Aviation Equipment Department

Remarks

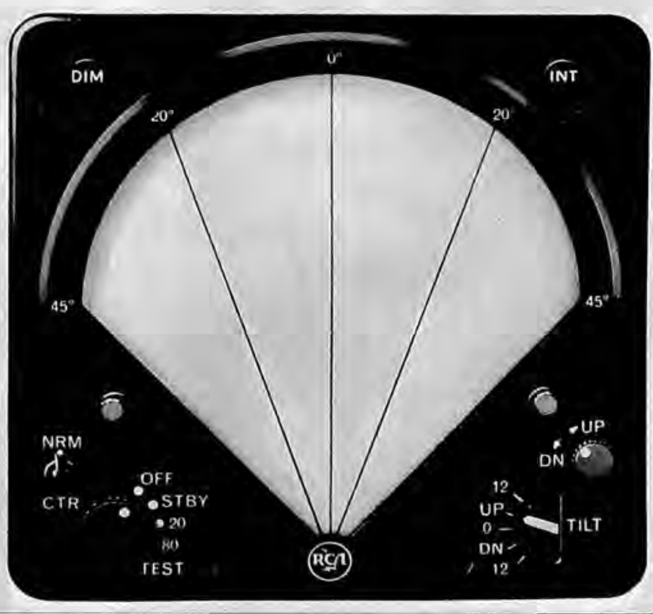
The AVQ-46 weather radar is a new, extended range X-band radar for the lightest twin-engine aircraft. Its 80-mile range makes it suitable for the new, faster turbocharged twins and also medium propeller and turboprop aircraft. The radar's X-band frequency gives it effective penetration of rainfall to reveal dangerous storm cells. These cells, indicative of heaviest rain and therefore the most severe turbulence, are displayed on the radar screen as black "holes" in the rainfall display when the contour switch is actuated. A 20-mile range is provided, as well as 80, and both ranges are displayed linearly with electronic range marks. The antenna scans a sector of 90 degrees of the forward area at 70 looks per minute, and it is electrically tilted 12 degrees up or down by an indicator control. Antenna reflectors are 10 or 12 inches in diameter. Only 3 units weighing a total of 24 pounds comprise the system, and no AC power is required. The radar also features a standby function and contour test.

COMMUNICATIONS SATELLITE ANTENNA

Prime Contractor: Rohr Corporation, Antenna Division

Remarks

This 85-foot-diameter tracking antenna at Paumalu, Hawaii, in operation since mid-1967, serves as a key earth station link in the worldwide communications satellite network. Erected under a subcontract to Sylvania Electric Products, a subsidiary of General Telephone & Electronics International, the precise antenna structure is of modular design, a concept which permitted erection of structural and mechanical hardwares within 5 weeks. Total schedule for completion, including design and manufacture of components at Rohr's Chula Vista, California, plant and erection and checkout was a record 9 months. The instrument's reflector is fabricated of solid surface precision aluminum panels. The manufacturing accuracy of the panels from a best-fit parabola was .011-inch RMS. Operational surface accuracy is .040-inch RMS. The azimuth and elevation motions are provided by 2 40-horsepower (80 horsepower per axis) electric motor drive systems. Tracking rate is 3 degrees per second. Operating modes are programmed pointing, manual position and automatic tracking. Total weight of the antenna is 440,000 pounds. Axis alignments and orthogonality of .003 degrees or better was achieved. The instrument is designed for precision operation in 30 mile per hour steady winds with peak gusts to 45 miles per hour. It can be driven to stow position (zenith) in 60 mile per hour winds and is designed to withstand winds up to 125 miles per hour in stow. The specially-designed foundation for the antenna was constructed of 16.5-inch octagonal solid concrete piles pretensioned and prestressed using 6,000 pounds per square inch concrete.

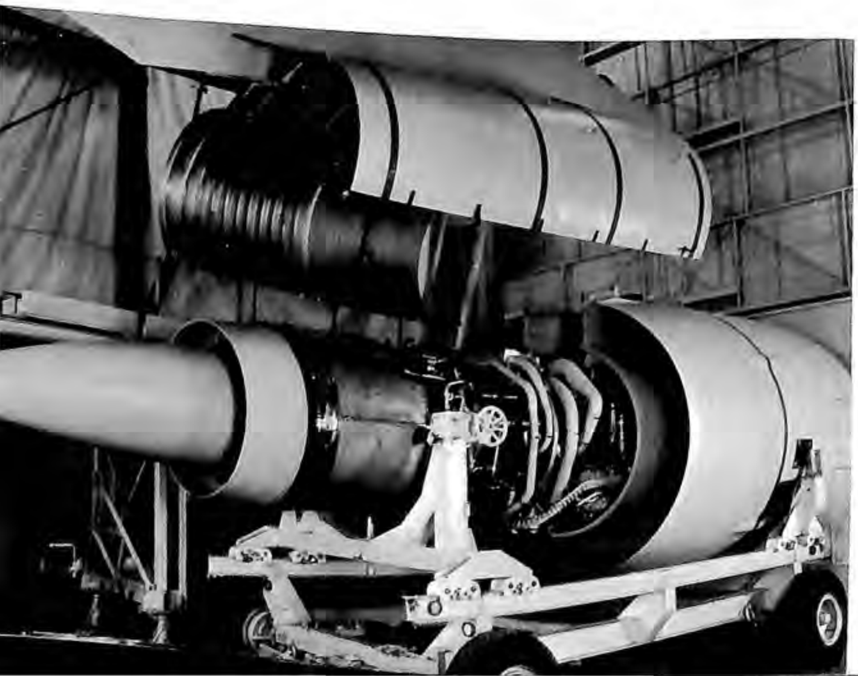


C-5A ENGINE NACELLE AND PYLON

Prime Contractor: Rohr Corporation

Remarks

Technical characteristics of the engine nacelles and pylons for the Lockheed C-5A Military Airlift Command transport encompass immense size with favorable strength-to-weight ratio. These requirements were achieved to a large degree through extensive use of bonded aluminum honeycomb structure in the nose cowl, cowl doors and pylon. Rohr's responsibility as a subcontractor to Lockheed includes installation of electrical harness, pneumatic ducts, hydraulic fuel lines and fire-detection system on the buildup of the 41,000-pound thrust General Electric TF-39 engines. The nacelle's major components include nose cowl, cowl doors, aft exhaust nozzle and plug. The cowl measures 26 feet in length with exhaust plug and 21 feet without. Outside diameter of the nose cowl is 8.5 feet. The pylon is 34.5 feet long and 6 feet high. Weight of the nacelle is 3,084 pounds and the Rohr systems on the engine buildup 975 pounds. The pylon weight is 4,180 pounds. There is considerable use of machined, hot-formed 8–1–1 and 6–4 titanium extrusions in the major structural members of the pylon. Titanium also is utilized in the framing and longerons of the cowl doors and apron assemblies. The pneumatic dust system is commercial titanium and inconel 718. The nose cowl circumferential inner barrel is a single-piece bonded structure, unique in an application of this type. The unit incorporates only a forward fan reverser, supplied by General Electric, and has no hot exhuast reverser.



PRECISION DROP GLIDER

Prime Contractor: Ryan Aeronautical Company

Remarks

The Precision Drop Glider system is being developed by Ryan Aeronautical Company for the Army as an all-weather aerial delivery system. Designed for delivery of 500-pound payloads of high-priority cargo, the vehicle can be air-launched from rotary or fixed-wing aircraft at altitudes up to 20,000 feet. An electronic system contained in the cargo package guides the vehicle to its predetermined landing site, using a small radio beacon as its homing signal.

Specifications

Dimensions (overall packaged) 42 by 32 by 42¾ inches; gross weight 628 pounds; payload capability 300 to 500 pounds; operational altitude 500 to 20,000 feet; delivery aircraft rotary or fixed wing; glide ratio 3 to 1; automatic landing accuracy, circular error probable of 200 feet; combat readiness 97 percent; flex wing (packed) 30 by 22 by 9 inches, weight 53 pounds; control platform 45 by 32 by 5½ inches, weight 68 pounds; cargo sling weight 7 pounds; total empty weight 128 pounds.

HAPDAR RADAR SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Gyroscope Division

Remarks

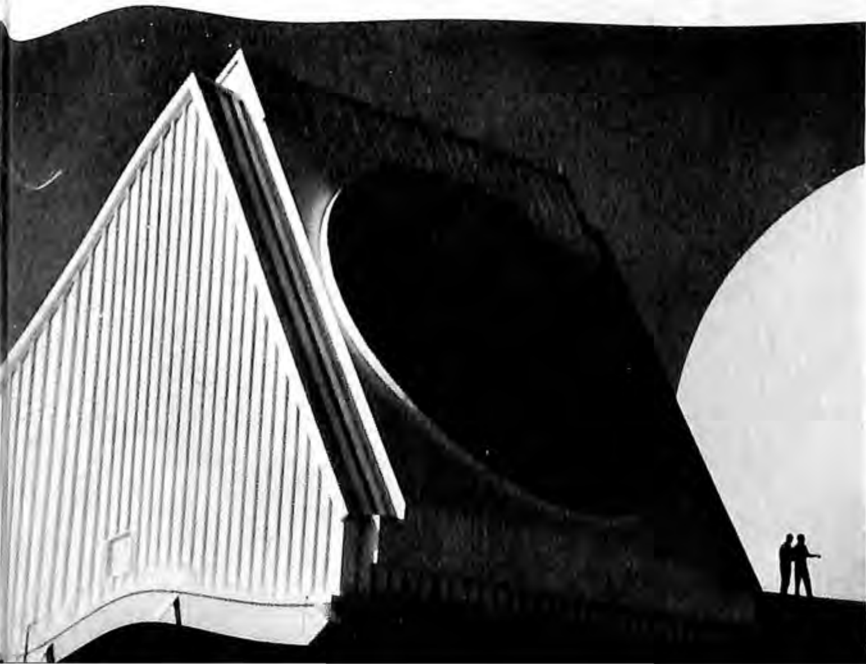
HAPDAR is an advanced electronically scanned radar system for use in improved antimissile defense systems, battlefield surveillance, and air traffic control. The HAPDAR electronically scanned radar, installed at White Sands Missile Range, New Mexico, has tracked multiple targets and is now an operational integrated system with its own transmitter. The radar is capable of simultaneously tracking several aircraft spaced many miles apart and going in different directions. Sperry designed and installed HAPDAR (Hard Point Demonstration Array Radar) under contract to the U.S. Army Missile Command with funding from the Department of Defense Advanced Research Projects Agency.

INERTIAL REFERENCE UNIT

Prime Contractor: Sperry Rand Corporation, Sperry Gyroscope Division

Remarks

Inertial Reference Unit is used aboard the Lunar Orbiter spacecraft to provide data on attitude and changes in velocity. This information is essential for putting the craft into the desired orbit and for positioning it correctly for taking pictures of the moon's surface. The 13.2-pound unit, which includes over 1,500 components and 9,000 hand-soldered joints, is one of the most densely packed assemblies of its type ever developed. Known as the "IRU," the unit has performed on the Lunar Orbiter spacecraft which successfully took pictures of future astronaut landing sites on the moon. Sperry Rand's Sperry Gyroscope Division supplied the IRUs to The Boeing Company, prime spacecraft contractor, under a $2,500,000 contract. National Aeronautics and Space Administration's Langley Research Center managed the program.



LORAN-C NAVIGATION SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Gyroscope Division

Remarks

Loran-C, like standard Loran, is a navigation system which determines position by timing signals from master and slave transmitters around the world. It is more accurate than standard Loran, however, and its 100 kilocycle frequency makes the signals usable over land. The microcircuit Loran-C receivers are 3 times more reliable than conventional Loran-C receivers and yet are smaller, require less power and are simpler to operate. Prototype Loran-C receivers, developed under the sponsorship of the Navy Bureau of Weapons, were extensively flight tested by the Air Force. The Air Force Aeronautical Systems Division accepted delivery of a number of receivers in April 1965. The Air Force is planning to use the precision navigator for Apollo recovery aircraft.

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 will enable these forces to operate from the same, exact position information, particularly important in a limited warfare operation where 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 quickly set up. Loran-D is on order for the U.S. Air Force. It will also be used in a radar system being built for the Canadian Navy.

UNIVAC CP-890 COMPUTER

Prime Contractor: Sperry Rand Corporation, UNIVAC Division

Remarks

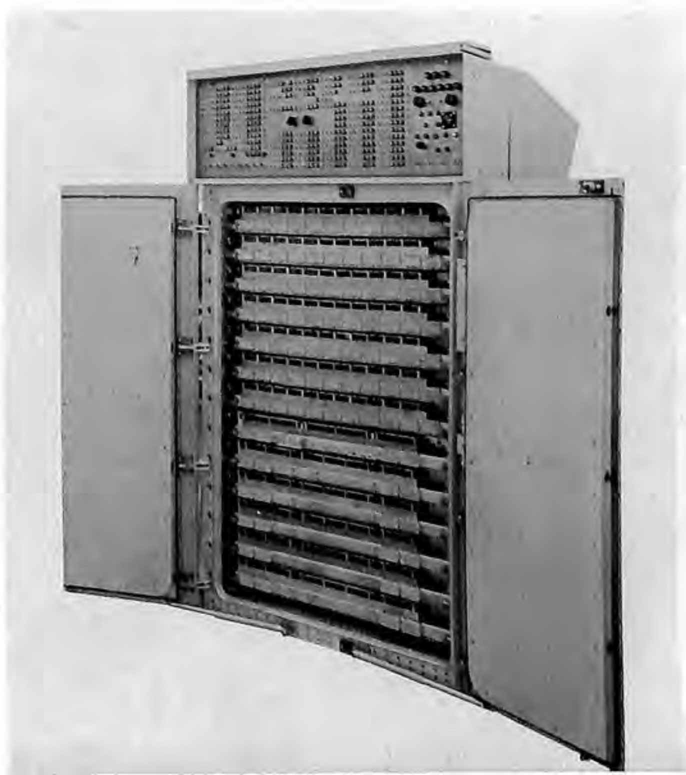
The UNIVAC CP-890 Computer, utilizing microelectronic circuitry and wire-wrapped connections, is equipped with a 1.8 microsecond memory of 32K 30-bit words and 12 I/0 channels expandable to 16. The cabinet measures 65 inches high, 22 inches wide, and 18 inches deep with chanfered corners designed to 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 U.S. 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.

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/0 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-nanosecond 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 1830A AVIONICS COMPUTER

Prime Contractor: Sperry Rand Corporation, UNIVAC Division

Remarks

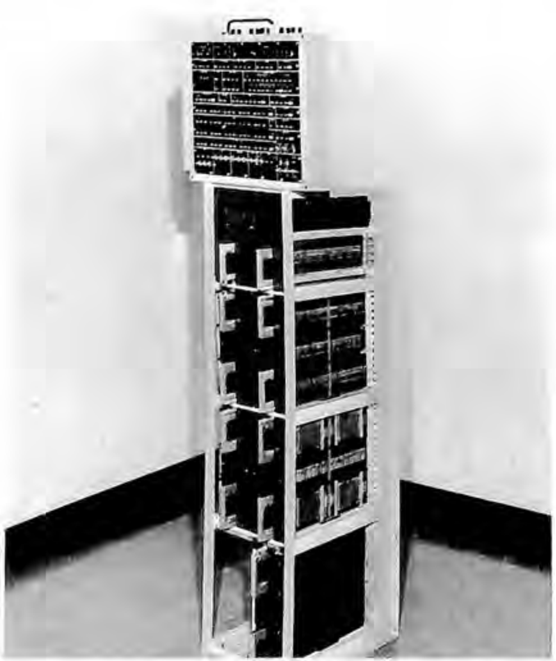
The UNIVAC 1830A computer is an integrated-circuit version of the UNIVAC 1230, designed for special application requiring a 32K memory, 30-bit parallel I/0 on each of 16 channels, occupying only 3 cubic feet of space. This computer was designed to MIL-E-5400 in a basic aerospace configuration, adapted to general, limited space utilization. The UNIVAC 1830A 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 sensor data, evaluates it, 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 this 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.

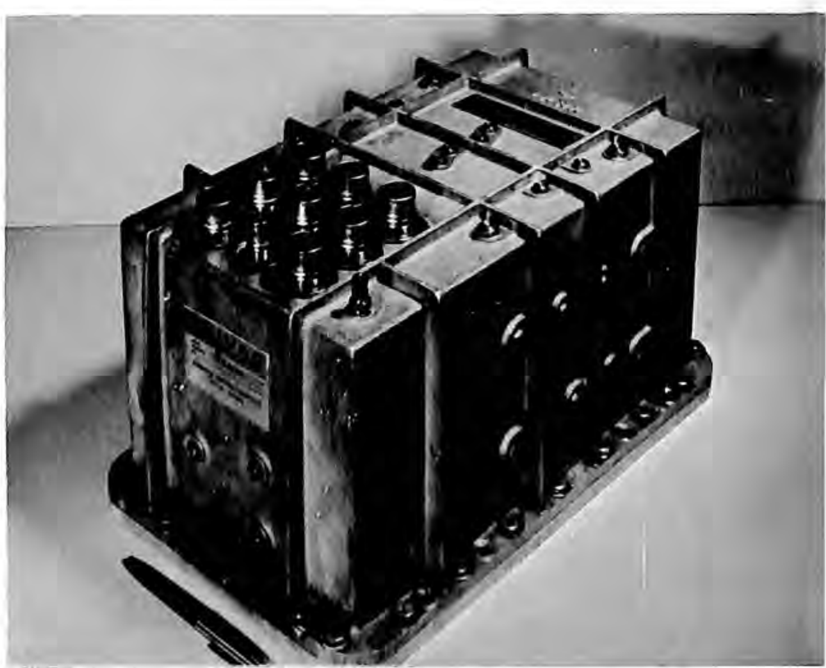
UNIVAC 1824 AEROSPACE COMPUTER

Prime Contractor: Sperry Rand Corporation, UNIVAC Division

Remarks

The UNIVAC 1824 Aerospace Computer is a general-purpose, ruggedized machine designed for use where high reliability and high environmental tolerance are required and where very small size, weight, and power consumption are premium considerations. The computer utilizes an advanced method of construction, combining integrated semiconductor circuits and magnetic thin-film memory elements to form a very compact unit. The original design was oriented toward the requirements of an advanced missile system; however, because of its general-purpose characteristics, the 1824 is adaptable to a wide variety of control applications. UNIVAC is under contract to develop and produce production quantities of a modified 1824 aerospace computer (MGC) and ground support equipment (GSE) for countdown, guidance, subsystem checkout, and self-check on the TITAN III launch vehicle.



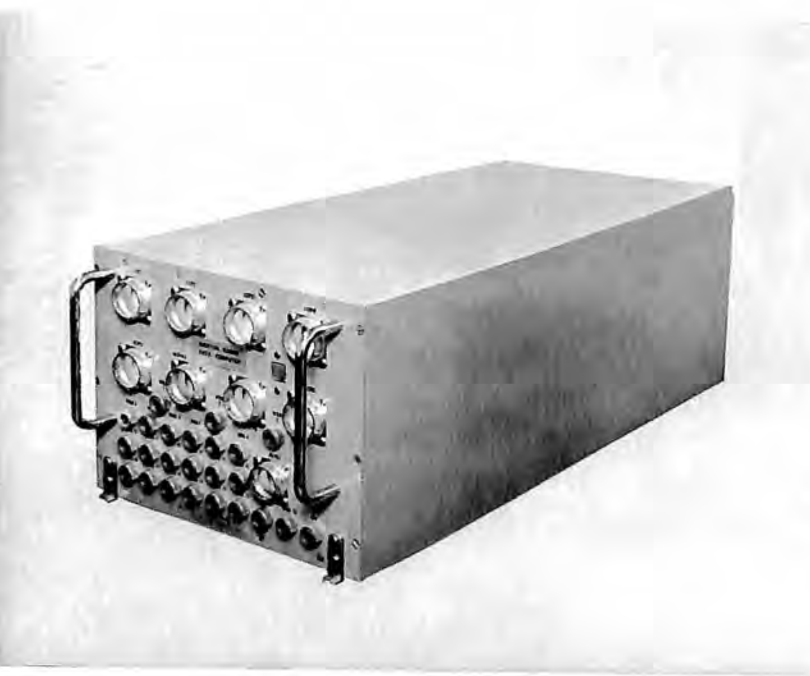


UNIVAC 1818 ILAAS COMPUTER

Prime Contractor: Sperry Rand Corporation, UNIVAC Division

Remarks

The UNIVAC 1818 ILAAS Computer is a microelectronic, general-purpose digital computer designed for use in a wide range of real time and other applications requiring ruggedness, small physical size and weight, medium scale computational capability, and high reliability. Typical applications include command and control, navigation, and fire control systems. This computer contains 2,048 20-bit words of coincident —current ferrite core memory with an effective cycle time of 4 microseconds, a maximum of 10,240 20-bit words of wired core rope memory with a 2 microsecond read time, 27 basic single address instructions (60 instructions total), 3 memory contained index registers, a maximum of 19 serial input and 4 serial output channels, and one paralled input and one paralled output channel (program controlled) with expansion capability to 8 parallel input and 8 parallel output channels. The UNIVAC 1818 ILAAS Computer has been designed for use in the Integrated Light Attack Avionics System (ILAAS).

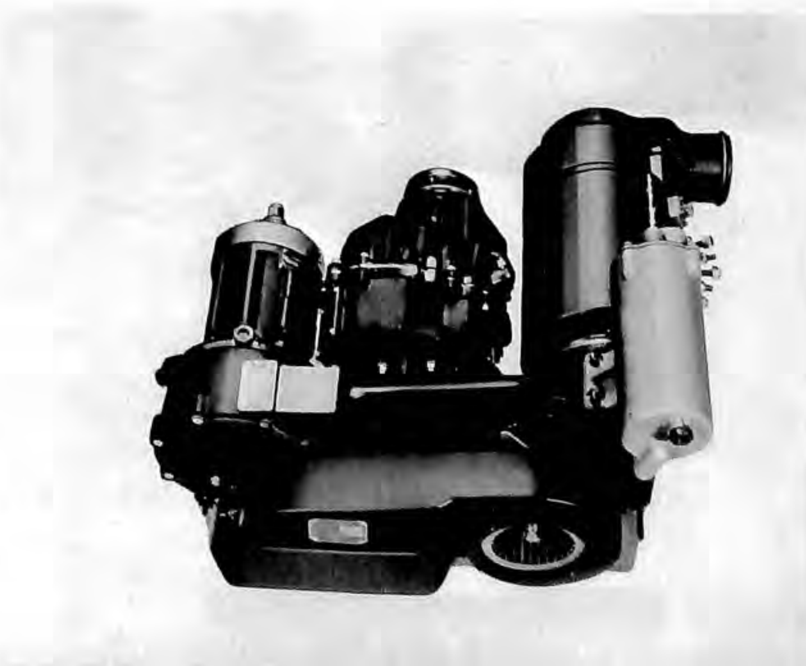


ACCESSORY DRIVE SYSTEMS

Prime Contractor: Sundstrand Aviation, Division of the Sundstrand Corporation

Remarks

Accessory Drive Systems (ADS) are used to transmit aircraft engine power to accessories such as the generator/drive package, air compressors, hydraulic pumps and motors. A variety of designs are currently in use aboard an assortment of aircraft types. Included among these are Accessory Drive Systems operating in high temperature environments on supersonic aircraft. The ADS for the CF-5 "Freedom Fighter" is shown here. One of its unique features is a gearbox driven at a constant speed by a CSD.



CONSTANT SPEED DRIVE TRANSMISSIONS

Prime Contractor: Sundstrand Aviation, Division of the Sundstrand Corporation

Remarks

A pioneer in the development of constant frequency AC electrical power for aircraft, Sundstrand Aviation manufactures a complete line of constant-speed drive transmissions for converting varying engine shaft speeds to a constant output speed to drive electrical generators. The C-5A constant-speed drive illustrated here is an example of the latest AGD CSD design of the type used on a number of military and commercial aircraft. The AGD drives have demonstrated remarkable reliability with Mean Time Between Failures (MTBF) figures in the neighborhood of 15,000 hours. During 1967, Sundstrand introduced the Integrated Drive Generator (IDG), which combines the AGD with a generator in a single package. This permits further reduction of system weight with an increase in overall system reliability.

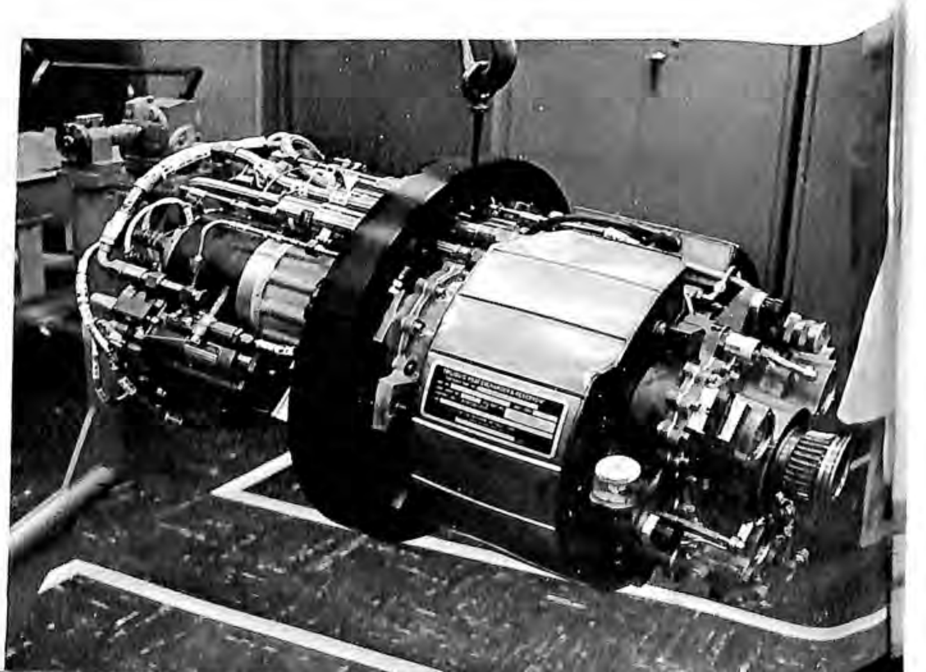
TORPEDO PROPULSION SYSTEM

Prime Contractor: Sundstrand Aviation, Division of the Sundstrand Corporation

Remarks

Sundstrand provided a significant advance in torpedo propulsion with the power plant shown here. Manufactured under contract from Westinghouse for the Mark 48 torpedo, in-water testing of the system continued in 1967 and production designs were completed. The first production prototype propulsion systems were delivered to Westinghouse in mid-1967.

R-262



6425 25 MILLIMETER CANNON SYSTEM

Prime Contractor: TRW Inc.

Remarks

The TRW 6425 25 millimeter cannon system comprises 3 major elements: 1) the cannon, featuring a dual feed, selective rate of fire which can be field stripped in seconds without tools; 2) a family of high velocity ammunition, designed for linkbelt feeding, which includes an armor piercing round that will penetrate 1 inch of steel at 60 degrees obliquity at 1,000 meters, and a high explosive round with self-destruct fuzing; 3) an enclosed cupola designed for 360-degree vision, power controlled and 1-man operated, designed for standard 34–40 inch hull openings. TRW 6425 is lighter (150 pounds) than any existing similar system and has twice the target effectiveness. The gun was designed to fill a need in lightweight armored vehicles for a weapon system that provides a tough, stand-off punch in contests against more heavily armored enemy vehicles. Development started in 1964 and TRW produced the first prototype in just 22 months. During 1966, field and engineering testing of the weapon system continued, conducted for the Army by Pacific Car & Foundry Company. In addition to ground-to-ground employment, the system has potential as a ground-to-air, air-to-air, or air-to-ground weapon. The U. S., British and French governments have bought the weapon for evaluation testing and orders from other NATO countries are pending.

ROLLER DRIVE AND ROLLER GEAR DRIVE

Prime Contractor: TRW Inc. Accessories Division

Remarks

The TRW Roller Drive and Roller Gear Drive are simple, bearingless, lightweight, high-speed ratio planetary transmission systems which use roller friction to transmit torque quietly with high efficiency, without lubrication. Essentially, the drive consists of a sun roller and clustered two-step planets, on each of which is maintained a three-line preload in such a manner that almost pure rolling is obtained between all contacting elements. Unlike conventional transmission systems, all stages of the TRW drive are placed in a single plane approximately the same diameter and thickness of one stage of a multistage planetary drive. Thus, the savings in volume and weight over conventional transmission systems is represented in the roller drive by approximately the number of stages eliminated. Bearings have been eliminated from all but the output ring of planets, where they are required to resist output torque reaction. Absence of bearings increases efficiency of each step and eliminates a cause of failure. Contracts have been received by TRW from the government to develop roller drive transmission for Army helicopters and marine silent power transmission systems for the Navy. Other applications currently under development by TRW include torque amplifier systems, high-speed centrifugal drives, aircraft accessory drives and aircraft utility pneumatic actuator systems.

XC-142A PROPELLER SYSTEM

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

The XC-142A's four 15½-foot main propellers and single 8-foot tail propeller have lightweight blades made out of fiberglass shell bonded to a steel, load-carrying core. This design makes the propellers 25 percent lighter than metal-bladed propellers of the same size. Additional weight-savings are achieved by integrating the propeller with the reduction gearing which is normally mounted on the engine. The integral gear box propeller eliminates duplicate shafting and reduces the weight and size of many gear and propeller components. During hover and transition between vertical to forward flight, the pilot controls the XC-142A by varying the pitch of the main propeller blades instead of wing and tail ailerons. He does this by increasing the pitch of the propellers on one side of the aircraft and decreasing pitch on the other side. The tail propeller is also used for attitude control during hover and flight transition. It is disengaged and braked in forward flight. Cross-shafting in the wing interconnects the propellers, and clutch mechanisms are used to transfer power of one turboprop powerplant to the propeller of another engine which has been shut down. Hamilton Standard is producing the propellers for Fairchild Hiller, who is responsible for the V/STOL transport's power transmission system, gearing, shafting and propellers, flaps and ailerons.

X-22A PROPELLER SYSTEM

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

The X-22A aircraft has 4 propellers mounted in ducts, 2 in the forward and 2 in the aft section of the aircraft. The ducted propellers swing vertically and horizontally for vertical and forward flight. To cut down on weight, the 7-foot diameter propellers have fiberglass blades (a fiberglass sleeve bonded to a steel, load-carrying core) and integral gear boxes. The lightweight blade design alone makes each X-22A propeller 25 percent lighter than metal-bladed propellers of comparable size. Further weight reduction is achieved by attaching the gear box directly to the propeller. An interconnected shaft system transmits power from the four turboshaft engines mounted on a wing in the aircraft's aft section. The right-hand propellers rotate clockwise, the left-hand propellers counterclockwise. A master governor controls the rotational speed of the propellers by automatically changing the blade angles. Hamilton Standard manufactured the fiberglass-bladed, integral gear box propellers for Textron's Bell Aerosystems.

XB-70 ENVIRONMENTAL CONTROL SYSTEM

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

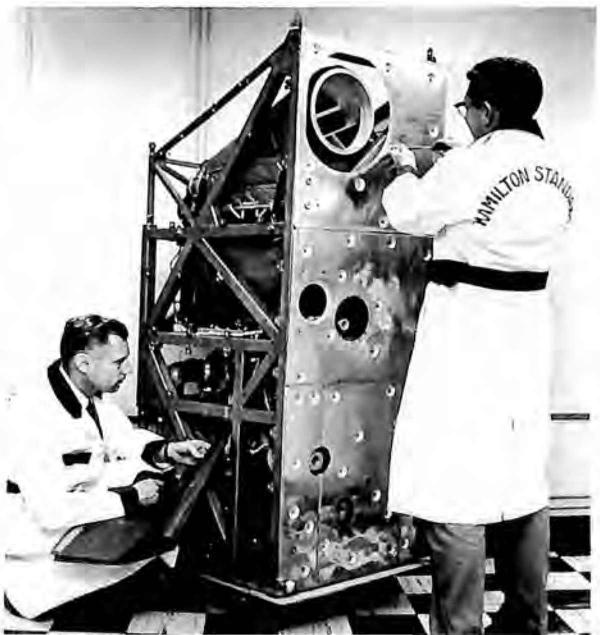
The XB-70's environmental control system is designed to provide a shirt-sleeve environment for the crew as the aircraft flies at subsonic and supersonic speeds, including Mach 3 when skin temperatures are more than 600 degrees Fahrenheit. The recirculating system cools, pressurizes, ventilates and controls the relative humidity inside the crew and electronic equipment compartments. It also supplies cooled air in the hollow space between the fuselage's inner and outer walls. Compartment pressure is regulated to an 8,000-foot altitude. The heart of the system is a 33-ton capacity Freon refrigeration package. A controlled airflow from the aircraft's jet engines supplies makeup air for leakage in the air supply used for ventilation and pressurization. Temperature of the engine bleed air is approximately 800 degrees Fahrenheit before it enters the system. Hamilton Standard manufactured the environmental control system for North American Rockwell Corporation.

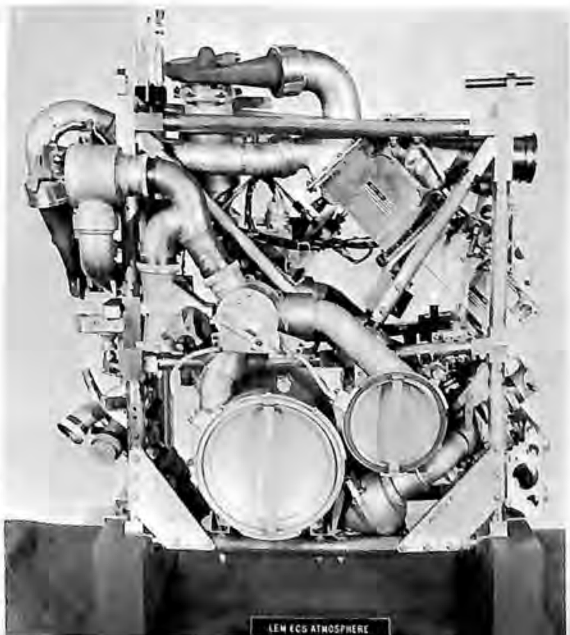
LM ENVIRONMENTAL CONTROL SYSTEM

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

The environmental control system for the lunar module (LM) supplies oxygen, pressurization and ventilation for the cabin and space suits worn by the 2 astronauts. It also removes carbon dioxide, odors and other contaminants from the cabin atmosphere. Thermal control includes the temperature of the ventilating gas for the cabin and space suits, electronic equipment and warming cryogenic fluids. During normal operation, the cabin and space suits are maintained at 5 pounds per square inch, permitting the crew to open the face plates and remove their gloves. When the cabin is depressurized, the astronauts seal their space suits and pressure is reduced to 3.5 pounds per square inch. The pressurizing gas is 100 percent oxygen. The major portion of this oxygen is stored cryogenically, but the environmental control system also includes a small gaseous oxygen accumulator for high-flow demands of short duration. Sufficient oxygen is stored for 6 cabin repressurizations, 2 fills and 4 refills of the oxygen tanks on the portable life support system to be worn by the space-suited crew when they explore the moon's surface, plus normal crew consumption and vehicle and suit leakage. The thermal control function employs an ethylene glycolwater mixture as a heat transport fluid, circulated through a closed loop. Waste heat from this loop is rejected to a self-regulating porous plate sublimator which discharges vapor to the vacuum of space. A positive expulsion tank is used for storage of water required for evaporation and for supplying the metabolic needs of the crew. The tank also stores sufficient water for 2 fills and 4 refills of the life support pack's water tanks.





PORTABLE LIFE SUPPORT SYSTEM FOR APOLLO SPACE SUIT

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

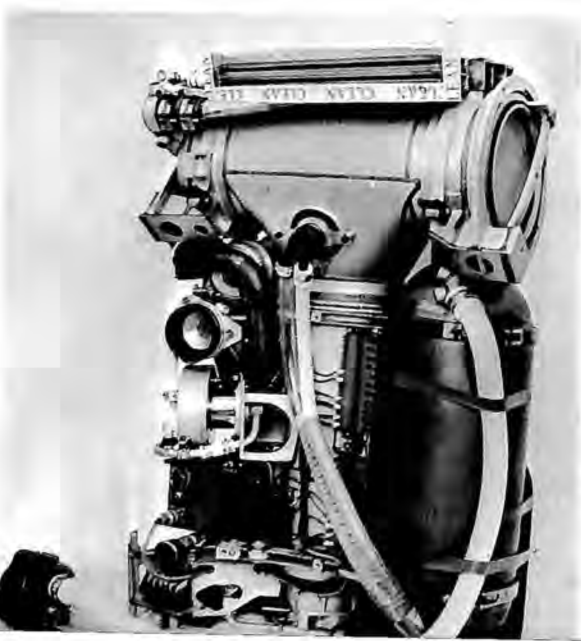
The Portable Life Support System (PLSS) is designed to be worn by space-suited astronauts when they explore the lunar surface. Weighing 60 pounds, it will supply oxygen, pressurization and control the temperature, relative humidity, carbon dioxide and other contaminants of the ventilating gases in the suit. The PLSS also recirculates and recools the water that flows through the tubing of the liquidcooling garment worn under the Apollo space suit. This water removes the astronaut's body heat. The life support pack will permit 4-hour extravehicular expeditions. Its expendables can be recharged in the lunar module (LM) for the pack's reuse. A 2-way radio and telemetry unit provides voice communications and the transmission of astronaut physiological and space suit data to the LM or to the command module for relay to earth. Hamilton Standard developed the PLSS for NASA's Manned Spacecraft Center.

C-5A MULTI-MODE RADAR SYSTEM

Prime Contractor: Norden Division of United Aircraft Corporation

Remarks

The C-5A multi-mode radar, developed by Norden for the 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, 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 while X-band offers decreased sensitivity to weather. The X and Ku band radars may be independently controlled at any of the 3 operator stations, and either radar may 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, while 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-5A is sponsored by the Aeronautical Systems Division, Air Force Systems Command.

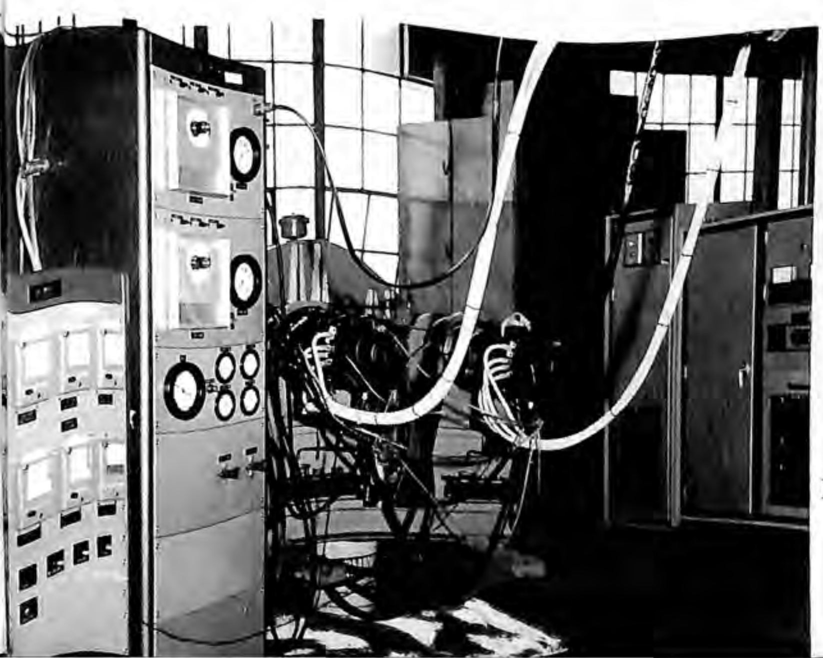


ELECTRIC POWER GENERATING SYSTEM

Prime Contractor: Westinghouse Electric Corporation, Aerospace Electrical Division

Remarks

The Aerospace Electrical Division (AED) has designed, developed, and tested the AC electric power system for the multimission F-111. The system provides the primary electric power source for the aircraft. It is a 2-generator, automatic bus transfer system rated at 62.5 KVA per bus. General Dynamics awarded AED a production contract for 431 aircraft. Each of the 2 aircraft systems consists of an oil-cooled, brushless, 62.5 KVA generator, a generator control and protection unit (GCU), and GCU mounting rack. As a part of the research, development, test and engineering program, AED demonstrated performance reliability by a 5,000 hour system test. Such test exceeded the specified MTBF by 189 percent (at 90 percent confidence level). During the test a complete system was run 40 percent beyond the recommended overhaul point. Inspection teardown following overhaul extension indicated all parts to be in excellent operating condition, and no degradation of operating performance parameters were recorded. The test also demonstrated generator seal capabilities by running at less than 6 percent of the oil leakage permitted by specification. The test supports excellent field operation results being achieved by this equipment at the airframe manufacturer and on flight tests. In photo, test stand.

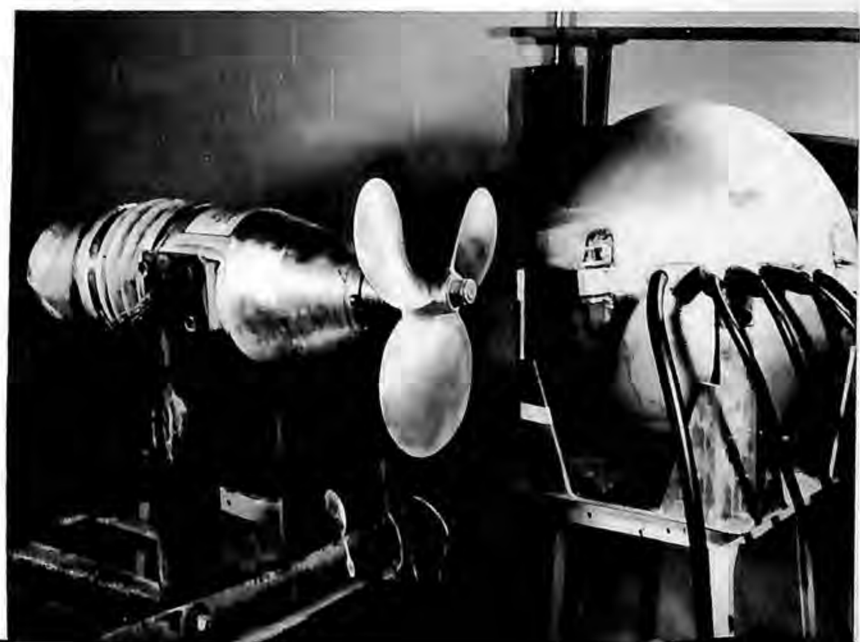


DEEP SUBMERGENCE PROPULSION SYSTEM

Prime Contractor: Westinghouse Electric Corporation, Aerospace Electrical Division

Remarks

The Westinghouse Aerospace Electrical Division, located at Lima, Ohio, has produced a propulsion system for deep diving submersibles in support of the Navy Deep Submergence Program. The system consists of a solid state control which changes the DC power from the vehicles' batteries to controlled 3-phase AC power which drives a pressure compensated induction motor. The solid state control is housed in a spherical pressure resistant enclosure. Pressure compensation of the motor is accomplished by filling the enclosure with oil and transmitting the external pressure to the oil by means of a flexible bellows in the housing. The use of an oil-filled motor eliminates the need for thick seawater resistant electrical insulations in its construction. Instead, a thin, durable wire enamel and varnish impregnation are used. This insulation system developed for aerospace electrical equipment provides good heat transfer from the windings to the oil in addition to providing a very compact design. System advantages are wide speed range, high efficiency, proven performance and light weight.



MAPPING RADAR

Prime Contractor: Westinghouse Electric Corporation, Defense and Space Center

Remarks

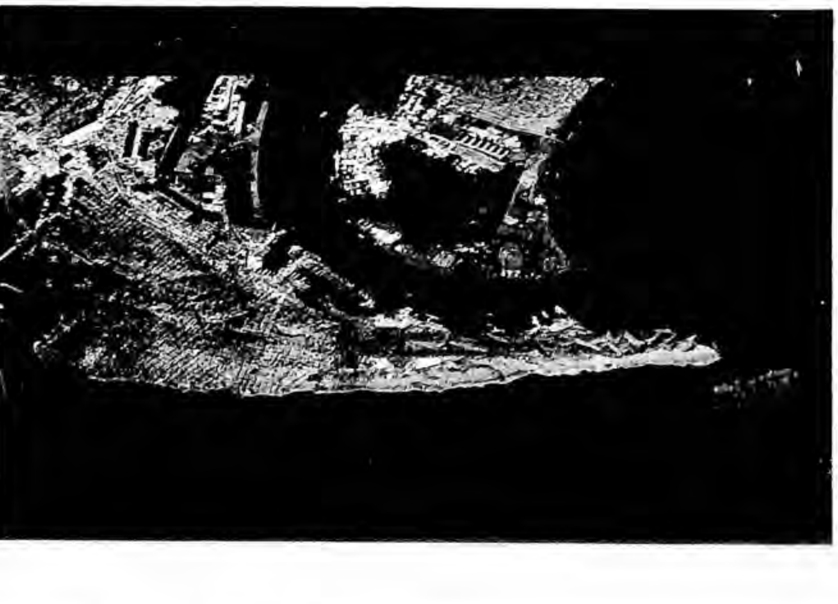
An airborne mapping radar system is being used to provide information for National Aeronautics and Space Administration's earth science resources program. A radar map of the San Diego harbor (photo) was made by a mapping radar built by the Aerospace Division of the Westinghouse Defense and Space Center. The radar, developed for the U. S. Army Electronics Command, produced this map as part of a project that provides remote sensing evaluation information for NASA. Radar mapping flights using Westinghouse radar have been made since 1965. In the radar mapping system, a photographic map of the area covered is produced from radar return signals which are analyzed and displayed on photographic film. By varying radar signal characteristics and processing methods, scientists can use side-look radar for such purposes as large-scale topographic mapping, agronomy investigation, and making profiles of geological characteristics. Some other studies underway or being considered are sea ice mapping, sea state determination, polar ice cap profiling, subsurface profiling, soil moisture content analysis, and determination of undulations in the geoid. Radar for geoscience research enables scientists to utilize the unique characteristics of another part of the electromagnetic spectrum, the microwave region, in addition to the visible and near-visible regions.

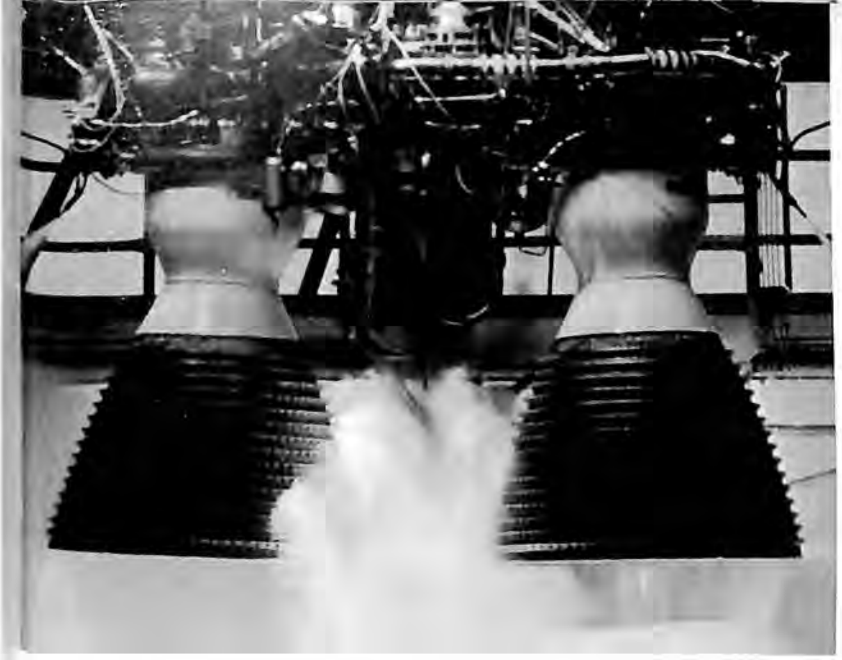
SNAP 23-A ELECTRIC POWER GENERATING SYSTEM

Prime Contractor: Westinghouse Electric Corporation, Astronuclear Laboratory

Remarks

The Astronuclear Laboratory (ANL) has won a competitive contract with the AEC to proceed with the development of a nuclear thermo-electric converter SNAP 23-A. Under terms of the contract Westinghouse will develop the isotope fuel supply and integrate the thermoelectric converter already developed under a previous contract. The aim is to develop a unit that weighs less than 1,000 pounds and is capable of operating at a cost of $10 per kilowatt hour for a period of 10 years unattended. Westinghouse will deliver to the AEC 7 prototype models—2 25-watt units, 4 60-watt units and one 100-watt unit. Originally conceived for space application, the SNAP program has been extended to power sources for remote weather monitoring equipment, navigation buoys and land based microwave repeater stations.





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 Operations at Sacramento, California—is the liquid rocket engine system which successfully boosted 20 astronauts into space from Cape Kennedy on the Gemini launch vehicle in addition to being 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, 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_20_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

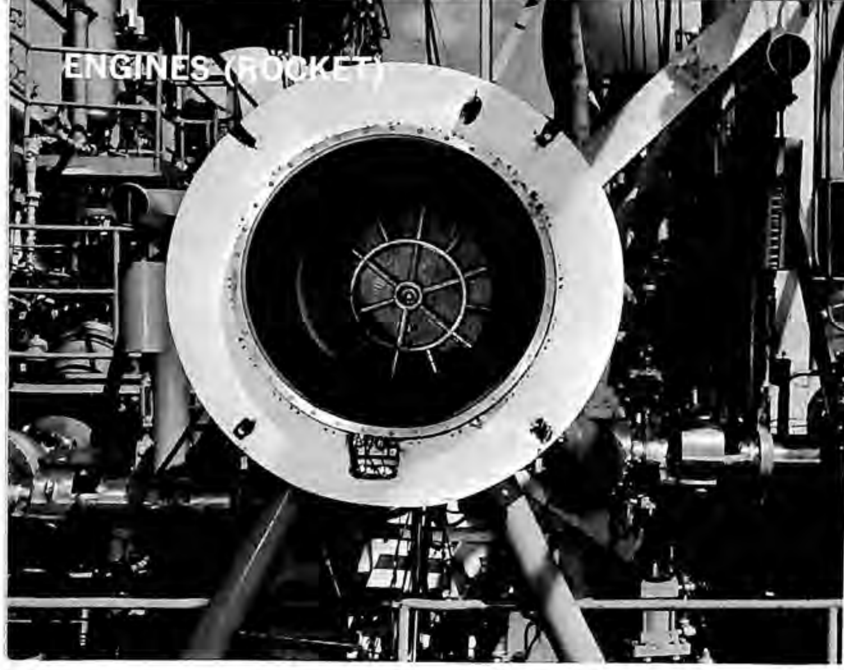
Prime Contractor: Aerojet-General Corporation

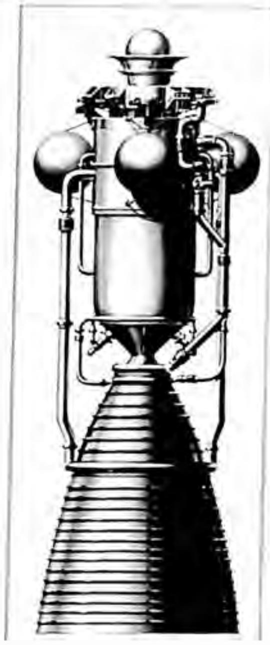
Remarks

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 is a vital stage in the space operations of 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 of high thrust hydrogen/oxygen engine systems is being conducted at Aerojet's Sacramento Plant 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 "break-through" injector. This "first-cut" injector has demonstrated excellent performance, mechanical integrity and good stability.

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 presently under development by the Aerojet-General Corporation with Westinghouse Electric Company, as principal subcontractor, providing the nuclear reactor. The NERVA engine development is based on the solid core, heat exchanger reactor concept. Liquid hydrogen (-423 degrees Fahrenheit) is provided from tankage to a turbopump which delivers high pressure hydrogen to the NERVA engine nozzle as a regenerative coolant, which then flows through the reactor where it is heated to thousands of degrees by fission energy and is 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. 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, Venus or for deep space probes. The operational NERVA II will have a 4-billion-watt reactor and will produce 200,000 pounds of thrust in space for upper-stage vehicle applications; a likely interim system will produce 75,000 pounds thrust.

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 other 2 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 ENGINE

Contractor: Aerojet-General Corporation

Remarks

The Apollo Service Propulsion System engine is America's largest and most powerful spacecraft rocket engine. Producing more than 20,000 pounds of thrust in space, it may be fired both automatically and manually by the Apollo astronauts. It is a pressure-fed liquid rocket engine capable of being restarted in space at least 50 times and uses a bipropellant feed system which makes possible a step-thrust capability from 70 percent to full thrust. Using hypergolic storable propellants UDMH 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 to 1—largest expansion ratio of any U. S. rocket engine. It has a design life of 750 seconds. Missions of the Aerojet SPS engine will be (1) mid-course corrections to and from the moon, (2) putting the Apollo spacecraft into proper lunar orbit through retro action, (3) maintaining correct lunar orbit as the lunar module descends to the moon's surface, (4) going down to within 12 miles of the lunar surface (if necessary) to rescue the LM and (5) providing power to break out of lunar orbit and return to earth. It will also be capable of any other large maneuvers required by the Apollo Command/Service Modules.

SVM-1 APOGEE KICK ROCKET

Prime Contractor: Aerojet-General Corporation

Remarks

The SVM-1 is a solid propellant 2,900 pound thrust motor for the Communications Satellite Corporation's Intelsat II satellite. Unit provides final velocity increment to place satellites into synchronous equatorial orbit. Motor is contained in the satellite, built by Hughes Aircraft.

MINUTEMAN III STAGE III MOTOR

Prime Contractor: Aerojet-General Corporation

Remarks

The new third stage solid rocket motor for the Air Force Minuteman III is being developed by Aerojet-General's Solid Rocket Operations. The motor employs the same type of propellant developed for the second stage of the Minuteman II ICBM. Features of the new motor are a glass filament wound case, an advanced thrust termination system, warm gas roll control system, liquid injection thrust vector control and a deeply submerged single nozzle.

ARES

Prime Contractor: Aerojet-General Corporation

Remarks

Aerojet's Liquid Rocket Operations is working under Air Force direction to develop a modular-type high chamber pressure engine applicable to use in any stage of future launch vehicles.

POLARIS MOTORS

Prime Contractor: Aerojet-General Corporation

Remarks

Aerojet-General has produced more than 2,000 solid propellant rocket motors for the Navy's Polaris fleet ballistic missile. While details of the power plant are classified, the engine shown is designed for use in the Polaris A-3, the 2,500 nautical mile range model and the latest to go into service. Aerojet-General started production of Polaris motors in 1959. The company produced all of the first and second stage motors for the 1,200 nautical mile range A-1 version, the first stage units for the 1,500-mile A-2, and is now producing the first stage engine for the A-3.

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 and 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.

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 UDMH and nitrogen tetroxide. Its record-setting 4 restarts on the same space flights in which it placed payloads in 4 different orbits has caused it to be labeled a space "switch" engine.

Performance

Thrust 8,000 pounds each engine; total 16,000 pounds.

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 any engine of this elevated thrust class. It has excellent durability and compatibility characteristics which have been demonstrated during 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 versatility of the Aerojet lightweight engine makes it suitable for a number of space missions where rapid provision of desired thrust levels is necessary for mid-course correction, rendezvous maneuvers, orbit insertion and landing deceleration. The engine is built for the Naval Air Systems Command.

ALGOL (photo)

Prime Contractor: Aerojet-General Corporation

Remarks

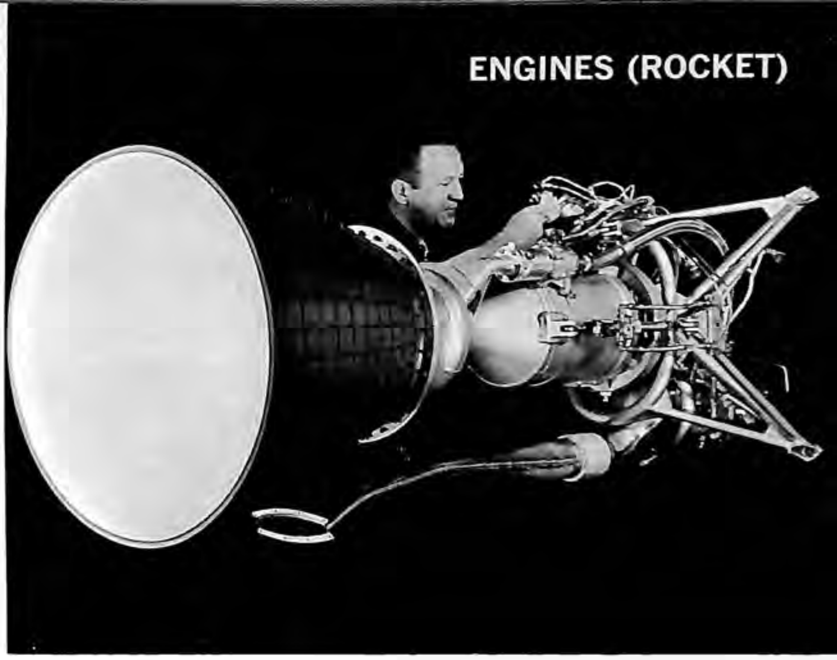
Algol is used as the first stage of the NASA Scout launch vehicle. Originally designed and developed by Aerojet-General Corporation's Solid Rocket Operations as a static test motor and the forerunner of such solid rockets as the Polaris and Minuteman, Algol is approximately 30 feet long, 40 inches in diameter and contains nearly 10 tons of propellant. It produces more than 100,000 pounds of thrust. Algol also serves as the first stage for the Air Force Blue Scout and it was used in clusters during the NASA Little Joe program.

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 Operations 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 10,100 pounds of thrust.



LUNAR MODULE ASCENT ENGINE

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The ascent rocket engine will propel the Apollo Lunar Module from launch on the lunar surface into a trajectory leading to a rendezvous with the orbiting Command and Service modules. The engine has been tested at Manned Spacecraft Center's White Sands Operation.

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.

AGENA ENGINE

Prime Contractor: Textron's Bell Aerosystem Company

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 Aerosystems since 1958, the Agena engine has orbited more than 80 percent of the Air Force and NASA satellites launched and 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.

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, and Bullpup. 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 0.93.

Specifications

Length 113 inches; diameter 30 inches; weight 2,285 pounds.

Performance

Thrust 14,000 pounds; time 36 seconds.

RANGER RETRO

Remarks

Originally designed for the Ranger lunar impacter, this motor (photo) is now used to place the twin Vela nuclear detection satellites in orbit.

Specifications

Length 31 inches; diameter 18 inches; weight 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.

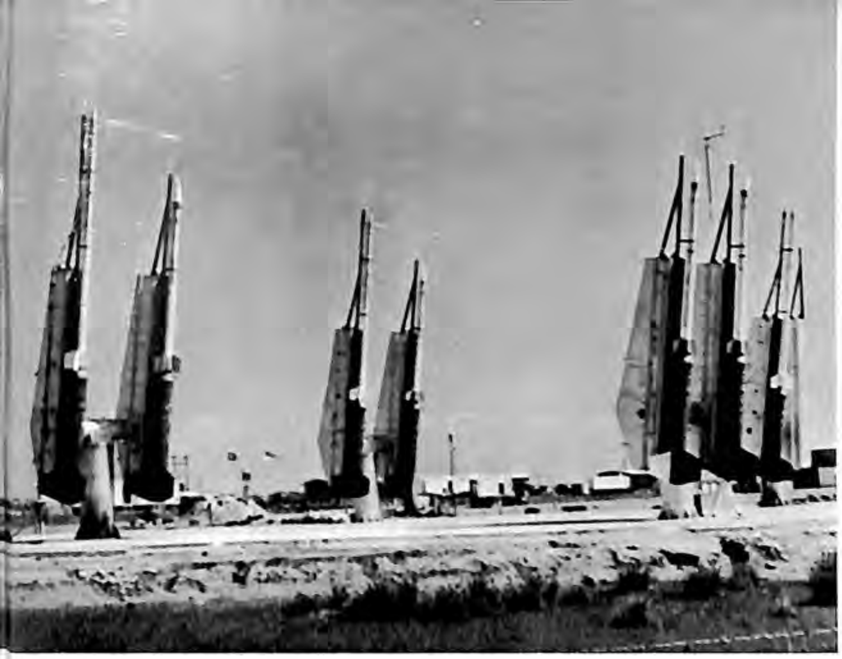
X259 ADVANCED ANTARES

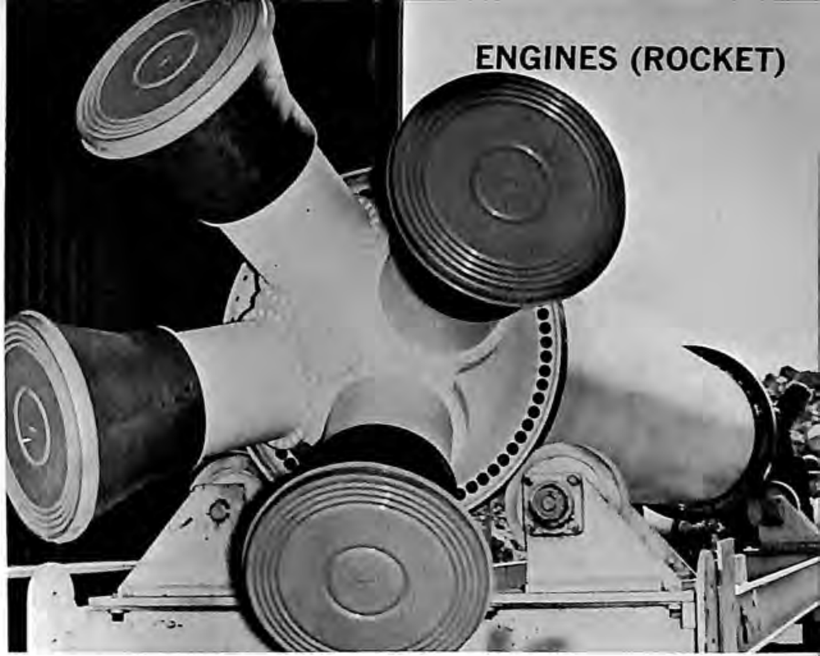
Specifications

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, while the Javelin II is a successful sled and sounding rocket. Photo shows 7 Nike-Javelin rockets ready for launch.

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.

Specifications

Length (1) 15 feet, (2) 2 feet; diameter (1) 26 inches, (2) 9 inches; weight (1) 4,700 pounds, (2) 50 pounds.

Performance

Thrust (1) 145,000 pounds, (2) 2,400 pounds.

LOCKHEED 156-INCH SOLID MOTOR

Prime Contractor: Lockheed Propulsion Company

Remarks

Lockheed's 156-inch diameter solid-rocket motors under an Air Force feasibility demonstration program 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.

SRAM PULSE MOTOR

Prime Contractor: Lockheed Missiles and Space 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 200 pulses during the 3 years it has been engaged in pulse motor work. In photo, technicians check over the first of three materials evaluation units to be test fired.

R-4D

Prime Contractor: The Marquardt Corporation

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 also serves as the velocity control rocket for NASA's Lunar Orbiter spacecraft. 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 five 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 Corporation

Remarks

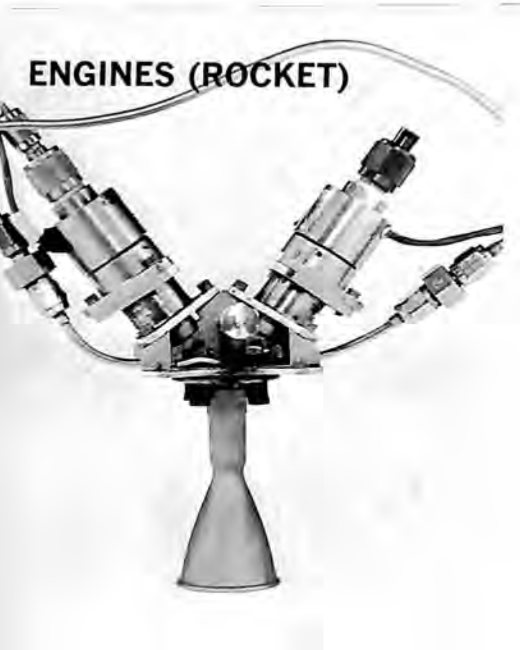
The Model R-5B liquid hypergolic bipropellant rocket engine was developed for NASA as an ullage and Delta-V rocket, originally for application on the Saturn S-IVB stage.

Specifications

Length 38.7 inches; diameter 17 inches maximum; weight 70 pounds; propellants: (oxidizer) nitrogen tetroxide and (fuel) 50-50 blend of nitrogen tetroxide and unsymmetrical dimethyl hydrazine; ablative chamber.

Performance

Thrust 1,750 pounds nominal vacuum.



R-6C

Prime Contractor: The Marquardt Corporation

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, 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 Corporation

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. Engine is developed for high pulsing and steady state performance in combination with reliable, long life operational characteristics.

Specifications

Length 10.1 inches; diameter 6.0 inches; weight 2.8 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.

R-12C

Prime Contractor: The Marquardt Corporation

Remarks

The Model R-12C, the test stand version of which is shown in the photo, 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 both in the steady state and pulsing modes.

Specifications

Length 5.47 inches; diameter 1.46 inches; weight .91 pounds; fuel, hydrazine.

Performance

Thrust one pound at nominal vacuum.

R-13C

Prime Contractor: The Marquardt Corporation

Remarks

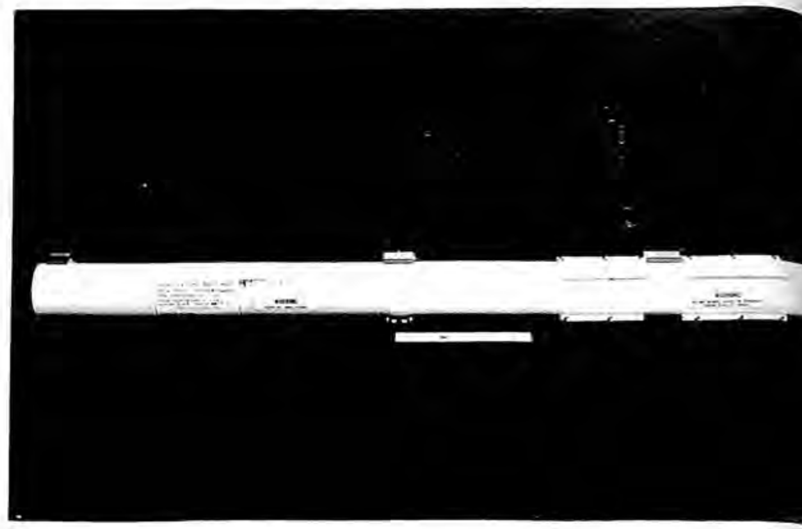
The Model R-13C is a monopropellant hydrazine rocket engine developed as a spin rate control station keeping and plane change engine for spacecraft. The engine has been developed for high performance reliability, and long life both in the steady state and pulsing modes.

Specifications

Length 6.65 inches; diameter 2.09 inches; weight 1.47 pounds, lightweight version .936 pounds; fuel, hydrazine.

Performance

Thrust 5 pounds at nominal vacuum.



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 powerplant for the Centaur and for the 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 successfully flown on the more recent Centaur flights.

Specifications

Length 69 inches; diameter at exhaust nozzle 40 inches; weight (approximate) 292 pounds; expansion ratio RL10A-3-1 40:1, 10A-3-3 57:1; propellants liquid hydrogen and liquid oxygen.

Performance

Thrust 15,000 pounds, throttling capability from 100 to 10 percent of rated thrust; specific impulse 10A-3-1 433 seconds; 10A-3-3 444 seconds.

SIDEWINDER IC ROCKET MOTOR (AIM-9C/D)

Prime Contractor: Rocketdyne Division of North American Rockwell Corporation

Remarks

Greater speed and range, plus improved operational characteristics have marked the second generation of Sidewinder with its advanced solid propulsion system being manufactured at Rocketdyne since 1963. This Navy air-to-air missile mounted on F-8s and F-4Bs was designed to destroy high-performance fighter aircraft and bombers. The rocket motor measures 72 inches long, 5 inches in diameter, and contains 60 pounds of Flexadyne propellant. Loaded with propellant the motor was subjected to extensive vibration, shock, drop tests simulating extremes of operational use, and 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, and 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 of North American Rockwell Corporation

Remarks

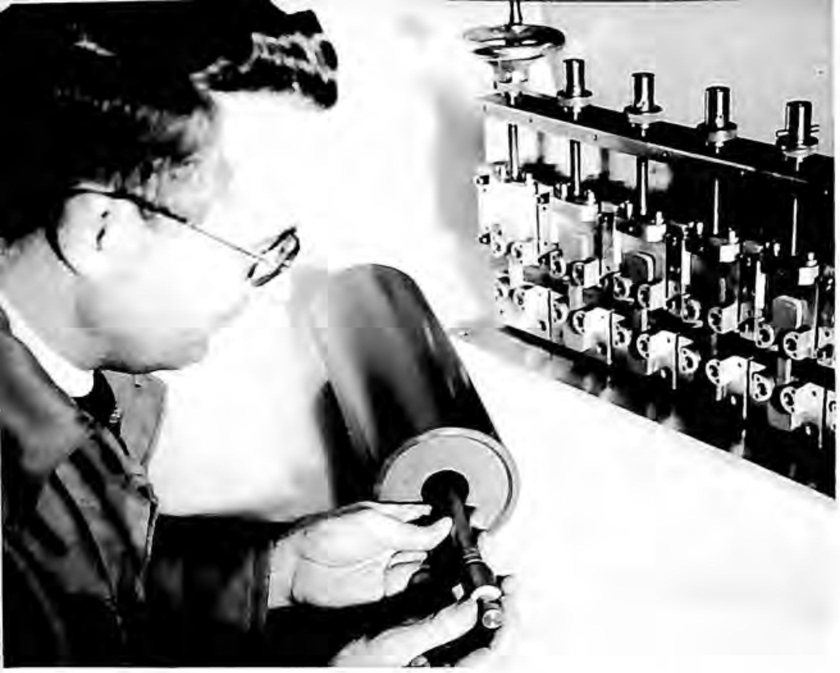
The solid propulsion system for Sparrow III, one of the Navy's most advanced air-to-air missiles, has been in production at Rocketdyne since early 1961. Development and qualification of the advanced propulsion system were completed in 22 months; successful flight tests were held 12 months after initial contract award. Specifically designed to propel the electronically-controlled Sparrow III 6-b, primary armament on the Navy F-4B and 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 sub-zero to over 300 degrees Fahrenheit; survived several days of continuous vibration; 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 combine a unique freestanding propellant charge (grain) with Flexadyne, a solid propellant which increases performance and operating temperature range, and resists cracking or tearing at extremely low temperatures. Rocketdyne has manufactured well over 9,000 Sparrow propulsion systems for both Navy and Air Force use.

SHRIKE ROCKET MOTOR (AGM-45A)

Prime Contractor: Rocketdyne Division of North American Rockwell Corporation

Remarks

First in a new generation of tactical weapons, the Navy's Shrike air-to-ground missile is powered by a solid-propellant rocket motor similar in design and performance to the propulsion system of Sparrow III 6-b. Both motors combine a unique free-standing propellant charge (grain) with Flexadyne, a solid propellant providing substantial performance increase and wider operating temperature range. Named after a small bird that attacks the eyes of its enemies, Shrike affords a new attack capability against heavily defended tactical areas, plus increased combat protection for pilots and planes. Rocketdyne has delivered well over 4,000 Shrike propulsion systems for both Navy and Air Force use.

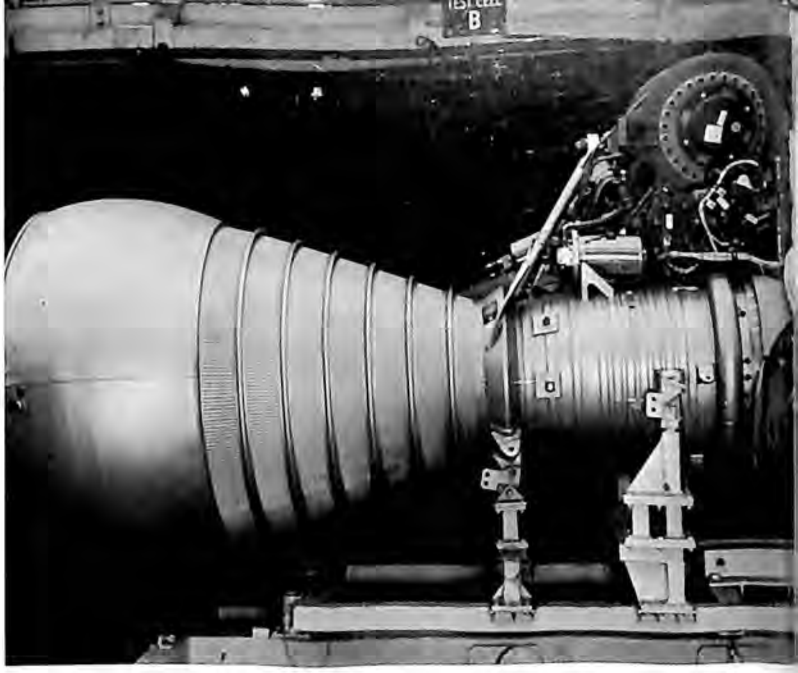


ROCKETDYNE SOLID MOTORS

Prime Contractor: Rocketdyne Division of North American Rockwell Corporation

Remarks

Rocketdyne's Solid Rocket Division at 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 8 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 Redhead-Roadrunner launch booster, the RS-B-202 zero launch booster for the F-104G, and turbine starters for H-1 and J-2 liquid rocket engines. In photo, solid propellant samples undergo test at the division's research laboratory.



H-1 ENGINE

Prime Contractor: Rocketdyne Division of North American Rockwell Corporation

Remarks

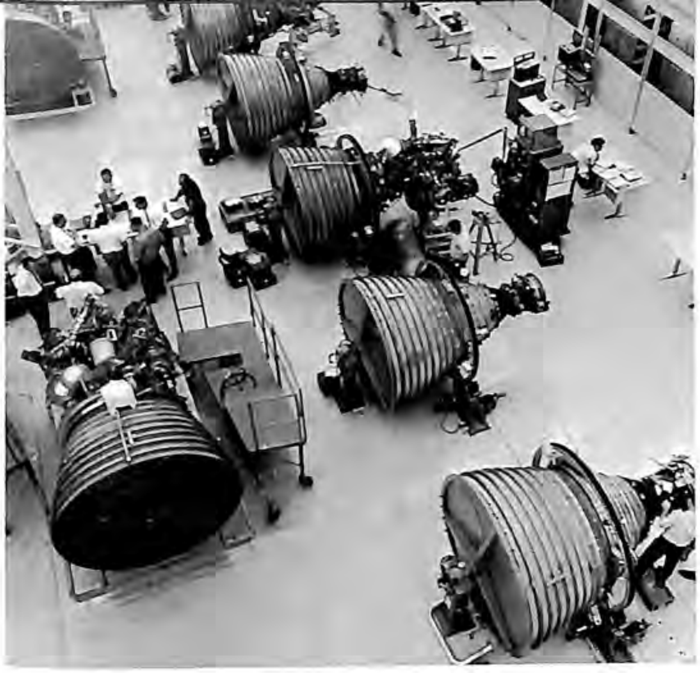
A key engine in the U.S. national space program, the H-1 in a cluster of eight units has been uprated to first stage thrust of 1,640,000 pounds for later flights of the Uprated Saturn I vehicles. Regeneratively cooled, it burns a combination of RP-1 fuel and liquid oxygen oxidizer. Engines are tested singly at Rocketdyne's Santa Susana Field Laboratory in California and at the company's Neosho, Missouri, plant prior to delivery to NASA's Marshall Space Flight Center and the Chrysler assembly plant at Michoud, Louisiana.

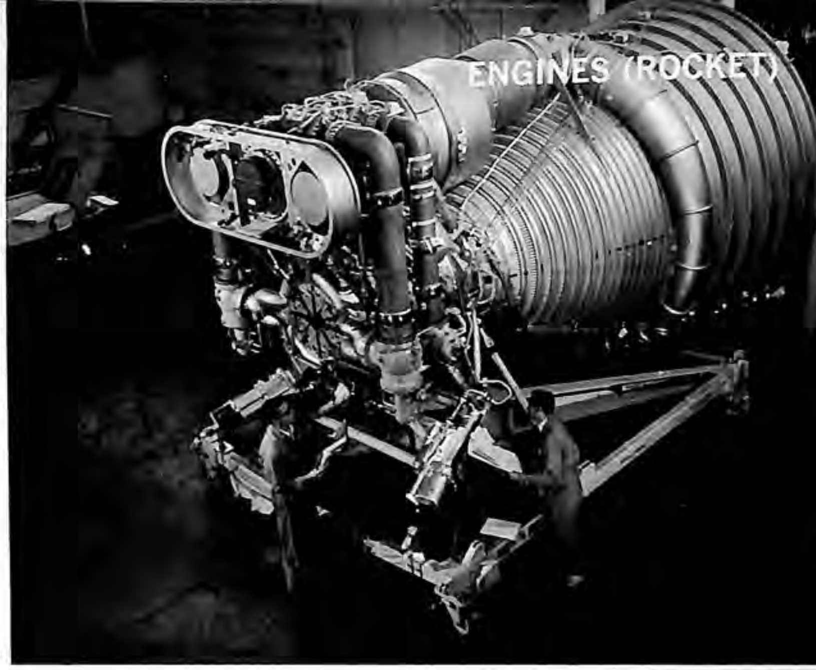
Specifications

Maximum envelope length 102 inches; maximum diameter 66 inches.

Performance

Thrust 205,000 pounds.





J-2 ENGINE

Prime Contractor: Rocketdyne Division of 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 and 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 200,000-pound thrust engine plays an important role in the nation's 2 largest launch vehicles: in the Uprated Saturn I 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 1,000,000-pound thrust cluster of 5 as the second stage and in the S-IVB as the third stage, which will send Apollo astronauts into a lunar trajectory. J-2 is being developed under the technical direction of NASA's Marshall Space Flight Center.

Specifications

Maximum envelope length 133 inches; maximum envelope diameter 80½ inches.

Performance

Maximum thrust 230,000 pounds.

F-1 ENGINE

Prime Contractor: Rocketdyne Division of North American Rockwell Corporation

Remarks

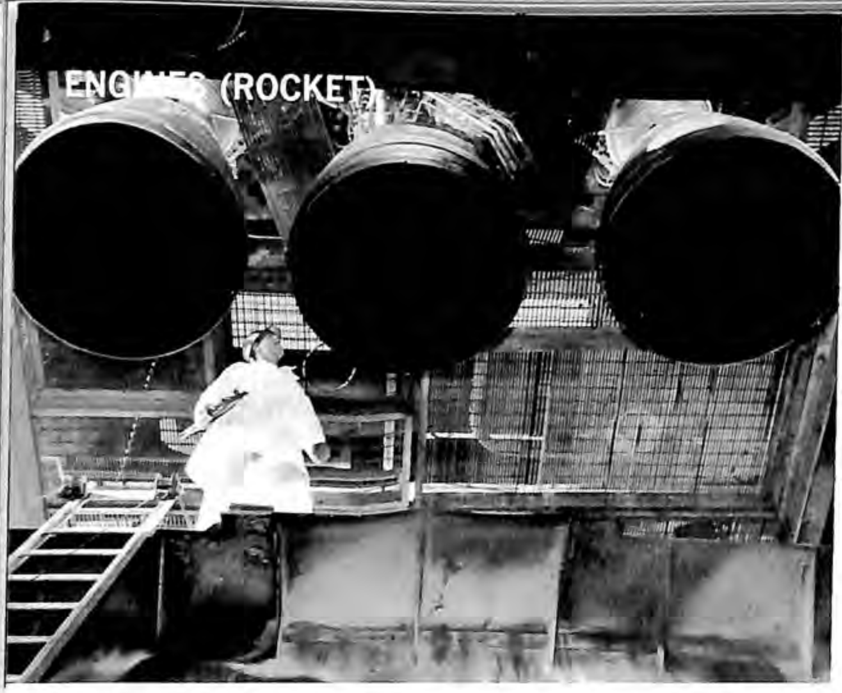
The primary engine in the U.S. manned space flight program, the F-1 is the most powerful liquid-fueled engine in the U.S. inventory. Being developed under the technical direction of NASA's Marshall Space Flight Center, it is regeneratively-cooled and it burns a combination of RP-1 fuel and liquid oxygen 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 which will send Apollo astronauts to the moon.

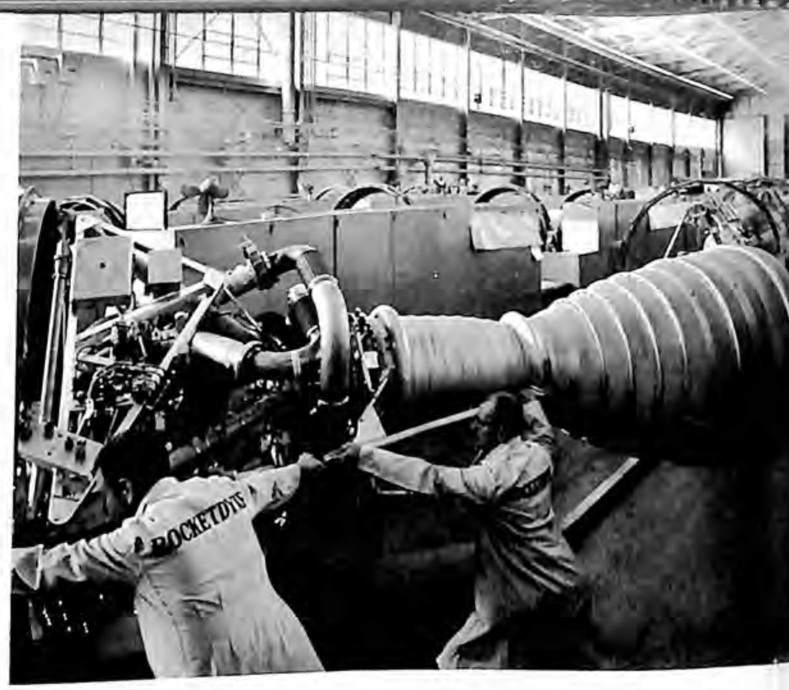
Specifications

Maximum envelope length 19 feet; maximum envelope diameter 12.4 feet.

Performance

Thrust 1,522,000 pounds.





ATLAS MA-5 SYSTEM

Prime Contractor: Rocketdyne Division of North American Rockwell Corporation

Remarks

The MA-5 system is the propulsion package for the SLV-3 launch vehicle. Generating 388,300 pounds of thrust, it was used for all Mercury Atlas astronaut launchings. In long-range missile tests the engine hurled the Atlas as far as 9,000 miles from the launching pad at Cape Kennedy. 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.

THOR MB-3

Prime Contractor: Rocketdyne Division of North American Rockwell Corporation

Remarks

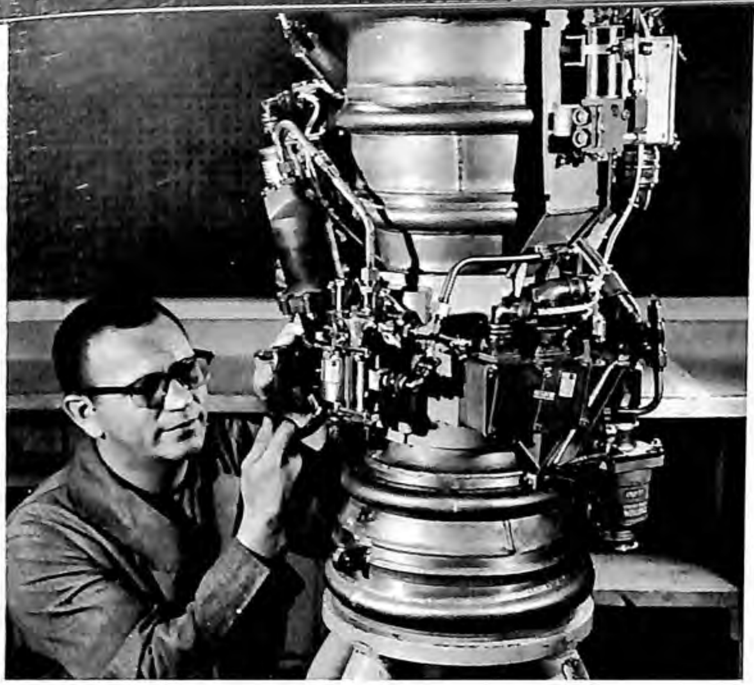
MB-3 engines for the Thor booster are produced for the Air Force by Rocketdyne. A liquid-propellant engine, the MB-3 features 2 small verniers (stabilizing engines) to provide roll control. More space vehicles have been boosted by Thor than by any other propulsion system.

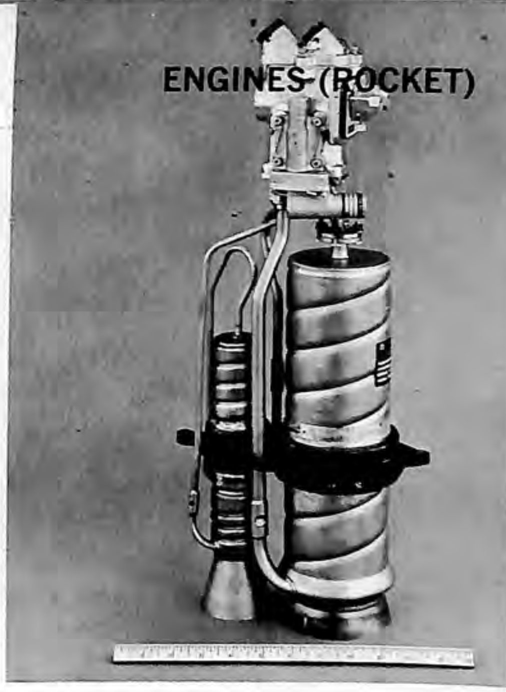
Specifications

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 of 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 more than 6,000 pounds.

Specifications

Length 32 inches; diameter 15 inches; weight 235 pounds; fuel JP-4 or 5; oxidizer hydrogen peroxide.

Performance

Thrust throttleable from 50 percent to maximum of 6,600 pounds at 35,000 feet.

P4-1 DRONE ENGINE

Prime Contractor: Rocketdyne Division of North American Rockwell Corporation

Remarks

The P4-1 storable liquid propellant 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 hydyne (MAF-4); oxidizer inhibited red fuming nitric acid.

Performance

Thrust sustainer 106 pounds at 70,000 feet, booster 550 pounds at 25,000 feet.

SE-7, SE-8, SE-9

Prime Contractor: Rocketdyne Division of North American Rockwell Corporation

Remarks

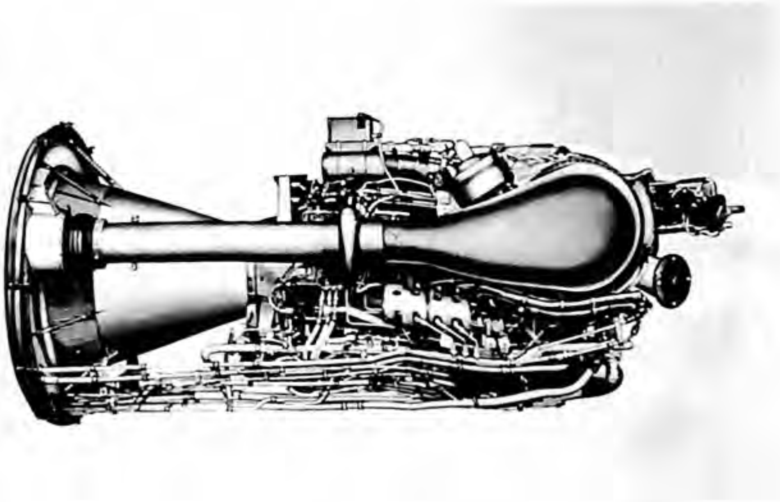
SE-7,-8,-9 are small liquid propellant thrusters. The SE-7 and 8 burn a combination of monomethylhydrazine fuel and nitrogen tetroxide oxidizer. The SE-9 uses a combination of hydrazine and unsymmetrical dimethyl hydrazine as fuel and nitrogen tetroxide as oxidizer. SE-7 is used for corrections of orbital attitude and maneuvering in the Gemini spacecraft; SE-8 for the attitude reentry control system in the Apollo command module; SE-9 for attitude control of the Titan III-C transtage. The units are employed in multiples, 16 in the SE-7 system including 6 to 100 pounds thrust, 2 of 85 pounds and 8 of 25 pounds. SE-8 has 2 sets of 6 engines each, one set redundant, all engines 93 pounds thrust. SE-9 consists of 2 3-engine modules plus 2 single engines, with 4 of the engines producing 45 pounds thrust and the other 4 25 pounds. In photo, a 3-engine module of the SE-9 system.

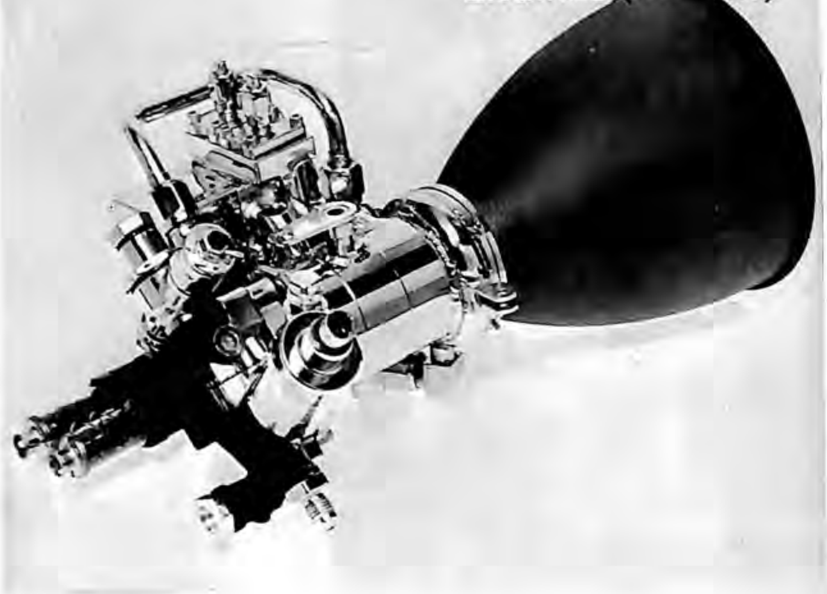
PHOENIX ROCKET MOTOR (AIM-54A)

Prime Contractor: Rocketdyne Division of North American Rockwell Corporation

Remarks

The solid propulsion system for the Navy's Phoenix missile was completing the last phase of an extensive qualification program at Rocketdyne late in 1967. 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.





YLR99-RM-1 TURBOROCKET

Prime Contractor: Thiokol Chemical Corporation

Remarks

The YLR99-RM-1 throttleable turborocket engine was developed by Thiokol's Reaction Motors Division to provide propulsion for the X-15 hypersonic manned research aircraft. The engine fulfills the manned safety requirements of MIL-E-5149 and incorporates extensive malfunction self-monitoring and safety features. The engine operates on liquid oxygen and anhydrous ammonia which is fed into the thrust chamber by a hydrogen peroxide-driven turbopump. Major engine components are a thrust chamber, injector gas generator, 2-stage igniter, turbopump and variable governor control, propellant control components, and electrical system. The engine has powered the X-15 to record speeds and altitudes for winged, piloted vehicles.

Specifications

Length 82.03 inches; diameter 39.31 inches; weight 910 pounds (dry) and 1,025 pounds (wet); operational life between overhauls, 1 hour.

Performance

Thrust continuously throttleable from 15,000 to 58,700 pounds (at infinite altitude); rated duration 180 seconds at full thrust depending on aircraft tankage; total propellant flowrate 212.5 pounds per second.

TD-339 SURVEYOR VERNIER ENGINE

Prime Contractor: Thiokol Chemical Corporation

Remarks

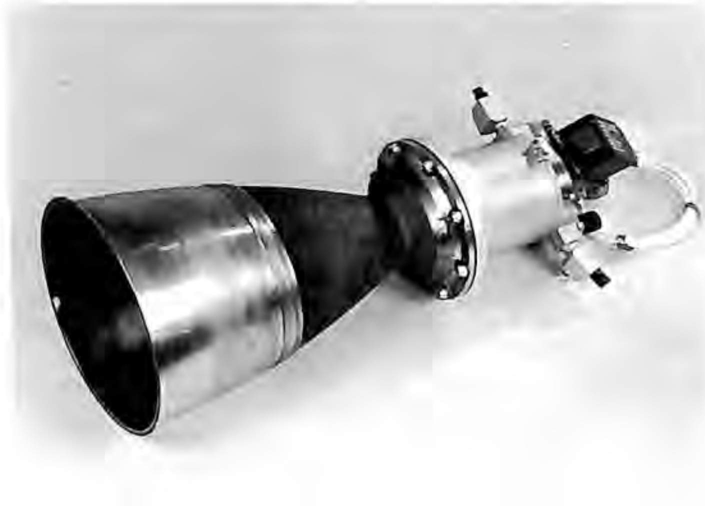
TD-339 vernier engines provided power for mid-course trajectory correction, final soft landing velocity and stability control during the lunar landings of America's Surveyor spacecraft. Three of these throttling liquid engines, produced by Thiokol's Reaction Motors Division, were installed on the Surveyor vehicles. The TD-339 is a small, regeneratively-cooled liquid system operating on pressure-fed mixed oxides of nitrogen and monomethylhydrazine hydrate fuel. Basic elements of the engine are the thrust chamber and injector assembly, dual propellant valve and propellant shutoff valve. A radiation-cooled molybdenum nozzle extension provides an 86:1 area ratio. Attitude and stability control are achieved by differential throttling of the 3 engines.

Specifications

Weight 5.9 pounds; length 11 inches.

Performance

Thrust continuously throttleable for 27 to 104 pounds; unlimited restart capability; specific impulse 287 seconds at maximum thrust.



THIOKOL SOLID ROCKETS

Prime Contractor: Thiokol Chemical Corporation

Remarks

Thiokol manufactures a varied line of solid rocket motors over a wide thrust range. Among its largest motors are the 156-1C and the 156-2C-1, the 156-7 fiberglass case motor (developing over 350,000 pounds thrust) and the 156-9 (1,000,000 pounds thrust). Thrust values are 1,400,000 pounds for the 1C and 3,000,000 pounds for the 2C. Other Thiokol motors include the TU-465 120-inch booster; with Hercules Incorporated, the first stage Poseidon C-3 motor; the TE-364 Surveyor main retro; TE-385 Gemini retros; TE-260-C Subroc booster; the Falcon TE-287, TX-143-25 and TX-58-4; TU-289 Genie booster; XM100 booster for the Sergeant missile (length 195.3 inches, diameter 32 inches, weight 6,910 pounds); M16E1 Matador booster; the 34,000 pound thrust Recruit rocket (length 102.22 inches, diameter 9 inches, weight 352 pounds); M30 Nike-Hercules sustainer (length 174 inches, diameter 28.44 inches, weight 2,660 pounds); the 64,000 pound Castor rocket (length 244.12 inches, diameter 40 inches, weight 8,746 pounds); the TX-33-36 Little Joe rocket, which produces 53,850 pounds thrust (length 237.44 inches, diameter 31 inches, weight 8,796 pounds); the 200,000 pound thrust M-55 (TU-122) Minuteman Stage 1/Wing 1 motor and the M-55E1 Wing 2 motor of unannounced thrust; the XM-15 Bomarc booster; the TX-135 Nike Zeus booster (length 203 inches, diameter 43.12 inches); the XM-105 Pershing first stage motor (length 78.55 inches, diameter 40 inches); XM-106 Pershing second stage motor (length 63.28 inches, diameter 40 inches); and motors for various other missiles.

C-1 RADIAMIC ENGINE

Prime Contractor: Thiokol Chemical Corporation

Remarks

Under contract to NASA's Marshall Space Flight Center, Thiokol's Reaction Motors Division is currently conducting the Phase II development of the C-1 Radiamic engine. Designated as the C-1 "Common Engine," this unit is intended for a variety of space vehicle missions. By employing 9 different, interchangeable nozzle configurations, the basic engine becomes adaptable for spacecraft attitude control and maneuvering systems and for launch vehicle ullage control. The engine uses storable liquid propellants consisting of nitrogen tetroxide with either a blend of unsymmetrical dimethylhydrazine and hydrazine, or monomethylhydrazine. The C-1 consists of a basic engine (thrust chamber and valve assembly) assembled to an ablative or radiation-cooled nozzle extension.

Specifications

Weight 6.26 pounds (with radiation-cooled nozzle), 7.98 to 14.90 pounds (with ablative cooled nozzle).

LR62-RM-2/4 ROCKET ENGINE

Prime Contractor: Thiokol Chemical Corporation

Remarks

The LR62 packaged liquid propellant rocket engines provide power for 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 is the same as 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 severe handling and thermal environments associated with high speed carrier aircraft operations.

Specifications

Length 61.20 inches; diameter 17.32 inches; weight 536 pounds (loaded).

Performance

Storage life 5 years; reliability 99.84 percent.

LR58-RM-4 ROCKET ENGINE

Prime Contractor: Thiokol Chemical Corporation

Remarks

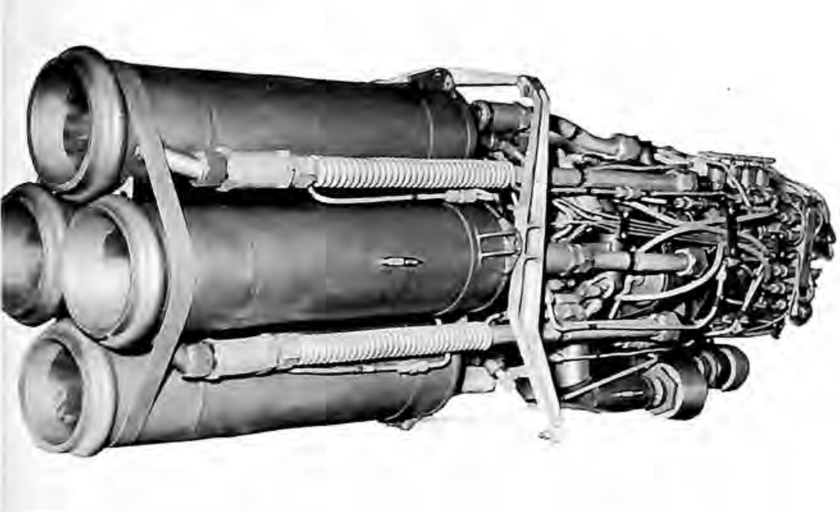
The LR58-RM-4 packaged liquid propellant rocket engine powers the Bullpup A (AGM-12B) air-to-surface guided missile. The LR58-RM-4 is produced by Thiokol's Reaction Motors Division and is the first factory-fueled liquid rocket to reach operational status. It is used by the U.S. Navy, Air Force and Marine Corps. Its hypergolic liquid propellants are inhibited red fuming nitric acid (IRFNA) and a mixed amine fuel (MAF-1). The propellants are loaded and hermetically sealed in high strength tankage at the production plant. A pressurized propellant feed system forces the propellants from the tanks to the combustion chamber by means of a shear slide injector, the only moving engine part. Engine operation is initiated by electrical impulse to an igniter which starts the solid propellant gas generator and begins the propellant pressurization and injection sequence to produce thrust.

Specifications

Length 40.47 inches; diameter 12.10 inches; weight 203 pounds (loaded).

Performance

Reliability 99.83 percent.



LR11-RM-5 ROCKET ENGINE

Prime Contractor: Thiokol Chemical Corporation

Remarks

The LR11-RM-5 engine was developed for use in early rocket-powered piloted aircraft. This engine powered the Bell X series aircraft which in 1946 was the first winged vehicle to break the sound barrier in level flight. Incorporating extensive malfunction safety provisions, the engine has been the 20 year workhorse of manned experimental flight, including the X-15 where a twin XLR11 system was utilized as interim propulsion early in the flight program. The LR11-RM-5 was produced by the Reaction Motors Division of Thiokol. It is a turborocket engine consisting of 4 clustered chambers with the turbopump and control system closely coupled to the forward end of the chambers. Each chamber contains an igniter to provide repeated restarts. LR11-RM-5 is throttleable in step-thrust increments by on-off operation of the chambers in any desired routine. The engine is currently being considered for use in various lifting body vehicles.

Specifications

Length 58 inches; diameter 18 inches; weight 345 pounds (dry).

Performance

Thrust 8,000 pounds (2,000 pounds per chamber); service life 1½ hours.

LUNAR MODULE DESCENT ENGINE (LMDE)

Prime Contractor: TRW Systems, TRW Inc.

Remarks

This throttleable space engine developed by TRW to land the Apollo Astronauts on the moon's surface was qualified in 1967. 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 for the Voyager Spacecraft must perform mid-course, retro and orbit adjust maneuvers and, therefore, operates at 2 discrete thrust levels of 10,000 pounds and 1,750 pounds. A third application of this engine finds it operating over a throttleable range of 8,000 pounds down to 550 pounds of thrust. Other applications being considered for LMDE include Mars Flyby and Lander, Maneuvering Spacecraft, Logistic Space Vehicles and Apollo Applications. LMDE uses storeable bipropellants at a mixture ratio of 1.6. The engine has an ablative chamber with a lightweight titanium nozzle extension.

SNAPOODLE RADIOISOTOPE THRUSTER

Prime Contractor: TRW Systems, TRW Inc.

Remarks

A radioisotope-fueled space engine capable of generating simultaneously thrust and usable electrical power, the Snapoodle is a development of TRW Systems in cooperation with the Air Force. It is a self-contained unit using heat from a radioisotope source for acceleration of gaseous hydrogen to create thrust and to generate electricity through a thermo-electric converter. Snapoodle's primary propulsive element is the Poodle thruster consisting mainly of a pair of concentric cylinders with an overall diameter of 4 inches, length 17 inches and weighing about 30 pounds. It generates about a quarter of a pound of thrust—suitable for sustaining a spacecraft in a low altitude orbit, transferring the vehicle from one orbit to another, or for providing maneuverability. The radioisotope is polonium-210, sealed within the core cylinder of the thruster. As it decays, fast-moving alpha particles are stopped by the metal container which becomes heated to temperatures in excess of 2,500 degrees Fahrenheit. Thermal energy normally radiated into space has been harnessed by means of a thermoelectric converter (which converts heat directly into electricity). Some of the radiated heat is thus converted into usable electrical power. The Snapoodle can deliver 70 watts of electric power while thrusting and a range of 200 to 250 watts with no propellant flow. Record heats approaching 3,000 degrees Fahrenheit have been attained. In photo Snapoodle (left) and Poodle (right).

URSA 100 R

Prime Contractor: TRW Systems, TRW Inc.

Remarks

This storeable bipropellant engine being developed by TRW was scheduled to complete its PERT early in 1968. Designed for both steady state and pulsing operation, the engine uses a radiation cooled chamber that is capable of being partially buried in a space vehicle. One version of the engine includes a gimbal ring and actuator. The engine is being qualified to the following requirements: thrust 100 pounds; specific impulse nominal 298 seconds, 30 minutes 295 seconds; life requirement 4,000 seconds steady state; demonstrated life 15,000 seconds; number of starts 50,000 demonstrated. The engine is 15.1 inches long, weighs 6.68 pounds with gimbal assembly and has a nozzle exit plane diameter of 6.125 inches.

INTELSAT III POPS

Prime Contractor: TRW Systems, TRW Inc.

Remarks

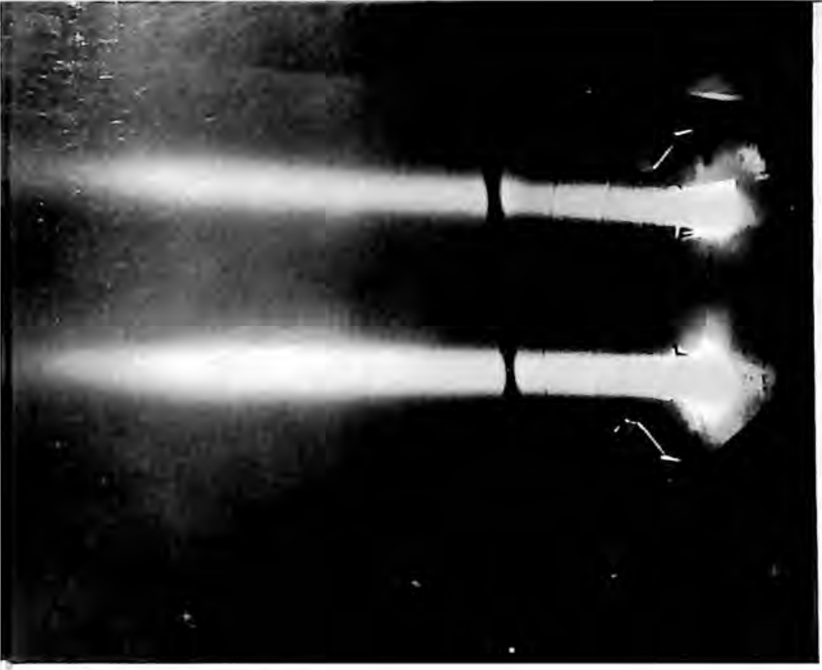
The Position and Orientation Propulsion System for Intelsat III is being developed by TRW Systems. This is a monopropellant hydrazine propulsion system which uses Shell 405 spontaneous catalyst to decompose the propellant. A series redundant valve on each thruster is designed for 50,000 cycles. The POPS is designed for 5 years in space operation. It was scheduled to be qualified in late 1967. The system operates over a blow down range of 4.0 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 0.53 pounds.

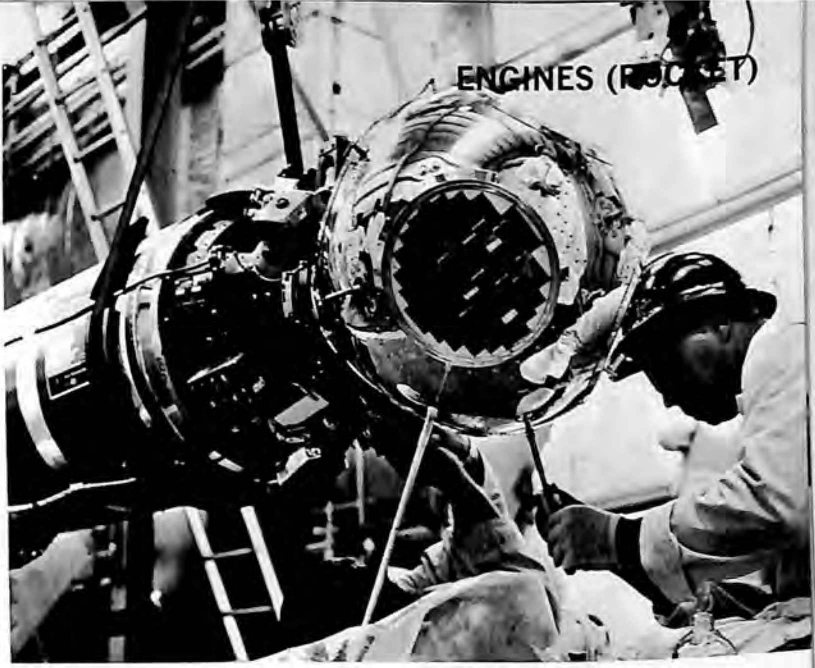
MARINER 69 PROPULSION SYSTEM

Prime Contractor: TRW Systems, TRW Inc.

Remarks

This system is being modified and requalified by TRW for Jet Propulsion Laboratory and NASA's Mariner 69 Spacecraft. The system uses monopropellant hydrazine which is decomposed with Shell 405 catalyst. The 50 pound thrust engine includes quad redundant squib valve and jet vanes for thrust vector control.





TRW ION ENGINE

Prime Contractor: TRW Systems, 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

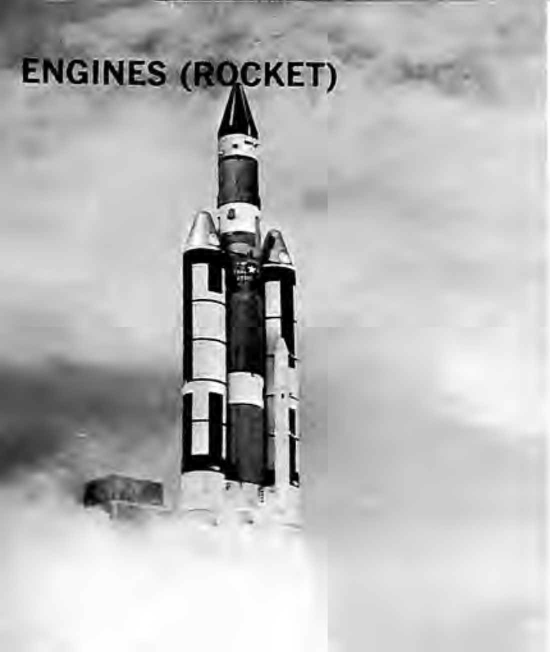
The FW-4 solid-propellant upper-stage rocket motor is designed for use on boost vehicles with orbital, probe, or reentry missions, as well as retro-rocket propulsion for space vehicles and as sounding rockets. It is being flown by NASA on the uprated Scout and thrust-augmented Delta launch vehicles, and by the Air Force as a top-stage on its Atlas and Thor boosters. The FW-4 is believed to have the highest mass fraction—92 percent—of any operational solid rocket. FW-4S is 6,000 pound thrust USAF version used as improved Scout fourth stage.

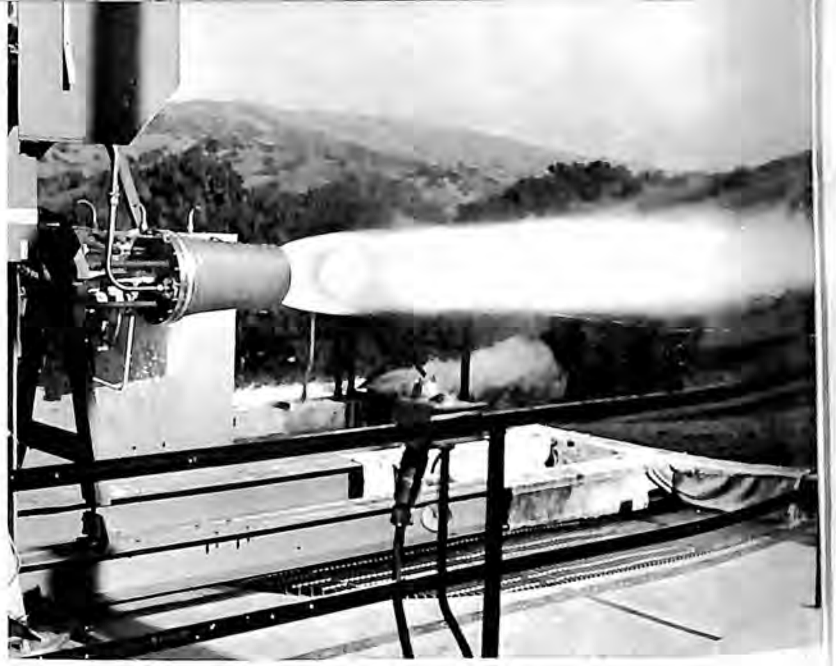
Specifications

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.





TITAN III-C BOOSTER ROCKETS

Prime Contractor: United Technology Center

Remarks

The Titan III-C is a versatile space launch vehicle designed for military, scientific, experimental, and exploratory payloads ranging from more than 25,000 pounds in earth orbit to 5,000 pounds in deep space. Its booster stage has operated flawlessly in all launches since its initial flight in 1965. It includes 2 boosters operating in tandem, thrust termination and destruct systems, and a secondary liquid injection system for steering. UTC has also been awarded a 3½-year contract to develop the booster stage for the TITAN III-C/D.

Specifications

Length 86 feet; diameter 120 inches; weight 500 tons. Propellant PBAN with aluminum additives and ammonium perchlorate oxidizer. Nozzle material steel with graphite cloth-phenolic and silica cloth-phenolic cone liner. Ignition is by small solid rockets.

Performance

Thrust 1,200,000 pounds each.

HIGH-PERFORMANCE, UPPER-STAGE LIQUID ROCKETS

Prime Contractor: United Technology Center

Remarks

UTC has developed a family of high-performance space storable liquid propellant engines that can remain in space with start/restart capability for as long as 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

Smallest 52 inches long, 26 inches diameter; largest 75.5 inches long, 48 inches diameter; weight, smallest 72 pounds, largest 185 pounds; propellant 50/50 hydrazine and unsymmetrical dimethylhydrogen and nitrogen tetroxide; nozzle composite structure with fiberglass shell and silica-phenolic liner; ignition hypergolic.

Performance

Thrust, smallest 2,000 pounds, largest 8,000 pounds.

TITAN III-C STAGING ROCKET

Prime Contractor: United Technology Center

Remarks

The Titan III-C'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 III-C 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 III-C. The only difference between the Titan II and Titan III-C 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.

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; 38 inches diameter; weight 12,375 pounds; propellant polyurethane with aluminum additives and nitrogen tetroxide as oxidizer; nozzle material steel and glass fiber shell with high-density graphite throat; ignition hypergolic bipropellant.

Performance

Thrust 40,600 pounds.

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 sub- and supersonic speeds. Its propulsion system will be the nation's first operational hybrid rocket, using a solid fuel and liquid oxidizer. It will also have, for the first time in any rocket engine, the ability to select a wide-range flight pattern by the simple twist of a mechanical dial. This system is known as "dial-a-thrust."

Specifications

Sandpiper will be 175 inches long, 10 inches in diameter, weight 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.

IO-720 SERIES FUEL INJECTED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, 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, Imco Model B1 agricultural sprayer and the Swearingen conversion of the Beech Queen Air 65. Like many of her sister engines in this family, the IO-720 incorporates piston cooling oil jets and a continuous flow fuel injection system. The basic engine will be turbocharged and power increased.

Specifications

Length 46.08 inches; width 34.25 inches; height 22.53 inches; weight 610 pounds; 5.125 inches bore; 4.375 inches stroke; displacement 722 cubic inches; 8.7:1 compression ratio.

Performance

400 horsepower continuous.

IO-540-K FUEL INJECTED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

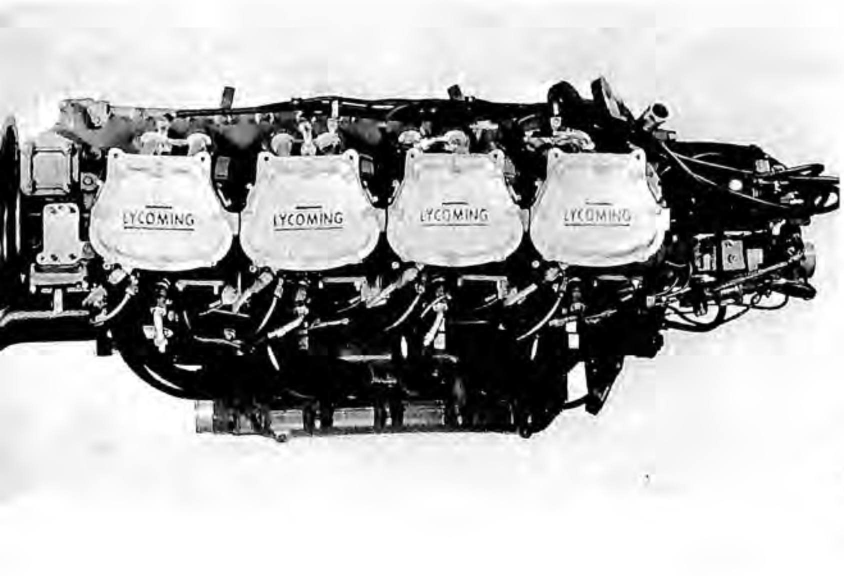
This fuel injected, flat opposed, direct drive piston engine powers the Piper Cherokee 300, a 6-place single engine utility aircraft. This engine incorporates piston cooling oil jets, a tuned induction system, a continuous flow fuel injection system, and like all Avco Lycoming direct drive engines, is 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.

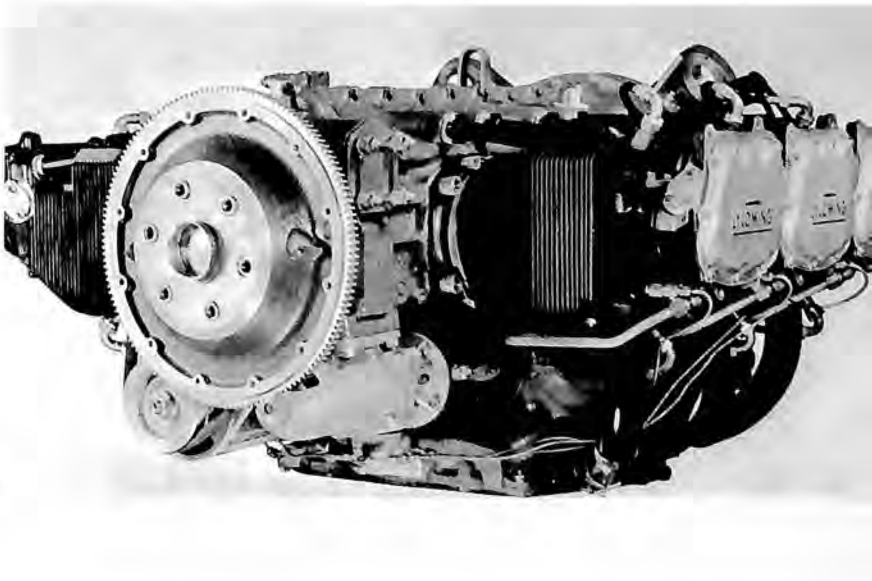
Specifications

Length 39.34 inches; width 34.25 inches; height 19.60 inches; weight 470 pounds; 5.125 inches bore; 4.375 inches stroke; displacement 541.5 cubic inches; 8.7:1 compression ratio.

Performance

300 horsepower continuous.





IO-360-A1A FUEL INJECTED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, 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; 5.125 inches bore; 4.375 inches stroke; weight 323 pounds; displacement 361 cubic inches; 8.7:1 compression ratio.

Performance

200 horsepower continuous.

TIO-540-A1A TURBOCHARGED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

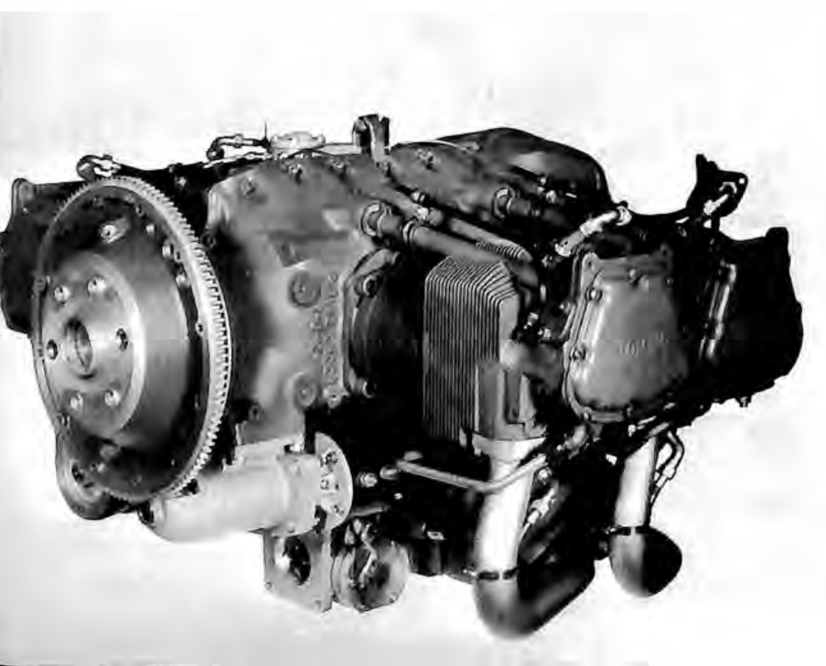
This turbocharged fuel injected engine powers the new Piper Navajo Twin on top of weather not possible with normally aspirated engines. The TIO-540-A1A, like all other Avco Lycoming engines supplied with a turbocharger, incorporates automatic controls. Also, all turbocharged engines built by Avco Lycoming feature shell moulded cylinder heads, ½ inch inconel steel exhaust valves, ni-resist exhaust valve guides and piston cooling oil squirts.

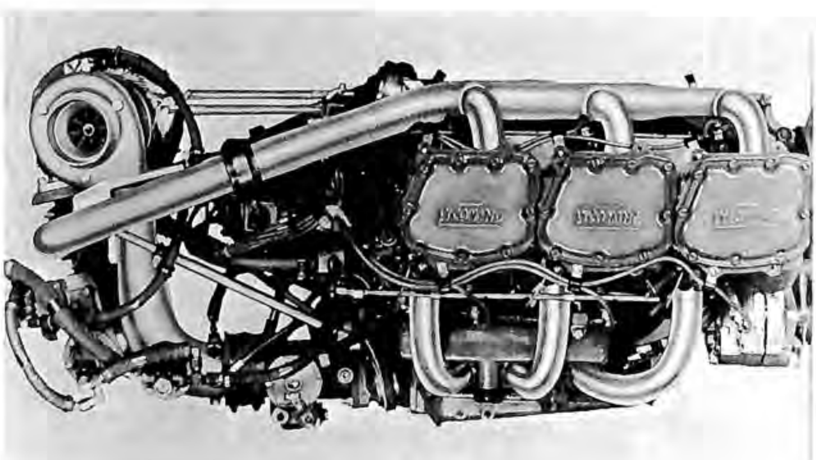
Specifications

Length 51.34 inches; width 34.25 inches; height 22.71 inches; weight 535 pounds; 5.125 inches bore; 4.375 inches stroke; displacement 541.5 cubic inches; 7.3:1 compression ratio.

Performance

310 horsepower continuous to 15,000 feet and 230 horsepower to 25,000 feet.





TIO-541 TURBOCHARGED PISTON ENGINE

Prime Contractor: Avco Corporation, 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 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; 5.125 inches bore; 4.375 inches stroke; displacement 541 cubic inches; 7.3:1 compression ratio.

Performance

TIO-541-A1A: 310 brake horsepower continuous; TIO-541-E: 380 brake horsepower continuous.

TIGO-541 SERIES TURBOCHARGED PISTON ENGINE

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

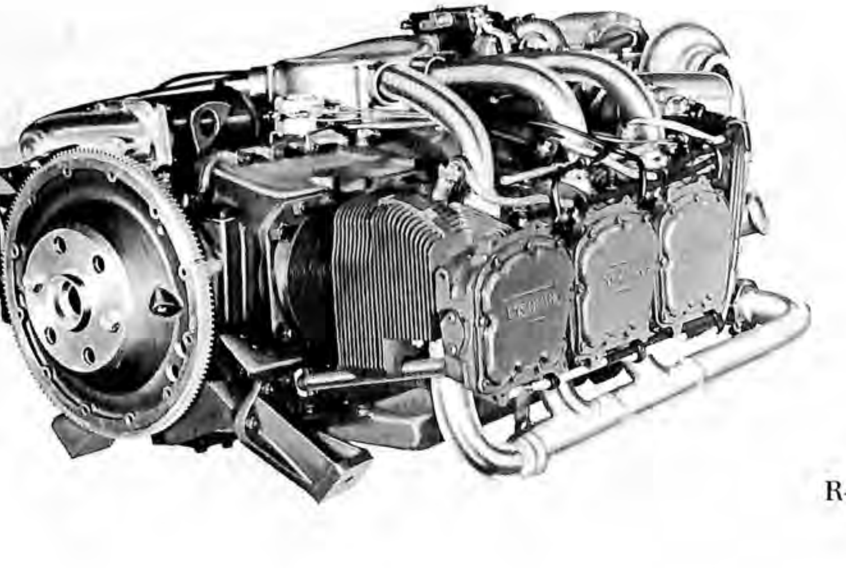
The second in the newest family of piston engines to come from Avco Lycoming will be the TIGO-541 model. Turbocharged for high altitude operation, this engine is basically a TIO-541 with an offset reduction gear having a ratio of 2 to 3. A 1-piece crankcase casting provides a housing for the reduction gear and power section as well as providing 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 torquemeter.

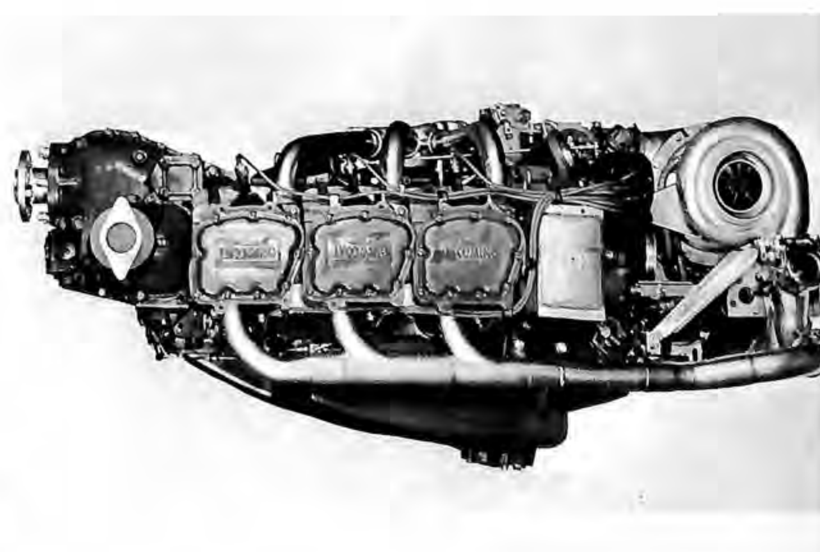
Specifications

Length 58.94 inches; width 35.66 inches; height 27.14 inches; weight 663 pounds; 5.125 inches bore; 4.375 inches stroke; displacement 541 cubic inches; 7.3:1 compression ratio.

Performance

400 brake horsepower continuous.





IGSO-540 SERIES SUPERCHARGED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, 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 envious record of safety and low maintenance costs. Side mounted accessories provide for 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 powerplant to increase the performance of other aircraft.

Specifications

Length 48.15 inches; width 34.25 inches; height 28.44 inches; weight 530 pounds; 5.125 inches bore; 4.375 inches stroke; displacement 541.5 cubic inches; 7.3:1 compression ratio.

Performance

380 brake horsepower take-off, 360 brake horsepower continuous.

MODEL O-200-A

Prime Contractor: Continental Motors Corporation

Remarks

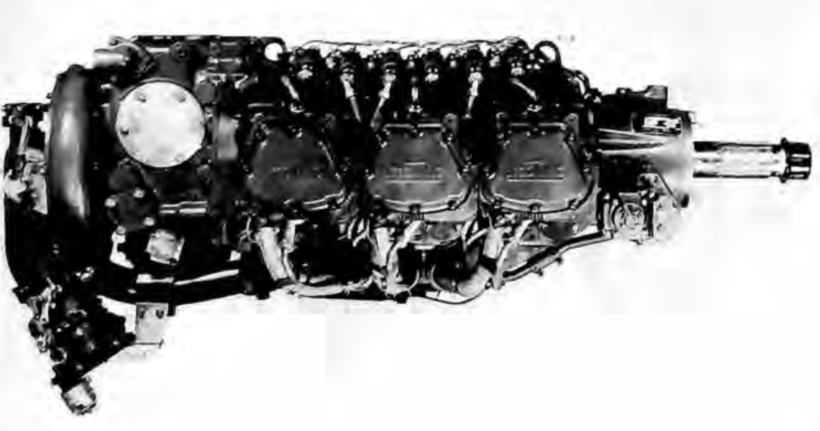
The O-200-A is the power plant for the Cessna Model 150, the Champion Citabria and Lancer, and the Thorpe Sky Scooter (tubular).

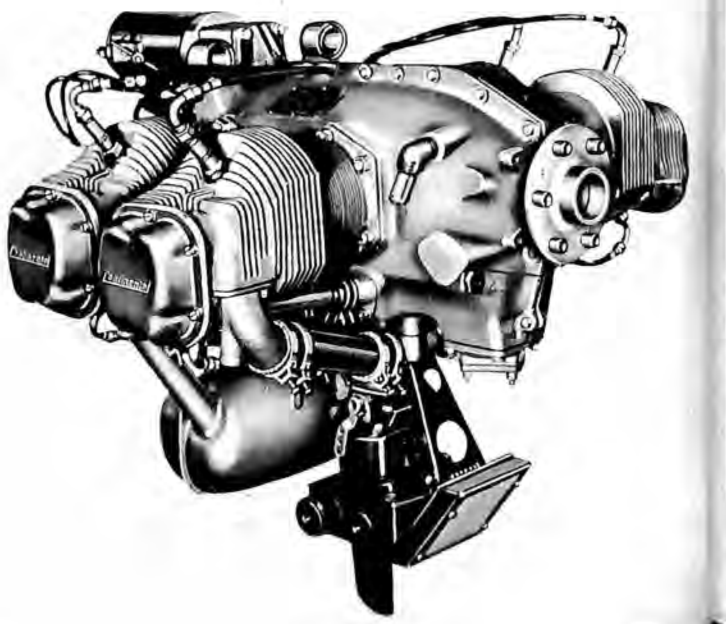
Specifications

Dimensions with standard equipment installed: length 28.53 inches, height 28.72 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 7.0:1.

Performance

Rated power, sea level, 100 horsepower; take-off power, sea level, 100 horsepower; recommended cruise rating, sea level, 75 horsepower; revolutions per minute at rated power 2,750; revolutions per minute at take-off 2,750; cruising revolutions per minute 2,500.





MODEL O-470-R

Prime Contractor: Continental Motors Corporation

Remarks

The O-470-R engine powers the Cessna 180, the Cessna 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 7.0:1.

Performance

Sea level rating 230 horsepower; sea level take-off rating 230 horsepower; sea level cruise rating 172 horsepower; rated power revolutions per minute 2,600; take-off power revolutions per minute 2,600; cruising revolutions per minute 2,450.

MODELS O-300-A,B,C,D

Prime Contractor: Continental Motors Corporation

Remarks

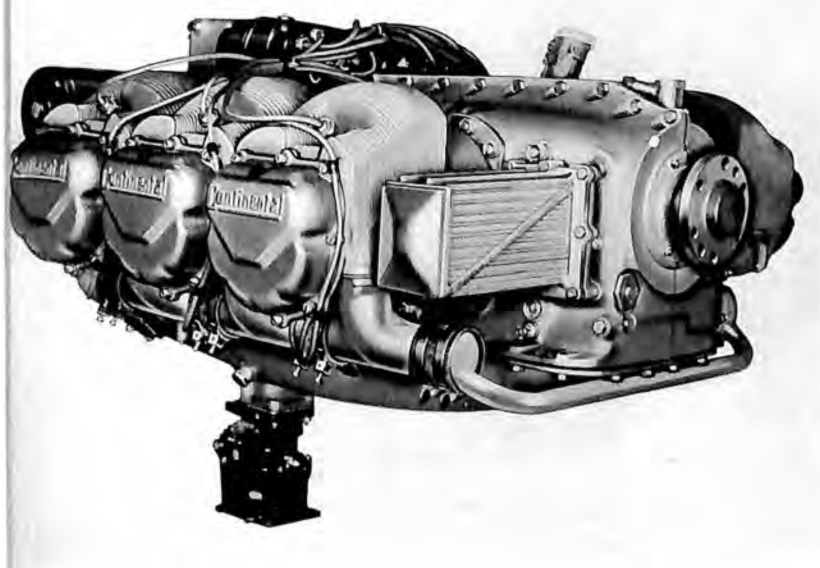
The O-300 engine powers the Cessna 170, the Cessna 172, the Cessna T-41A (military), and the Maule Bee Dee M-4.

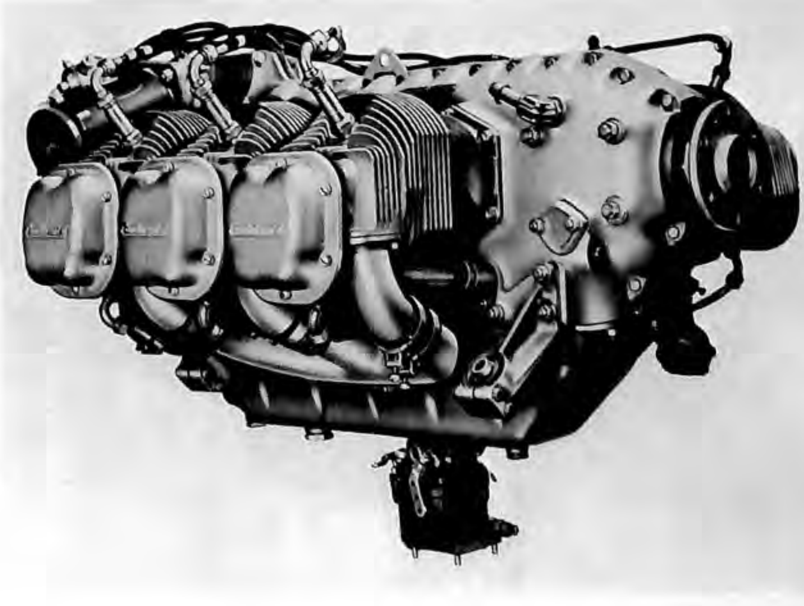
Specifications

Dimensions, with standard equipment installed: length 39¾ inches (D 36 inches), height 23¼ inches (D 27 inches), width 31½ inches; dry weight, with carburetor, 268 pounds; cylinders 6; bore 4 1/16 inches; stroke 3⅞ inches; displacement 301 cubic inches; compression ratio 7.0:1.

Performance

Sea level rating 145 horsepower; sea level take-off power 145 horsepower; cruise 108 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off power 2,700; cruising revolutions per minute 2,450.





MODEL IO-360-C, -D

Prime Contractor: Continental Motors Corporation

Remarks

The IO-360 engine is the power plant for the Cessna 337, Cessna T-41B, O2A and O2B (military).

Specifications

Dimensions with standard equipment installed: length 35.34 inches, height 23.74 inches, width 3.40 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; take-off rating at sea level 210 horsepower; cruise rating 157 horsepower; revolutions per minute at rated power 2,800; revolutions per minute at take-off power 2,800; cruising revolutions per minute 2,600.

MODEL IO-520-A, -D, -E, -F

Prime Contractor: Continental Motors Corporation

Remarks

The IO-520-A engine is the power plant for the Cessna 210 and 206, and the Aero Commander 200-D.

Specifications

Dimensions with standard equipment installed: length 41.41 inches, height 19.75 inches, width 33.56 inches; dry weight with accessories 471.28 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 8.5:1.

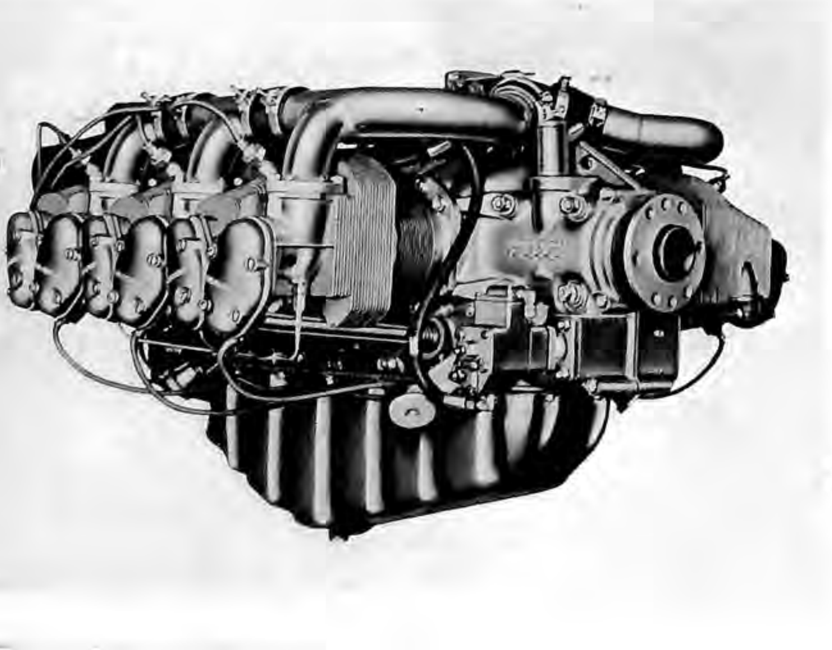
Performance

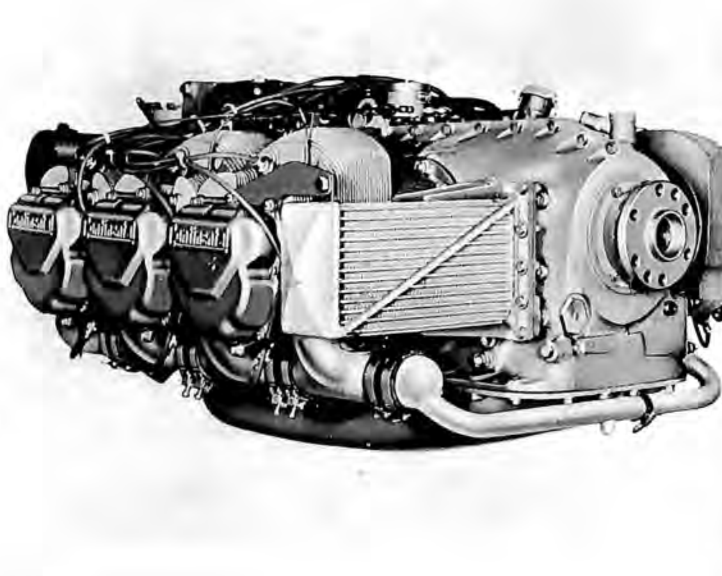
Sea level rating 285 horsepower; take-off rating 285 horsepower; cruise rating 215 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off power 2,700; cruising revolutions per minute 2,500.

Model IO-520-D, used in the Cessna 188 Agwagon, Cessna 185 Skywagon and Bellanca Viking, has same specifications except for: length 38.86 inches; height 23.79 inches; dry weight 455.56 pounds; take-off rating 300 horsepower; take-off revolutions per minute 2,850; cruising horsepower 215 at 2,550 revolutions per minute.

Model IO-520-E, used in the Aero Commander 500-A, is 47.66 inches long, 19.75 inches high and 35.56 inches wide; take-off rating 300 horsepower at 2,850 revolutions per minute; rated power 285 horsepower at 2,700 revolutions per minute; cruise rating 213 horsepower at 2,500 revolutions per minute.

Model IO-520-F, used in the Cessna U206, is 41.41 inches long, 19.75 inches high and 33.56 inches wide; take-off rating 300 horsepower at 2,850 revolutions per minute; rated power 285 horsepower at 2,700 revolutions per minute; cruise rating 215 horsepower at 2,550 revolutions per minute.





MODEL TSIO-520-B, -E

Prime Contractor: Continental Motors Corporation

Remarks

The TSIO-520-B is the power plant in the Cessna 320D Skynight.

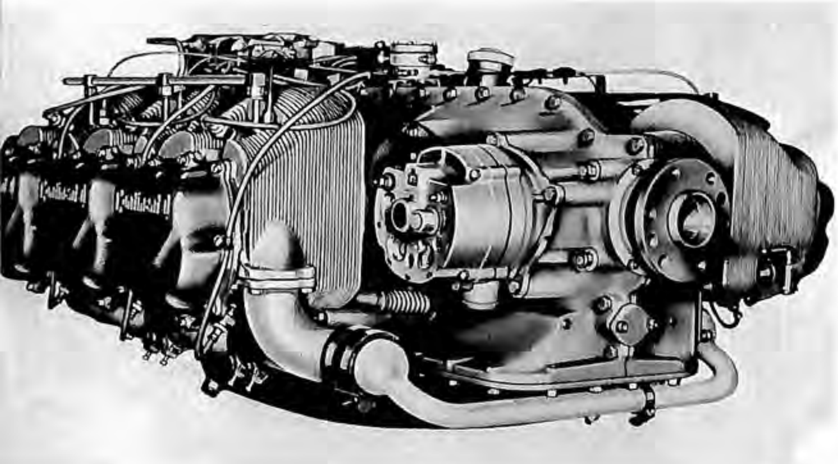
Specifications

Dimensions with standard equipment installed: length 39.75 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

Sea level rating 285 horsepower; take-off rating at sea level 285 horsepower; cruise rating 215 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off 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-C

Prime Contractor: Continental Motors Corporation

Remarks

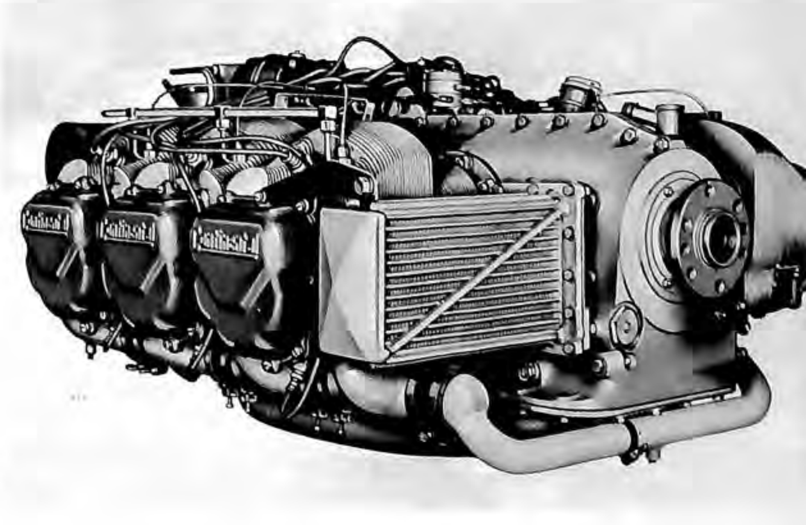
The TSIO-520-C engine is the power plant in the Cessna Turbo Super Skylane T210F Centurion.

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; take-off rating at sea level 285 horsepower; cruise rating 215 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off power 2,700; cruising revolutions per minute 2,500.



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; take-off rating, sea level, 340 horsepower; cruise rating 255 horsepower; revolutions per minute at rated power 3,200; revolutions per minute at take-off power 3,200; cruising revolutions per minute 2,800.

MODEL GTSIO-520-D

Prime Contractor: Continental Motors Corporation

Remarks

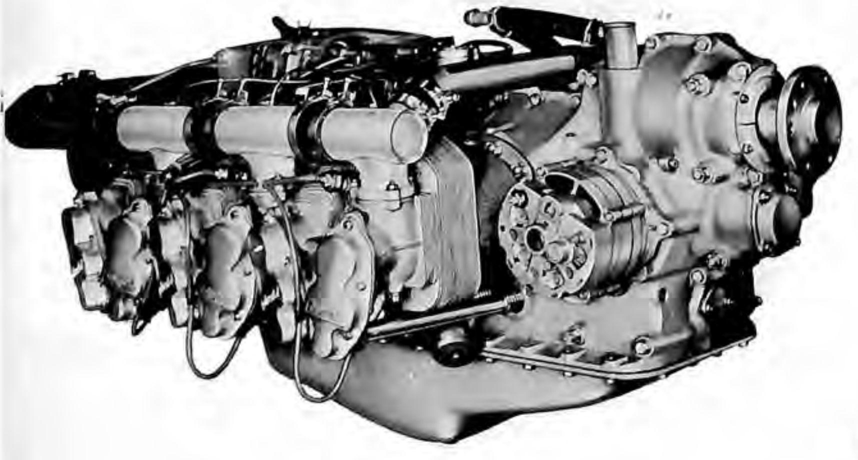
The GTSIO-520-D engine is the power plant in the Cessna 421.

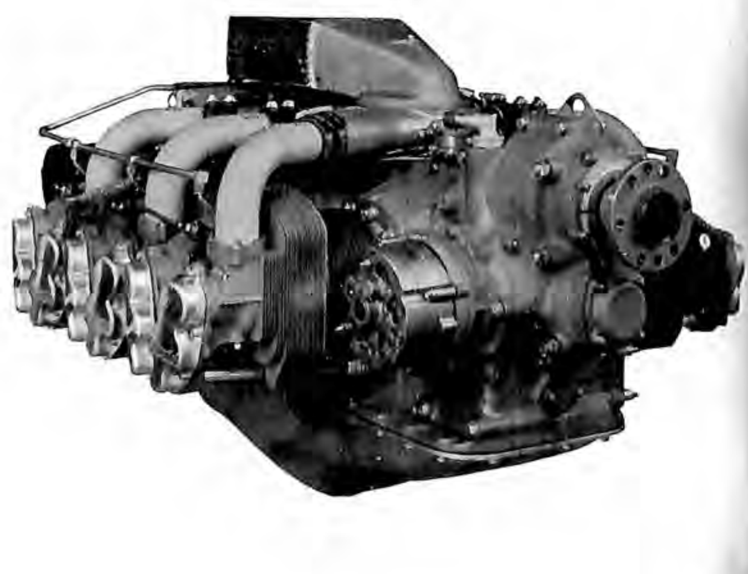
Specifications

Dimensions with standard equipment installed: length (including turbocharger) 64.25 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; take-off rating, sea level, 375 horsepower; cruise rating 282 horsepower; revolutions per minute at rated power and take-off 3,400; revolutions per minute at cruise 2,900.





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, 296.50 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; take-off rating, sea level, 165 horsepower; cruise rating 125 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off power 2,700; cruising revolutions per minute 2,450.

MODEL IO-520-B

Prime Contractor: Continental Motors Corporation

Remarks

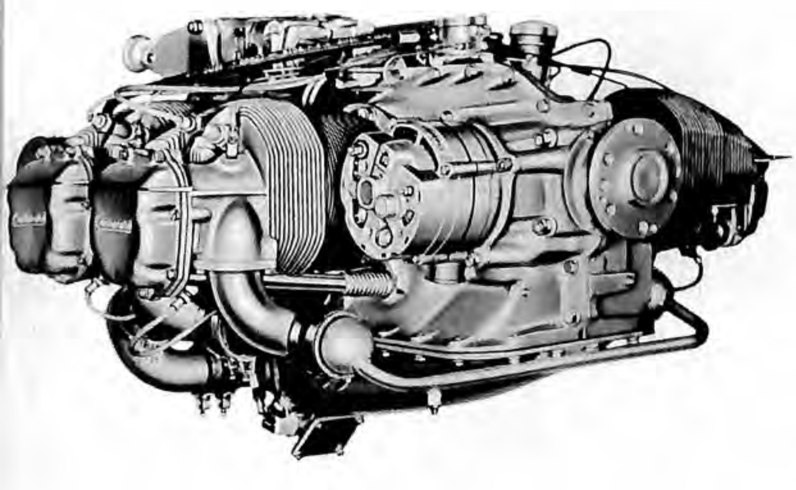
The IO-520-B is the power plant in the Beechcraft Bonanza S-35, Beechcraft Debonair B-33-A, and the Navion.

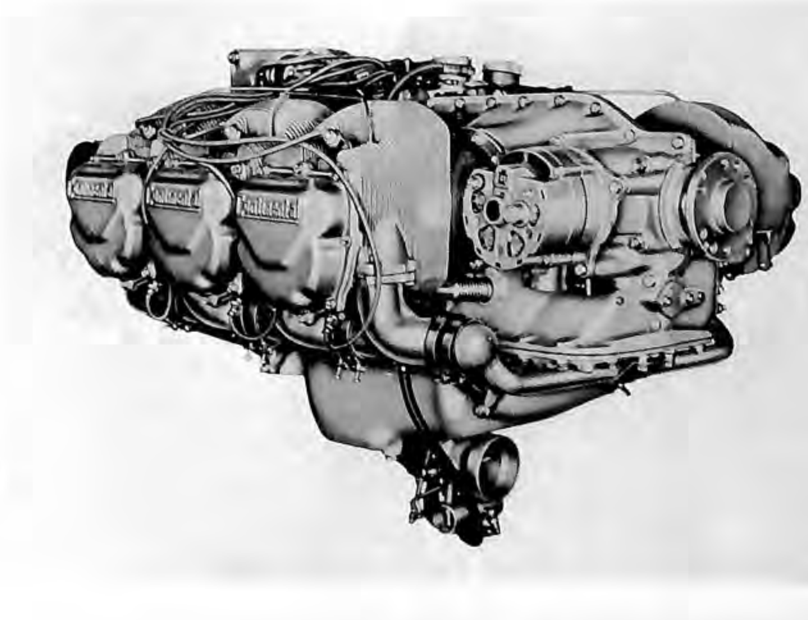
Specifications

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; take-off rating, sea level, 285 horsepower; cruise rating 213 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off 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; take-off rating, sea level, 285 horsepower; cruise rating 213 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off power 2,700; cruising revolutions per minute 2,500.

MODEL TSIO-520-D

Prime Contractor: Continental Motors Corporation

Remarks

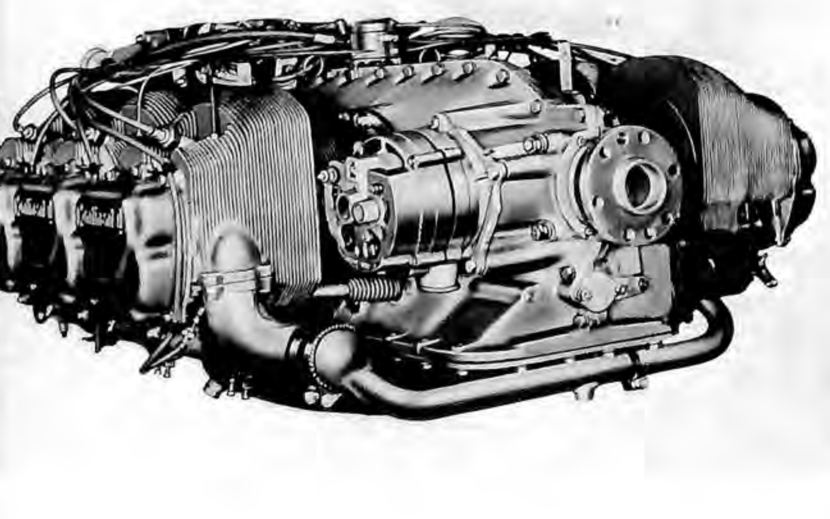
The TSIO-520-D engine is the power plant in the Beechcraft Turbo Bonanza.

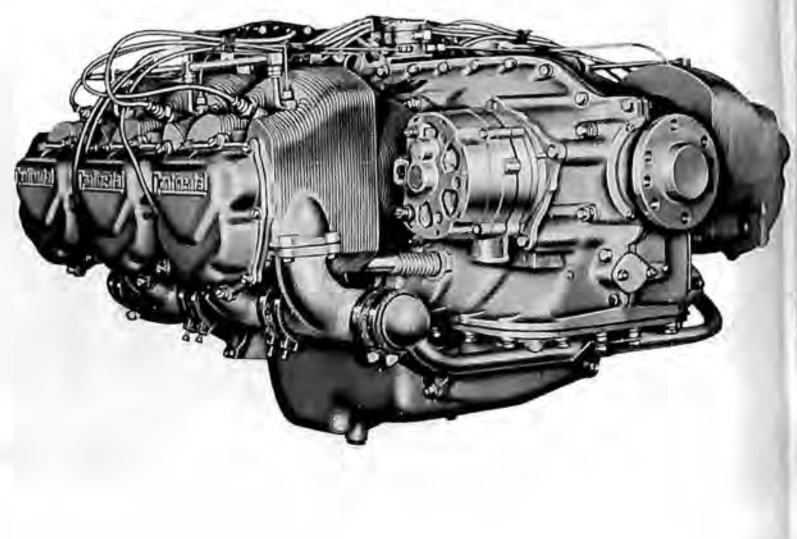
Specifications

Dimensions with standard equipment installed: length (turbo not included) 42.58 inches, height 29.40 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; take-off rating, sea level, 285 horsepower; cruise rating 214 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off power 2,700; cruising revolutions per minute 2,500.





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

Take-off power at sea level 1,525 brake horsepower.

R3350-32W ENGINE (TC18)

Prime Contractor: Curtiss-Wright Corporation

Remarks

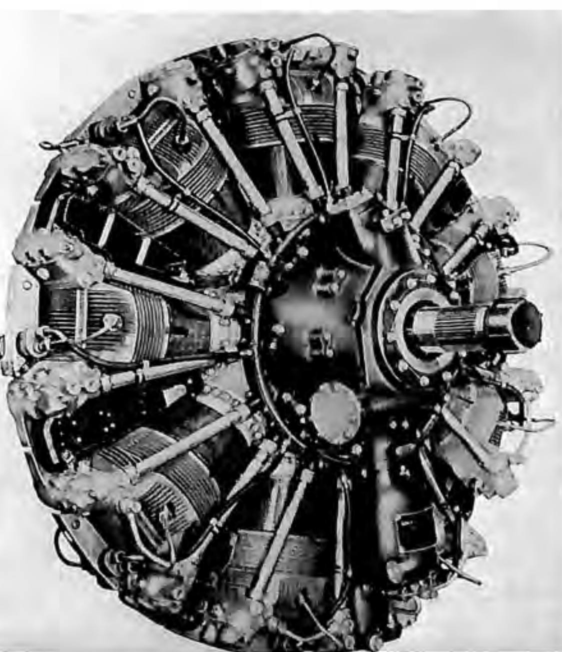
The TC18 is an 18-cylinder double row radial turbo compound reciprocating engine used by the military services in P-2 and P-5 series aircraft.

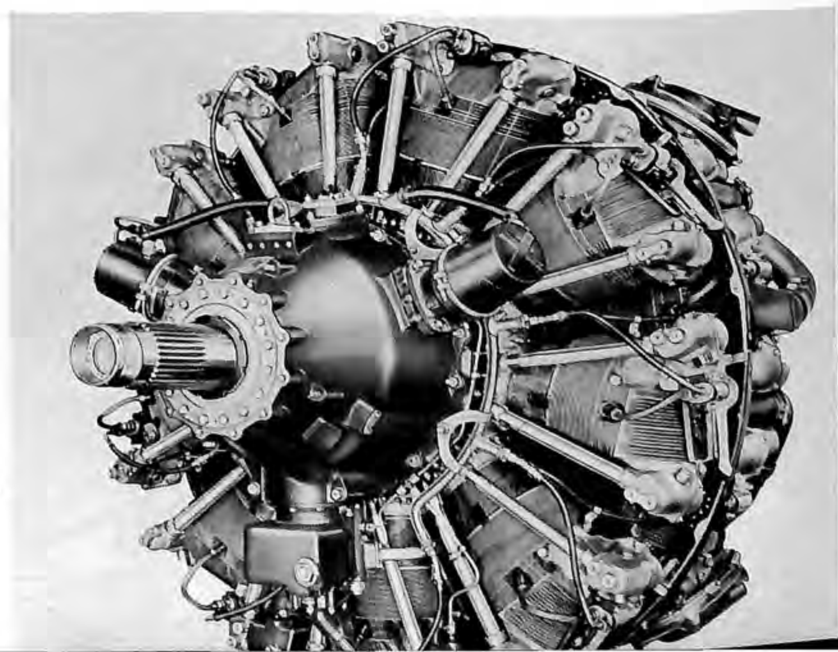
Specifications

Dry weight 3,560 pounds; length 91.8 inches; diameter 56.59 inches; fuel grade 115/145.

Performance

Take off 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 18.0 inches; width 20.7 inches; weight 278 pounds.

Performance

Take-off rating 310 brake horsepower at 6,000 revolutions per minute.

R3350-26WD ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

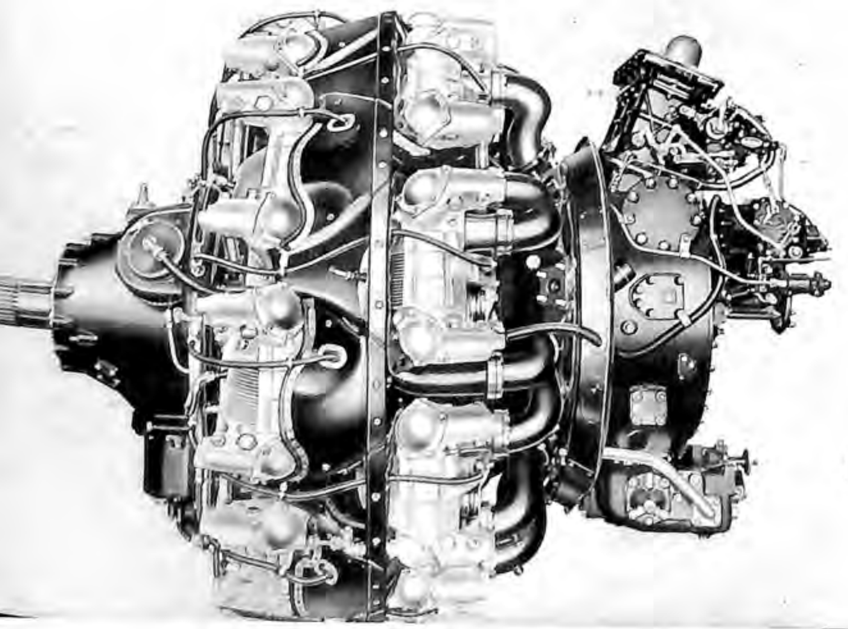
An 18 cylinder double row radial reciprocating engine, the R-3350-26WD is manufactured for the Douglas AD series and Lockheed P2 series aircraft.

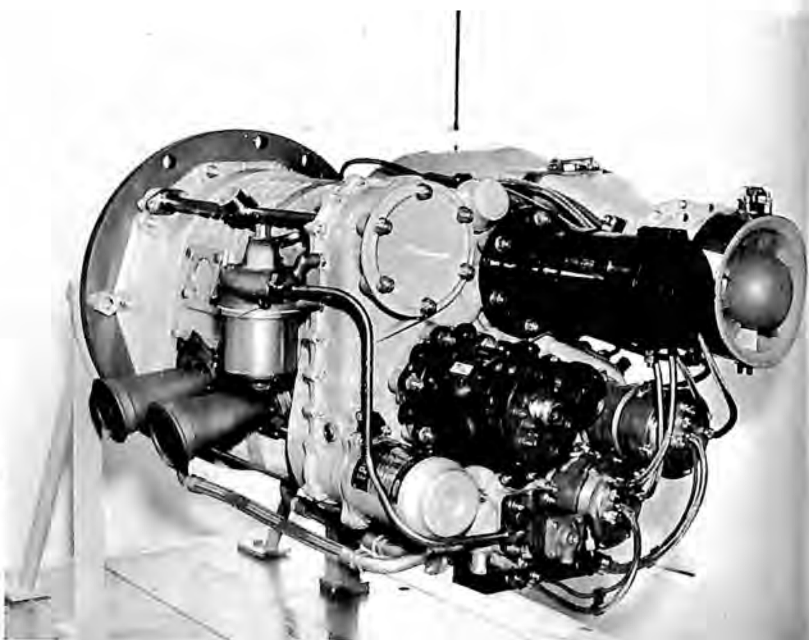
Specifications

Dry weight 2,925 pounds; length 81.23 inches; diameter 55.62 inches; fuel grade 115/145.

Performance

Take-off power at sea level 2,700 horsepower.





R1830 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

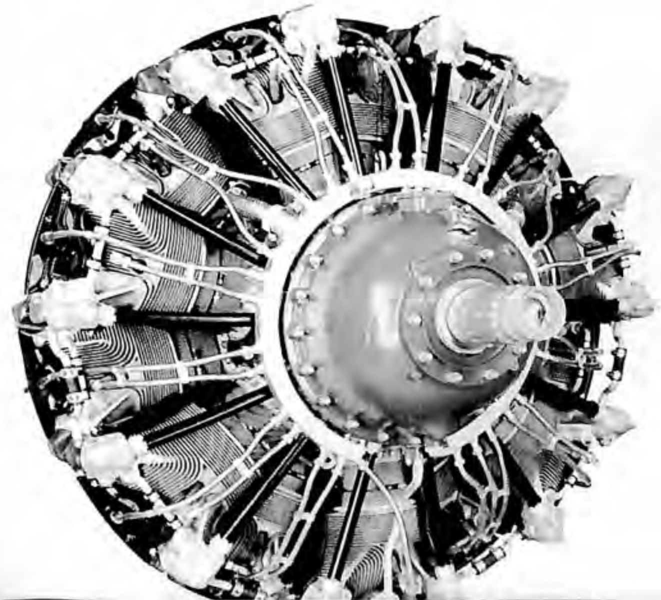
First installed in the famous Pan American Airways Martin China Clipper, in the early 1930s, the R1830 Twin Wasp is a 14-cylinder radial air-cooled piston engine, now out of production but still in service. A 1,000 horsepower engine was installed in the Douglas DC-3 and the 1,200 horsepower version eventually powered most of the DC-3s. This engine, also the powerplant for the Lockheed Lodestar and other aircraft, was manufactured in greater numbers than any other Pratt & Whitney model between 1932 and 1947.

Specifications

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.



R1340 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

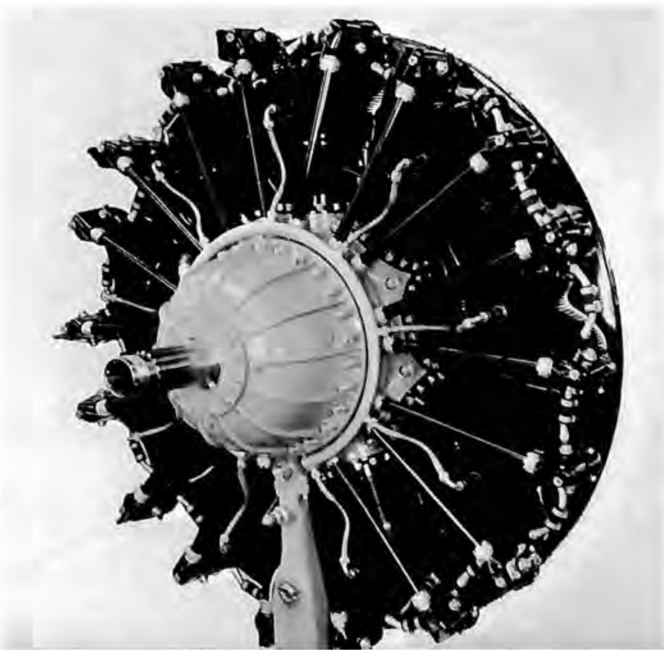
Still in use, the R1340 Wasp was produced in numerous configurations for 35 years—longer than any other Pratt & Whitney engine. It powered many military and commercial airplanes in aviation's pioneering days. Among the planes still flying with R1340 engines are the deHavilland Otter, the Grumman Mallard and various helicopters.

Specifications (Model A)

Length 42.63 inches; diameter 51.44; dry weight 745 pounds.

Performance

Rating 410 brake horsepower.



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 Army's CX-2B or deHavilland DHC-4 Caribou.

Specifications (Model 2SD13-G)

Length 59.66 inches; diameter 49.10 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.

R2180 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

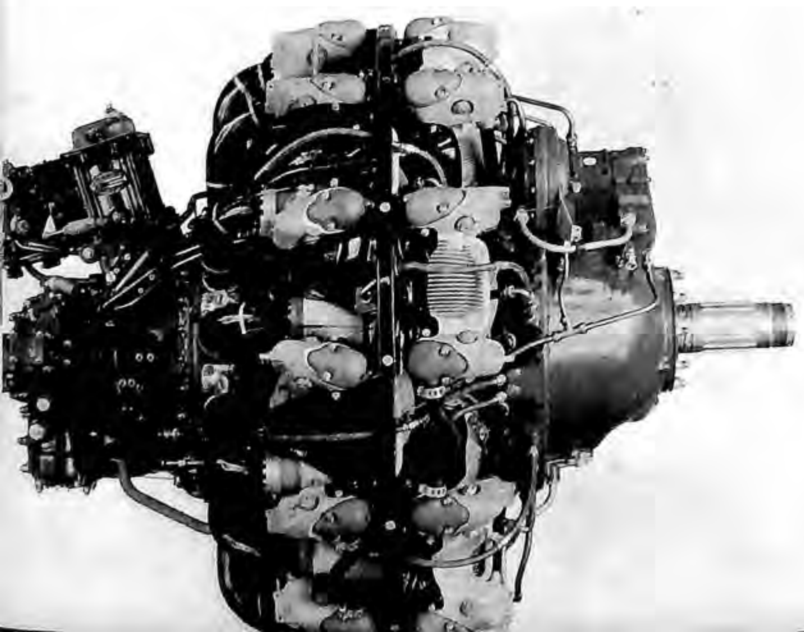
The R2180 Twin Wasp, 14-cylinder radial air-cooled piston engine was developed after World War II but had a short production life. It is used in the SAAB Scandia transport.

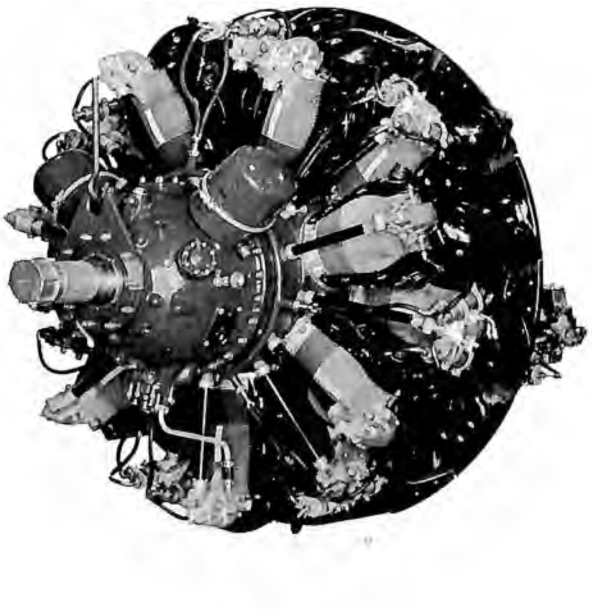
Specifications

Length 76.20 inches; diameter 54 inches; bore 5.75 inches; stroke 6 inches; displacement 2,181 cubic inches; compression ratio 6.7:1 dry weight 1,870 pounds.

Performance

Rating 1,800 brake horsepower.





R2800 MILITARY-COMMERCIAL RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

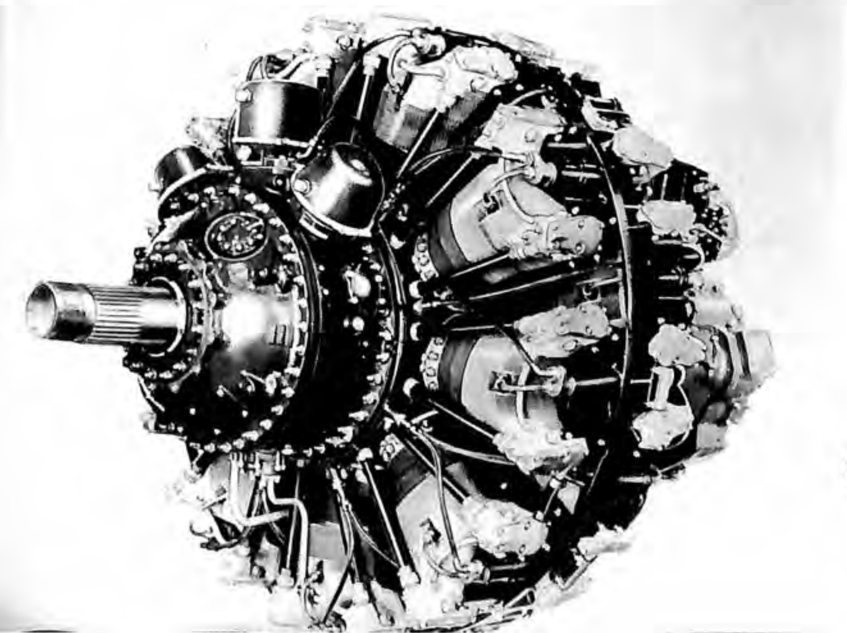
Still in military and commercial service, the R2800 Double Wasp is an 18-cylinder radial air-cooled piston engine which powered many military aircraft in World War II. Between 1939 and 1960, 125,443 of these engines were manufactured.

Specifications (CB16)

Length 78.40 inches; diameter 52.80 inches; bore 5.75 inches; stroke 6 inches; displacement 2,804 cubic inches; compression ratio 6.76:1; dry weight 2,350 pounds.

Performance

Rating 2,500 brake horsepower.



R4360 MILITARY-COMMERCIAL RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

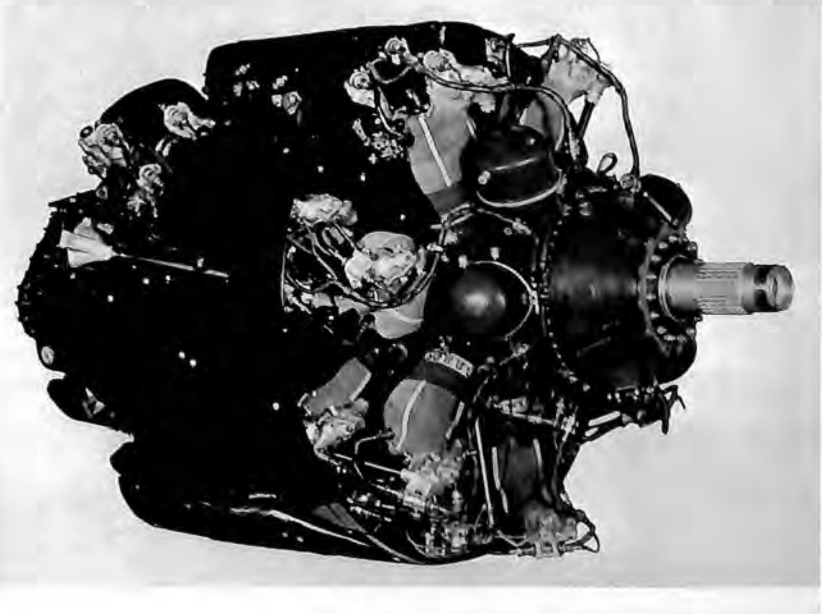
A 28-cylinder radial air-cooled piston engine, the R4360 was the most powerful engine of its type produced. It was developed during World War II and still powers the Boeing C-97, Fairchild C-119, Douglas C-124 Globemaster transports and the Boeing 377 Stratoliner.

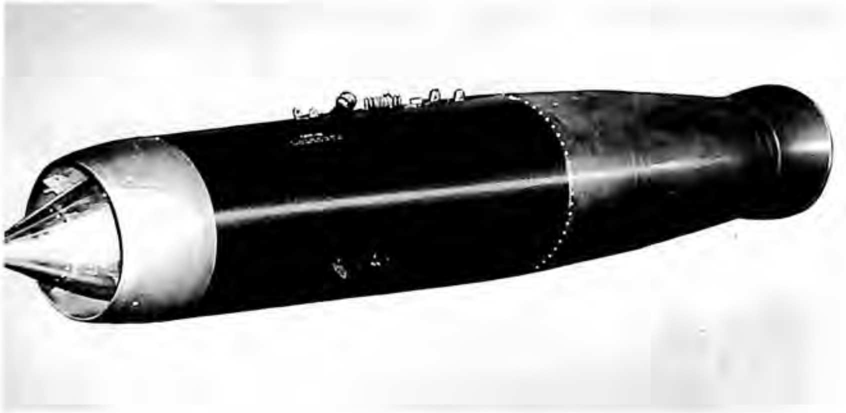
Specifications (Model TSB3-6)

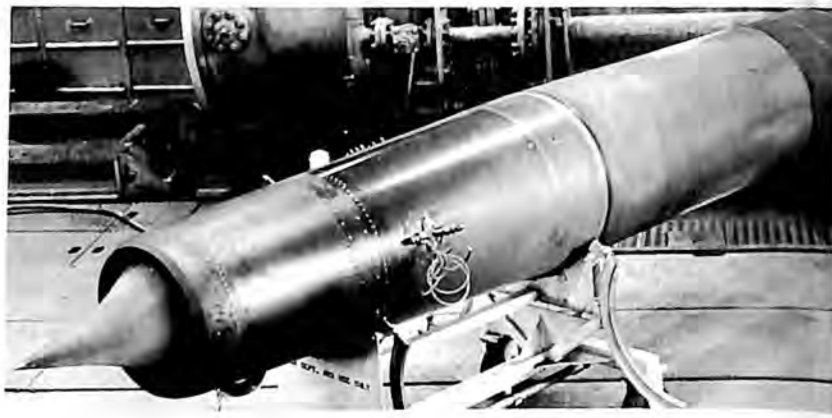
Length 96.50 inches; diameter 54 inches; bore 5.75 inches; stroke 6 inches; displacement 4,363 cubic inches; compression ratio 6.7:1; dry weight 3,482 pounds.

Performance

Rating 3,500 brake horsepower (with water injection).







RJ-43-MA-3 MILITARY RAMJET

Prime Contractor: The Marquardt Corporation

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 currently operational 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 MILITARY RAMJET

Prime Contractor: The Marquardt Corporation

Remarks

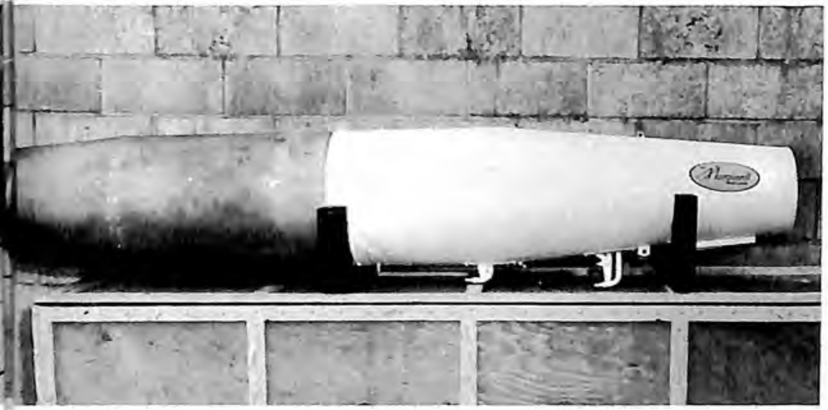
The RJ-43-MA-11, produced for the Air Force, is a complete nacelle-type supersonic ramjet engine with a high compression inlet spike. This engine (2 units) provides the cruise propulsion source for the Boeing Bomarc B interceptor missile.

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.



MA74-ZAB RAMJET

Prime Contractor: The Marquardt Corporation

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 Redhead/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 Corporation

Remarks

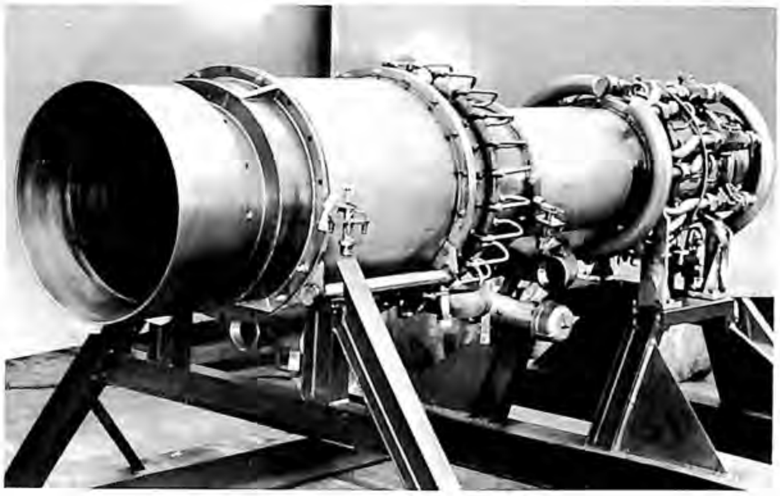
The MA150-XAA is a nacelle-type subsonic and supersonic ramjet engine with normal shock inlet. It provides the cruise propulsion for the Army's North American Rockwell Advanced Redhead/Roadrunner target missile system for high and low altitude application.

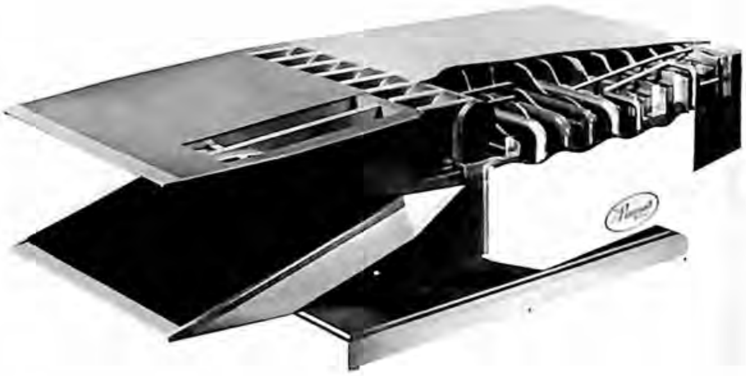
Specifications

Length 104.5 inches; diameter 19.0 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 Corporation

Remarks

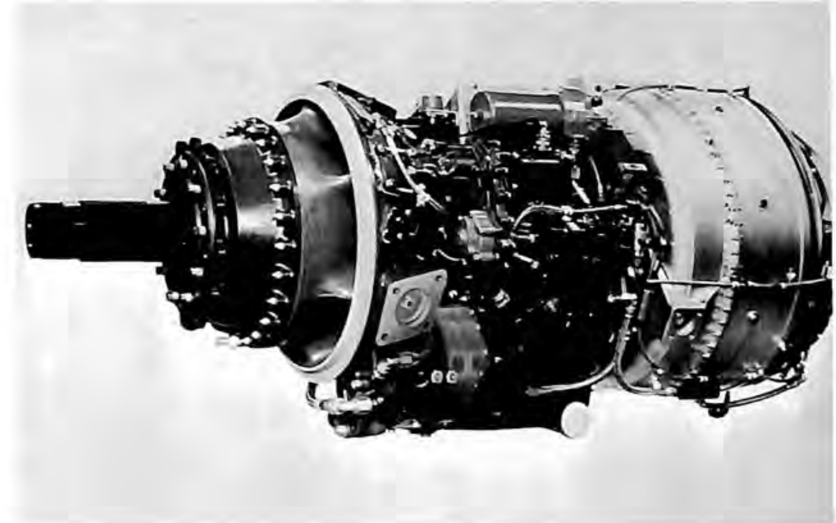
The Ejector Ramjet is a composite (rocket-ramjet) engine concept developed by Marquardt under Air Force sponsorship. It has potential application to missile propulsion, advanced high-payload ratio orbital launch vehicles and advanced "next generation" aircraft. Engine concept combines rockets and ramjets into simple and lightweight acceleration-and-cruise propulsion system which provides vehicle performance (1) superior to separate rockets and ramjets due to commonality of structure plus rocket thrust augmentation and (2) competitive with complex turbomachinery at hypersonic flight speeds.

SCRAMJET

Prime Contractor: The Marquardt Corporation

Remarks

Development of supersonic combustion ramjet for hypersonic acceleration and cruise performance; applications include hypersonic cruise vehicles, recoverable launch vehicles and defense and tactical missile systems.



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 used for a variety of output configurations. A significant result of this approach has been the development of turbofan engines wherein a high bypass ratio fan has been mated to a T55 power producer. This same configuration is feasible for the T53. This design is ideally suited to both standard and steep gradient aircraft requiring substantial operating economies and which operate in the medium altitude, Mach. 8 and below range. Medium-sized business jets and long range patrol aircraft are potential applications for the Avco Lycoming turbofan.

Specifications (Approximate)

(PLFIC-1) (Mated to T55-L-7C): length 66 inches; fan diameter 41 inches; bypass ratio 6:1; weight 1,010 pounds; other specifications same as basic engine to which fan is mated. (PLFIC-2) (Mated to T55-L-7C): length 66 inches; fan diameter 50 inches; bypass ratio 8.2:1; weight 1,130 pounds; other specifications same as basic engine to which fan is mated.

Performance

(PLFIC-1): 5,220 pounds thrust; specific fuel consumption .41 pounds per pound of thrust per hour. (PLFIC-2): 6,700 pounds thrust; specific fuel consumption .36 pounds per pound of thrust per hour.

T53 TURBOPROP GAS TURBINE ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

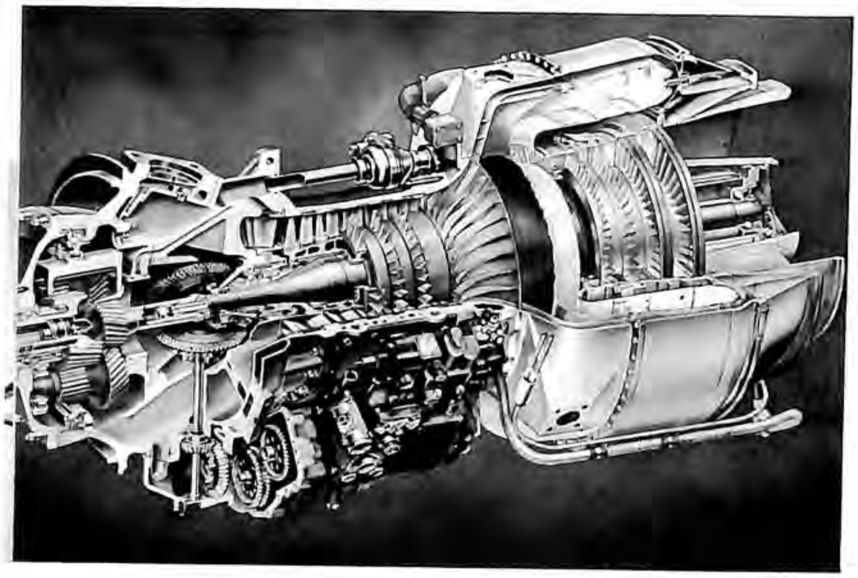
The turboprop version of the T53, designated L-7, powers the Army's Grumman OV-1 "Mohawk" STOL surveillance aircraft. This engine is basically the same as the shaft version except for the front-end gearing which mates the engine to a conventional propeller. The 1,160 shaft horsepower T53-L-15 is the latest production configuration and will be installed on advanced Mohawks.

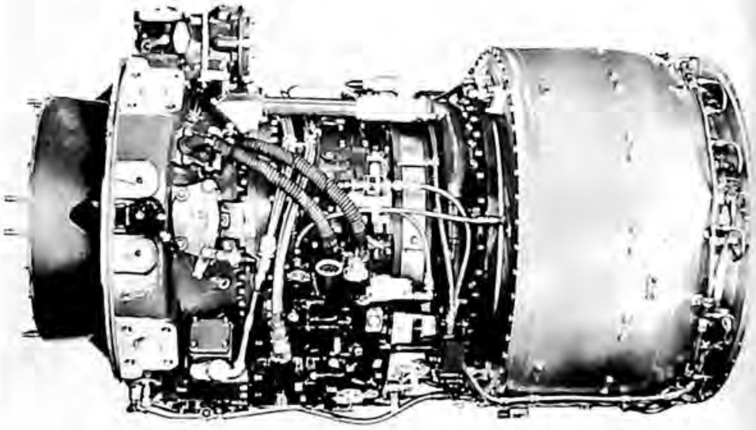
Specifications

Length 59 inches; diameter 23 inches; weight 555 pounds; compressor stages 5 axial, 1 centrifugal; compressor turbines 2 (1 in L-7 version); power turbines 2 (1 in L-7 version).

Performance

(T53-L-15): 1,160 shaft horsepower (1,400 thermodynamic); specific fuel consumption .62 pounds per shaft horsepower per hour. (T53-L-7) (photo): 1,100 shaft horsepower; specific fuel consumption .69 pounds per shaft horsepower per hour.





T53 TURBOSHAFT GAS TURBINE ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

With multi-million hour flight experience accumulated under diverse environmental conditions, the T53 turboshaft engine is the most experienced of its class in the world. It has powered helicopters to world-recognized records and has been installed in many pioneering VTOL, STOL, and V/STOL vehicles. Current versions power the Army's Bell UH-1 "Huey" and AH-1G "HueyCobra" tactical helicopters as well as the Air Force's Kaman HH-43 "Huskie" rescue helicopter. The engine also powers the commercial Bell model 204. A pair of T53s capable of full vertical operation are installed on the Canadair CL-84 tilt-wing V/STOL. All T53s are of modular design to facilitate field maintenance. Development to 1,800 shaft horsepower is impending.

Specifications

Length 48 inches; diameter 23 inches; weight 496 pounds; compressor stages 5 axial, 1 centrifugal; pressure ratio 6:1; compressor turbines 2 (one in L-11 version); power turbines 2 (one in L-11 version); power turbines 2 (1 in L-11 version.)

Performance

(T53-L-13) (photo): 1,400 shaft horsepower; specific fuel consumption .58 pounds per shaft horsepower per hour. (T53-L-11): 1,100 shaft horsepower; specific fuel consumption .68 pounds per horsepower per hour.

T55 TURBOSHAFT GAS TURBINE ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

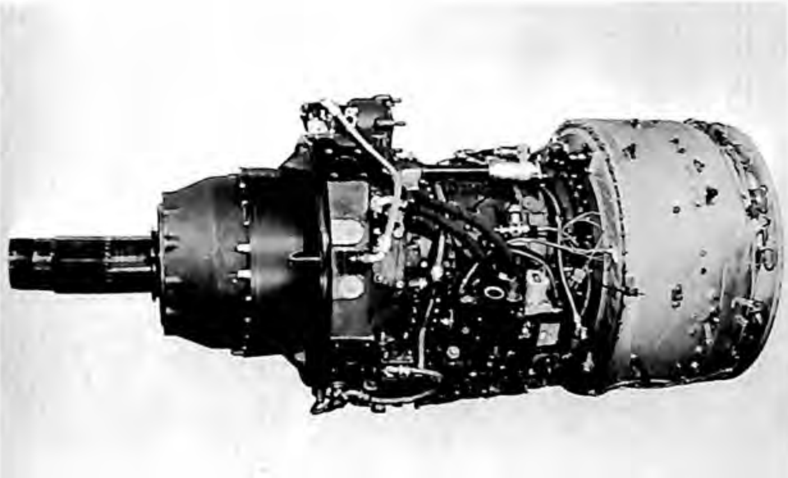
Maintaining the proven T53 design philosophy, the T55 is the more powerful of Avco Lycoming's 2 families of gas turbine engines. Twin 2,850 shaft horsepower T55-L-7Cs power the Army's battle-tested Boeing Vertol CH-47 "Chinook" medium transport helicopter. Uprated 3,750 shaft horsepower T55-L-11s will power the advanced CH-47C, providing it with substantially increased payload and cruising speed. Development programs will elevate the basic T55's output to the 5,000 shaft horsepower range. The engine now has the highest power-to-weight ratio in its class.

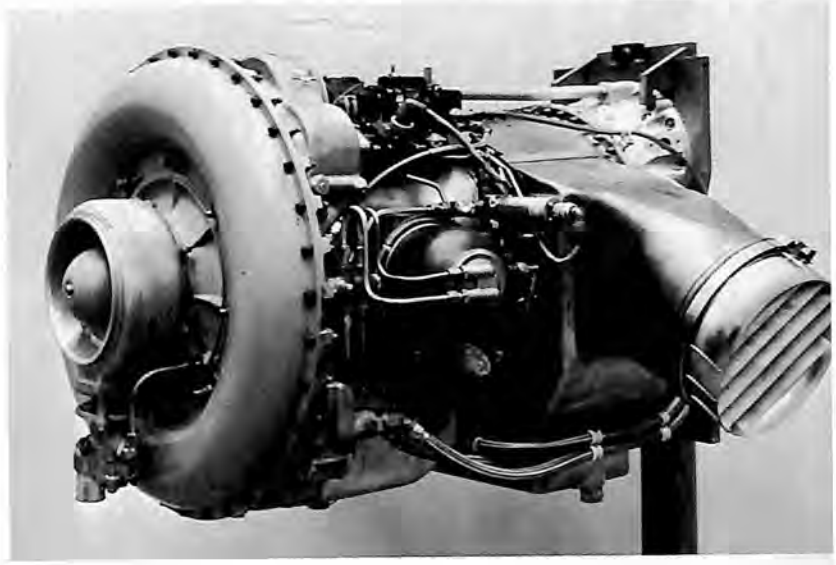
Specifications

(T55-L-7C): length 44 inches; diameter 24¼ inches; weight 590 pounds; compressor stages 7 axial, 1 centrifugal; pressure ratio 7:1 compressor turbines 1; power turbines 2. (T55-L-11): length 44 inches; diameter 24¼ inches; weight 640 pounds; compressor stages 7 axial, 1 centrifugal; pressure ratio 8.2:1; compressor turbines 2; power turbines 2.

Performance

(T55-L-7C): 2,850 shaft horsepower; specific fuel consumption .60 pounds per shaft horsepower per hour. (T55-L-11): 3,750 shaft horsepower; specific fuel consumption .52 pounds per shaft horsepower per hour.





T55 TURBOPROP GAS TURBINE ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

The turboprop 2,445 shaft horsepower T55-L-9 was the powerplant for North American Rockwell's YAT-28E, which was under evaluation by both the Navy and Air Force. The engine is currently being developed for 3,690 shaft horsepower. This version is designated LTC4R-1.

Specifications

(T55-L-9): length 62 inches; diameter 24¼ inches; weight 795 pounds; compressor stages 7 axial, 1 centrifugal; pressure ratio 6.4:1; compressor turbines 2; power turbines 2. (LTC4R-1): length 62 inches; diameter 24¼ inches; weight 920 pounds; compressor stages 7 axial, 1 centrifugal; pressure ratio 8.2:1; compressor turbines 2; power turbines 2.

Performance

(T55-L-9): 2,445 shaft horsepower; specific fuel consumption .62 pounds per horsepower per hour. (LTC4R-1): 3,690 shaft horsepower; specific fuel consumption .52 pounds per horsepower per hour.

T50 MILITARY TURBOSHAFT

Prime Contractor: The Boeing Company

Remarks

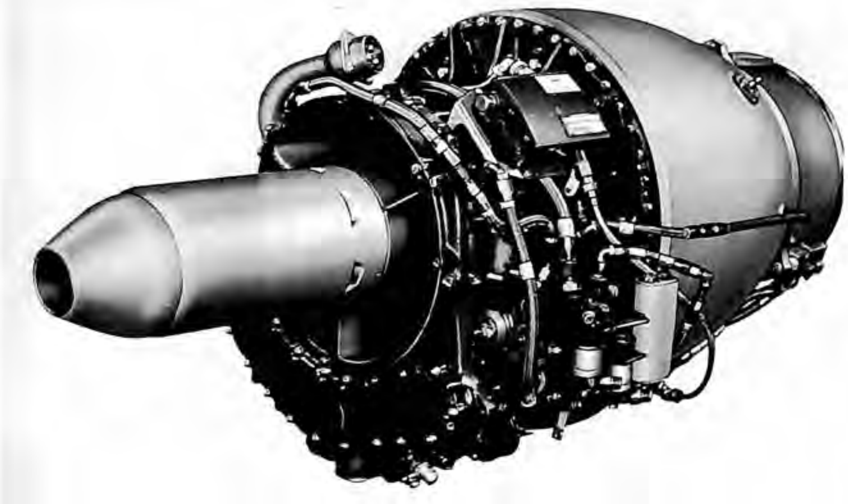
Configurations of the T50 military turboshaft engine power the Navy/Gyrodyne QH-50 series drone antisubmarine helicopters.

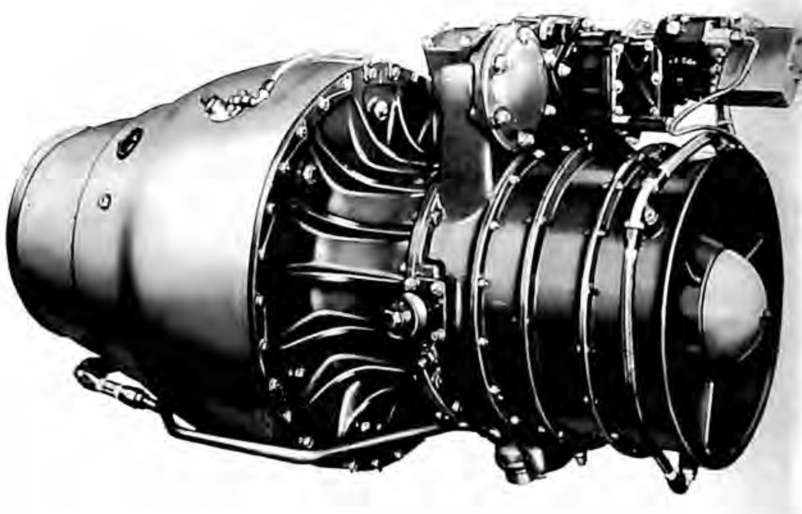
Specifications (T50-BO-12)

Length 37.5 inches; diameter 24.0 inches; weight 250 pounds; compression ratio 6.1:1; axial flow 2-shaft engine; compressor 1 axial, 1 centrifugal; turbine stages 2, 1 gas producer, 1 power output.

Performance

Rating 365 shaft horsepower at 60 degrees Fahrenheit sea level (– 12 model); 300 shaft horsepower at 60 degrees Fahrenheit sea level (– 8A model).





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

1,025 pounds maximum thrust; 880 pounds normal rated thrust; 1.12 specific fuel consumption; oil consumption 0.5 pounds per hour.

J69-T-29 TURBOJET

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

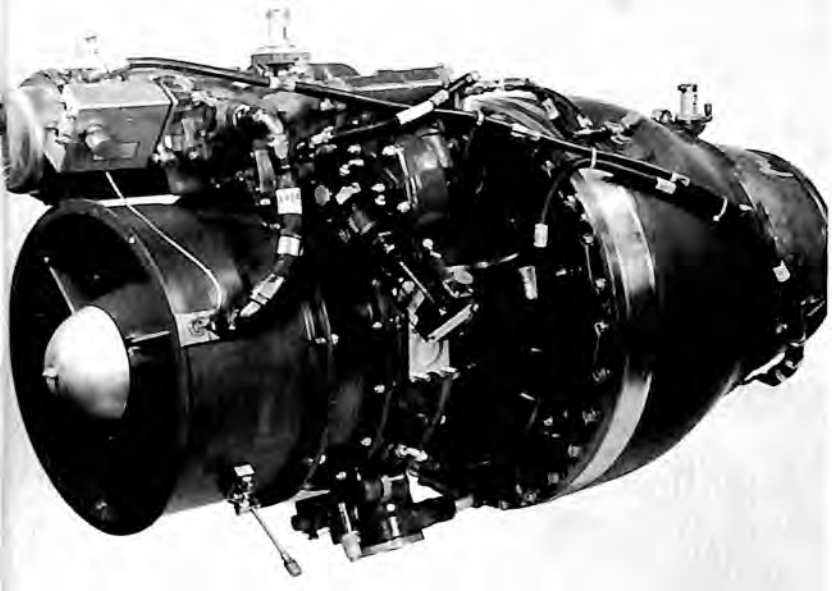
Current production installation is Ryan Q-2C "Firebee."

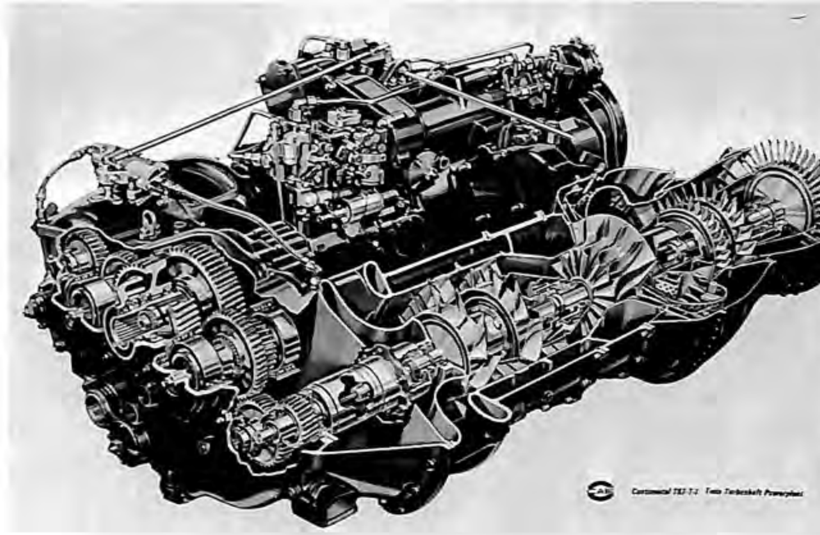
Specifications

Length 44.8 inches; diameter 22.3 inches; compression ratio 5.3:1; compression stages 2; turbine stages 1; weight 340 pounds.

Performance

1,700 pounds thrust maximum; 1,375 pounds thrust normal rated; 1.10 specific fuel consumption; 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

1,920 pounds thrust; 1.10 specific fuel consumption.

T67-T-1 TWIN TURBOSHAFT

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

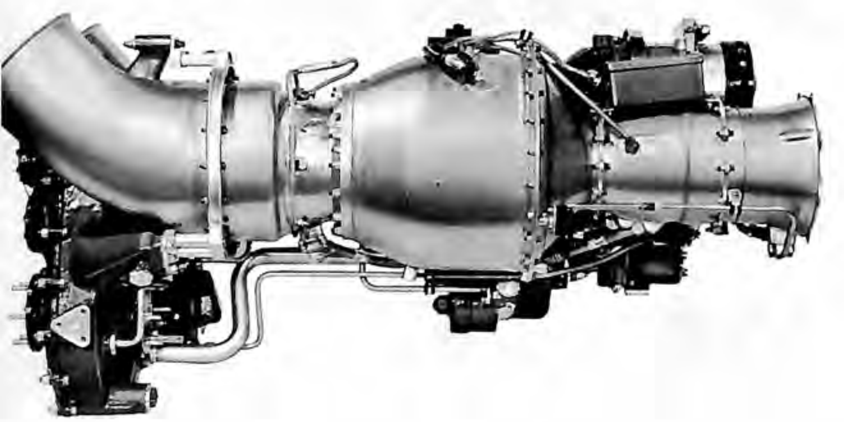
Featuring two independent engines combined with automatic power sharing system, the T67-T-1 has been flight tested in a UH-1D helicopter. Qualification is pending.

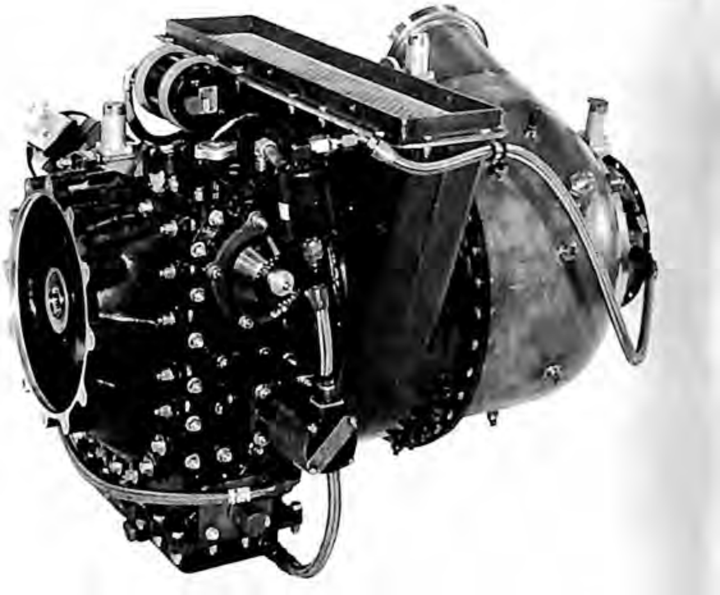
Specifications

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

1,600 shaft horsepower maximum, 1,300 continuous, 0.55 specific fuel consumption.





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 0.67 specific fuel consumption.

TS120-G6 TURBOSHAFT

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

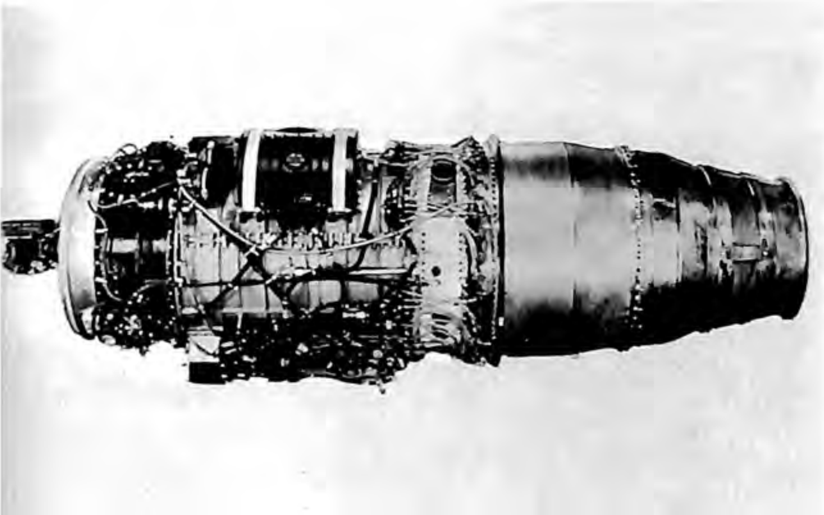
Model TS120 industrial gas turbine engine is being developed under contract to U.S. Army Mobility Equipment Research & Development Center.

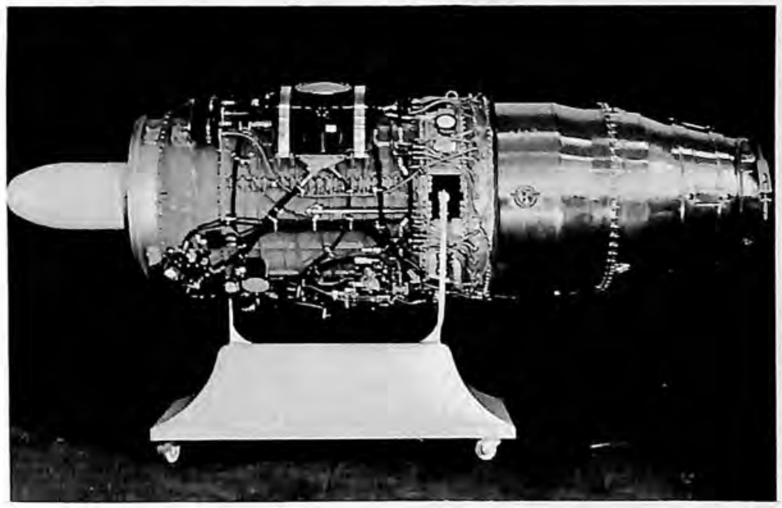
Specifications

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 0.65 specific fuel consumption.





J65-W-7 ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

The J65-W-7, used by the military in the F/RF84F aircraft, is a single spool axial flow compressor type jet power plant.

Specifications

Dry weight 2,795 pounds; length 115.0 inches; diameter 37.5 inches; type fuel JP-4.

Performance

Take-off power at sea level 7,800 pounds thrust.

J65-W-16A ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

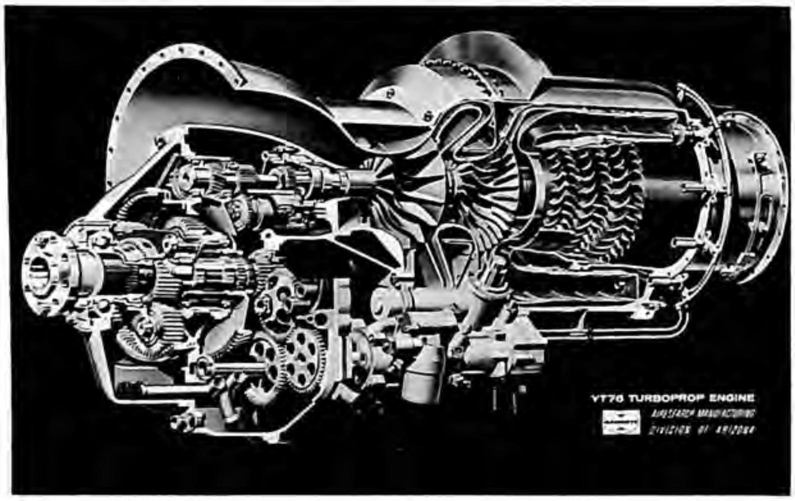
The J65-W-16, used by the military in the A-4A, A-4B, A-4C series aircraft, is a single spool axial flow compressor type jet power plant.

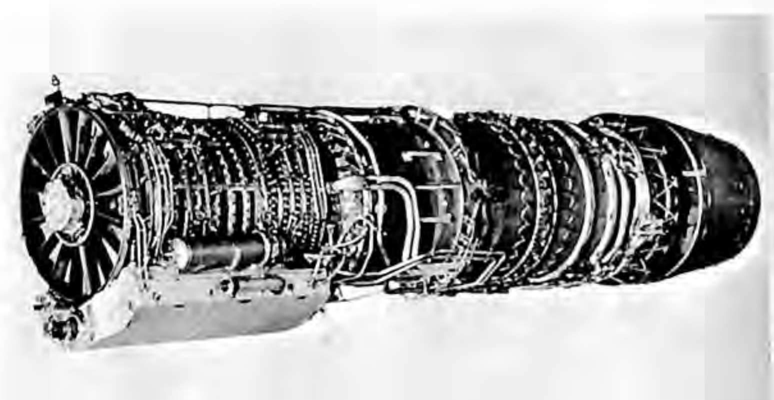
Specifications

Length 108.0 inches; diameter 37.5 inches; weight 2,757 pounds; fuel JP-4.

Performance

Take-off rating at sea level 7,700 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 OV-10A (COIN) aircraft. A commercial version designated TPE 331 is in production for Aero Commander's Turbo Commander, the Mitsubishi Mooney MU-2, Volpar Beech 18 modifications, the Fairchild and Pilatus Heli-Porters, Carstedt jetliner, and others. Among the features of this engine are opposite counter-rotation 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 320 pounds; compressor 2-stage centrifugal; turbine 3-stage axial.

Performance

Rating 715 shaft horsepower (T76); 605 equivalent shaft horsepower (TPE 331). An uprated 700 equivalent shaft horsepower version of the TPE 331 is also being offered.

YJ93 MILITARY TURBOJET

Prime Contractor: General Electric Company

Remarks

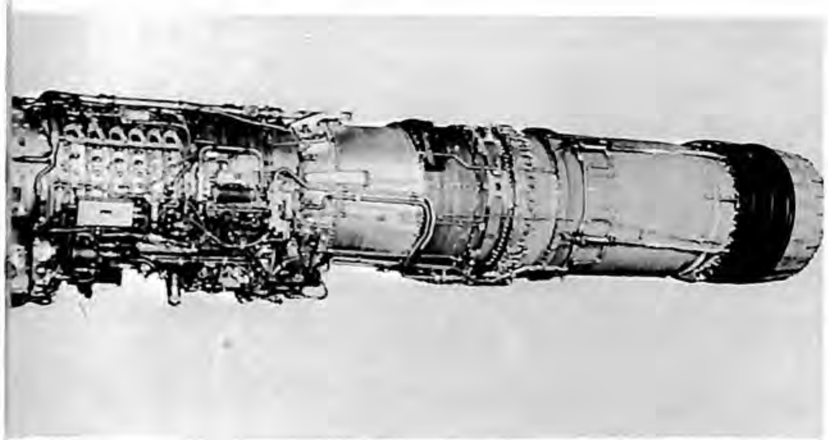
The YJ93 is a Mach 3 engine designed to power the Air Force's North American Rockwell XB-70 at a speed of 2,000 miles per hour above 70,000 feet.

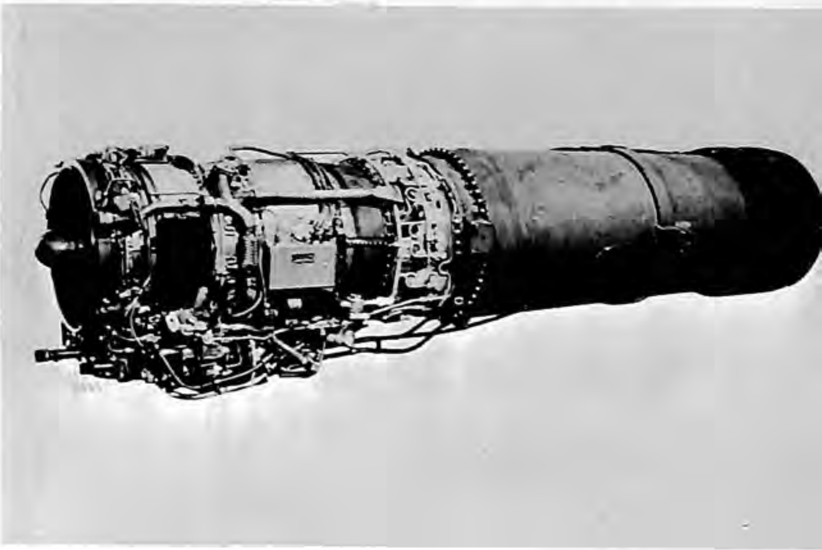
Specifications

Length 237 inches; maximum diameter 52.5 inches; thrust to weight ratio above 5:1; turbine stages 2.

Performance

Thrust class (sea level static) 30,000 pounds; speed capability sustained Mach 3.





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, Convair B-58, North American Rockwell RA-5C and the McDonnell 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

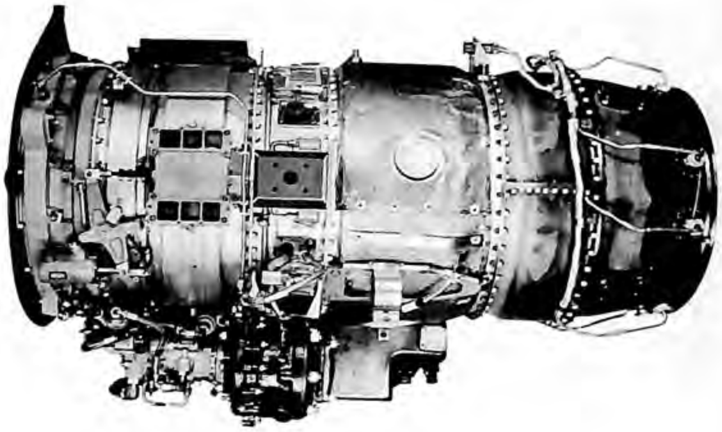
Power plant for high performance aircraft and air breathing missiles, the J85 turbojet is available in both afterburning and non-afterburning configurations. It has the highest power-to-weight ratio of any production engine in its class in the free world. This engine provides power for Northrop's F-5 and T38A and Fiat's G91Y. An advanced version, with 5,000 pounds of thrust, is designated J85/J1A.

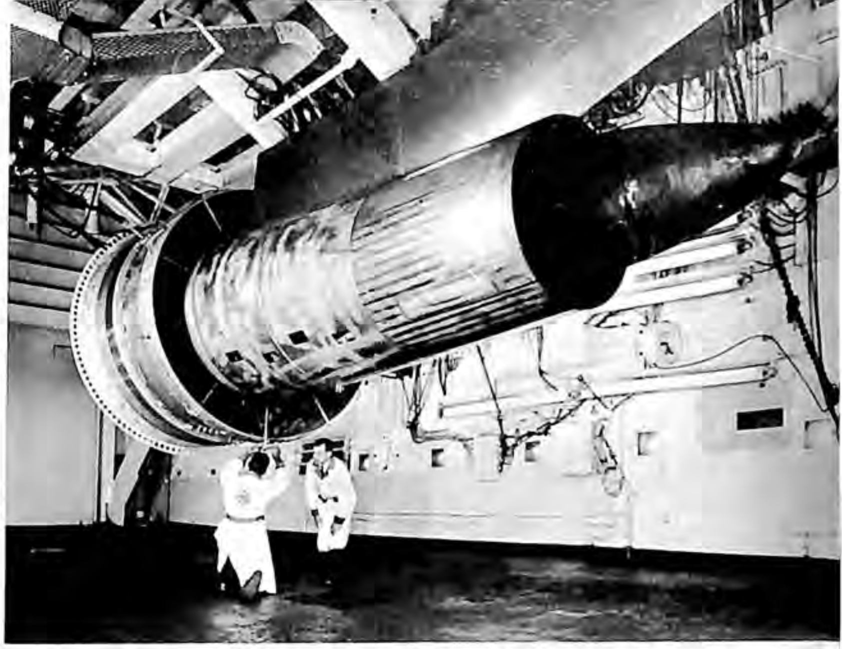
Specifications (J85-5A, -13, -15)

Length 108.9 inches, flange diameter 21 inches; compressor stages 8; turbine stress 2; weight (-5A) 584 pounds, (-13) 597 pounds, (-15) 615 pounds; thrust/weight ratio (-5A) 6.59:1, (-13) 6.84:1, (-15) 6.99:1.

Performance

Maximum thrust (-5A) 3,850 pounds; (-13) 4,080 pounds; (-5) 4,300 pounds.





J85 NON-AFTERBURNING TURBOJET

Prime Contractor: General Electric Company

Remarks

The dry J85 turbojet is a derivative of the J85 afterburning engine. The compact, lightweight design makes it an ideal powerplant for transports, trainers, fighters, VTOL aircraft, missiles and take-off boost applications. This engine provides power for Lockheed's XV-4B, Canadair CL-41G, Cessna A-37A, McDonnell GAM-72, GE/Ryan XV-5A, Bell X-14A, and Fairchild-Hiller's C-123K. A VTOL version (YJ-19) rated at 3,015 pounds thrust with a 7.8:1 thrust/weight ratio is being qualified.

Specifications (J85-17)

Weight 398 pounds; thrust-to-weight ratio 7.2:1; length 45.5 inches; diameter 17.7 inches; compressor stages 8; turbine stages 2.

Performance

Maximum thrust 2,850 pounds.

TF39 MILITARY TURBOFAN

Prime Contractor: General Electric Company

Remarks

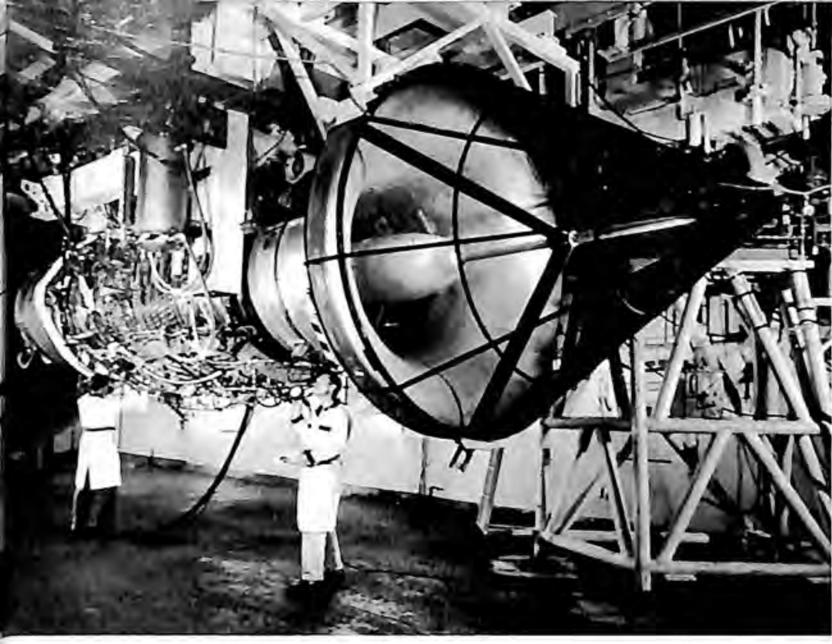
The TF39 is a high bypass ratio turbofan designed to power the Air Force's Lockheed C-5A heavy logistics transport over exceptionally long distances. Engine parts are designed for unusually long life.

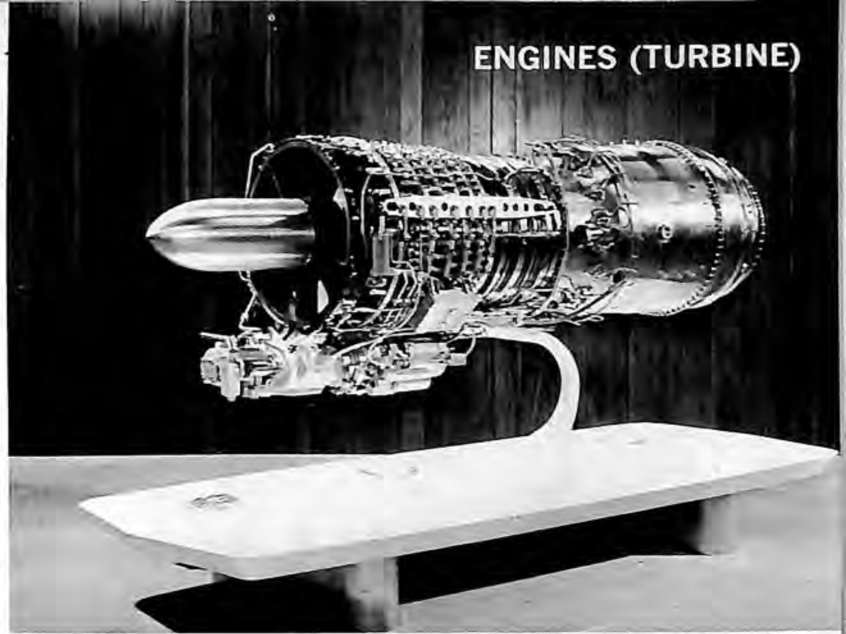
Specifications

Length 189.5 inches; maximum diameter 100 inches; thrust to weight ratio is 5.5 plus; bypass ratio is in the 8:1 class; pressure ratio at cruise altitude is in the 25:1 class.

Performance

Maximum thrust 41,100 pounds.





GE4/J5 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.

Specifications

Length 308 inches; exhaust nozzle exit diameter 74 inches; weight 11,000 pounds; fuel, commercial aviation kerosene.

Performance

Take-off thrust 63,200 pounds.

GE1 MILITARY/COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

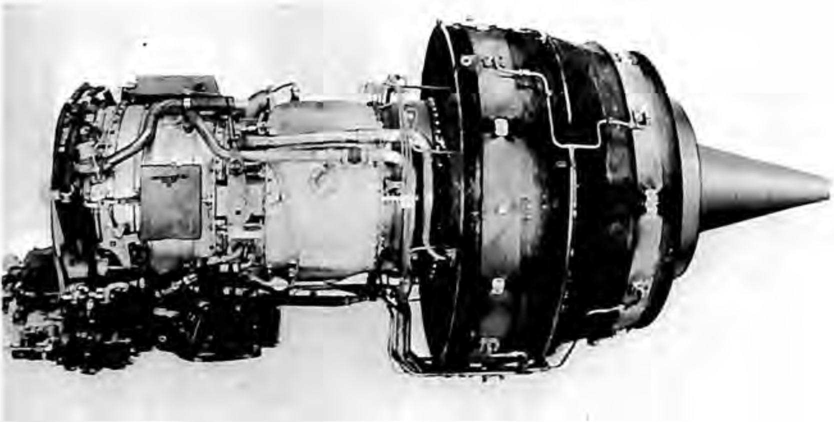
The GE1 Building Block approach provides for one gas generator as the basis of a family of advanced propulsion systems. Building Block components—turbofans, afterburners, thrust vectoring devices—are added to the GE1 gas generator to provide performance and configurations tailored to specific aircraft missions and designs. The GE1 features application versatility, time and cost savings and hardware standardization.

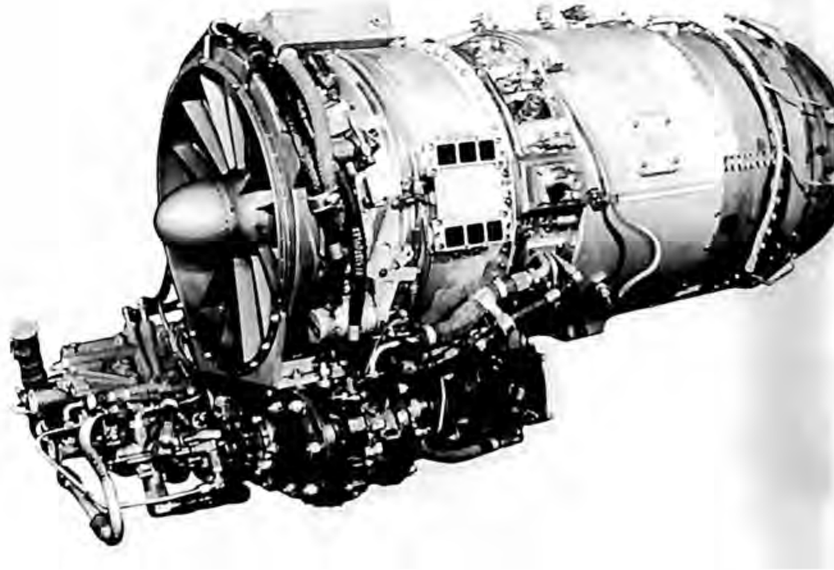
Specifications

The GE1 compared with the earlier J47 engine represents a 51 percent reduction in length, 79 percent reduction in volume plus 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.





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 Dassault Fan Jet Falcon 10 passenger business jet aircraft. It is also used in the Bell lunar landing research vehicle to equalize the forces of gravity and rockets for pilot control movements.

Specifications

Length 53.6 inches; fan diameter 33.1 inches; weight 725 pounds; compressor stages 8, axial flow; turbine stages 2, axial flow.

Performance

Take-off thrust 4,125 pounds; maximum continuous thrust 4,000 pounds.

CJ610 COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

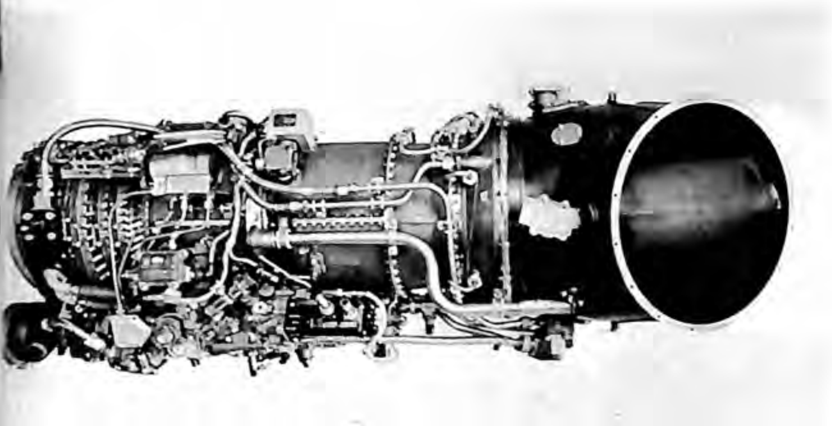
The CJ610 is a derivative of the J85 turbojet and is available in 4 configurations. Twin CJ610 engines power the Aero Commander Jet 1121, HFB 320 Hansa and the Lear Jet business aircraft.

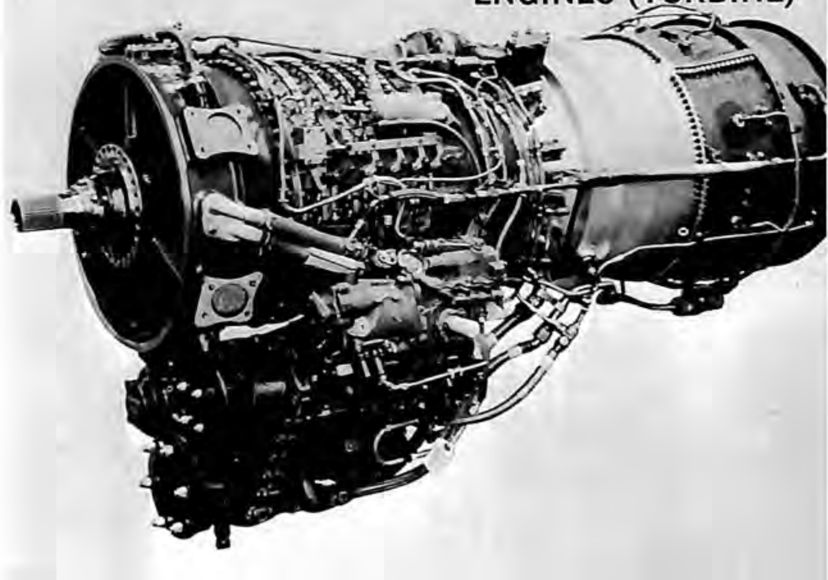
Specifications (CJ610-6)

Length 51.1 inches; flange diameter 17.7 inches; weight 339 pounds; thrust to weight ratio 7.14:1; compressor stages 8; turbine stages 2.

Performance

Take-off thrust 2,950 pounds.





T58 MILITARY TURBOSHAFT

Prime Contractor: General Electric Company

Remarks

There are in production several configurations of the T58 turboshaft engine, powerplant for a wide variety of helicopters and VTOL aircraft. Applications include Sikorsky SH-3A/D, Kaman UH-2A/B, Boeing Vertol CH-46A/D, Sikorsky HH-52A, Sikorsky CH-3C/E, Sikorsky HH-3E, Bell UH-1F, Kaman UH-2C, Agusta Bell 204-B and Bell X-22A. A higher rated version of engine is under development.

Specifications (T58-5)

Length 58.6 inches; maximum diameter 20.6 inches; weight 335 pounds; compressor stages 10; turbine stage 3.

Performance (T58-5)

Maximum shaft horsepower 1,500.

T64 MILITARY TURBOSHAFT/TURBOPROP

Prime Contractor: General Electric Company

Remarks

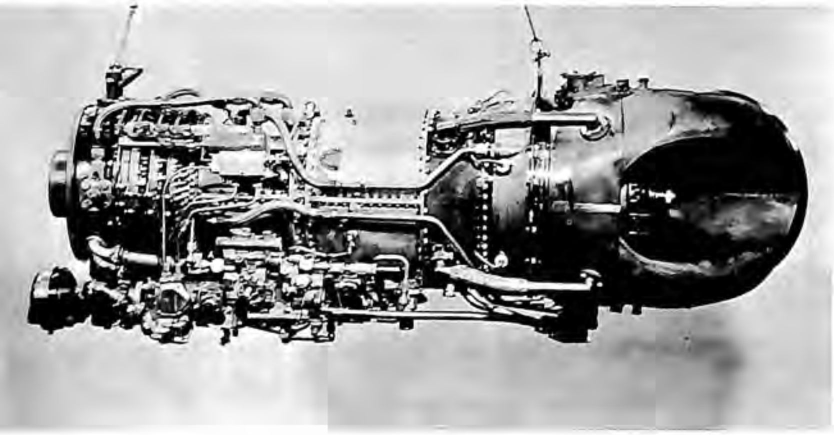
The T64 is a free turbine power plant for helicopter and V/STOL aircraft. The basic engine is designated T64-6. With a single reduction gearbox added it is the T64-2. Addition of a planetary reduction gear creates the turboprop configuration with the T64-4 2-stage gearbox below the engine centerline and the T64-8 gearbox above the engine centerline. Military applications of the T64 include: deHavilland Buffalo, Sikorsky CH-53A, Ling-Temco-Vought XC-142A, Fiat G222, Kawasaki P2J, Shin Meiwa PX-S and the Lockheed AH-56A.

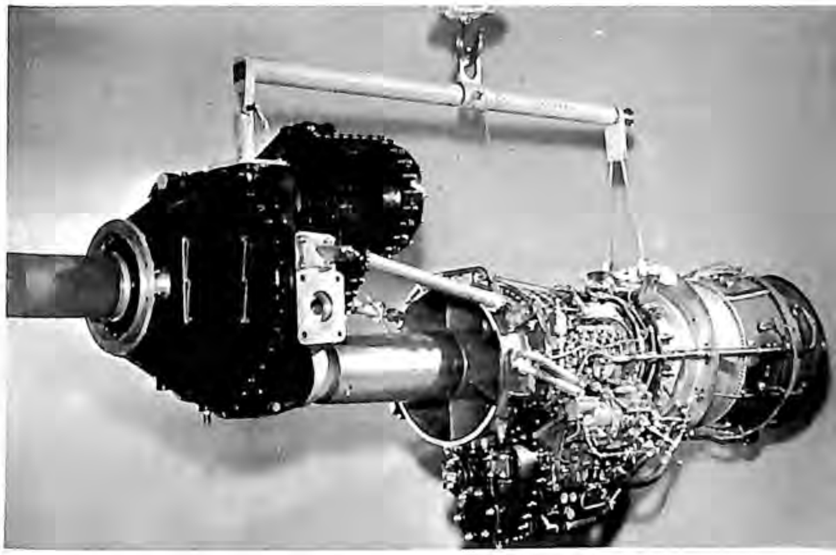
Specifications (T64-6)

Length 83.4 inches; maximum diameter 30 inches; horsepower/weight ratio 4:1; compressor stages 14; turbine stages 4, weight 723 pounds.

Performance (T64-6)

Maximum shaft horsepower 2,850.





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

Take-off rating 1,400 horsepower (CT58-140); 1,250 horsepower (CT58-110).

CT64 COMMERCIAL TURBOSHAFT/TURBOPROP

Prime Contractor: General Electric Company

Remarks

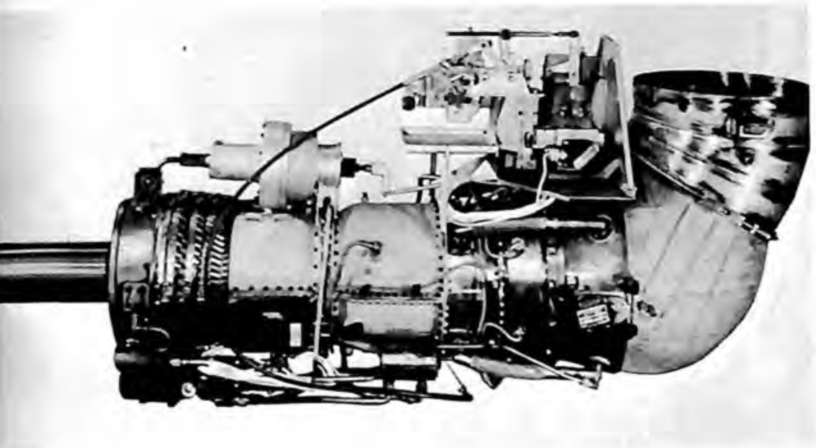
Configurations of the T64 commercial turboshaft/turboprop are in production and certified for civil use. The CT64-410-1, and CT64-810-1 are turboprop engines and the CT64-610-1 is a direct drive powerplant.

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.



LM100 GAS TURBINE

Prime Contractor: General Electric Company

Remarks

Derived from the T58 aircraft engine, the turboshaft LM100 is a jet engine for marine and industrial uses, developing 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 offered for use in large off-highway vehicles, oil well fracturing units, gas pipeline pumping and emergency power generation.

LM1500 GAS TURBINE

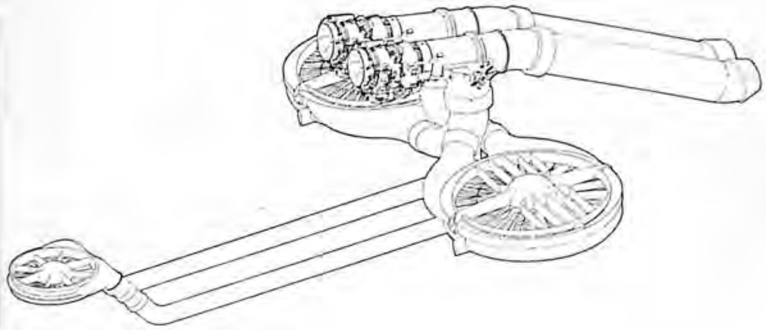
Prime Contractor: General Electric Company

Remarks

Available as a shaft power engine or a gas generator, the LM1500 is derived from the J79 aircraft engine. It supplies high-speed propulsion for new U.S. Navy Patrol Motor Gunboats and powers the Navy's hydrofoil ship U.S.S. Plainview. The LM1500 is also used for gas pipeline pumping and power generation for electric utilities.

Performance

14,000 horsepower at normal 80 degrees Fahrenheit.

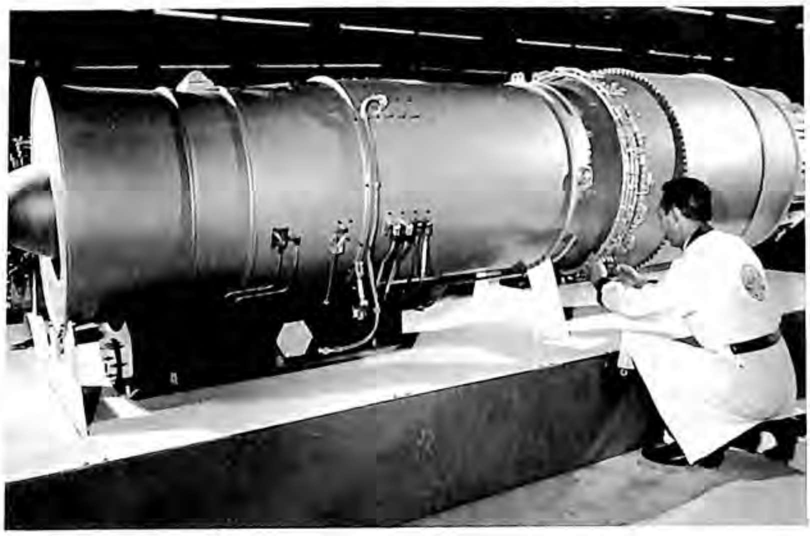


LF1 "TURBOTIP" LIFT FAN SYSTEM

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 XV-5A Army VTOL research aircraft nearly triple the gas generator thrust of the twin J85 power plants.

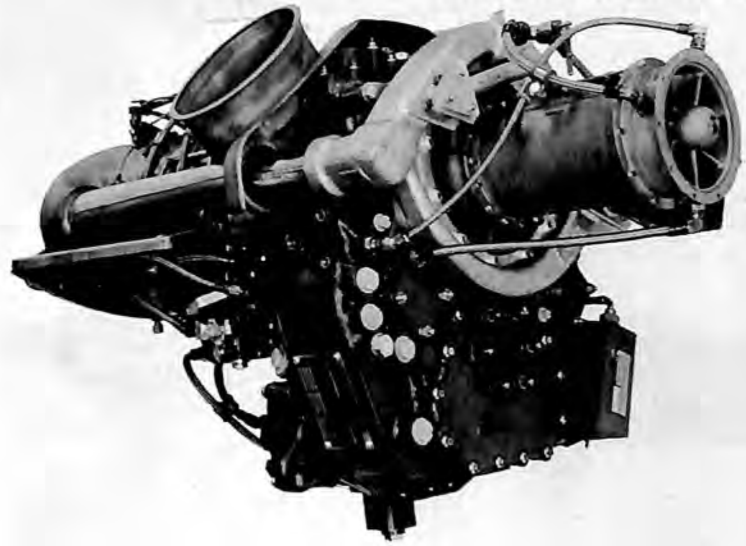


GE1/10 AUGMENTED TURBOFAN

Prime Contractor: General Electric Company

Remarks

The GE1/10 augmented turbofan engine is a derivative of the GE1 turbojet first tested in 1963. The GE1/10 is directed toward proposed advanced tactical fighters like the US/FRG and other advanced V/STOL fighters and attack aircraft. The GE1/10 is approximately 38 inches in diameter, 143 inches in length and has a turbine inlet temperature in excess of 2000 degrees Fahrenheit.



501-D13D COMMERCIAL TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

The 501-D13D is the powerplant for the Convair 580 operating with 5 airlines, 14 corporations, the Federal Aviation Administration, U.S. Air Force and Royal Canadian Air Force. 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

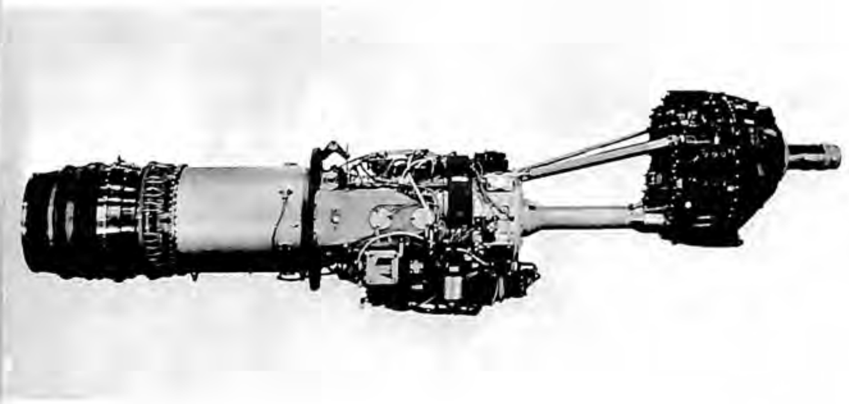
Model 250 powers the Bell Jetranger, Fairchild Hiller FH-1100, and Hughes 500 light helicopters.

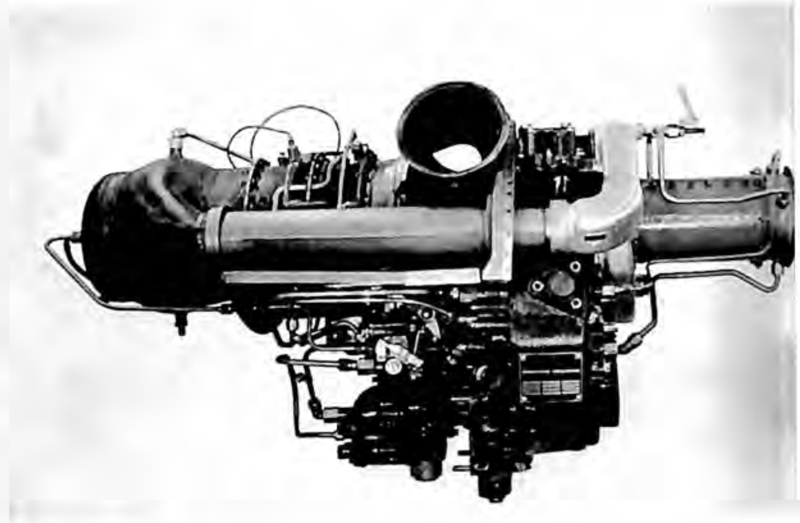
Specifications

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.





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 4,050 equivalent shaft horsepower

T63-A-5A MILITARY TURBOSHAFT

Prime Contractor: Allison Division of General Motors

Remarks

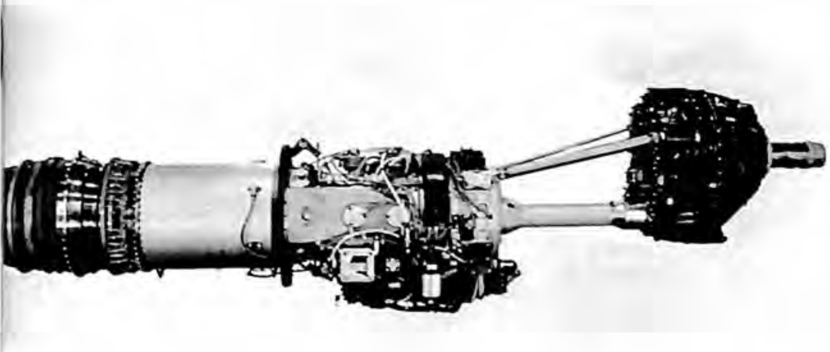
The T63-A-5A powers the Army OH-6A light observation helicopter.

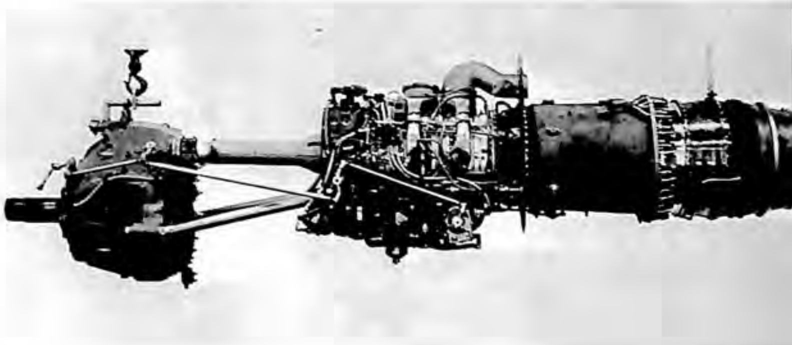
Specifications

Length 40 inches; diameter 22.5 inches; weight 136 pounds; compression ratio 6.2:1; compressor stages 6 axial, 1 centrifugal; turbine stages 4.

Performance

Rating 317 equivalent shaft horsepower.





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, Coast Guard, Marine Corps, Military Airlift Command and the Navy, as well as governments of 11 foreign nations. 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

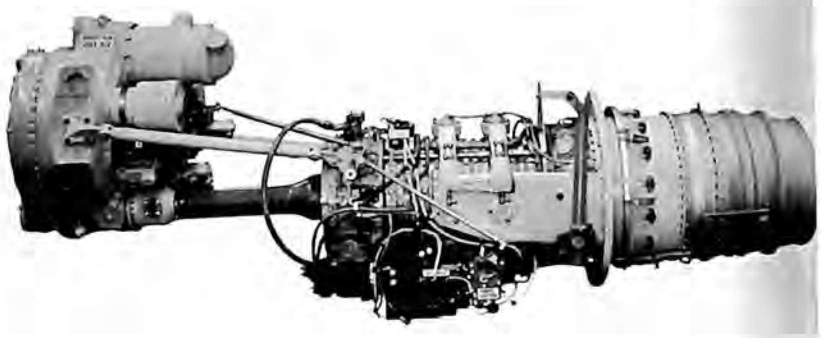
The T56-A-14 is a follow-on military engine for the Lockheed P-3 antisubmarine warfare plane.

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 powerplant for the Lockheed HC-130H search, rescue, 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.

T56-A-18 MILITARY TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

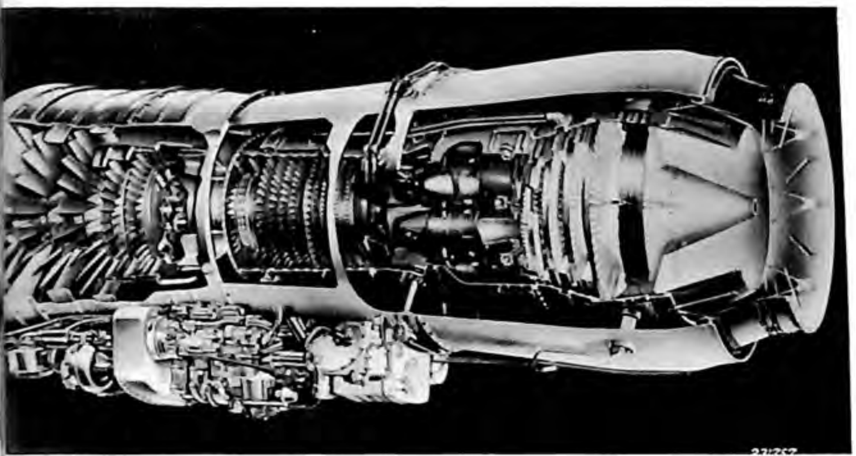
A growth version of the T56 engine, T56-A-18 is being developed for Navy use.

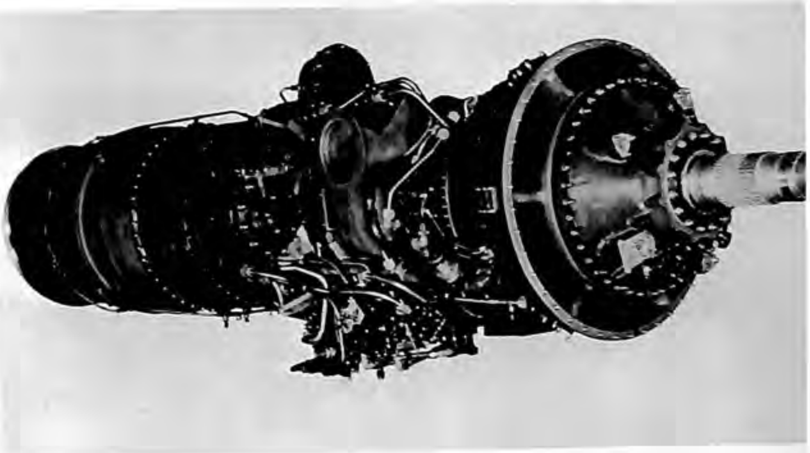
Specifications

Length 115 inches; width 29 inches; height 45 inches; compressor ratio 9.65:1; compressor stages 14; turbine stages 4 with air-cooled first and second stage blades and vanes; weight 1,554 pounds.

Performance

Rating 5,000 equivalent shaft horsepower.





TF41 MILITARY TURBOFAN

Prime Contractor: Allison Division of General Motors

Remarks

The TF41 is being developed jointly by Allison and Rolls-Royce, Ltd., to power the U.S. Air Force's new LTV A-7D close-support aircraft.

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.

Performance

Thrust 14,250 pounds.

T34 MILITARY TURBOPROP

Prime Contractor: Pratt & Whitney Aircraft

Remarks

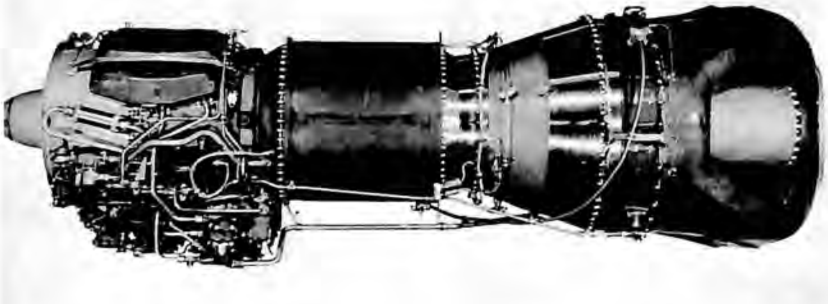
Development of the T34 (PT2) axial flow turboprop engine began in 1945. The engine was put into production in 1953. It powers the Douglas C-133 Cargomaster.

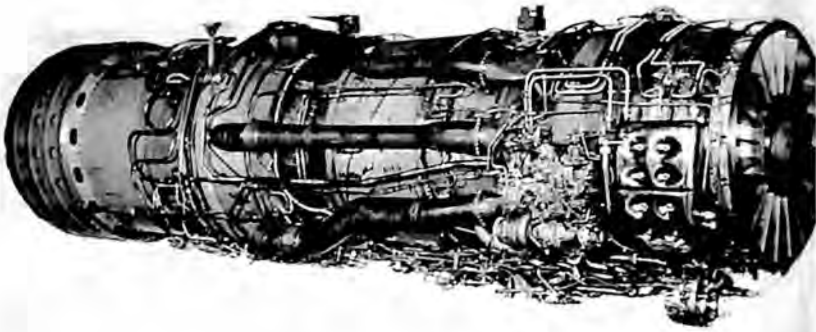
Specifications

Length 155.12 inches; diameter 34.06 inches; weight 2,870 pounds; compression 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

Length 108 inches; diameter 21.9 inches; weight 882 pounds; compression ratio 6.5:1 free turbine drive; compressor stages 9; turbine stages 4.

Performance

Rating 4,050 shaft horsepower.

J58 MILITARY TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

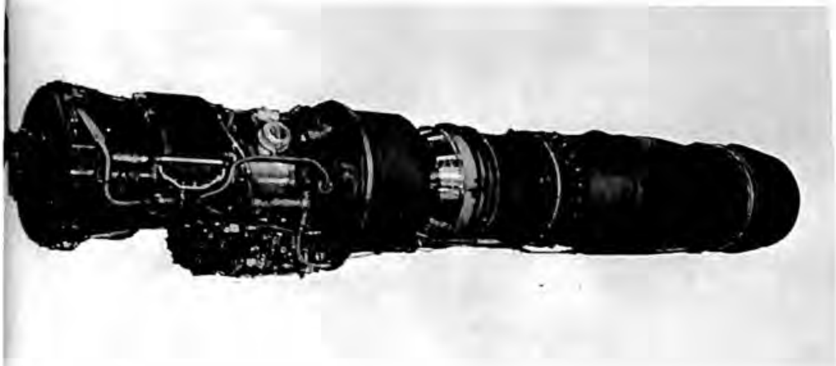
The J58 powers the twin-engine Mach 3 Lockheed YF-12A interceptor and the SR-71 strategic reconnaissance aircraft.

Specifications

Classified.

Performance

Thrust in the 30,000-pound class.



J57 MILITARY TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

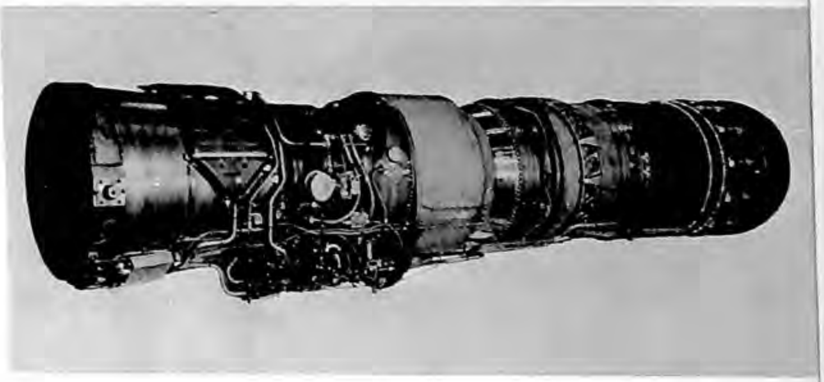
The J57 turbojet which put American military aircraft into supersonic flight was produced from 1951 to 1965. Winner of the 1952 Collier Trophy, it was also the first engine to reach 10,000 pounds of thrust. Among the craft it powers are: the Boeing B-52 bomber, KC-135 tanker-transport and C-135A transport; the North American F-100, McDonnell F-101, Convair F-102, Ling-Temco-Vought F-8, Douglas F-6 and A-3. Over 43,000,000 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, compression ratio 13; weight 3,870 pounds, axial flow, dual rotor; compressor stages 16; turbine stages 3.

Performance

Thrust 13,750 pounds; afterburning versions 18,000 pounds.



J75 MILITARY TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

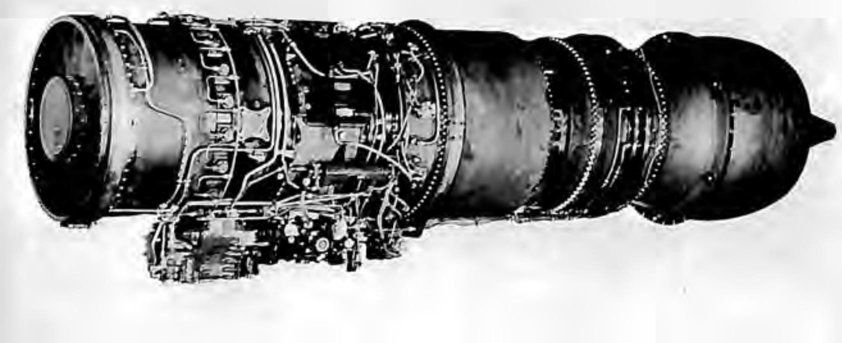
Design work on the J75 (JT4 commercial) began in 1952. To design an engine with 50 percent more output but only slightly larger than the similar J57 (JT3) at the time, engineers took the advanced step of increasing the hub to tip ratio. This essentially reduced the diameter of the hub which reduced weight and increased the airflow. The engine is used in the Republic F-105 and GD/Convair F-106. More than 1,500 engines were shipped between April 1957 and July 1964.

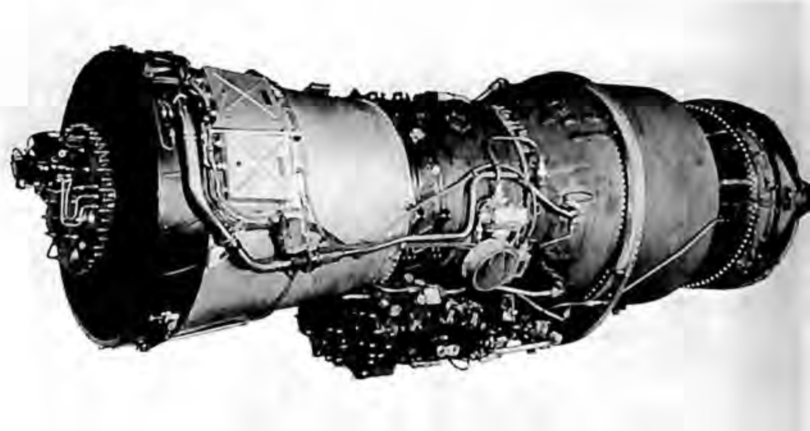
Specifications

Length (J75-P-17) 237.6 inches, (P-19W) 259.3 inches; diameter 43 inches; compression ratio 12:1; axial flow, dual rotor; compressor stages 15; turbine stages 3; total weight (P-17) 5,875 pounds, (P-19W) 5,960 pounds.

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 Douglas A-4F Skyhawk and TA-4E, the Grumman A-6A and the North American Rockwell Hound Dog missile.

Specifications

Length 116.9 inches; diameter 30.15 inches; compression ratio 12; weight (P-8A) 2,118 pounds; axial flow, dual rotor; compressor stages 12; turbine stages 2.

Performance

Thrust (P-8A) 9,300 pounds.

JT3 COMMERCIAL TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

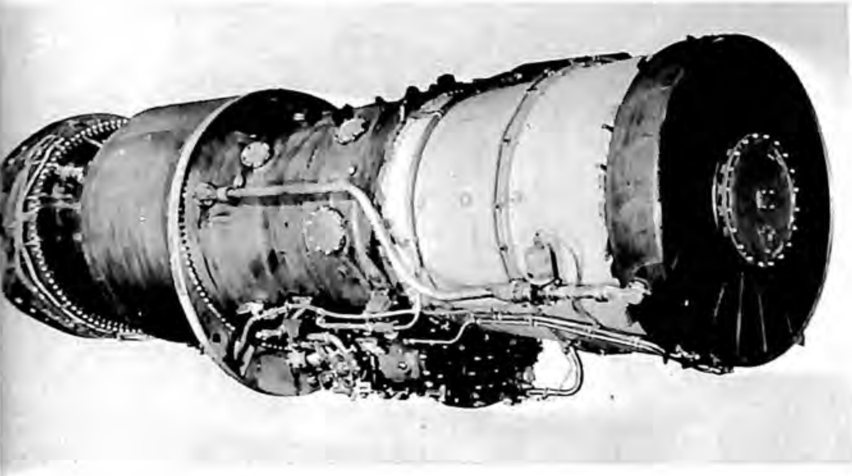
On October 26, 1958, the JT3 Turbo Wasp ushered in the American commercial jet age. A commercial version of the J57, this engine was produced from 1958 to 1961. Configurations are in wide service on the Boeing 707-120 and 720, and the Douglas DC-8-10.

Specifications (JT3C-6)

Length 138 inches; diameter 38.8 inches; weight 4,234 pounds; compression 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

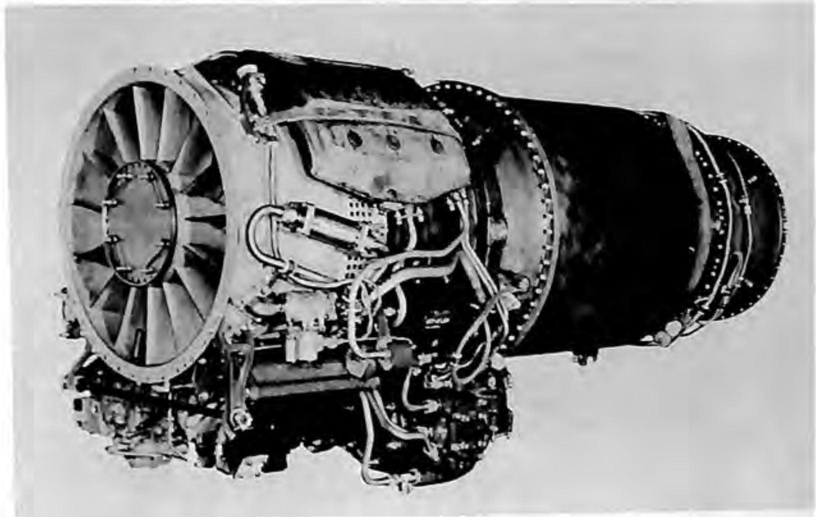
A larger, advanced configuration of the JT3, the JT4 (military version J75) is used in the long-distance Boeing 707-320 and Douglas DC-8-20, -30 airliners. Built between 1959 and 1961, it has attained a time between overhaul (TBO) of 9,500 hours.

Specifications (JT4A-9)

Length 144.1 inches; diameter 43 inches; weight 5,050 pounds; compression ratio 12; axial flow, dual rotor; compressor stages 15; turbine stages 3.

Performance

Thrust 16,800 pounds.



JT12/J60 TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

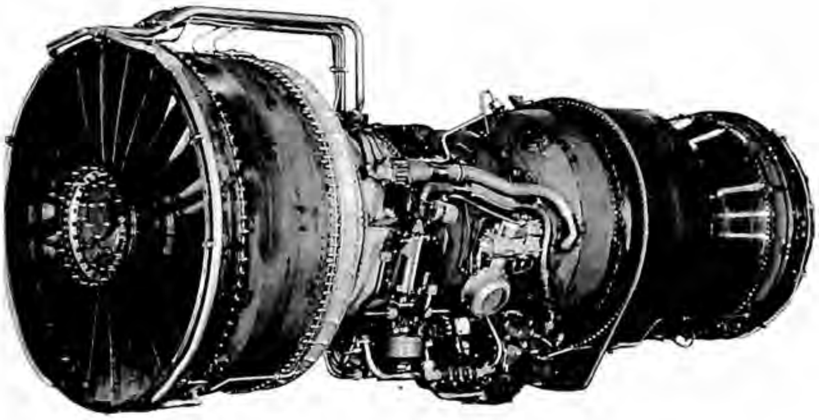
The JT12A-8 (military designation J60), smallest in the company's jet engine family, powers the 4-engine Lockheed JetStar and twin-engine North American Rockwell Sabreliner business aircraft.

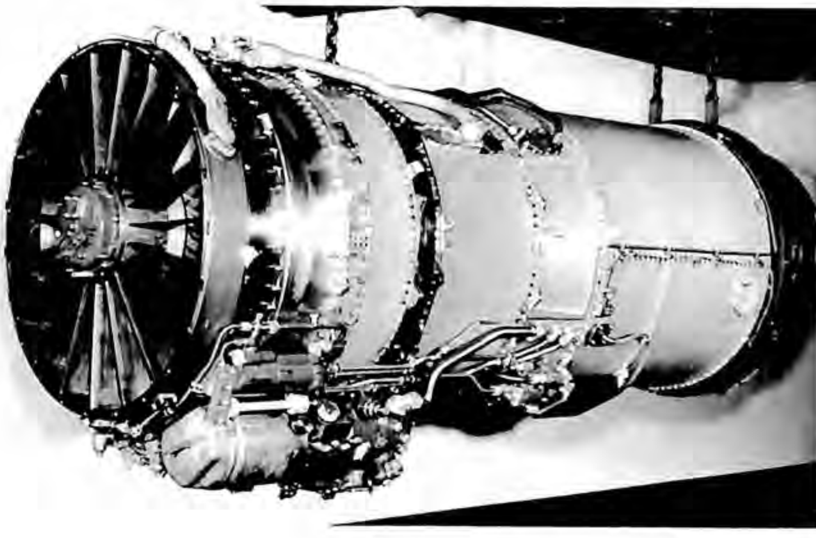
Specifications (JT-12)

Length 78 inches; diameter 21.9 inches; weight 468 pounds; compression ratio 6.5:1; axial flow, single rotor; compressor stages 9; turbine stages 2. J60 same except for length: 77.9 inches in P-3, -5 versions, 70.6 inches in P-6, -4.

Performance

Thrust 3,300 pounds, either version.





JT3D COMMERCIAL TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

A widely used turbofan engine, 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, 707-320B and C; the Douglas DC-8-50, DC-8F, and the Super Sixty series.

Specifications (JT3D)

Length 136.3 inches; diameter 53 inches; weight 4,260 pounds; compression ratio 13.5; axial flow, dual rotor; compressor stages (including fan) 15; turbine stages 4.

Performance

Thrust to 19,000 pounds.

JT8D COMMERCIAL TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

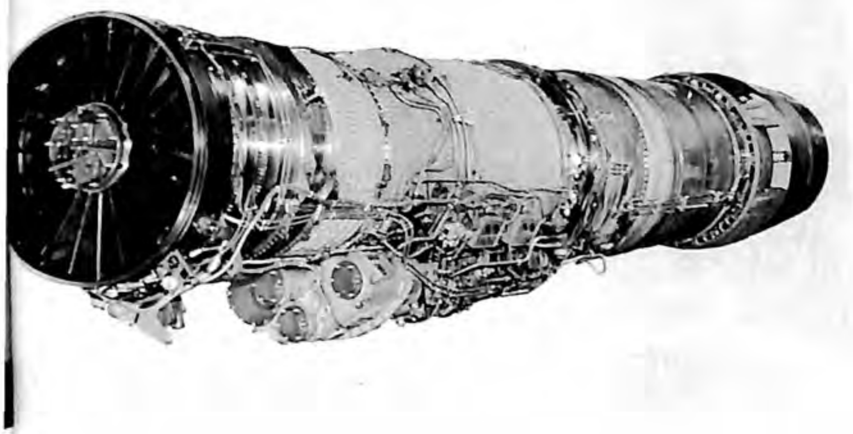
The company-financed JT8D was designed and developed from the outset for application to short and medium range aircraft. This engine has reached a maximum time between overhaul (TBO) of 7,100 hours. The JT8D turbofan engine powers the Boeing 727 and 737, the twin-engine Douglas DC-9 and the Sud Aviation Super Caravelle 10B, 10R, and 11R.

Specifications (JT8D)

Length 123.5 inches; diameter 42.5 inches; weight 3,196 pounds; compression ratio 16.5:1; axial flow, dual rotor; compressor stages including fan 13; turbine stages 4; full-length fan duct.

Performance

Thrust 14,500 pounds.

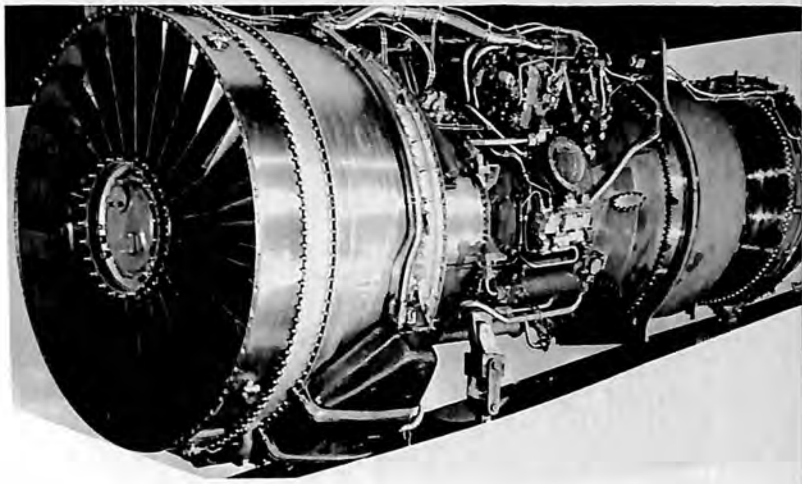


TF30 MILITARY TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

The 20,000-pound-thrust-class TF30 was the first after-burning turbofan engine to complete an official 150-hour qualification testing. Configurations of this engine power the twin-engine General Dynamics F-111A and B variable sweep wing supersonic fighters. A non-afterburning version is the powerplant for Ling-Temco-Vought's A-7A and A-7B aircraft. Specifications are classified.



TF33 MILITARY TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

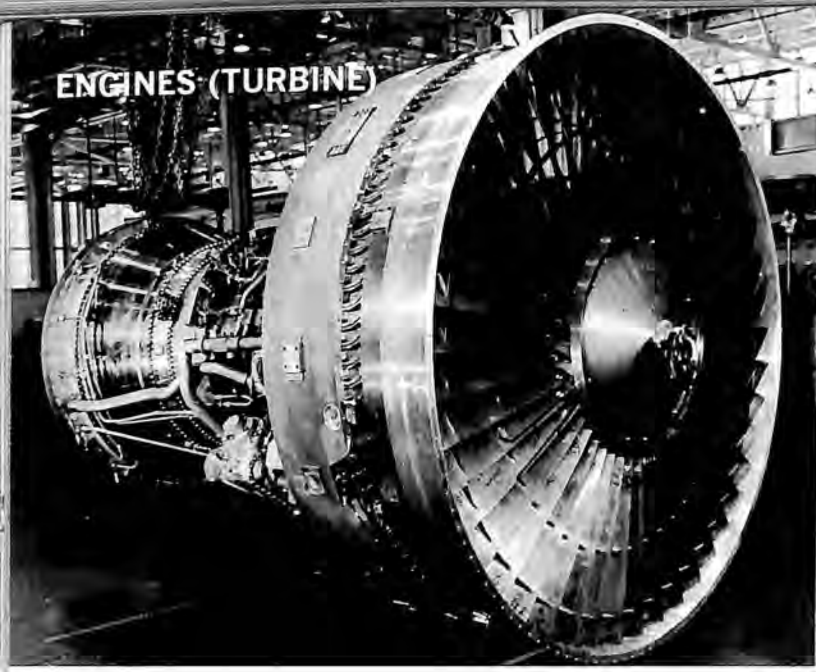
Configurations of the TF33 (JT3D in the commercial version) power the Boeing B-52H bomber, the C-135B and KC-135B, as well as the Lockheed C-141A.

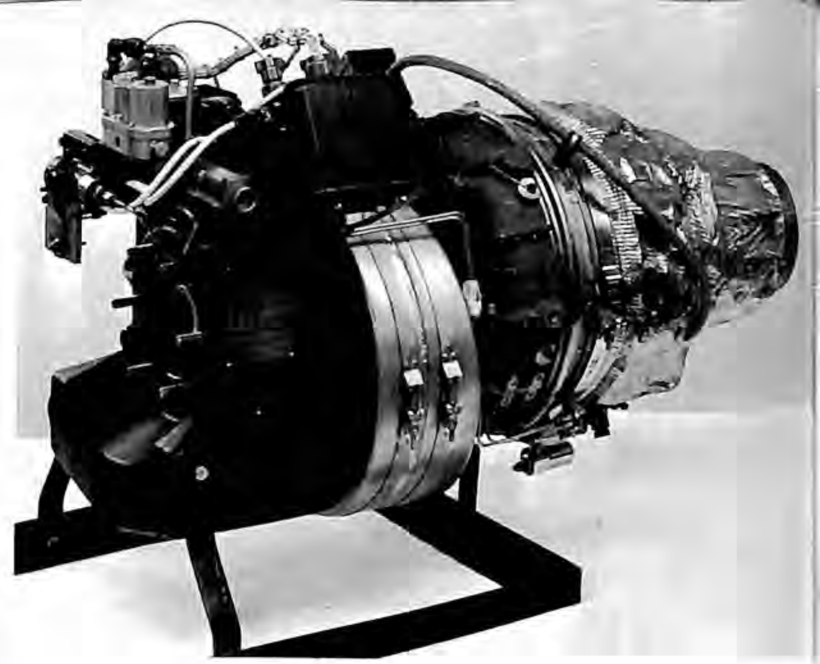
Specifications (TF33)

Length 136–142 inches; diameter 53 inches; weight 4,200–4,600 pounds; compression ratio to 16:1; axial flow, dual rotor; compressor stages (including fan) 15 or 16; turbine stages 4.

Performance

Thrust to 21,000 pounds.





JT9D COMMERCIAL TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

The Pratt & Whitney Aircraft JT9D, which will power 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 18,000-pound-thrust JT3D turbofan engine which is the workhorse of the long-range Boeing 707 and Douglas DC-8 commercial jet fleets and the military Lockheed C-141 StarLifter. Yet, in spite of its size, the JT9D is quieter than current jet engines and is only 128 inches long—6 inches shorter than the JT3D. The new engine weighs 8,430 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 air flow conditions and has a plug nozzle in the exhaust section. The engine has a total airflow of 1,484 pounds per second (19,000 cubic feet) and a bypass ratio of 5 to one. It has one fan stage, 15 compressor stages including the fan, and 6 turbine stages. The low-speed compressor section has 3 stages and the high-speed compressor section has 11 stages. The low-speed turbine section has 4 stages and the high-speed section has 2 stages. The turbine section is air-cooled and the engine has both titanium and high-alloy nickel steel parts. The JT9D will have a 23 percent better specific fuel consumption than the JT3D-3B now used in the intercontinental range jetliners. On take-off, the fan bypass airflow will develop 77 percent of the thrust and 61 percent of the thrust at cruise altitudes.

T62T GAS TURBINE ENGINE

Prime Contractor: Solar, A Division of International Harvester Company

Remarks

The T62T (Titan) is an extremely rugged and 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 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 and JetStar 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.

Specifications

Length 26 inches; diameter 12.5 inches; weight 70 pounds; radial flow; electric or hydraulic starting.

Performance

Rating 80 to 150 horsepower.

SOUNDING ROCKETS

Listed under system contractor: manufacturer's nomenclature, type, stages and thrust, launch weight and overall length, performance, remarks and using organizations.

Niro

AEROJET-GENERAL CORPORATION (SPACE-GENERAL PLANT)

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 (150), 1,943 pounds; length (150), 29.67 feet; weight (150A), 1,941 pounds; length (150A), 30 feet; 150 pound payload to altitude of 152 miles; maximum acceleration 10.3 g; tower-launched; 150 version has 3 fins, 150A has 4 fins; attitude control and recovery systems available in both vehicles; NASA, AF, 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 (300), 33.00 feet, (300A), 33.30 feet; 35 pound payload to altitude of 300 miles; maximum acceleration 63.8 g; 300A has 4 fins; NASA, AF.

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's; 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, Iroquois second stage 40 to 180 pounds to altitudes of 180 to 85 miles, respectively; boom-launched, under development AFCRL; maximum acceleration of 36 g's; 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

ARCAS

Single-stage solid sounding rocket; over 6,000 flown; ARC 29KS-336; weight 65 pounds; length 7.5 feet; 10 pound payload to altitude of 44 miles; all services and NASA, Germany, France, Argentina, Canada, Brazil.

BOOSTED-ARCAS I

Two-stage solid sounding rocket; 1st—ARC MARC 14 A1 (0.8KS-2700), 2nd—ARC ARCAS (29KS-324); weight 102 pounds plus payload; length 10 feet 7 inches; 12 pound payload to 54 miles; NASA.

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; 12 pound payload 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-29s (122,000 pounds total thrust); weight 10,000 pounds; length 21 feet; 500 pound payload to altitude of 200 nautical miles; first stage Shotput; 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; 50 pound payload to altitude of 94 miles; all services and NASA.

SOUNDING ROCKETS

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; 50 pound payload 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 M-5 Nike (48,700 pounds thrust); weight 5,464 pounds; length 40 feet; 250 pound payload 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; 300 pound payload to altitude of 750 miles; Army, AF.

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; 250 pound payload to altitude of 118 miles; Army, AF, NASA.

ARGO C-23

Three-stage solid sounding or research rocket; 1st—Thiokol TX-33 with 2 Thiokol TX 77s (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; 150 pound payload 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 & 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; 100 pound payload to altitude of 550 nautical miles; NASA, AF, 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 & 3rd—Lockheed Lance (47,000 pounds thrust each), 4th—Hercules X-248 (3,000 pounds thrust); weight 14,000 pounds; length 62.0 feet; 135 pound payload to altitude of 1,260 nautical miles: Mach 24; holds record for highest altitude (1,269 nautical miles) for recovered payload; NASA, Sandia.

Argo D-4 (Javelin)

HYDRA-IRIS

Single-stage solid sounding rocket with launch boost; 1st—3 clustered Aerojet Sparrow MK6 Mod 3, 2nd—ARC 52KS-3850; weight 1,720 pounds plus payload; length 27 feet; 100 pound payload to altitude of 200 miles; launch from submerged, floating launch rail; Navy.

METARC

Single-stage low altitude meteorological rocket; reusable; ARC 0.72KS-177; weight 6.7 pounds with net payload and parachute; 3 feet 8½ inches long; 5,000 feet altitude; 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; 40 pound payload 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; 12 pound payload to 72 miles; all services, NASA and Norway.

SPARROW-ARCAS

Two-stage sounding rocket; 1st—Aerojet Sparrow Mk 6 Mod 3, 2nd—HV ARCAS (29KS-324); weight 206 pounds plus payload; length 12 feet 6 inches; 12 pound payload 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-29s (122,000 pounds total thrust), 2nd—Lockheed Lance (47,000 pounds thrust), 3rd—Hercules Altair X-248 (3,000 pounds thrust), 4th—ARC/NASA 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; NASA, Army, AF.

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-19s (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 up to 300-kilometer altitude, remaining stages packaged in reverse to achieve 20-kilometer-per-second reentry velocity, 15 degrees off vertical at 75-kilometer altitude; 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 which contains 2 sets of the 3rd and 4th stages mounted in reverse; 1,575 pounds; 27.5 feet; 2 stages up to 120-kilometer altitude, 2 separate reentries of different pellet materials each with 11-kilometer-per-second reentry velocity, 15 degrees off vertical at 75-kilometer altitude; NASA.

NAVAL MISSILE CENTER, POINT MUGU, CALIFORNIA

SPAROAIR

Air-launched 2-stage research rocket for use on F3B or F6B jet aircraft; Mach 0.8 at 32,000 feet; 1st and 2nd—Aerojet Sparrow IIIs; 35 pound payload to altitude of 65 nautical miles; used in Projects Tee Pee, Jane, and Night Owl for plasma generation, infrared and ultraviolet research, respectively; Navy, Army, General Motors Corporation.

ROCKET POWER, INC.

HOPI CHAFF DART

Single-stage RPI 2.4-5600 HOPI-II solid motor; weight 95 pounds; length 11 feet; 11.5 pound payload 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; 10 pound payload (standard AF Mylar Robin Sphere) 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; 10 pound payload 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; 10 pound payload 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-II; weight 320 pounds; length 18 feet; 10 pound payload 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; 10 pound payload 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; 20 pound payload to altitude of 400,000 feet; all services.

Nitehawk 9

SANDIA CORPORATION

NITEHAWK 9

Two-stage solid propulsion sounding rocket; 1st—NIKE M5 (48,700 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,500 pounds thrust); 9 inches diameter; 125 pound gross payload to 200 mile altitude; Mach 8.5; Atomic Energy Commission.

NITEHAWK 12

Two-stage solid propulsion sounding rocket; 1st—NIKE M5 (48,700 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,500 pound thrust); 12 inches diameter; 200 pound gross payload to 110 mile altitude; Mach 6.2; Atomic Energy Commission.

THIOKOL CHEMICAL CORPORATION ASTRO-MET DIVISION

NIKE-TOMAHAWK

Two-stage solid sounding rocket; 1st—Hercules M-5, M5E1, 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; 80 to 240 pounds, 6¾- to 12-inch diameter payloads to altitudes between 95 and 300 miles; NASA, AF, 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; 125 pound payload to altitude of 60 miles (low-drag configuration with 60 pound payload to altitude of 130 miles and high-drag configuration with 80 pound payload 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; 140 pound (Dart) payload to altitude of 57 miles; NASA, Sandia.

ADVANCED TERRIER-TOMAHAWK

Two-stage solid sounding rocket; 1st—Hercules BT-3 Advanced Terrier (17,000 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,500 pounds thrust); weight 2,820 pounds; length 29.8 feet; 75 pound payload to altitude of 350 miles; Sandia.

SANDHAWK

Single-stage solid sounding rocket; Thiokol TE-M-473 Sandhawk (24,500 pounds thrust); weight 1,610 pounds; length 23.5 feet; 100 pound payload to altitude of 130 miles or 300 pound payload to altitude of 85 miles; Sandia.

Nike-Tomahawk

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