THE 1969 AEROSPACE YEAR BOOK

FORTY-SEVENTH EDITION

AIA

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

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FOREWORD

by Karl G. Harr, Jr.

President,
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The epochal Christmas lunar flight of Apollo 8 was an appropriate capstone to a year which was marked by record levels of activity across the entire aerospace spectrum.

The pinpoint perfection of the flight which for the first time placed man in orbit around the moon has been termed man's greatest technological achievement. To a major degree, it was made possible by the effective coordination between government and industry to satisfy a national requirement. The capability was possible because of the quality and maturity of technological and managerial resources and talents the aerospace industry has been building.

These resources and talents have not been limited to space spectaculars alone. Their application to other elements of aerospace activity resulted in other equally important, if less dramatic, advances, and indicated perhaps greater promise for the future. To an ever-increasing degree the aerospace industry is applying its ingenuity and resources to the solution of problems outside the traditional aerospace limits. This 1969 issue of the AEROSPACE YEAR BOOK records the aerospace industry's accomplishments during 1968 which establish a base on which to build progress in the future.

Statistically, the industry achieved new records by nearly every economic barometer—sales, backlog, exports, payrolls and commercial aircraft sales. Details of these economic indicators are reported on pages 44 and 45.

A purely quantitative measurement of accomplishment ignores the visible qualitative achievements of the year which may be even more meaningful.

In addition to the great advance in space exploration, transportation of people and payloads set records as industry marked the 10th anniversary of turbine-powered commercial flight by U.S.-built transports. Since the first U.S. turbojet was delivered in 1958, passenger miles have increased 300 percent and cargo ton-miles 441 percent. The predicted curve still shows an upward swing.

Reflecting such a predicted growth, production plans were announced for the high passenger capacity L-1011 and the DC-10 turbine transports while the intercontinental-range 747 with its ultimate capacity of 500 passengers was rolled out. The C-5A, the world's largest aircraft, made its first flight.

The effect of these huge new transports on air commerce and logistics promises to be as revolutionary as that of the first jet transports introduced in 1958. Such aircraft, together with the supersonic transport, provide the basis for an expansion in air travel during the next decade at least equal to the enormous growth during the one just completed.

Not to be outdone, utility and executive aircraft also continued their gains. The air taxi market, the so-called third-level carriers, made remarkable advances. It is now possible to travel from Florida to the State of Washington using only air taxi services. The general aviation industry today has more than met predictions of its growth and scope of service.

Commercial helicopter deliveries for the first time exceeded 500 units. Each year the industry is pushing more rapidly toward the ultimate billion-dollar market that awaits an economically viable vertical lift aircraft for inter- and intra-city passenger travel.

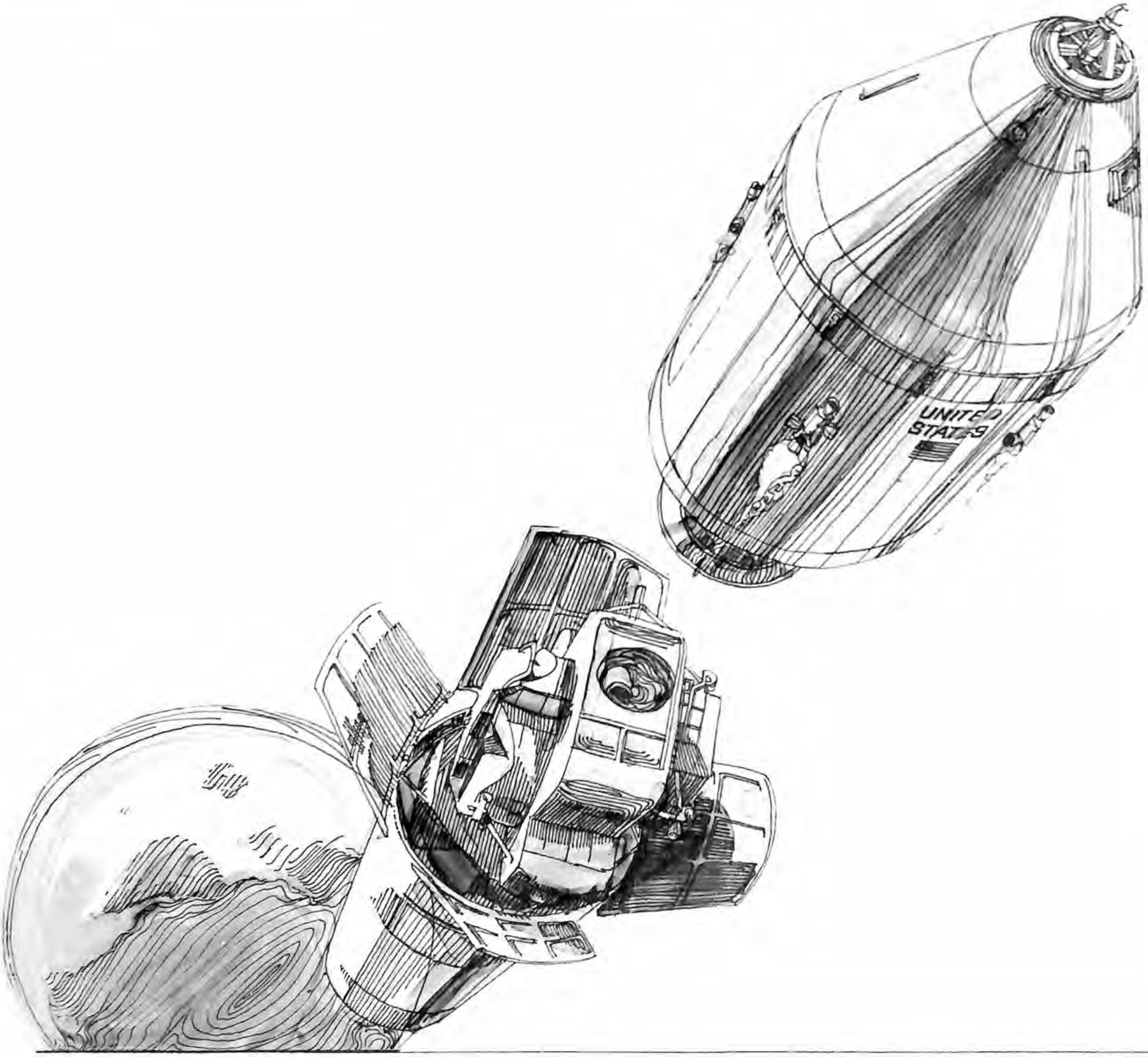
In other fields of aerospace activity, the lunar Surveyor program was successfully completed and the year also saw the launching of the world's most sophisticated and complex scientific satellite, the Orbiting Astronomical Observatory, from whose views of the universe space scientists confidently expect to gain more knowledge of astronomy than has been acquired in all the years since Galileo's invention of the telescope.

Going beyond its response to challenges in defense, commerce and space, the aerospace industry continued its search to apply its talents to the solution of socioeconomic problems. Certain that the appropriate capabilities exist, the industry has sought to demonstrate, through successful but relatively small-scale projects, the validity of this potentiality.

The President's 1968 report to the Congress on aeronautics and space activities gave recognition to such developments, stating: "A sound basis for determining that our nation benefits from such activity (space exploration) may be seen in the advances which have taken place in communications, meteorology, navigation, and earth resources observation, as well as the spin-offs from space research in the form of new products, new services, and novel managerial techniques. Beneficial beginnings have also been achieved in the application of space-proven systems analysis to urban problems and other non-space needs."

On a more parochial note the beginning of 1969 also marked the year of the 50th anniversary of the Aerospace Industries Association. AIA was formed in 1919 as the Aeronautical Chamber of Commerce. In 1945 the name was changed to Aircraft Industries Association. In 1959, the present name was adopted to reflect the industry's heavy involvement in missiles and space exploration.

Changing with the ever-changing needs of its environment, the Association has successfully met the demands of the past half-century. The accelerating pace of change will demand even greater resolve and adaptability in the half-century to come.



1968 Aerospace Events

A I A

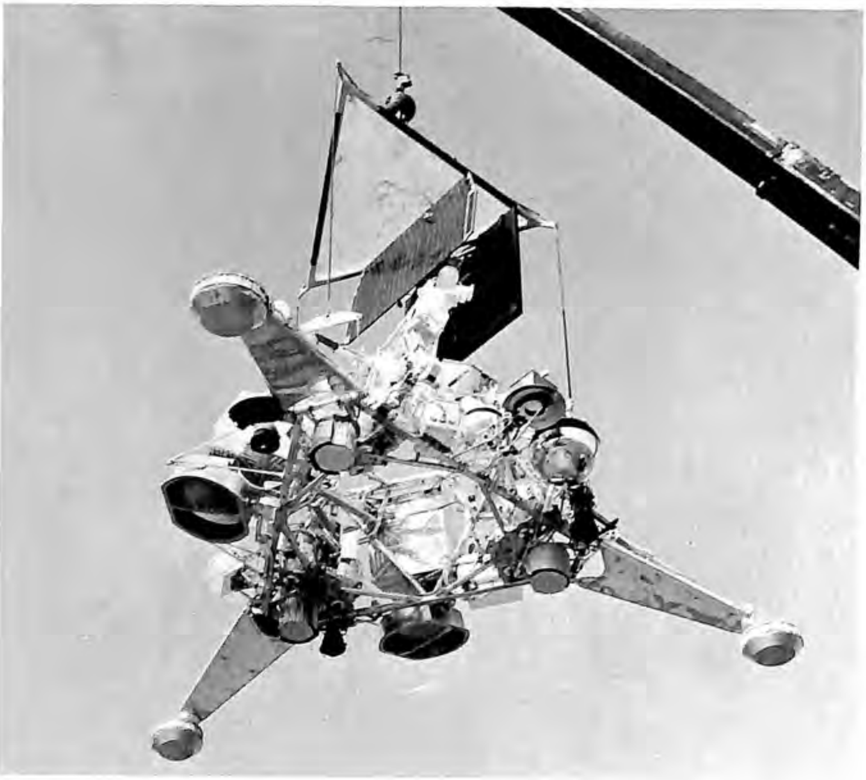
The highlights of the aerospace year, including major developments involving aerospace people and equipment and the aircraft, missiles, launch vehicles, spacecraft, engines and systems which passed notable milestones in 1968.

APOLLO

The most dramatic space flight yet made, possibly the greatest exploratory venture in history, highlighted the 1968 aerospace year. On December 21, NASA launched Apollo 8, crewed by (left to right in photo) James A. Lovell, Jr., William A. Anders and Frank Borman. The Apollo spacecraft, minus its Lunar Module, flew 240,000 miles to the moon, made 10 lunar revolutions in 20 hours, then returned safely to earth. Splashdown, following the fastest manned reentry ever made, occurred in the Pacific 147 hours after launch. Apollo 8 was the fourth Apollo mission of the year. The first manned flight of the Apollo program, Apollo 7, was launched October 21 into earth orbit. Astronauts Walter M. Schirra, Jr., Donn F. Eisele and Walter Cunningham checked out the spacecraft in a flight that covered 163 revolutions and 263 hours 56 minutes. The year's 2 unmanned Apollo flights included Apollo 5, launched January 22 into earth orbit, a successful first test of the Lunar Module, and Apollo 6, which sent a Command/Service Module spacecraft into earth orbit in what was primarily a test of the Saturn V launch vehicle. Major spacecraft contractors include North American Rockwell Corporation, Command/Service Modules; Grumman Aircraft Engineering Corporation, Lunar Module; Aerojet-General Corporation, basic spacecraft propulsion system; TRW Inc., Lunar Module descent engine; and Rocketdyne and Bell Aerosystems Company, LM ascent engine.

APOLLO APPLICATIONS

NASA continued definition studies and awarded new hardware contracts for Apollo Applications, the follow-on to the lunar landing program. In photo, a model of the cluster configuration planned as the first ApAps long-duration mission in the 1971-72 period. At top is the Apollo Telescope Mount with solar paddles extended. Familiar Apollo Command/Service Module manned ferry at left slips into docking adapter. Large module at right is the Orbital Workshop, a manned space experimental station. Major contractors are McDonnell Douglas Corporation and Martin Marietta Corporation.

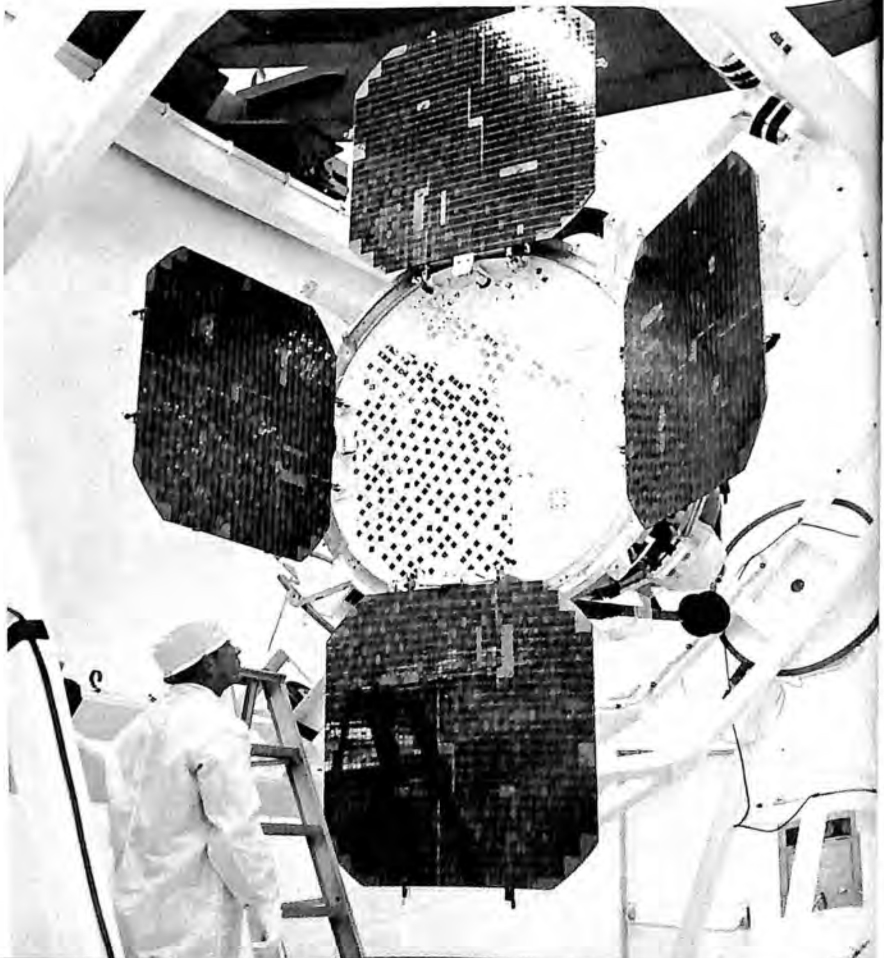


SURVEYOR

Launched January 7, Surveyor 7 landed on the moon January 10, successfully performed its photographic mission and conducted soil digging and analysis experiments. The flight concluded the Surveyor program with 5 successes in 7 tries. Hughes Aircraft Company built the Surveyors.

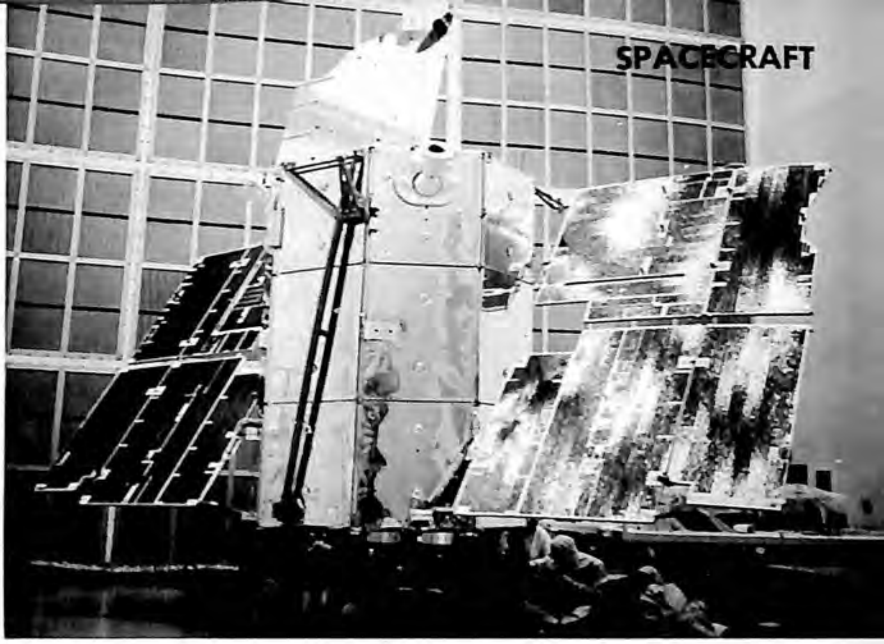
LUNAR ORBITER

After 6 months of successful lunar photography, Lunar Orbiter 5 was deliberately crashed to the moon's surface on January 31, ending the program with 5 successes for 5 attempts. In photo, a prelaunch test of the spacecraft's solar paddles, built for The Boeing Company, prime contractor, by RCA Astro-Electronics Division.



ORBITING ASTRONOMICAL OBSERVATORY

NASA scored a major success with the December 7 successful launch of the second Orbiting Astronomical Observatory. The largest U.S. unmanned spacecraft at 4,400 pounds, the Grumman-built OAO carried 7 telescopes to view the stars in the ultraviolet portion of the light spectrum, the portion not visible to the human eye or to ground-based observatories.



ORBITING GEOPHYSICAL OBSERVATORY

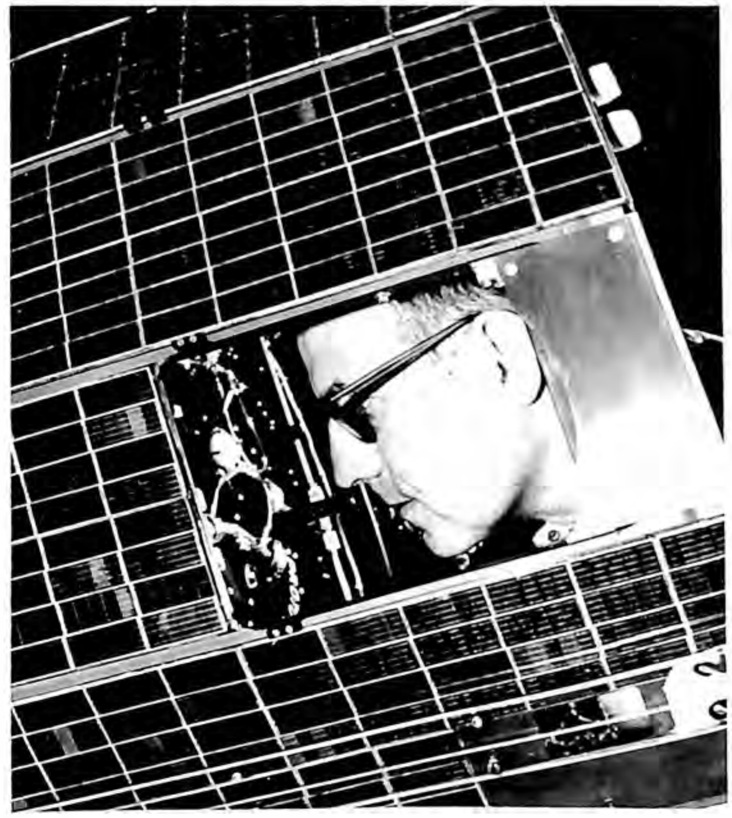
The fifth in a series of Orbiting Geophysical Observatories initiated in 1964 was successfully launched on March 4. Built by TRW Systems, OGO V was the heaviest of the OGOs and it carried the most experiments (25). Five of the experiments became inoperative, but the remainder continued to send back excellent data.

PIONEER

Another in the Pioneer series of interplanetary explorers was launched November 8 and at year-end it was operating successfully. Pioneer IX, for which TRW Inc., is prime contractor, joined 3 other active Pioneers in solar orbit. In addition to data on solar plasma, energetic particles and magnetic fields in the interplanetary environment, Pioneer IX was conducting a special study of solar flares.

INTELSAT III, IV

The U.S. Communications Satellite Corporation, launching agent for the 62-nation International Telecommunications Satellite Consortium, suffered the loss of the first of its new Intelsat III spacecraft in September but followed with a successful launch on December 18. The satellite went into synchronous orbit at 22,300 miles altitude over the Atlantic off the coast of Brazil. The TRW-built Intelsat III series spacecraft have 5 times the capacity (1,200 circuits) of any other civil comsat. In October, Comsat Corporation awarded Hughes Aircraft Company a contract for 4 Intelsat IV spacecraft, to provide more than 5,000 channels in the 1970s. In photo, Intelsat IV mock-up dwarfs early Syncom in foreground.



ESSA

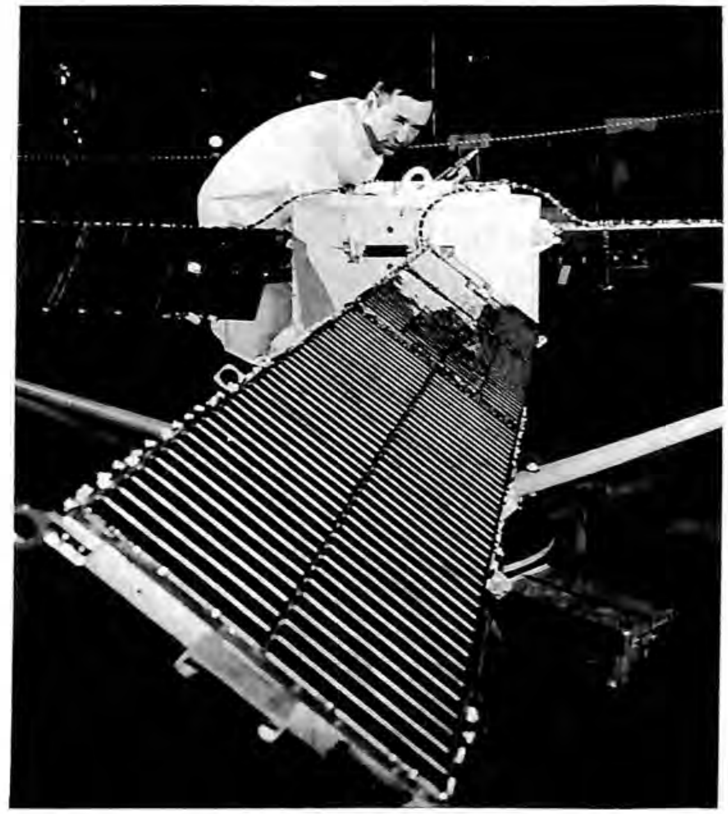
NASA launched, for the Environmental Science Services Administration, ESSA 7 (August 16) and ESSA 8 (December 15), operational meteorological satellites built by RCA. In photo, technician examines the interior of the solar-cell-covered ESSA 7.

INITIAL DEFENSE SATELLITE COMMUNICATIONS SYSTEM

On June 13, the Air Force launched 8 Philco-built Initial Defense Satellite Communications System spacecraft to complete the IDSCS network and bring to 25 the number of satellites in the system.

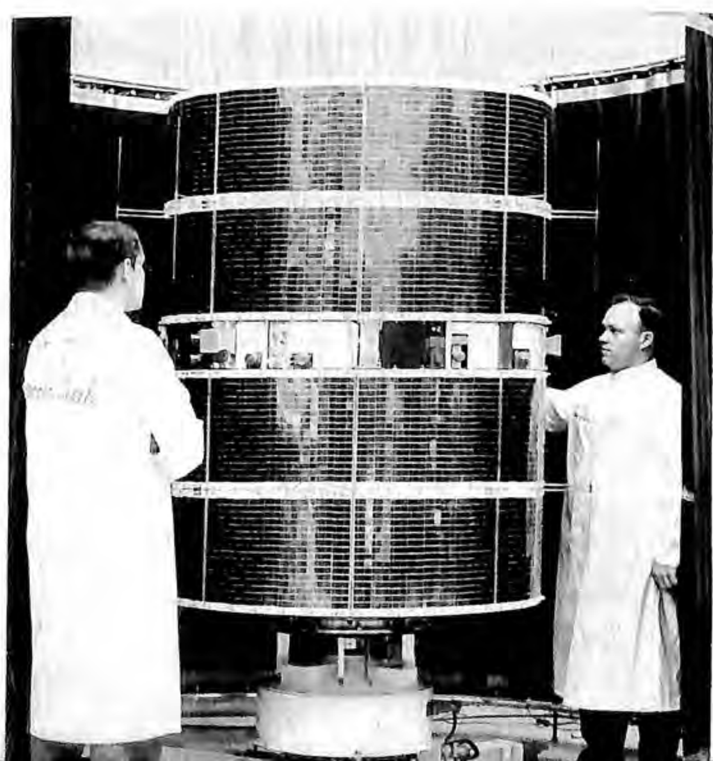
RADIO ASTRONOMY EXPLORER

NASA launched the first of 4 planned Radio Astronomy Explorer satellites on July 4. RAE 1 was launched into earth orbit to monitor low-frequency radio signals emanating from such sources as the Milky Way galaxy, possibly other galaxies, the sun, Jupiter and the earth environment. Goddard Space Flight Center was program director.



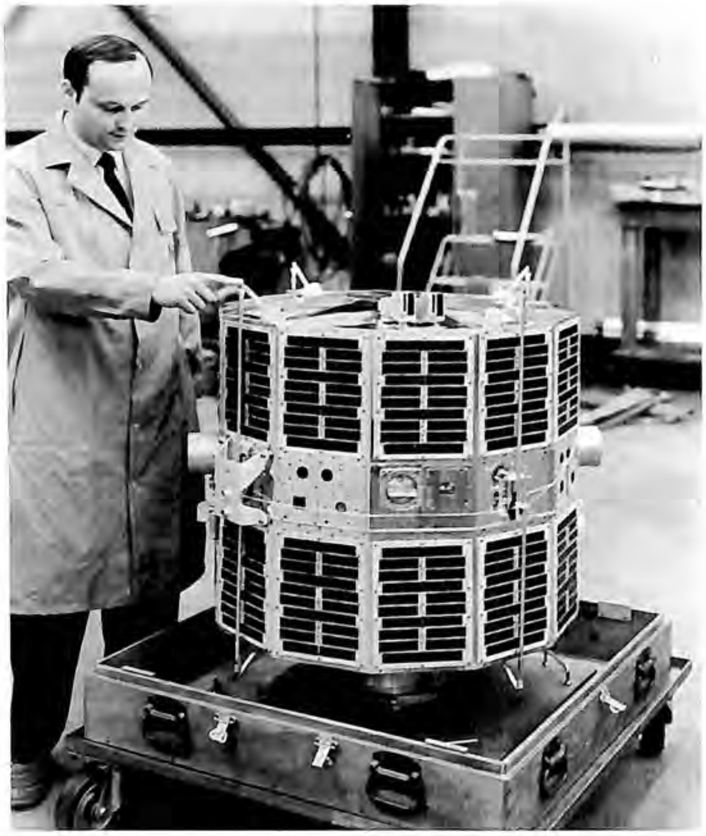
NAVIGATION SATELLITE

In March, the first operational Navy Navigation Satellite was launched. The Navy's navsat system is designed to enable Polaris/Poseidon submarines, surface attack vessels and other ships to fix their positions with an accuracy of approximately 600 feet, compared with 2 to 4 miles with conventional navigation methods. RCA's Astro-Electronics Division built the satellite under the technical direction of Johns Hopkins Applied Physics Laboratory.



LINCOLN EXPERIMENTAL SATELLITE

On September 26, the Air Force launched LES-6, the sixth in a family of experimental spacecraft designed and built by Lincoln Laboratory of Massachusetts Institute of Technology. Placed in synchronous orbit, LES-6 was designed to aid in development of a Department of Defense tactical communications satellite.



EXPLORER

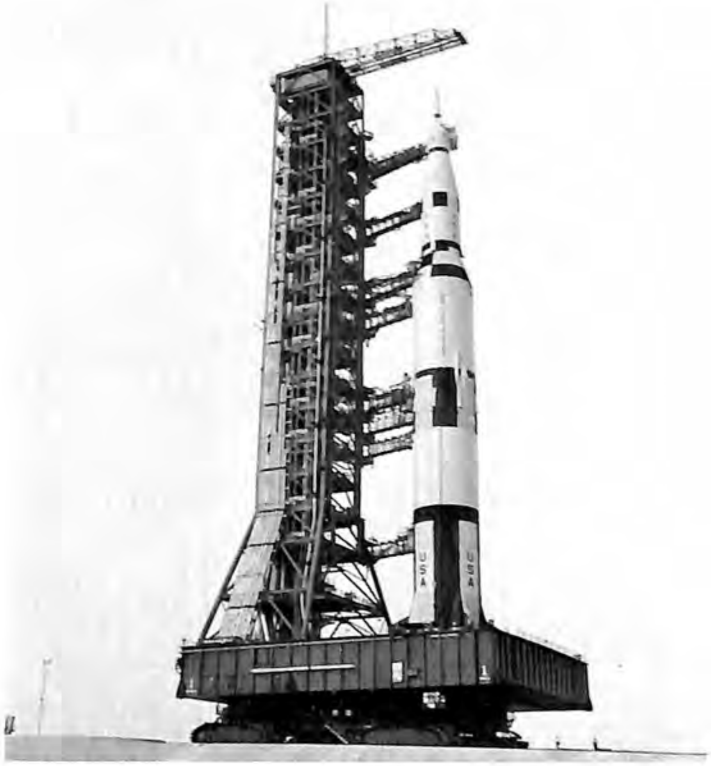
NASA launched 4 more of its Explorer series of scientific satellites in 1968. The first, launched January 11, was Explorer XXXVI, a geodetic satellite designed to provide highly accurate measurements of the spacecraft's trajectory in relation to the positions of selected sites on earth. Explorer XXXVII, launched March 5 in conjunction with the Naval Research Laboratory, was designed to measure solar X-ray and ultraviolet emissions. Explorer XXXIX, launched July 8, was seeking atmospheric density data and Explorer XL, a second payload on the same boost, was investigating charged particles. In photo, Explorer XXXVII.

ORBITING VEHICLES (No Photo)

In addition to more than a score of classified spacecraft, the Department of Defense continued to launch a series of scientific satellites called OVs (Orbiting Vehicles), among them OV1-13 and OV1-14, built by General Dynamics, launched April 6, to study radiation; OV1-15 and OV1-16, launched July 11 and also built by General Dynamics, the former an experiment in air density and solar radiation correlation, the latter an ionospheric drag experiment; the Northrop-built OV2-5, launched September 26, a comprehensive environmental research satellite carrying 11 experiments; and TRW's OV5-2 and OV5-5, also launched September 26 in a multiple launch with LES-6, the former to study radiation and the latter to obtain data on heat transfer under weightless conditions.

ESRO, HEOS

NASA provided launch support for 3 spacecraft designed and built by the European Space Research Organization. ESRO II-B, launched May 16, was a radiation investigator; ESRO I, launched October 3, carried experiments to study the aurora; and HEOS I, sent into orbit December 5, was designed to study interplanetary physics. In photo, launch of ESRO I from the Western Test Range.



TITAN III-C

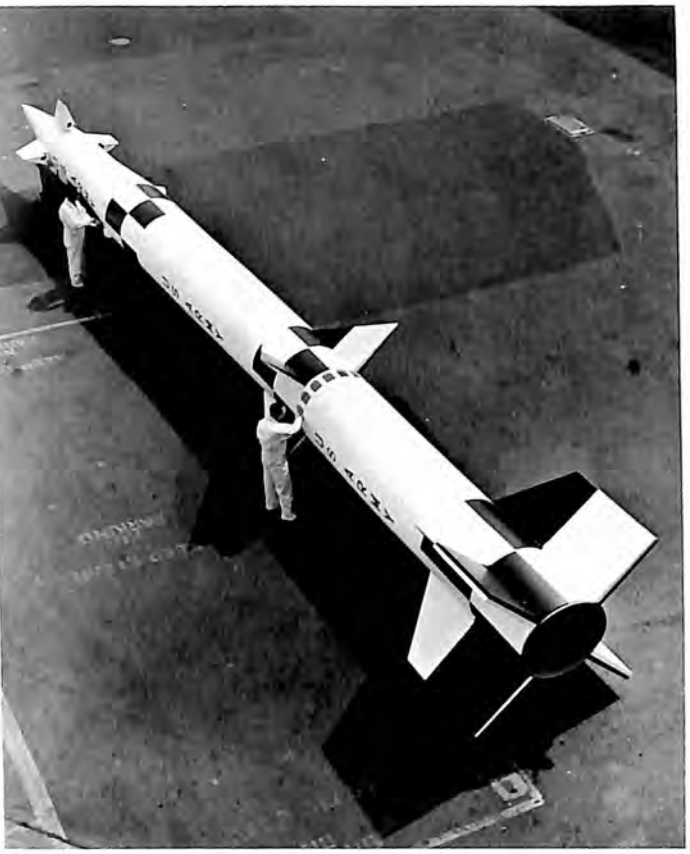
The USAF's Titan III-C made 2 additional flights in 1968, boosting 8 more military comsats on June 13 and sending into orbit the LES-6 experimental tactical comsat and other scientific payloads on September 24. Martin Marietta Corporation is vehicle prime contractor; Aerojet-General Corporation supplied the liquid-propellant engines, United Technology Center the solid-propellant boosters.

SATURN V

The Saturn V successfully completed its second and third flights, the latter boosting the historic Apollo 8 lunar mission (see page 1). The earlier flight, on April 4, involved launch of an unmanned Apollo 6 and qualification of Saturn V for manned flight. Major Saturn V contractors include The Boeing Company (first stage and integration); North American Rockwell's Space Division (second stage); McDonnell Douglas Corporation (third stage); IBM Federal Systems Division (Instrument Unit); and Rocketdyne Division of North American Rockwell (propulsion systems for all stages).

LONG TANK DELTA

Newest member of the workhorse Delta family, the Long Tank Delta, made its flight debut on August 16, launching the ESSA 7 weather-watch satellite. The launch vehicle is built by McDonnell Douglas Corporation.



A

B

SENTINEL

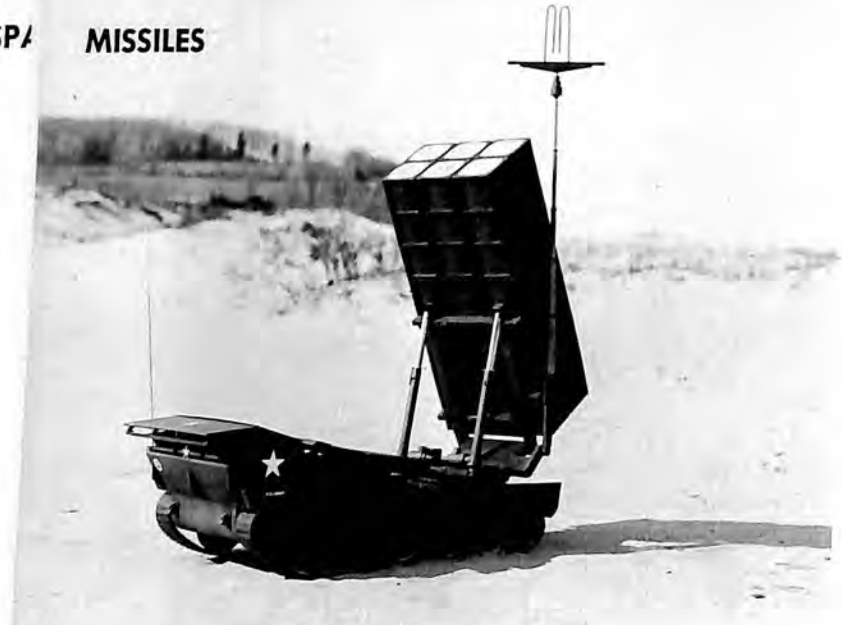
The Army's Sentinel Missile Defense System moved into a new developmental phase with initial firings of the Spartan missile and start of an advanced test program on the Sprint missile. Spartan, the long-range member of the 2-missile team in the anti-ICBM system, made its first flight on April 4 at Kwajalein Test Range in the Marshall Islands. The 55-foot Spartan (photo A), capable of intercepting incoming warheads at ranges of "several hundred" miles, is built by McDonnell Douglas Corporation's Missile and Space Systems Division. Also in the spring, at White Sands Missile Range, New Mexico, the Army initiated tests in which the Sprint blasts its way through the fiberglass lid of its launch cell (photo B), a technique designed to reduce reaction time to the minimum. Early tests showed that the missile suffered no damage on the "fly-through" that would affect its flight performance. Sprint is built by Martin Marietta Corporation.

POSEIDON

Poseidon, the latest of the Navy's family of submarine-launched ballistic missiles, made its first full-scale flight on August 16 and it was pronounced a "complete success." Built by Lockheed Missiles & Space Company, Poseidon has double the payload of its predecessor, the A3 Polaris, and is twice as accurate. It is scheduled to arm 31 of the 41 Fleet Ballistic Missile submarines and can be fitted into Polaris launch tubes.

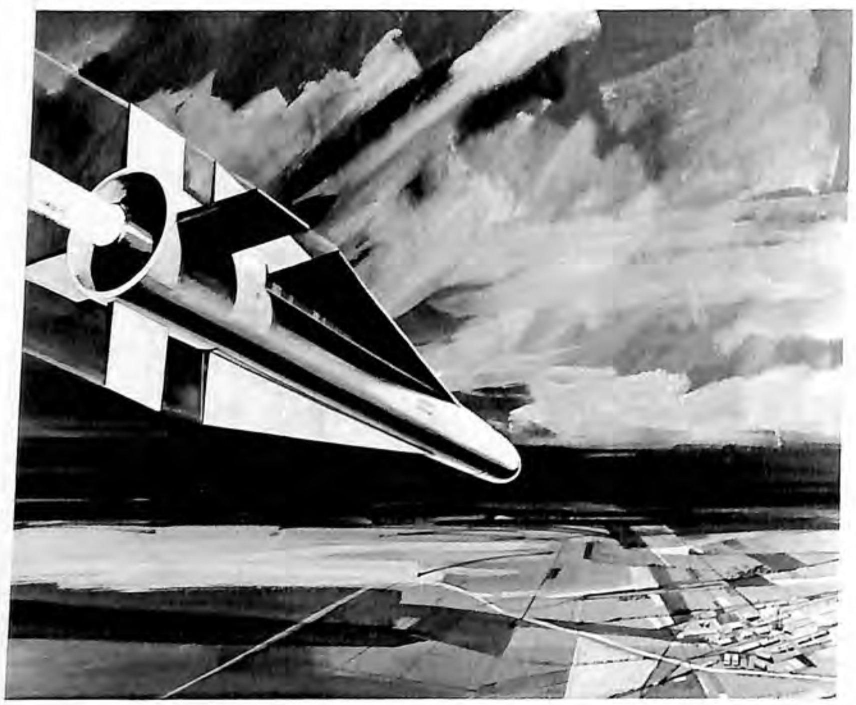
MINUTEMAN III

Also test flown for the first time on August 16 was the Air Force's Minuteman III, newest version of the 3-stage solid-fueled ICBM. Minuteman III has a new reentry system and a third-stage engine of increased diameter to provide added flexibility in delivering heavier payloads than earlier models. Weapon systems integrator for Minuteman III is The Boeing Company.



SAM-D

In advanced development at Raytheon Company's Missile Systems Division was SAM-D, an Army multiple-launch air defense system designed for field use against aircraft or short-range missiles. In photo, a mock-up of SAM-D's tracked launcher and the missile launch group.



MAVERICK

In midsummer, Hughes Aircraft Company received a contract to develop, test and produce the Maverick, a TV-guided air-to-ground weapon designed to knock out enemy tanks, armored vehicles and field fortifications. Maverick will be carried by tactical aircraft such as the McDonnell Douglas A-7 and F-4 and the General Dynamics F-111.

SRAM

Initial tests were conducted on SRAM (Short-Range Attack Missile), an Air Force weapon for air-launch use against ground targets. The system is being developed by The Boeing Company.

REDEYE

In 1968, the Army deployed the bazooka-like Redeye to Europe and General Dynamics' production rate reached 1,000 missiles a month. The company was awarded a contract to develop an air-launched version of Redeye called RAM.

CHAPARRAL

Production testing was started on the Army's Chaparral, built by Aeronutronic Division, Philco-Ford Corporation. Chaparral was selected as one of 2 weapons to be included in new air battalions being organized to provide field commanders with defense against low-flying aircraft.

DRAGON

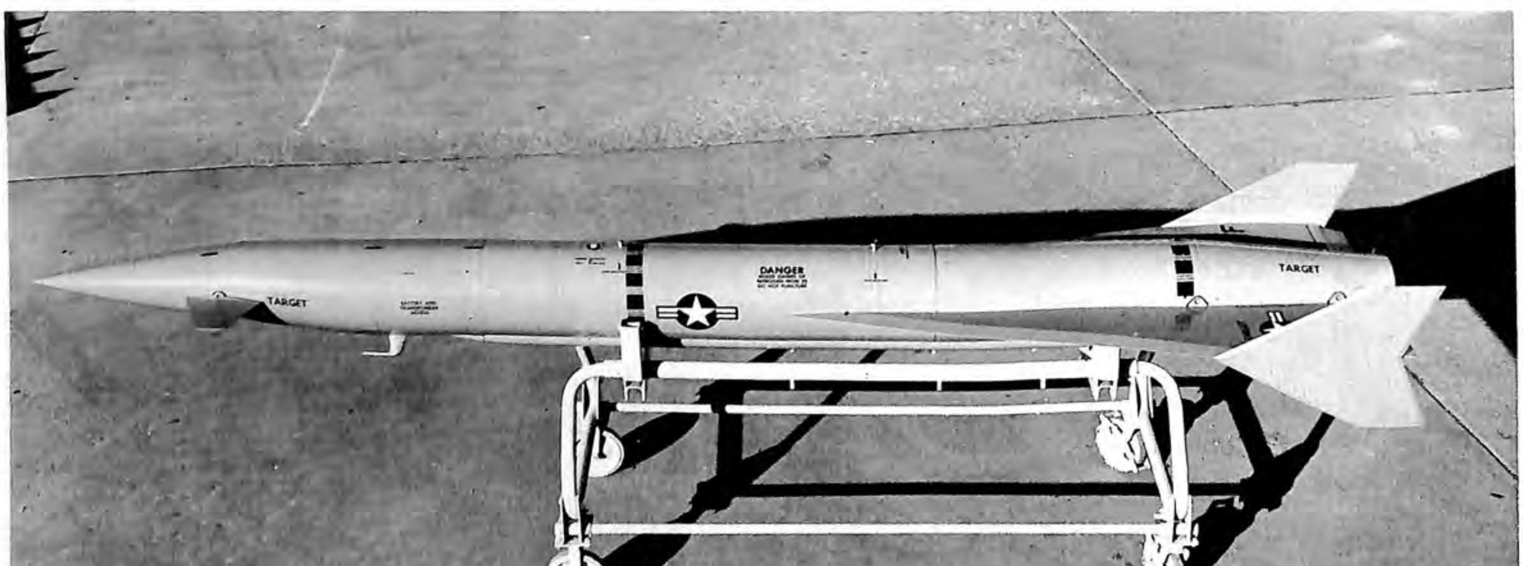
The Army's McDonnell Douglas-built Dragon was fired for the first time with manned guidance on July 5 at Redstone Arsenal, Alabama. Dragon is a shoulder-fired weapon designed for use against armor and field fortifications.

FIREBEE II

Initial test flights of the Navy's Firebee II supersonic target system, built by Ryan Aeronautical Company, began in June. By September, Firebee II had reached its design speed of Mach 1.5. Ryan was under contract to build 14 prototypes, and operational targets were to be in fleet use by 1970.

SANDPIPER

First flight tests got under way on the Sandpiper supersonic target missile, built by Beech Aircraft Corporation for the Air Force. In early flights, Sandpiper reached speeds of Mach 2 after launch from a McDonnell Douglas F-4C; design called for Mach 4 at 90,000 feet, to be attained in later tests. Tests were conducted at Eglin AFB, Florida.

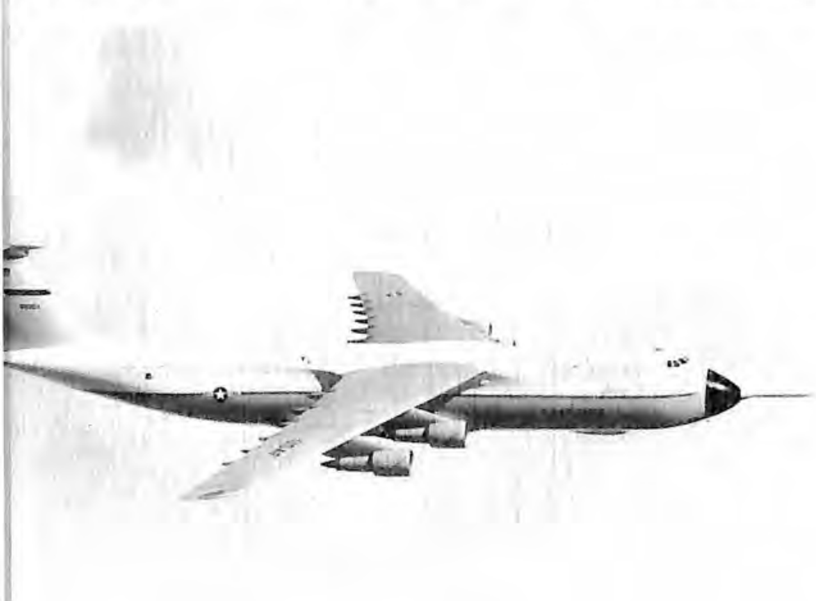


BOEING SUPERSONIC TRANSPORT

The U.S. supersonic transport, being developed by The Boeing Company, underwent another major design change in 1968. The company dropped the swing-wing approach and said it would recommend to the Federal Aviation Administration early in 1969 the design pictured here. The design has a fixed-sweep wing and a conventional tail; also dropped were the forward canard surfaces on the earlier design.

BOEING 747

The Boeing 747 superjet, which will become the world's largest commercial airliner when deliveries begin late in 1969, was unveiled in a public showing September 30 at the company's Everett, Washington, facility. The 747 will gross 710,000 pounds.



LOCKHEED C-5A GALAXY

Currently the world's largest airplane, the Lockheed C-5A Galaxy completed an initial series of 8 test flights between June 30 and August 5. Officials of Lockheed-Georgia Company pronounced the tests "extremely successful." A second series of tests of the USAF heavy logistics transport was under way at year-end.

LOCKHEED L-1011

Lockheed Aircraft Corporation announced its intention to build a "new-generation" jetliner, to be powered by 3 turbofans and to cruise at 600 miles per hour. The L-1011 will carry from 256 to 345 passengers. The L-1011 program will be conducted at Lockheed-California Company.

McDONNELL DOUGLAS DC-10

McDonnell Douglas Corporation also announced plans to build an advanced technology jetliner. Designated DC-10, the plane will be able to carry 345 passengers in an all-economy configuration and 252 passengers in a mixed-class configuration.

BOEING 737

The Boeing Company started deliveries of its 737 twin-jet airliner. First to go into European service with the 737 was Britannia Airways, which had on order 4 of the long-bodied 737-200s.

LOCKHEED P-3C ORION

Lockheed-California's advanced P-3C version of the Orion made its initial flight. The computer-based A-NEW sub detection system carried by the P-3C enables retrieval, transmission and display of tactical data with unprecedented speed and accuracy.

McDONNELL DOUGLAS DC-8 SUPER 63CF

The McDonnell Douglas DC-8 Super 63CF, the world's largest commercial cargo transport in airline service, successfully completed its maiden flight on March 21. The 63CF is a convertible cargo-passenger transport which can lift a maximum payload of 110,000 pounds of bulk-loaded cargo.

McDONNELL DOUGLAS DC-9 SERIES 40, 20

McDonnell Douglas Corporation's Douglas Aircraft Company introduced 2 new versions of the DC-9. Certification was completed and first deliveries were made of the DC-9 Series 40, 10 feet longer than the preceding series. The first model of the Series 20 (shown), designed for service on routes with small airfields, made its initial flight on September 18.

McDONNELL DOUGLAS C-9A

The McDonnell Douglas C-9A Nightingale, an aeromedical airlift version of the DC-9, started flying in June and first deliveries to the Air Force were made in August. The company was building 12 of the planes, for operation by Military Airlift Command's 375th Aeromedical Airlift Wing.

McDONNELL DOUGLAS 188

McDonnell Douglas Corporation, Eastern Airlines and the Federal Aviation Administration teamed in a 1968 demonstration of the capabilities of a STOL aircraft on airline routes. The McDonnell Douglas 188 was operated for 7 weeks over Eastern's Washington, New York and Boston routes. This was followed by a 3-week evaluation of the STOLplane at FAA's National Aviation Facilities Experimental Center.

LEARJET 25

Lear Jet Industries commenced deliveries of the new Learjet 25 (left in photo), which carries 2 additional passengers and is more than 4 feet longer than the 8-place Learjet 24 (at right).

CESSNA 500

Cessna Aircraft Company announced a broadening of its product line to include the Fanjet 500, an 8-place corporate aircraft powered by 2 fanjets developing a total of 4,400 pounds take-off thrust. Deliveries will start in 1972.

BEECH 99

Beech Aircraft Corporation received FAA certification and made the first delivery in May of the Beech 99 airliner. The company also introduced an 8-10 place corporate version of the 99.

SWEARINGEN MERLIN IIB, METRO

Swearingen Aircraft received a type certificate on June 12 for its Merlin IIB corporate aircraft, which first flew in 1967. Swearingen also had in prototype construction the Metro, a 20-passenger commuter airliner, a joint development with Fairchild Hiller Corporation.

PIPER POCONO

Piper Aircraft Corporation entered the commuter airliner field with its 18-place PA-35 Pocono. The plane made its initial flight on May 13.

FAIRCHILD HILLER C-123K

A new model of the venerable Fairchild Hiller C-123, the C-123K, went into operational service in Vietnam. The assault transport is equipped with auxiliary jet engines to give it STOL characteristics.

GRUMMAN EA-6B

Grumman Aircraft Engineering Corporation's EA-6B, Navy tactical countermeasures aircraft, made its first flight in May. The EA-6B is an advanced, 4-place version of the in-service 2-place EA-6A.

GENERAL DYNAMICS FB-111A

The first production version of the General Dynamics FB-111A strategic bomber made its initial flight in July. The FB-111As are scheduled to replace the USAF's Strategic Air Command B-52s, C through F series.

GENERAL DYNAMICS F-111

The Royal Australian Air Force formally accepted the first of 24 General Dynamics F-111Cs in September.

McDONNELL DOUGLAS F-4K, F-4M

On April 29, McDonnell Douglas Corporation delivered the first F-4K to the United Kingdom's Royal Navy at Yeovilton, England. In July, McDonnell Douglas started deliveries of the Royal Air Force version, the F-4M.

CESSNA A-37B

Cessna Aircraft Company rolled out and started flight testing the first models of the A-37B attack aircraft, an advanced version of the A-37A operational in Vietnam. The company had USAF orders for 127 of the Bs.

LOCKHEED AH-56A CHEYENNE

Lockheed-California Company received the Army production go-ahead in January for 375 AH-56A Cheyenne compound helicopters. The Cheyenne was to undergo Army service evaluation in 1969.

SIKORSKY HH-3F

The Coast Guard took first deliveries of the Sikorsky HH-3F, which is equipped with some of the most sophisticated navigational and communications equipment ever carried by a rotary-wing search and rescue aircraft.

BELL OH-58A

Textron's Bell Helicopter Company won a re-opened Army competition for light observation helicopters with the OH-58A. The company received orders for 2,200 of the 5-place turbine-powered helicopters, with deliveries to begin in 1969 and continue through 1972.

BELL TH-57A

The Navy selected as its light turbine training helicopter the Bell TH-57A, a variant of the Model 206A JetRanger. Bell received an initial order for 40 helicopters.

BELL UH-1N

Bell Helicopter Company developed a twin-engine version of the UH-1 Iroquois series. The USAF ordered 76 of the twinned versions, with deliveries to start in 1969.

BELL AH-1J

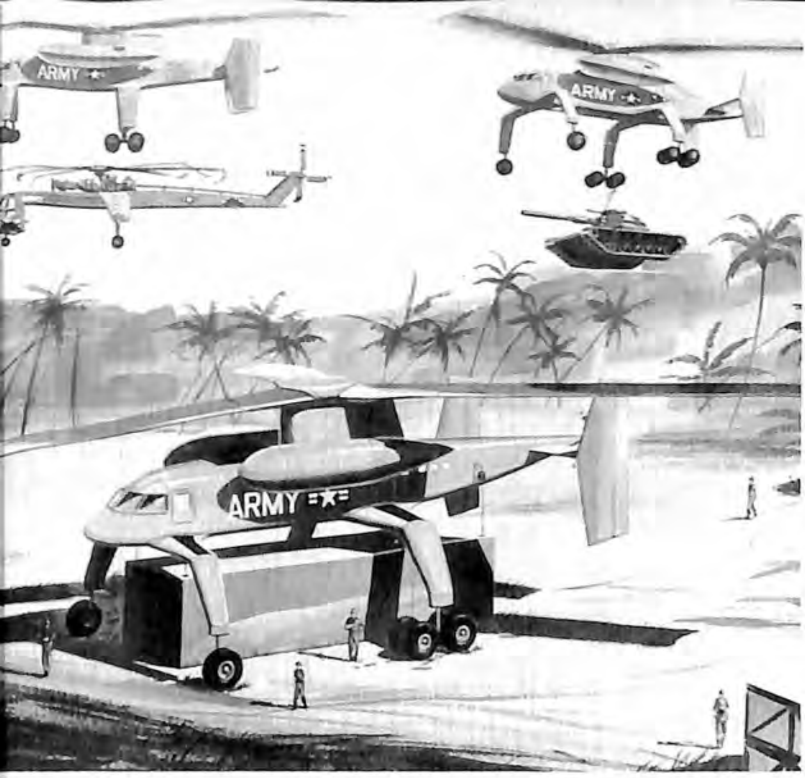
Bell also developed a twinned version of its high speed HueyCobra, which has scored an outstanding record in Vietnam. The Marine Corps ordered 49 of the new twins and gave the craft the designation AH-1J.

BELL 212

For the civilian market, Bell started development of the 212 Twin Jet, a 15-place helicopter powered by 2 turbine engines. First deliveries were planned for 1970.

FAIRCHILD HILLER FH-1100

Fairchild Hiller Corporation added an ambulance configuration to the FH-1100 helicopter line. The air ambulance carries 2 litters, a medical attendant and a pilot.



HUGHES HEAVY LIFTER

In November, Hughes Tool Company announced plans to develop a heavy-lift helicopter to have a payload 3 to 5 times that of 1968's best lifting helicopter. The design will employ the "hot cycle" concept.

RYAN XV-5B VERTIFAN

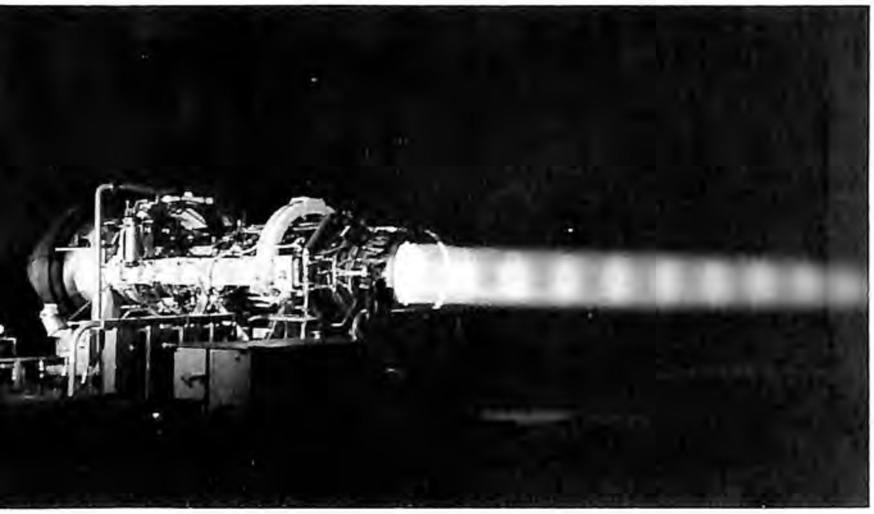
The Ryan XV-5B, an Army research V/STOL turned over to NASA for additional testing, completed its airworthiness flight test program after extensive renovation from the A to the B configuration. The Vertifan, which employs wing fans for vertical lift, was delivered to NASA's Ames Research Center on August 28.

LOCKHEED-GEORGIA XV-4B

The USAF's XV-4B Hummingbird, VTOL research plane, began captive flight tests on June 24. Built by Lockheed-Georgia Company, the XV-4B has 4 engines mounted vertically for direct lift and 2 mounted horizontally for lift-cruise power. Lockheed test pilot B. J. Dvorscak stands beside XV-4B in test rig.

NORTHROP HL-10

The Northrop-built HL-10, NASA lifting body research vehicle, started first powered flights in October. The craft is powered by a Thiokol XLR-11 4-chamber rocket engine.



GENERAL ELECTRIC GE4

The General Electric GE4, engine for the U.S. supersonic transport, shown on test at the company's Peebles, Ohio, outdoor facility, reached a thrust level of 63,000 pounds in September. By year-end, the engine had accumulated more than 600 test hours.

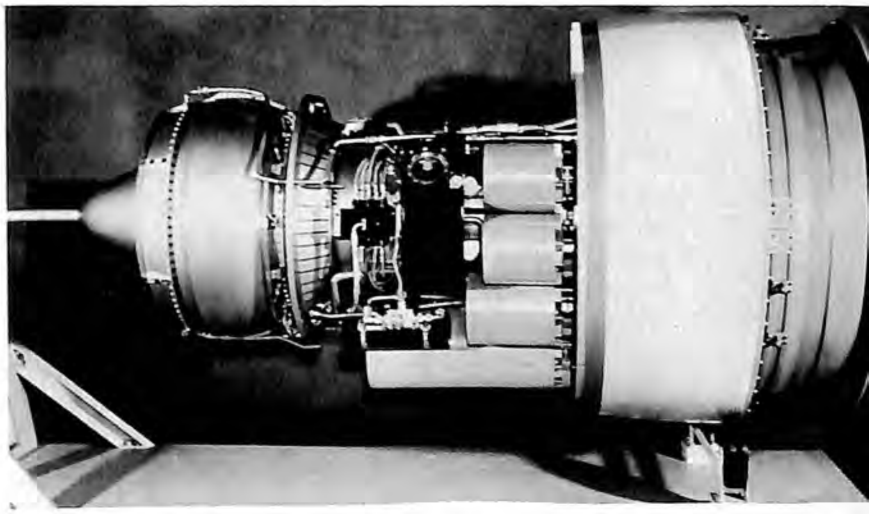
PRATT & WHITNEY AIRCRAFT JT9D

The Pratt & Whitney Aircraft JT9D advanced technology turbofan, slated to power the Boeing 747 and McDonnell Douglas DC-10 Series 20, started flight testing in June aboard a modified B-52. First deliveries of engines with 43,500 pounds thrust were made and higher thrust models were planned.

ALLISON TF41 TURBOFAN

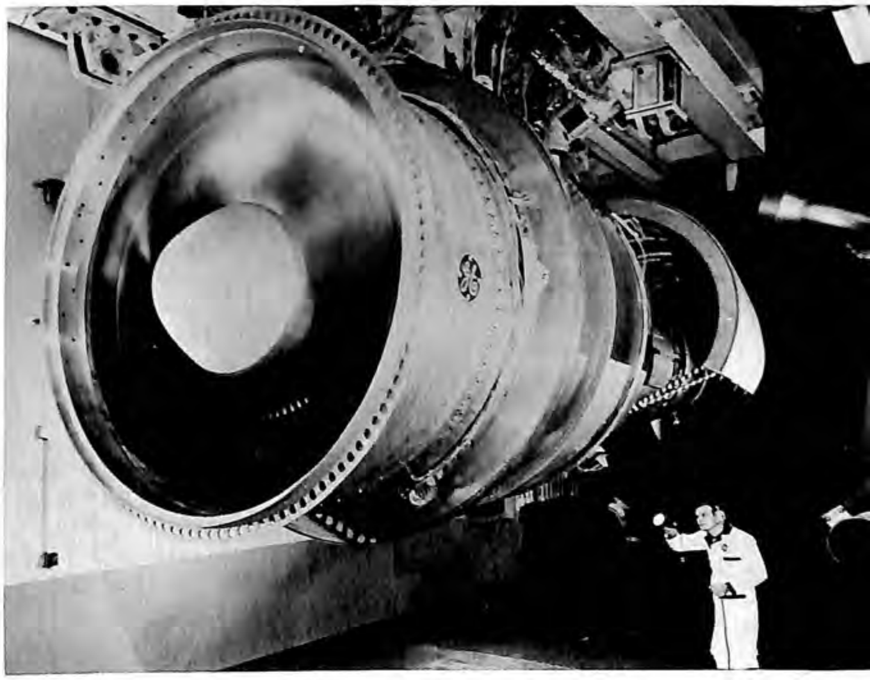
The TF41 turbofan engine, developed by Allison Division of General Motors jointly with Rolls-Royce Ltd., made its maiden flight in the spring and entered production in June. Power plant for the USAF's A-7D attack bomber, the TF41 produces 14,250 pounds thrust.

GENERAL ELECTRIC TF34, TF39

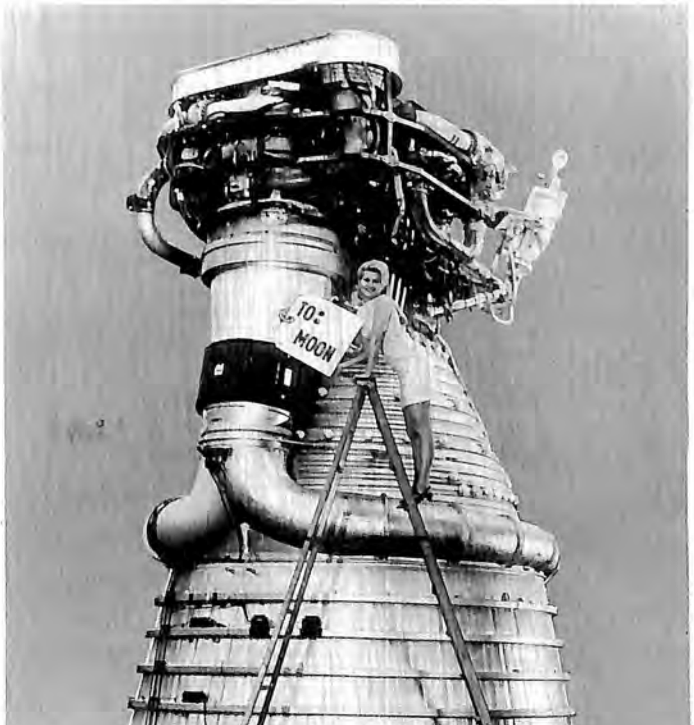


On May 27, GE unveiled a mock-up of its new TF34 high bypass ratio turbofan, selected by the Navy to power the proposed VSX anti-sub aircraft. GE said that the TF34 (photo) is an extension of technology pioneered in the TF39, the 41,000-pound-thrust turbofan which first flew June 30 on the initial flight of the Lockheed C-5A.

GENERAL ELECTRIC CF6



General Electric Company ran its CF6 turbofan for the first time on October 21 and the engine reached its guaranteed thrust rating only a week later. The 42,000-pound-thrust CF6 will power the McDonnell Douglas DC-10 Series 10.



ROCKETDYNE F-1

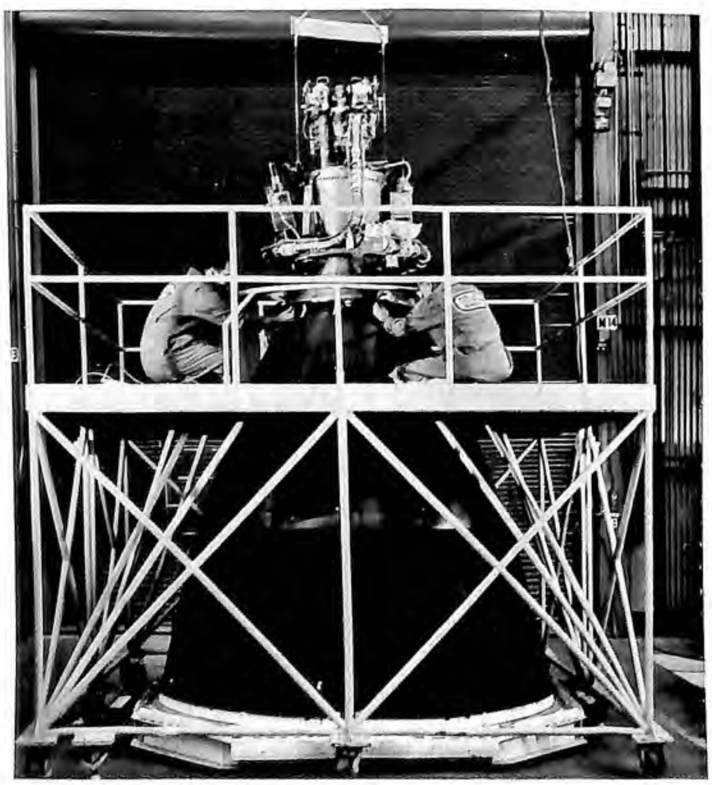
The F-1, world's most powerful rocket engine, was uprated to 1,522,000 pounds thrust. Five F-1s powered the basic stage of Saturn V in the launches of Apollo 7, first manned Apollo flight, and Apollo 8, first lunar mission.

THIOKOL 156-INCH SOLID MOTOR

With a static firing of its 156-inch-diameter motor, the TU 562, Thiokol Chemical Corporation closed the Air Force Large Solid Rocket Motor Program, making available a large solid booster for future use.

APOLLO SERVICE PROPULSION SYSTEM

The Apollo Service Propulsion System, built by Aerojet-General Corporation, performed perfectly on its first deep space test, Apollo 8. The 20,500-pound-thrust engine made a series of precise burns, including the all-important firing that took the astronauts out of lunar orbit.



LUNAR MODULE ENGINES

The 2 propulsion systems in the Apollo Lunar Module—the TRW-built descent engine (photo) and Bell Aerosystems/Rocketdyne ascent engine—made their space debuts in January. Both performed well on the Apollo 5 unmanned test of the Lunar Module launched January 22.

PHOEBUS 2A/NERVA

Another step toward development of a reactor system for the NASA/AEC NERVA nuclear rocket engine was taken June 26, when the powerful Phoebus 2A reactor ran for 32 minutes, including 12 minutes above 4,000 megawatts, at Jackass Flats, Nevada.

The term "systems" is used 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.

RCA CAMERA

RCA's Astro-Electronics Division developed the 4½-pound TV camera which made possible the first "live" transmissions from the moon.

HONEYWELL LASER

Honeywell Systems and Research Center conducted the first demonstration of voice signal transmission by means of a carbon dioxide laser. The work, aimed at deep space applications, was done for NASA's Marshall Space Flight Center.

BELL AEROSYSTEMS POGO

The Body-Controlled Pogo Vehicle, being developed by Textron's Bell Aerosystems Company as a future lunar flying vehicle, made its first manned free flight in August.

GOODYEAR MINITIRES

For smoother cargo handling on the Boeing 747 jetliner, Goodyear Tire & Rubber Company developed the Terra-Tire, only 9 inches in diameter. The 747 cargo handling system will employ 45 of the minitires and a system of rollers to "float" cargo containers.

RCA NAVIGATION/LANDING SYSTEM

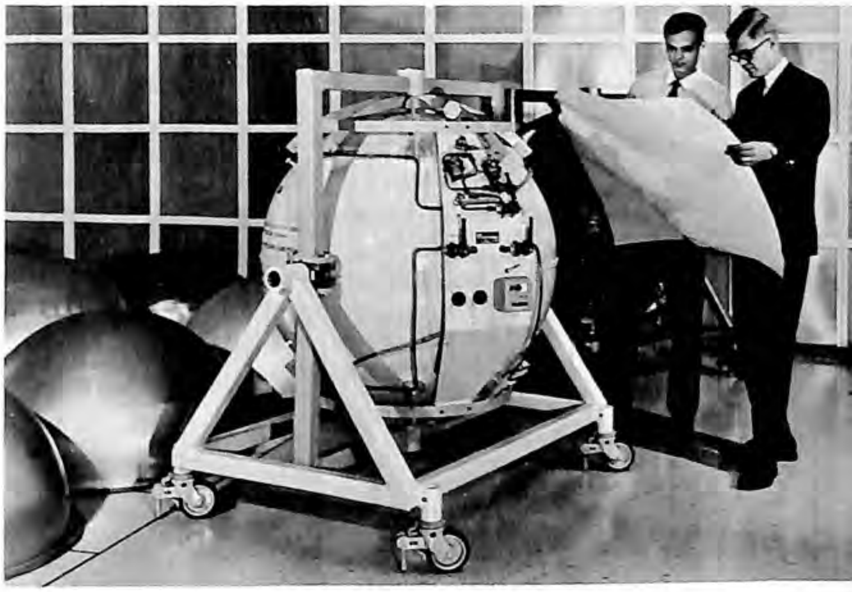
RCA's Aviation Equipment Department introduced a compact new system (left) that combines into one unit all the navigation and instrument landing functions required by an aircraft and replaces as many as 6 separate "black boxes."

LEAR SIEGLER/COLLINS AVIONICS

Lear Siegler, Inc., and Collins Radio Company initiated development of the avionics flight control system for the Lockheed L-1011 trijet under a $40,000,000 contract.

BENDIX CRYOGENIC STORAGE SYSTEM

The Bendix Corporation's Instruments & Life Support Division developed a cryogenic gas storage system for long-duration use. It was being evaluated for the first 56-day mission of NASA's Apollo Applications program.



GOODYEAR BAGGAGE CONTAINER

Goodyear Aerospace developed a new baggage handling system for the Boeing 747. Its major feature is the bonded aluminum container shown, which holds up to 55 suitcases.

WESTINGHOUSE ALPS

Westinghouse Electric's Missile Launching & Handling Department developed ALPS (Automatic Loading and Positioning System) for loading from tender to sub missiles like Poseidon, too heavy for man handling. The system was tested successfully during 1968.

SPERRY UNIFIED DISPLAY

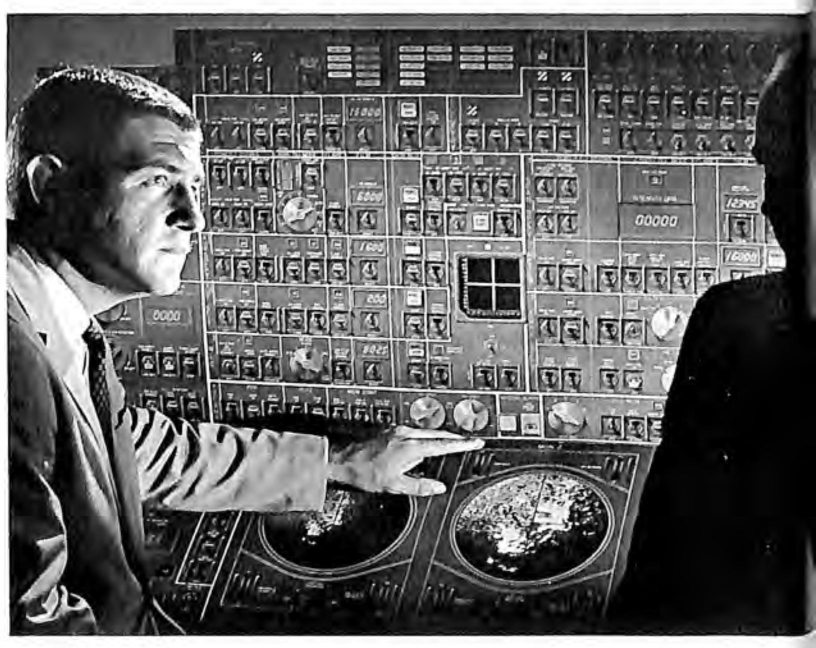
Composite picture illustrates the new unified display of air traffic being used in the New York area. Aircraft landing or taking off at any of the area's 3 airports appear as blips on large screens in the New York Common IFR Room. Heart of the system is 2 Sperry Rand UNIVAC 1219 computers, which process the radar signals.

RYAN ROBOT JEEP

Artist's concept shows operation of a remotely controlled mine-detecting jeep being developed for the Army Mobility Equipment Research and Development Center by Ryan Aeronautical Company.

BENDIX ATM DISPLAYS

In mock-up form are the Bendix controls and displays for stabilizing the spacecraft and conducting experiments aboard the Apollo Telescope Mount. ATM is a manned spacecraft with which NASA will conduct a 56-day study of the sun. Bendix' Navigation & Control Division is developing the system.

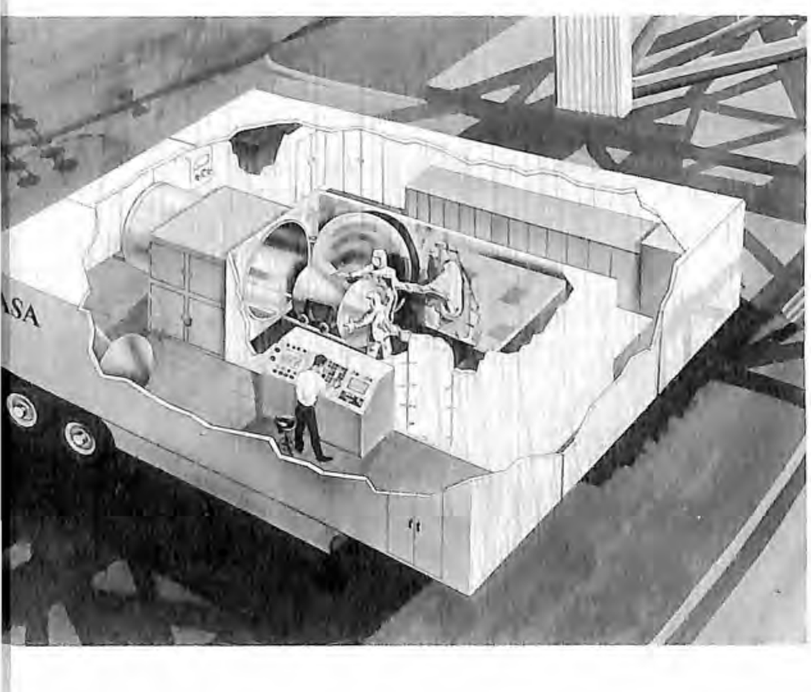


FAIRCHILD HILLER SSU

Fairchild Hiller's Space and Electronics Systems Division designed and developed the SSU (Space Support Unit) to provide support services for ion engine experiments in the SERT II program. The SSU's functions include acquisition and tracking, command link, telemetry, control moment gyro operation, instrumentation and signal conditioning, and structural and thermal provisions.

ITT LORAN-C/D

ITT Avionics developed the AN/ARN-92 Loran-C/D, the first aircraft navigation system providing fully automatic operation. The system's automatic capability extends the variety and scope of Loran applications to include weapons delivery, reconnaissance, parachute drop control and search/rescue.



AVCO STERILIZATION UNIT

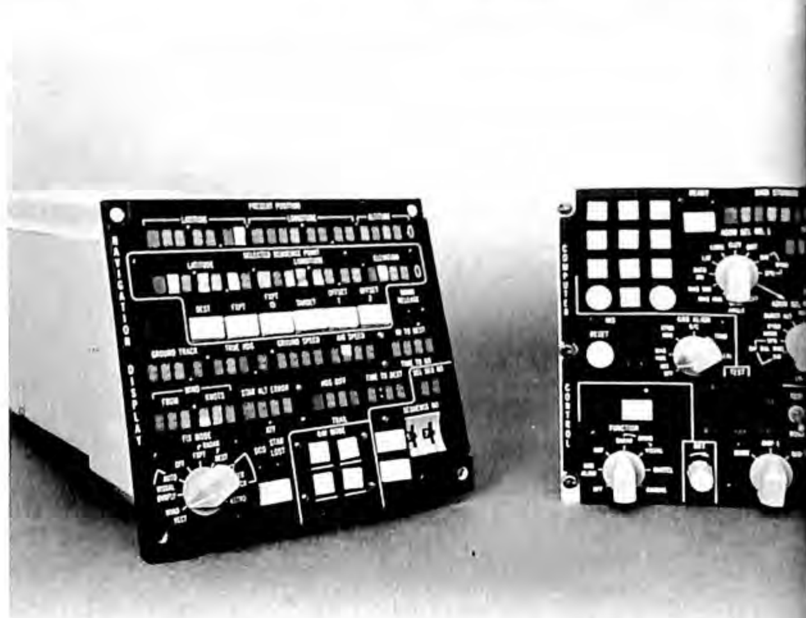
For NASA's Langley Research Center, Avco Corporation's Space Systems Division developed a mobile sterilization unit in which interplanetary spacecraft can be assembled or repaired. The mobility factor of MAST (Model Assembly Sterilizer for Test) permits spacecraft repairs or component replacement at the launch site with minimal interruption to countdown and no risk of contamination.

BELL ACLG

Textron's Bell Aerosystems made the first flight demonstrating the new braking technique for the experimental Air Cushion Landing Gear (ACLG). A temporary nose wheel and outrigger-like wing skids were installed to maintain a level ground attitude when the air cushion bag is deflated and the aircraft rests on its hull.

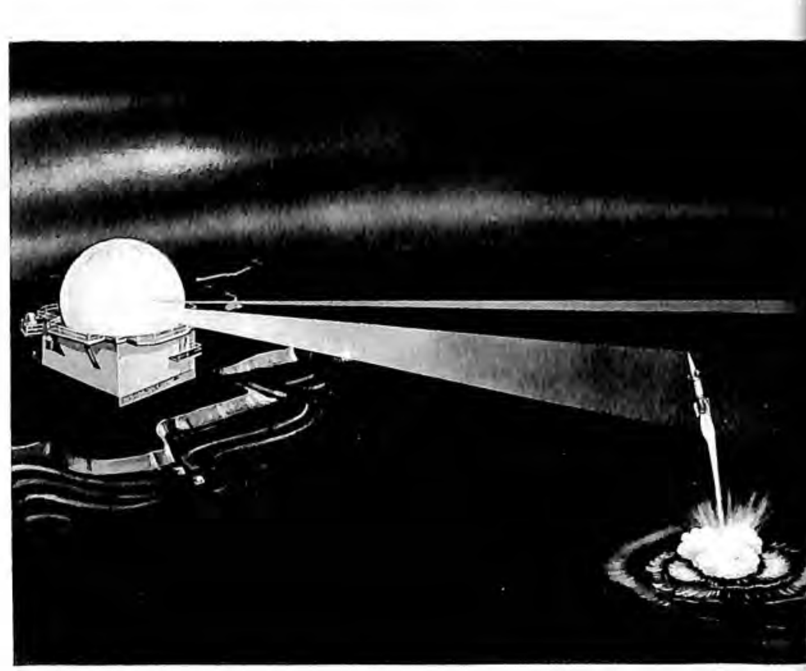
SINGER-GENERAL PRECISION DISPLAYS

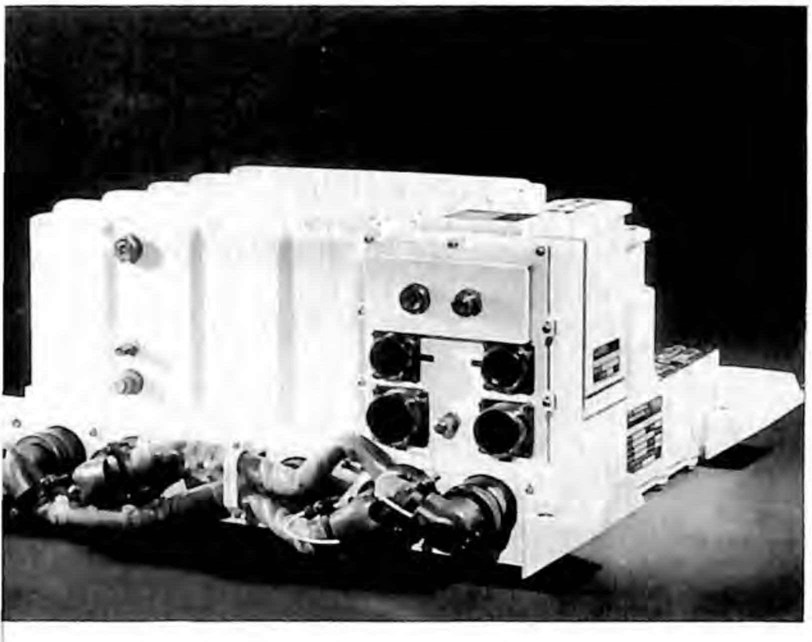
Singer-General Precision's Kearfott Group developed new controls and displays for the General Dynamics FB-111 bomber. At left, the Navigational Display Unit, at right the Computer Control Unit.



AVCO RADAR

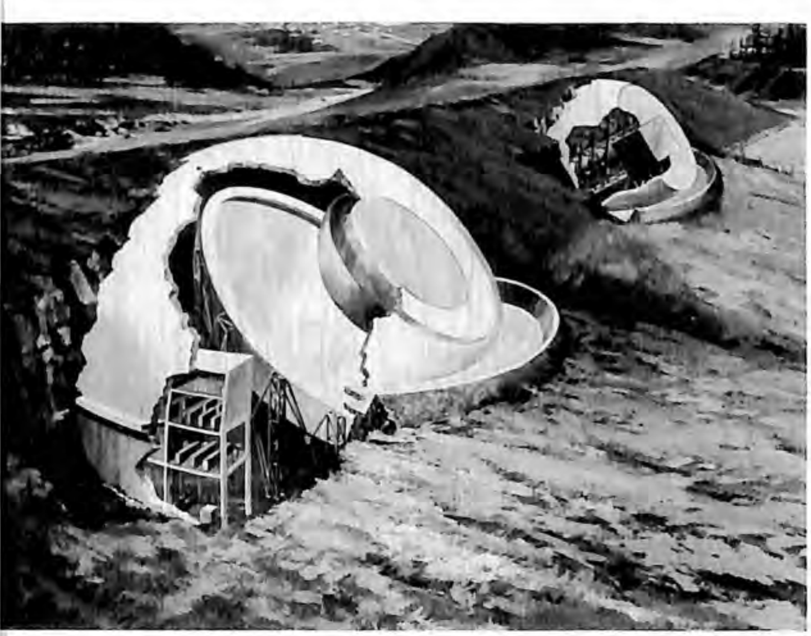
Artist's concept shows the AN/FSS-7 radar detecting a ballistic missile after it has been launched from underwater by an enemy submarine. Avco's Electronics Division is prime contractor on the development for the USAF's Systems Command.





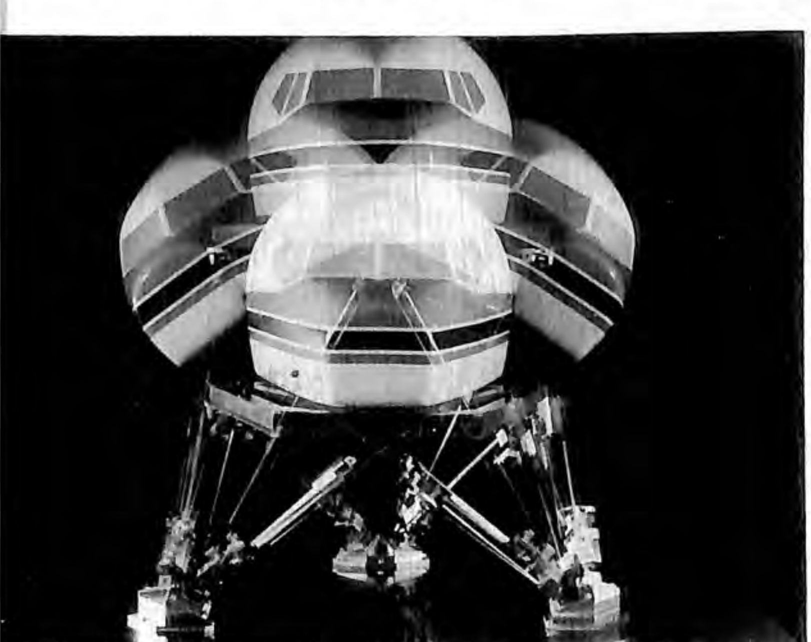
KEARFOTT COMPUTER

Kearfott Group of Singer-General Precision, Inc., provided a tiny (typewriter-size) computer for the Surveyor program, completed in 1968. The GPK-33, first digital computer in space, is the nerve center for the Atlas-Centaur launch vehicle.



HUGHES ADAR

Under Army contract, Hughes Aircraft Company was building a scaled-down prototype of what could become the world's most powerful long-range radar system. Called ADAR (Advanced Design Array Radar), it is designed for defense of cities and the full-scale version could be operational in the early 1970s.



LINK TRAINER

Latest in the long line of flight simulators built by Link Group of Singer-General Precision, Inc., is the Boeing 747 trainer. Equipped with a 6-degree-of-freedom motion system, the simulator includes a full-size 747 cockpit, an instructor station and a visual system, weighing in all about 10 tons.

LOCKHEED GUN CONTROLLER

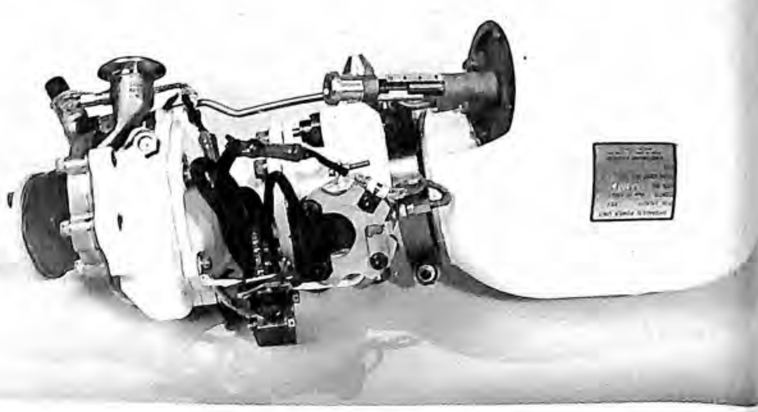
Lockheed Electronics Company developed a digitally oriented, lightweight gunfire control system with multiple sensor subsystems for defense against surface and air targets. In photo, key elements of the system mounted on the USS *Barry* for shipboard firing tests: the radome and the Remoted Optical Sight, below radome.

NORTHROP NORVIPS

Northrop Corporation's Nortronics Division received an Army contract for NORVIPS (Voice Interruption Priority System) installation on fixed-wing aircraft and helicopters. NORVIPS is a safety system, also operational with the USAF, which alerts crews to potentially hazardous situations by means of a prerecorded voice warning.

SUNDSTRAND POWER UNIT

Sundstrand Aviation Division of Sundstrand Corporation developed a hydraulic power unit being used in advanced missile applications. The unit provides power for nozzle gimbaling to make missile course corrections.



AIA LEADERSHIP

In November, Karl G. Harr, Jr. (top), was reelected president of Aerospace Industries Association. James R. Kerr (lower left), president and chief operating officer of Avco Corporation, was elected chairman of the AIA board for 1969. He succeeded E. Clinton Towl (lower right), chairman of the board of Grumman Aircraft Engineering Corporation.

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 and Record Board compiled this list of records completed during 1968 by U.S. participants.

CLASS	DATE	AIRCRAFT	PILOT	RECORD DESCRIPTION	RECORD
ABSOLUTE WORLD RECORDS					
MANNED SPACECRAFT					
World	12/21-27/68	Apollo 8	Frank Borman James Lovell William Anders	Altitude (absolute)	231,040 miles
World	10/11-22/68	Apollo 7	Walter M. Schirra Walter Cunningham Donn Eisele	Greatest mass lifted	32,557 pounds
World	12/21-27/68	Apollo 8	Frank Borman James Lovell William Anders	Greatest mass lifted	279,338 pounds
World	12/21-27/68	Apollo 8	Frank Borman James Lovell William Anders	Duration of lunar mission	146 hours, 59 minutes, 49 seconds
WORLD CLASS RECORDS					
MANNED SPACECRAFT (LUNAR MISSION)					
K	12/21-27/68	Apollo 8	Frank Borman James Lovell William Anders	Altitude	231,040 miles
K	12/21-27/68	Apollo 8	Frank Borman James Lovell William Anders	Greatest mass lifted	279,338 pounds
K	12/21-27/68	Apollo 8	Frank Borman James Lovell William Anders	Duration in lunar orbit	20 hours, 14 minutes, 13.2 seconds
K	12/21-27/68	Apollo 8	James Lovell	Total time in space	572 hours, 9 minutes, 23 seconds
K	10/11-22/68	Apollo 7	Walter M. Schirra Walter Cunningham Donn Eisele	Precision of landing	Distance from target .33 mile
K	10/11-22/68	Apollo 7	Walter M. Schirra Walter Cunningham Donn Eisele	Greatest mass lifted	32,557 pounds
BUSINESS JET AIRCRAFT					
CJ-1.a (6,614-13,277 pounds)					
CJ-1.a	2/20/68	Lear Jet Model 25	Henry G. Beaird	Time to climb to 12,000 meters	6 minutes, 19.1 seconds

CLASS	DATE	AIRCRAFT	PILOT	RECORD DESCRIPTION	RECORD
HELICOPTERS					
Unrestricted Weight					
E-1	12 30 68	Sikorsky CH-54A	CWO W. T. Lamb	Altitude in horizontal flight	31,280 feet
E-1	12 30 68	Sikorsky CH-54A	CWO James T. Ervin	Time to climb to 3,000 meters	1 minute, 35.8 seconds
E-1	12 30 68	Sikorsky CH-54A	CWO James T. Ervin	Time to climb to 6,000 meters	3 minutes, 31.5 seconds
E-1	12 30 68	Sikorsky CH-54A	CWO James T. Ervin	Time to climb to 9,000 meters	7 minutes, 35.4 seconds
TURBOPROP AIRCRAFT					
C-1.c (2,204-3,858 pounds)					
C-1.c	5 31 68	Piper PA 24-400	Jack T. Womack	Altitude	42,560 feet
PISTON-ENGINE AIRCRAFT					
C-1.e (6,614-13,227 pounds)					
C-1.e	9 6-7 68	Piper Aztec	Max Conrad	Distance in a closed circuit	5,312.2 miles
C-1.d (3,858-6,614 pounds)					
C-1.d	6 24-25 68	Cessna P-206	Jerrie Mock	Distance in a closed circuit	4,065.81 miles
C-1.d	6 24-25 '68	Cessna P-206	Jerrie Mock	**Speed over recognized courses:** Columbus, Ohio/San Juan, P.R.	108.9 mph
C-1.d	6 24-25 68	Cessna P-206	Jerrie Mock	San Juan, P.R./Columbus, Ohio	110.33 mph
C-1.d	6 24-25 68	Cessna P-206	Jerrie Mock	Columbus/San Juan/Columbus	108.99 mph
C-1.d	6 8 68	Beech Baron	James F. Nields	Gander, Newfoundland/Santa Maria, Azores	218.37 mph
C-1.c (2,204-3,858 pounds)					
C-1.c	10/17/68	Siai Marchetti	Hal Fishman	Las Vegas/Los Angeles	214.07 mph
C-1.a (under 1,102 pounds)					
C-1.a	11/2/68	Mooney Mite	Donald C. Sinclair	Speed over a 3-kilometer course	136.19 mph
FEMININE RECORDS					
Piston-Engine Aircraft					
C-1	6/24-25/68	Cessna P-206	Jerrie Mock	Distance in a closed circuit	4,065.81 miles
C-1	6/24-25/68	Cessna P-206	Jerrie Mock	**Speed over recognized courses:** Columbus, Ohio/San Juan, P.R.	108.9 mph
C-1	6/24-25/68	Cessna P-206	Jerrie Mock	San Juan, P.R./Columbus, Ohio	110.33 mph
C-1	6/24-25/68	Cessna P-206	Jerrie Mock	Columbus/San Juan/Columbus	108.99 mph
GLIDERS					
D-1 (Single-place)					
D-1	3/3/68	Schleicher KA 8B	Karl Striedieck	Distance to a goal and return	476.6 miles
U.S. NATIONAL RECORDS					
Commercial Airlines					
Commercial	5/29/68	Boeing 737	Captain L. W. McNames, Piedmont Airlines	Speed on a special air route Seattle/Wilmington, N.C.	512.31 mph

WRIGHT BROTHERS MEMORIAL TROPHY

The Wright Brothers Memorial Trophy was presented to Senator Warren G. Magnuson (D., Washington) for more than 2 decades of enlightened leadership in the field of aviation legislation. The trophy presentation was made at the Wright Memorial Dinner in Washington, D. C., on December 17 by Secor D. Browne, senior vice president of the National Aeronautic Association, which administers the trophy. In photo, Senator Magnuson (left) receives trophy from Browne (right) as Irving Roth, president of the Aero Club of Washington, sponsor of the Wright Memorial Dinner, looks on.

COLLIER TROPHY

In May, Vice President Hubert Humphrey presented the Robert J. Collier Trophy to Lawrence A. Hyland (right), vice president and general manager of Hughes Aircraft Company, builder of the NASA Surveyor spacecraft. Hyland accepted in behalf of the "tens of thousands" who participated in the lunar soft-landing program. Surveyor scored 5 successes out of 7 launches and sent back to earth more than 86,000 photographs of the lunar surface.

HARMON TROPHY

On December 3, President Johnson presented the Harmon International Aviator's Trophy to Major William J. "Pete" Knight, USAF, for a series of flights in the North American Rockwell X-15A-2 research airplane. Knight attained the greatest speed ever achieved by an atmospheric vehicle, 4,520 miles per hour. He was cited for obtaining information "directly applicable to the future construction of hypersonic transport planes." In photo, to left of President, Knight and his family, to right, the Harmon trustees: Vice Admiral C. E. Rosendahl, USN (Ret.), Ansel E. Talbert and Edward F. X. Ryan.

BREWER TROPHY

The Frank G. Brewer Trophy went to Dr. Roland Spaulding, professor emeritus of New York University, for "40 years of continuous, outstanding and pioneering contributions in aerospace education." The trophy was presented in behalf of the National Aeronautic Association by Dr. Mervin K. Strickler, Jr., at the banquet of the National Aerospace Education Congress. In photo, left to right, Walter Zaharevitz, executive director, National Aerospace Education Council; Dr. Spaulding; his daughter Rita; and Dr. Strickler.

A

B

AMERICAN HELICOPTER SOCIETY AWARDS

The Dr. Alexander Klemin Award, top honor of the American Helicopter Society, went to Rene H. Miller, professor of flight transportation at Massachusetts Institute of Technology, for "notable achievement in the advancement of rotary-wing aeronautics." The presentation was made May 10 at the society's Honors Night Dinner by Russell O'Neal (left in photo A), Army Assistant Secretary for Research and Development. In photo B, Leon L. Douglas, AHS board chairman (center), presents certificates of the Captain William J. Kossler Award to representatives of the armed services in Southeast Asia whose "imaginative operation techniques" contributed to the effectiveness of the helicopter. The Grover E. Bell Award went to Edwin J. Ducayet (photo C), president of Bell Helicopter Company, and the HueyCobra team "for the successful and timely development of an attack helicopter for the escort and direct aerial fire support roles." Other honors included the Paul E. Haueter Memorial Award, to John P. Campbell of NASA's Langley Research Center, for his contributions to VTOL progress, and the Frederick L. Feinberg Award, to Captain Jerome R. Daly, U.S. Army, for outstanding achievement as a helicopter pilot in Vietnam.

C

A

B

AIAA AWARDS

Three engineers who figured prominently in development of the TF39 turbofan engine received the Goddard Award of the American Institute of Aeronautics and Astronautics at the institute's Honors Banquet, January 23 in New York. Shown receiving their awards (photo A) from AIAA former president Harold T. Luskin (second from left) are, left to right, James E. Worsham, general manager of General Electric's Military Advanced Engines Department; E. Clifford Simpson, chief, Turbine Division, USAF Aero Propulsion Laboratory; and Donald C. Berkey, general manager of GE's TF39 department. AIAA's Hill Space Transportation Award went to Dr. W. H. Pickering, director of Jet Propulsion Laboratory, for his supervision of several significant satellite programs. In photo B, Pickering (right) is presented the award by Floyd L. Thompson, AIAA president. Other AIAA award winners included: Roy V. Harris, Jr., Lawrence Sperry Award; Joseph LaRussa, de Florez Training Award; Arthur E. Bryson, Jr., G. Edward Pendray Award; Loren D. Carlson, John Jeffries Award; Harold Rosen, Aerospace Communications Award; Harold B. Finger, Wyld Propulsion Award; the late Virgil I. Grissom, Haley Astronautics Award; and Robert V. Knox, Mechanics and Control of Flight Award.

A

B

AFA AWARDS

The Air Force Association's highest award, the H. H. Arnold Trophy honoring the "Aerospace Man of the Year," went to General William W. Momyer, commander, USAF Tactical Air Command, for his service in Vietnam as deputy commander for air operations and commander of the Seventh Air Force. In photo A, General Momyer accepts the trophy from Jess Larson, chairman of AFA's board. Brigadier General Robin Olds (right in photo B), commandant of cadets at the Air Force Academy, won the David C. Schilling Trophy for Flight. Major General Charles G. Chandler, Jr., deputy chief of staff, Pacific Air Force, became the first individual to receive the Thomas P. Gerrity Trophy for Systems and Logistics. Presenting the award (left in photo C) is Robert W. Smart, AFA president. The Hoyt S. Vandenberg Trophy was awarded to Marion B. Folsom, former Secretary of Health, Education and Welfare, for his actions in the passage of the National Defense Education Act.

C

A

B

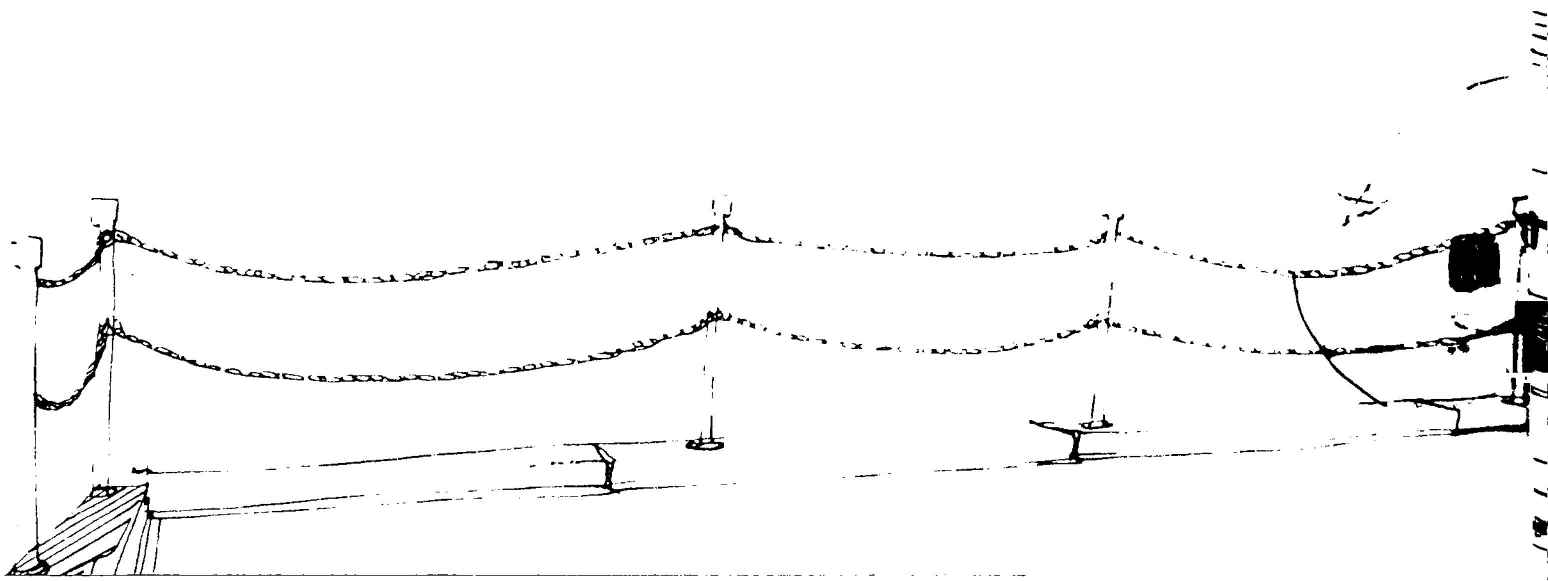
C

AAAA AWARDS

The Army Aviation Association of America presented its "Army Aviator of the Year" Award to Major Robin K. Miller, Vietnam helicopter pilot. In photo A, General Bruce Palmer, Jr., Army vice chief of staff, addresses AAAA Honors Luncheon in presenting the award to Miller, right. The James H. McClellan Aviation Safety Award went to Francis P. McCourt of Army Aviation Materiel Laboratories for contributions to safety research; in photo B, McCourt (left) receives the trophy from Howard E. Haugerud, president of the McClellan Foundation. Named "Army Aviation Soldier of the Year" was Sergeant First Class Jesse J. Dodson, Jr., who was recognized for outstanding achievement as a helicopter maintenance shop foreman in Vietnam. In photo C, Dodson receives his award from Army Secretary Stanley R. Resor. The "Outstanding Army Aviation Unit Award" went to the 52nd Combat Aviation Battalion for its support of U.S. and RVN forces in Vietnam.

PHILCO Ford

PHILCO-FORD CORPORATION
Aeronutronic Division
Newport Beach, Calif. • 92663



The Aerospace Industry

AIA

Aerospace industry sales in 1968 reached a record $30.1 billion, a 10.5 percent increase over the $27.3 billion in sales for 1967, Karl G. Harr, Jr., president of the Aerospace Industries Association, reported.

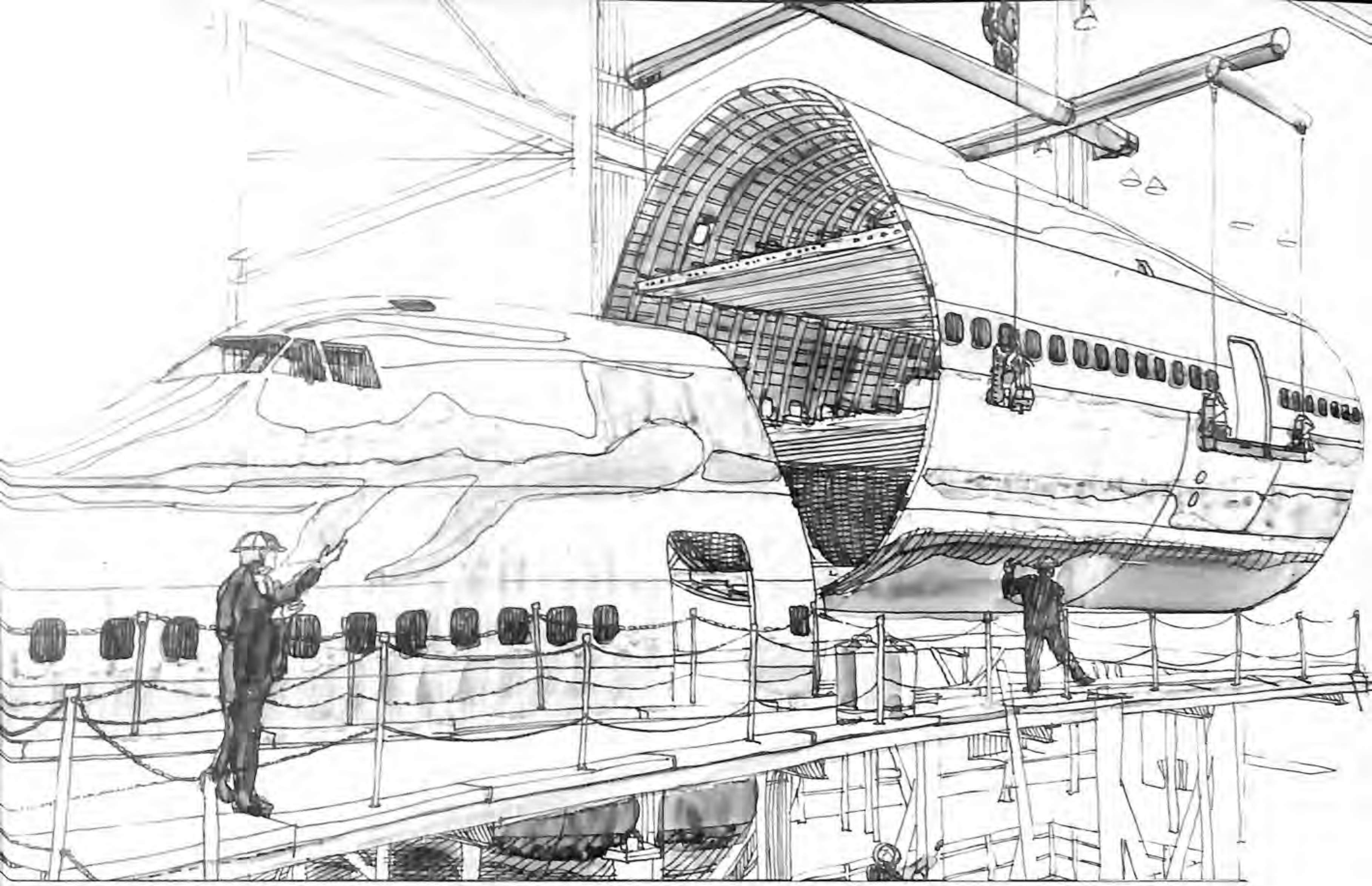
Significant increases were made in several major areas: commercial transport aircraft, defense procurement and non-aerospace sales.

Commercial aerospace sales, which include jet transports, executive and utility fixed-wing aircraft, helicopters, aircraft engines and spare parts, rose between 1967 and 1968 from $4.632 billion to $6.436 billion, a 38.9 percent increase.

A substantial increase in turbine-powered transport sales accounted for a major portion of the sales growth. In the 2-year period from 1965 to 1967, sales increased from $1.197 billion in 1965 to $2.458 billion in 1967, a gain of 105.3 percent; from the 1965 sales to 1968 sales of $3.729 billion, the increase was 211.5 percent.

Production of utility and executive aircraft increased between 1967 and 1968 from 13,577 to 14,000 units, and the total value of shipments rose from $360,000,000 to $424,000,000.

Civilian helicopter production increased from 455 units to 511 units between 1967 and 1968. Value of this production rose from $43,000,000 to $57,000,000. Civil helicopters were being used primarily for business purposes, although increasing numbers were being used for traffic control and surveillance.



Other major sales trends between 1967 and 1968 included:

- Sales by the aerospace industry to the Department of Defense in 1968 were $16.9 billion compared with $15.9 billion in 1967, an increase of 6.7 percent.
- Military aircraft sales rose from $10.4 billion in 1967 to $11 billion in 1968, partially in response to increasing requirements for Vietnam operations.
- Missile sales in the same period rose from $4.417 billion to $4.817 billion, an increase of more than 9 percent.
- Military space programs in 1968 rose from $1.088 billion to $1.121 billion, an increase of 3 percent.
- Nonmilitary space sales declined from $4.202 billion in 1967 to $4.047 billion in 1968, a decline of 3.7 percent.

Sales of non-aerospace products and services increased slightly between 1967 and 1968 from $2.579 billion to $2.726 billion. Those sales represented work by aerospace firms utilizing aerospace technology in such areas as marine sciences, water desalination, crime control, rapid transit, job retraining and other areas.

Aerospace industry sales in 1969 were expected to decline 1.6 percent to $29.6 billion from $30.1 billion in 1968. Primarily, it was expected, this decline would result from a temporary decline in air transport sales as some models phased out prior to the major expanded production buildup of new models.

Commercial aerospace sales, because of declining deliveries of civil transports, were expected to drop from $6.4 billion to somewhat less than $5.7 billion. Transport production was predicted to decline from 691 to 515 units between 1968 and 1969.

This decrease in aircraft deliveries in 1969 was to take place despite increasing orders for jet transports. The year 1969 was expected to be an interim period with a gradual phasing out of existing models and the advent of the high passenger capacity, third-generation jet transport aircraft. The long-range outlook appeared excellent, with passenger traffic projected to triple over a 10-year period.

Utility and executive aircraft production was expected to exceed that in 1968, increasing from 14,000 to 15,450 units. The dollar value of general aviation production should approximate $500,000,000.

Helicopter production was expected to reach a record 545 units.

Department of Defense sales were estimated to rise from $16.914 billion to $17.214 billion between 1968 and 1969. Increases in missile and military space programs were expected to offset declining military aircraft sales.

Nonmilitary space sales were predicted to approximate $3.8 billion in 1969, with non-aerospace sales continuing to register modest gains.

ABEX CORPORATION

In 1968 Abex Corporation's airborne hydraulic capabilities in Europe, Canada and the United States were combined into a single Aerospace Division, headquartered in Oxnard, California. Products supplied by the division were pumps and motors, servovalves, landing gear, flight controls and actuating systems for military and commercial use. Over 70 airlines were using Aerospace products.

During the year the U.S. facility was successful in selling pumps, motors and servovalves as new equipment for the Bell OH-58A, Boeing 747, Lockheed C-5A, Grumman A-6A, Sikorsky CH-53A and Boeing SST. Follow-on contracts were substantial for the Boeing 727 and 737, the General Dynamics F-111 and a number of other current programs of both commercial and military nature. A significant servovalve development program was also initiated for the Aerojet NERVA engine.

The Canadian facility became the major supplier of main gear for the Boeing 737 and was selected as a manufacturer of nose gear for the McDonnell Douglas DC-10. Additional contracts were received for General Dynamics' F-111 wing-sweep actuation systems, Vertol CH-47 landing gear and Fokker F-28 primary and secondary flight controls. The plants also produced landing gear for the de Havilland DHC-4 Caribou and DHC-5 Buffalo, the Northrop F-5, the Canadair CF-5 and the LTV A-7D. A new, large profiling facility was added in Waterloo, Ontario, and a $2,500,000 plant was constructed in Montreal to consolidate, enlarge and modernize production capacity in that city.

The Aerospace plant in Wiesbaden, West Germany, continued to ship rotating equipment and servovalves for the Concorde SST, various SAAB programs, Fokker's F-28 and Agusta-Bell helicopters. Among the newer programs participated in were the Fiat G91Y and G-222, the Dornier helicopter and VTOL transports, the Handley Page HP-317, the BAC One-Eleven commercial transport and several VFW requirements including a wing tilt system for the VC-400 VTOL transport. The plant increased its contract overhaul work for hydraulic pumps and components used on NATO fighters and commercial aircraft.

The Denison Division of Abex was deeply involved in ground support activities in aerospace areas, both military and commercial. Denison hydraulic power units activate many highly sophisticated flight simulators such as the Boeing 727 commercial digital simulator and the F-111 flight and mission simulator manufactured by the Link Group-Systems Division, Singer-General Precision, Inc. Flight crews on the Boeing 747 will be trained in the latest Link flight simulator, also utilizing Denison hydraulic power. Denison additionally was furnishing ground support for the 737, 747 and C-5A.

An electrohydraulic system supplied by Denison was involved in the final testing of rotor transmissions for Lockheed's 2-man helicopter, the Cheyenne. Denison fluid power components were being used extensively in other test equipment—in production and on the flight line.

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

American Brakeblok Division, the major manufacturer of friction (braking) materials for jet aircraft, was selected as supplier of brake materials for the Lockheed L-1011 and C-5A.

At the Abex Research Center, preliminary tests on large superalloy castings for gas turbine rotors were completed successfully. Full-scale casting and testing of 20-inch-diameter, hollow rotor discs for a commercial aircraft turbine engine were initiated. Airframe structural parts were cast successfully by means of vacuum melting.

Drop test facility at Abex Corporation's Montreal plant can simulate roughest of aircraft landing conditions.

AERODEX, INC.

Aerodex began tooling up during 1968 to begin overhaul programs on such commercial airline engines as those which power the Boeing 727 and 737, the McDonnell Douglas DC-9 and the Lockheed Electra and L-100. It also began new 3-year programs to overhaul engines powering the Air Force C-119, C-124 and C-130 transports.

The company broadened the scope of its engine parts overhaul and manufacturing subcontract business in 1968. New overhaul programs included military contracts to repair parts on J57 and J79 turbojet engines; contracts with 4 airlines to repair worn jet engine blades, using electron beam welding and other new materials engineering techniques; and the first contract to apply one of the company's diffusion coatings as the finishing touch to commercial airline jet engine blades overhauled elsewhere.

Paralleling these new overhaul activities, Aerodex began initial manufacturing subcontract programs on parts and/or prototype components for the new "giant jet" engine programs (the Boeing 747, Lockheed C-5 and McDonnell Douglas DC-10) as well as for the Boeing supersonic transport. The company commenced manufacture of key components for a new U.S. Army tank gas turbine engine and for a diesel engine which powers trucks and other earthbound vehicles.

The company received its first airframe parts manufacturing subcontract business during 1968, involving landing gear components for the U.S. Navy F-111B fighter. Another new program calls for supplying control valves and control housing castings for the U.S. Naval Weapons Center Shrike air-to-ground missile.

In other new developments, Aerodex installed the largest vacuum heat treating furnace in the Southeast at its manufacturing and parts overhaul subsidiary, API Corporation, adjacent to Miami International Airport. In this new unit, parts are heat treated and brazed at temperatures up to 2,400 degrees Fahrenheit. The furnace joins other high-temperature units in which thousands of aerospace parts are processed monthly in a pure hydrogen atmosphere.

Aerodex completed development of a family of new diffusion coatings, known as the API-10 process, on which patents have been applied for. Testing at the company of one of the new formulations, API-10 STF, demonstrated its ability to protect samples of the high-strength nickel base alloy, B-1900, during more than 360 hours' exposure to temperatures over 2,000 degrees Fahrenheit. Upon completion of further testing, both at Aerodex and at engine manufacturers, the company planned to combine this coatings development with its existing investment casting manufacturing activity to supply finished, machined and coated turbine blades for prime engine manufacturers.

Inner worn surface of a T56 compressor section is restored at Aerodex with oxyacetylene torch "metal spray" technique.

The company continued its landing gear overhaul business, and at year-end was overhauling gear assemblies and components at the rate of more than 17,000 a year for such aircraft as the McDonnell Douglas DC-3, DC-4, DC-6, DC-7, DC-8 and DC-9; the Boeing 707 and 727; the Convair 340, 440, 880 and 990; the Lockheed Electra; and the Fairchild F-227.

AEROJET-GENERAL CORPORATION

Aerojet-General Corporation, which pioneered the propulsion systems that got man off the earth into space, fittingly enough developed the first rocket engine to get him back from the moon. The Service Propulsion System engine on Apollo 8 that successfully placed the astronauts in orbit around the moon and then fired to return them to earth set the tone for Aerojet technology in 1968.

Among other accomplishments, Aerojet began building the first earth station for satellite communications on the African continent, automated an accurate test for syphilis, developed a one-pass membrane for the desalination of water by reverse osmosis, began a study of waste management problems in the greater Kansas City region, and continued its role in space equipment fabrication by building the propellant tanks for the Apollo Lunar Module engine.

Aerojet remained a leader in propulsion technology, producing the first-, second- and third-stage liquid-propellant engines for the Air Force Titan III-C space booster and the second- and third-stage propulsion systems for the Air Force's Minuteman III missile, which was successfully flight tested for the first time in 1968.

Production of the Delta second stage continued and a new family of rocket engines (SVM-1), used initially to position the Intelsat II communications satellites in a precise synchronous orbit above the equator, was developed. Advanced versions were being produced for use with the Intelsat III series of communications satellites.

Significant progress was recorded on development work with NERVA, the nation's only nuclear-powered rocket engine. A series of "cold flow" tests was completed on the full system, leading the way to a "hot test" firing in 1969.

Rocket engines representative of Aerojet's quarter century of contributions to rocketry development were presented to the Smithsonian Institution in special ceremonies.

Aerojet continued as the largest producer of research rockets and supporting subsystems in the country, introducing and successfully flying the Aerobee 170, newest member of a distinguished family. During the year 51 Aerobees and 27 NIRO rockets were flown from launch sites throughout the northern hemisphere and a new, advanced Attitude Control System, the Mark II, was developed. Aerojet also became the leading supplier of advanced Attitude Control Systems to the European Space Research Organization.

Expansion of Aerojet activities in the fabrication of jet engine and jet aircraft parts, begun in 1966, continued with important contracts to develop components for the Air Force C-5A cargo aircraft, the F-111 sweptwing fighter aircraft and Boeing's 747 and supersonic transport aircraft.

Aerojet involvement in nucleonics at facilities in both San Ramon, California, and Idaho Falls, Idaho, led to the solution of important waste handling problems confronting the power reactor industry. Aerojet converted highly radioactive liquid wastes to a safer solid form on a production basis for the first time anywhere in the world. A production-scale run indicated that the process is applicable to a variety of nuclear waste problems.

Additionally, uranium alloy sodium-bonded fuel elements were fabricated by Aerojet for the EBR-II program with initial deliveries of elements that meet AEC specification. Fuel element pre-assemblies (inert components) were also being produced for the EBR-II reactor.

Progress on SNAP-8, the largest space power generating system in development testing, continued with follow-on contracts from the National Aeronautics and Space Administration. The 35,000-watt system will be capable of providing electric power for communications, support systems and experiments for both manned and unmanned space missions.

Successful full-scale power tests of the first experimental model of an advanced company-developed organic Rankine cycle power conversion system were completed by Aerojet and record power output and efficiency levels were achieved. The Aerojet ORACLE (acronym for Organic Rankine Cycle) is a closed-cycle power unit designed to convert energy from nuclear, isotopic, chemical or solar sources into electricity for a broad spectrum of earth, marine and space applications.

Aerojet's electronics capability led to increased funding by the Air Force of a major research and development program involving unmanned space technology, bringing the total value to $93,000,000.

In other electronics activities, Aerojet was emerging as a leader in the development of sensor systems. Under contract to the U.S. Air Force, a flight-safe infrared subsystem for the Advanced Manned Strategic Aircraft was being developed and fabricated. In another sensor program, sponsored by the Navy, a long-wavelength, infrared mosaic terminal guidance system study to meet future requirements for an advanced airborne guided-weapons system continued.

Aerojet also developed the first 60 GHz, solid-state, radiometric receiver for applications ranging from weather forecasting and spacecraft control to intersatellite communications and short-range, interference-free, point-to-point surface communications.

Significant contracts were won to develop a microwave reconnaissance system for the U.S. Air Force and to conduct radiometric investigations of snow packs for the Department of the Interior, with the goal of developing a radiometry system for use with aircraft and satellites to better manage water resources.

High-volume production of the U.S. Navy Mark 46 torpedo, an advanced antisubmarine weapon, continued into the third year with the award of a $12,000,000 contract for advanced versions. Total manufacturing awards to Aerojet for the Mark 46 exceeded $230,000,000 at year-end.

Full production of the Navy's newest mine, the Mark 56, got under way in 1968 at Aerojet under a 4-year contract awarded in 1967. The Mark 56 is the most advanced mine system in production.

Construction began in the fall on the first earth station for satellite communications to be built in Africa. Engineering design and development were being carried out under contract to SOMATELSAT, a company jointly formed by the government of Morocco and Aerojet-General to construct and operate the station. When completed, the station will enable Morocco to communicate via satellite with America, Africa and parts of the Middle East and Asia.

Aerojet inroads into medical and environmental systems technology were greatly advanced on a number of fronts with the following developments:

• A new medical instrument for the diagnosis of syphilis, the SeroMatic System, entered production after successfully completing extensive tests in hospitals and laboratories.

• A significant reduction in time for physicians being trained in anesthesiology was demonstrated in an experimental, comparative training program using the world's first computer-controlled manikin, Sim One, in place of human patients.

• Successful completion of the conceptual design of an atomic power source for artificial hearts led to a contract from the National Heart Institute to fabricate and test a breadboard model.

• A single-pass membrane for the desalination of seawater by reverse osmosis was developed and was under test for the Office of Saline Water, Department of the Interior, and a low-cost, automated manufacture of tubular reverse osmosis units was under development.

• For the Kansas City Metropolitan Region Planning Commission, a computer program for solid waste management optimization was being developed to meet future needs.

• In Sacramento, California, sewers were being studied for the Federal Water Pollution Control Administration to develop alternative systems for handling liquid waste and water from rainstorms.

• A dual version of Aerojet's pneumatic transport system for refuse and soiled linen handling, the first to be installed in the United States, was going into the new Martin Luther King Memorial Hospital under construction in the Watts area of Los Angeles.

• A cryogenic facility, under construction in Lowell, Massachusetts, for the Lowell Gas Company, will liquefy natural gas, store it and regasify it as needed to serve the New England area during winter peak periods.

Aerojet facilities were expanded with the activation of an Orbital Mission Simulator Complex at the Electronics Division, Azusa, California. The facility gives Aerojet a combination of advanced capabilities unique in the nation for testing large optical satellite systems under closely simulated environments as high as 100 miles in space.

The new facility encompasses a total of more than $3,400,000 in equipment and occupies about two-thirds of a 25,000-square-foot building completed in the fall. The $1,000,000 building also houses the Aerojet Microelectronics Department's computerized production facilities for vacuum-deposited, hybrid, thin-film microelectronics circuit manufacture for military/aerospace applications.

AERONCA, INC.

The successful splashdown of Apollo 7 coincided with the 40th anniversary of Aeronca, Inc. While the spacecraft, with the outer structure of its command module made up of brazed stainless steel honeycomb panels fabricated by Aeronca, symbolizes the contribution that Aeronca technology is making to the space effort, the most significant factor in the company's recent growth lies in the technology itself.

Specifically, the key to Aeronca's success in 1968 and in the immediate future is to be found in a proliferation of the company's existing and projected technology.

Aeronca's transition from producing the first light aircraft made for personal use to an important role in the aerospace market is best exemplified in the resurgence of the commercial aviation market, where the company's widely recognized developmental work in brazed stainless steel honeycomb fabrication techniques has grown into an aircraft structures capability of the first order.

In addition to its fabrication of structural components for the aerospace industry, through major plant operations in Middletown, Ohio, and Torrance, California, Aeronca continued in 1968 to design and manufacture highly engineered environmental control systems and a related line of proprietary products, marketed and manufactured both in the United States and abroad, the latter through licensing agreements in Europe and Asia.

At year-end about two-thirds of Aeronca's sales were in aerospace products, with a big increase in commercial aviation. Volume production was scheduled to begin in 1969 on subcontracting work in the commercial aviation field which will further increase the commercial portion of Aeronca's business.

Materials technology was responsible for most of the firm's growth during 1968. The company has pioneered in fabrication of brazed and bonded honeycomb construction, which has gained broad acceptance in the aerospace industry. The use of honeycomb was expected to increase greatly because of its exceptionally high strength and light weight. Over the last several years Aeronca has broadened its aircraft structures capability impressively with the development of brazed Inconel and titanium honeycomb structures and its ability to manufacture autoclave bonded aluminum and fiberglass honeycomb structural components.

One of the most significant research and development contracts in Aeronca's recent history was awarded the company by Boeing in April 1968. This initial contract called for Aeronca to evaluate application of new titanium honeycomb brazing processes to the structural requirements of the supersonic transport. Aeronca believed its special structures capability offered potential application in several areas which can help reduce weight in the SST and other new-generation aircraft.

Aeronca was already fabricating structural components for all Boeing commercial jetliners being produced, and 2 new contracts valued at more than $30,000,000 were awarded the company in 1968 for

Boeing's 747 superjetliner program. One contract covered the production of nearly 900 turbine thrust reverser plug assemblies and the other contract increased Aeronca's production of inspar wing ribs from 53 shipsets to 203 shipsets, with deliveries on both contracts expected to continue through mid-1971.

In all, the company had contracts totaling $55,000,000 for the Boeing 747 program, covering only the first 200 shipments of the aircraft, which has a potential of 600 shipments. Aeronca was also seeking participation in the Lockheed and McDonnell Douglas air bus programs, largely in the belief that these programs could utilize Aeronca experience and Aeronca fabrication processes and techniques now being employed in the newest Boeing projects.

Although the company's most notable contribution to the U.S. space program in 1968 was the outer structure for the Apollo 7 and 8 Command Modules, Aeronca also fabricated the blast panels for operation in the exhaust of the Saturn IB launch vehicle which carried Apollo 7 aloft.

In military aviation, Aeronca's programs in 1968 continued to be fuel tanks for the Northrop F-5 Freedom Fighter and pylons for the F-4 Phantom. In March the company was awarded a new contract by Grumman to produce bonded structural assemblies for the A-6A Intruder. The initial contract was for about $500,000 and it was expected to be increased and continued over several years. Despite the company's significant contributions to military aviation, only about 3 percent of total sales were related to the Vietnam conflict, a figure which has not increased since 1966.

Besides its proliferating materials technology, the company was advancing into another field within the aerospace market—cargo handling. Aeronca was producing fiberglass air cargo containers for jet freighters under a contract with American Airlines and was developing an automated hydraulic system for moving these cargo igloos within freight terminals, from terminal to aircraft and within the aircraft.

A solid third of Aeronca's business was derived from sales of its environmental control systems and related proprietary products in the U.S. and abroad. In 1968 the Buensod Division of the Aeronca Environmental Control Group, headquartered in New York and producing highly engineered industrial air conditioning and other environmental control systems, reported a pair of major contracts. The first was an addition of approximately $1,000,000 to an original contract for $3,842,592 from Westinghouse Electric Corporation covering environmental control systems for a large nuclear turbine plant being built near Charlotte, North Carolina. The second was a $2,500,000 contract with E. I. duPont de Nemours & Company, Wilmington, Delaware, to provide specialized fabricated metal products for various duPont plants.

During the year Aeronca facilities were enlarged through building and plant site acquisition, including a new 40,000-square-foot addition to the Torrance, California, facility to handle Boeing production, the installation of a 400-ton stretch press at Torrance and the purchase of a manufacturing facility at Rockhill, South Carolina, to house expanded activities of the Environmental Control Group.

In a financial move undertaken to help assure advancement in its main fields of interest, Aeronca achieved a substantial reduction in its long-term debt through the conversion of convertible debentures into common stock. In October Smith Barney & Company arranged for the private placement with institutional investors of $5,000,000 of 6 percent Senior Subordinated Notes. With this private placement the company was planning to further increase its bank borrowings to provide for increased growth.

As of September 30, 1968, Aeronca's 9-month sales were $36,114,281 compared to $31,385,439 a year earlier. Net earnings for the period were $1,120,984, or $1 per share, a rise of 30 percent over $862,774, or 83 cents per share, for the same period a year earlier. The company indicated year-end net earnings would be significantly higher than 1967.

On October 7 the company was listed and began trading on the Midwest Stock Exchange, in addition to its listings on the American, Pacific Coast and Cincinnati stock exchanges.

THE AEROSPACE CORPORATION

Increasingly sophisticated operations in space by the Air Force remain dependent upon reliable and powerful launch vehicles; during fiscal year 1968 The Aerospace Corporation in El Segundo, California, continued to work in the areas of development and engineering necessary to meet today's more stringent military launch vehicle requirements. At the same time company scientists and engineers were performing research and planning to assure adequate booster capability for future missions.

During the last 6 years, Aerospace has assisted the Air Force Space and Missile Systems Organization in working with industry to improve space booster flight reliability. Such activity was initiated on Atlas with the SLV-3 Standard Launch Vehicle program for standardization and reliability improvement. Beginning with the space booster based on the Atlas D, each model has benefited from the technical support supplied by Aerospace. In 1962 the Atlas flight reliability was only 60 percent on a 20-moving-average basis; since then, this has been increased to 100 percent by an unbroken series of 39 successful Atlas space launches.

After 123 consecutive successes with the Thor

SLV-2 space launch vehicle, since November 26, 1963, a Thor failed during launch May 18, 1968. Even though SLV-2 launch No. 124 was a failure, the impressive record remains—the result of a cooperative effort in which Aerospace, as one member of the team, provided technical review and evaluation to the Air Force-managed program.

Aerospace continued its GSE/TD responsibilities for the Air Force Titan III standard launch vehicle system. At present the Titan system includes 4 models: 2 employ the III liquid-engine core plus 5-segment solid boosters; one uses the III core plus 7-segment solid boosters; and one uses the III core without solid boosters.

The company was active in the planning and development effort on satellite systems for national defense. An outstanding example of this work was the Phase I Defense Satellite Communications Program (DSCP) in which Aerospace, in support of Air Force responsibilities in the program, performed technical direction of the satellite-payload program throughout all phases of design, development and test.

The climax of Aerospace work on this initial phase of DSCP (which, actually, had begun in the company's earliest days) came on June 13, 1968, when 8 additional satellites were placed in orbit by a single Titan III-C. This successful launch raised to 25 the total number of the spin-stabilized, active-repeater DSCP satellites in orbit.

Aerospace provided GSE/TD on the Manned Orbiting Laboratory (MOL) program in 1968, a responsibility it has had since the program's inception by the Air Force. In congressional testimony in March, Dr. Alexander H. Flax, Assistant Secretary of the Air Force (Research and Development), noted that the MOL program had reached the stage at which all major components had been defined and the specifications for the interfaces written and agreed to by all the contractors. With the contract definition phase completed, the program was well into the development phase and metal was being cut by the contractors for engineering and qualification models.

Throughout 1968, Aerospace in San Bernardino, in association with SAMSO, explored advanced missile and reentry vehicle concepts to assure the timely application of new technology to the national strategic missile force structure.

The Advanced Ballistic Reentry System Program (ABRS) is a Department of Defense-established national program supporting the Air Force, Navy and Army. Its purpose is the development of advanced reentry systems and the extension of reentry technology to provide the United States' strategic missile weapon systems with the capability to penetrate enemy defenses and destroy enemy targets. Aerospace Corporation was providing planning and technical direction of all the contractors involved.

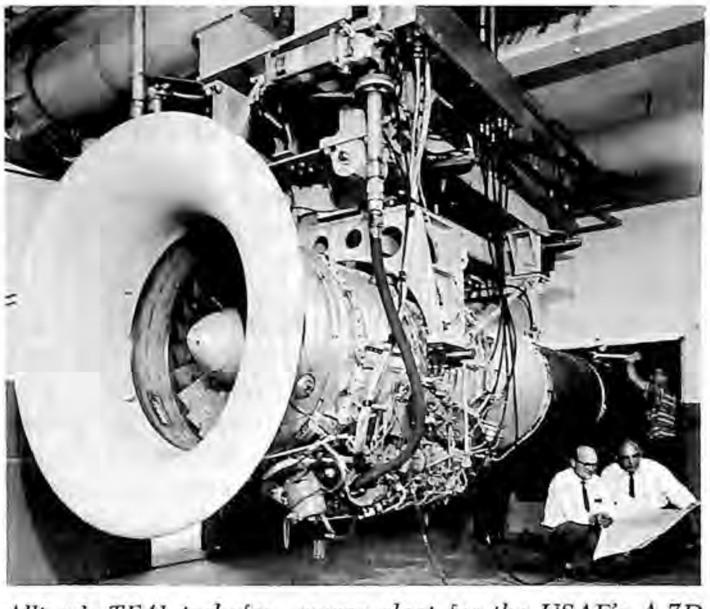
ALLISON DIVISION
GENERAL MOTORS CORPORATION

The highly successful maiden flight of its new TF41 turbofan engine for the U.S. Air Force's A-7D attack bomber marked one of 1968's major milestones for the Allison Division of General Motors as it continued to expand its gas turbine product line.

Rated at 14,250 pounds thrust, the TF41-A-1 powered an LTV A-7 on a 2-hour flight during a series of demonstrations over Edwards Air Force Base, California, at altitudes up to 23,000 feet and at speeds exceeding 650 miles an hour.

Developed jointly with Rolls-Royce Ltd., Derby, England, the TF41 entered production at Allison in June, a month highlighted by a special "TF41 First Production Engine" ceremony attended by military and government officials, business and civic leaders, and news media.

Development and initial production of the TF41-A-1 was covered by a $227,300,000 contract awarded by the USAF Aeronautical Systems Division, which provides technical direction.



Allison's TF41 turbofan, power plant for the USAF's A-7D attack bomber, entered production in 1968.

In a parallel program, Allison was awarded a $35,700,000 contract for production of a TF41-A-2 version for the Navy's A-7E light attack aircraft. This production award followed by only a few months an $8,000,000 development contract to increase the output to 15,000 pounds thrust. Deliveries of flight test -A-2 engines were to start in March 1969, with deliveries of production engines to begin in August 1969.

Sales and production of the larger turboprops continued strong in 1968. Two new installations for the Model 501 engine, rated at 4,050 horsepower, were announced. One is the Guppy series of 4-engine carriers of outsized cargo being developed by Aero Spacelines, Inc. The other is the TIFS, a twin-engine inflight simulator for training flight crews in the operation of various types of jet aircraft. The latter is being developed by Tex Johnston, Inc. Both are subsidiaries of Unexcelled, Inc. The 501s also power the Lockheed Electra and Convair 580 airliners, and Convair 580s operational with 14 major U.S. corporations, the Federal Aviation Administration, the U.S. Air Force and the Royal Canadian Air Force.

T56 Series turboprops, rated at 4,910 horsepower, were in production for several 4-engine and twin-engine military aircraft, including the Lockheed C-130 Hercules operational with the Air Force, Navy, Coast Guard, Marine Corps and Military Airlift Command; the Navy's Lockheed P-3 Orion antisubmarine warfare plane; and the Grumman carrier-based E-2A Hawkeye reconnaissance plane.

Extending further the horsepower growth of T56 Series engines, the T56-A-18 turboprop was in development with Navy funds. Equipped with air-cooled blades and vanes in its first 2 stages, the -A-18, at a rating of 5,325 equivalent shaft horsepower, is approximately 350 pounds lighter and 30 inches shorter than the original T56-A-1, rated at 3,750 equivalent shaft horsepower. The official 50-hour preliminary flight rating test was completed successfully in 1968.

Allison announced 2 new 400-horsepower gas turbine aircraft engines: the Model 250-C20, a 155-pound turboshaft for light helicopters; and the 180-pound Model 250-B17 turboprop for small single- and twin-engine aircraft. Both are expected to be available in April 1970.

The 2 engines are outgrowths of the current production 317-horsepower, 139-pound T63 turboshaft engine, which powers the Army's OH-6A light observation helicopter, and the commercial Model 250-C18, which powers the Bell JetRanger, Hiller FH-1100 and Hughes 500 helicopters, now being sold worldwide in increasing numbers. A 317-horsepower turboprop version, the Model 250-B15, entered production late in the year for light, fixed-wing aircraft.

Two other engines were in development. One, a turbojet direct-lift engine for vertical take-off and landing aircraft, is being developed as a joint project by the United States and the United Kingdom, with Rolls-Royce as the U.K. representative. Allison also conducted a series of successful demonstrations of an advanced turboshaft engine at power levels over 7,000 horsepower with low specific fuel consumption.

Allison propellant tanks were aboard the Apollo 8 when the 3 astronauts carried out their dramatic moon orbit in December 1968. Four of the tanks, each 11 feet long and 4 feet in diameter, carried the propellants necessary to guide the spacecraft to the moon, put it in lunar orbit, boost it free from lunar orbit, and guide it back to earth.

At the Allison-operated Cleveland Army Tank-Automotive Plant, prototypes of the versatile new Main Battle Tank (MBT-70) were in development. MBT-70 is the product of a joint development effort by the U.S. and the Federal Republic of Germany. Incorporated are many innovations that make the vehicle unique, including 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.

Production continued at the Tank Plant 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; in addition, the M551 incorporates a unique Allison-developed gun-launcher breech mechanism. In production also were gun mounts for both vehicles, mortar shell cases, transmission components, and a vehicle rapid fire weapons system to adapt a 20-millimeter cannon to the M114 commander's cupola, presently equipped with a .50-caliber machine gun.

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

AVCO CORPORATION

AVCO AEROSTRUCTURES DIVISION

In April 1968 Avco/Aerostructures, Nashville, Tennessee, received from Lockheed Aircraft Corporation the largest single airframe subcontract ever awarded in the history of either company: a record $575,000,000 order to build 350 sets of wings for the L-1011 luxury jetliner.

The 660-mile-per-hour airplane is a project of Lockheed-California Company, headquartered in Burbank. The wing sets Avco will produce for the wide-cabin intermediate-range jet span 155 feet each, cover an area of almost 3,500 square feet and weigh some 45,000 pounds. New manufacturing techniques were under development and an investment of approximately $20,000,000 in new plant and tooling was in progress targeting toward production start-up by midsummer of 1969. Delivery of the first wing assembly was scheduled for early the following year, with airline service anticipated by 1971. Avco chose the outsize Guppy cargo aircraft operated by Aero Spacelines to airlift a minimum of 50 shipsets directly from its Nashville facility to Lockheed's assembly plant in Palmdale, California.

A significant milestone was reached on June 30, 1968, with the first and highly successful flight of the C-5 Galaxy military cargo and troop jet transport built by Lockheed-Georgia Company, for which Avco was under a long-term contract to fabricate the center, inner and outer wing sections. The equivalent of 31 wing sets were delivered during 1968. A commercial cargo version designated the L-500 was under development by Lockheed; it is felt that this will greatly increase the potential of the plane and significantly extend production requirements.

The division continued production of wing sets for the Grumman Gulfstream II business jet as well as tailboom assemblies for both the military and commercial versions of the Bell Huey helicopter. It continued constructing ballistic cases for the Lance missile as well as cold plates for space vehicles. Its long association as producer of metal office furniture for Globe-Wernicke Company, a subsidiary of the Shellar-Globe Corporation, was further enhanced during the year by additional contractual commitments.

A production milestone was reached during 1968 when the Aerostructures Division shipped to Lockheed-Georgia the 1,000th C-130 empennage. The division has been in continuous production of this hardware since June 1953—one of the longest subassembly contracts in aviation history—and had on-going commitments extending C-130 empennage manufacture through February 1970.

The division's role as one of 7 principal subcontractors of The Boeing Company's supersonic jet transport program led to a research and development contract from that company for a prototype of an advanced structural beam using boron-reinforced titanium. The test item was delivered at year-end for evaluation by Boeing in connection with advanced SST manufacturing techniques.

Employment at the division located in Nashville remained constant at about 4,000 at year-end. This total, however, was to begin a steady increase in mid-1969 as the L-1011 wing goes into production.

AVCO ELECTRONICS DIVISION

The Electronics Division continued its leadership in high-frequency communications technology for both ground and airborne communications. During 1968 production increased on both the AN/ALR-23 Countermeasures Receiving System and the AN/ARC-123 radio system, both for the F-111A. Increases were marked also in ultra-high-frequency antenna development and production, and production was begun on the AN/TLQ-17 Electronic Countermeasures Equipment. Infrared research and development work for all military services was also expanded during the year.

Avco continued production and deliveries of its command and receiving equipment for a variety of military and space programs, including the Digital Uplink Assembly which will update the Apollo Lunar Module guidance computer for moon landing and 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 and detection system and its display subsystem.

The division's Huntsville (Alabama) Operation successfully marked its first year in the information systems industry, the largest single contract being from Lockheed-Georgia Company to design and develop the largest combined computer-controlled structural loading and data acquisition system ever produced. It was to be used for testing the Air Force C-5 Galaxy. Also in its data acquisition group, the Huntsville Operation introduced a new series of logic cards (STD-10); the SAM-6 amplifier and the LC-210 Load Commander, both used on the C-5 test system; and low-cost digital-to-analog converters and improved analog-to-digital converters.

The Tulsa (Oklahoma) Operation enhanced its position in the shock machine market from 15 to nearly 35 percent of the market with its line of 5 pneumatically driven shock testers and 5 free-fall impact testers.

Avco/Tulsa has one of the nation's 3 mass spectrometer laboratories certified by the Atomic Energy Commission. The laboratory offers complete isotopic analysis of gases and solids by electronic bombardment. The Tulsa facility also designs and builds mass spectrometers to special order.

During the year Tulsa also received a contract to build an MOL dosimetry system to make direct measurements of ionizing radiation absorbed by astronauts in orbit. A new version of its ion attitude sensor, which determines spacecraft attitude through naturally occurring ions in the atmosphere, was revealed. The new unit, called an omni-sensor, will permit attitude determination from ion particles to higher altitudes than the previous unit and also permits such sensing through environments, such as the Van Allen Radiation Belt, heretofore considered hostile to ion attitude sensors.

The Commercial Operation continued its production of home intercom systems, fire alarms and burglar alarms for sale to leading suppliers in the home building industry. Electronic educational aids were also produced by the Commercial Operation.

Activity at the division's Field Engineering Operation continued in aviation support, depot maintenance and technical services.

Foreign sales of equipment developed and produced for the U.S. military services played an increasing part in the Electronics Division's 1968 business activity.

AVCO EVERETT RESEARCH LABORATORY

Avco Everett Research Laboratory continued in 1968 its effort to develop large magnetohydrodynamic power plants for the electric utility industry including a "peaking" system to prevent blackouts. In addition, considerable effort was mounted to investigate the practicality of developing lightweight MHD power units for Air Force aircraft needs. The Air Force was interested in megawatt-sized MHD systems to produce power for special electronics and illumination needs aboard tactical and strategic aircraft. Avco Everett was studying airborne MHD generators that burn high-energy fuels and air. Such generators would be compact enough for airborne use and could be operated for several hours before needing refueling.

The possibilities of using pulsed gas lasers for a variety of applications were being actively pursued. One of the most promising applications seemed to be a pulsed gas laser system for measuring the amount of pollutants being emitted by smokestacks, automobiles, etc.; it also offered application in high-speed photography and photochemical research. Another laser system that could measure landing visibility for aircraft was being investigated. A third system uses a pulsed gas laser to map the underwater profile of beach and coastal areas; this system was being developed jointly by AERL and Syracuse University Research Corporation. The laboratory was also conducting extensive gas laser research for the Department of Defense.

The Intra-Aortic Balloon Pump was designed to give immediate aid to heart victims by reducing the heart's work load. The Balloon Pump performed excellently in animal tests. The laboratory was working with Massachusetts General Hospital and several other Boston-area medical teams in this program. Also, a family of special medical materials that resists blood-clotting effects was developed. These materials were undergoing tests to determine their full potential for prosthetic devices. The relation of blood flow to the clotting mechanism continued to be investigated for the National Heart Institute.

The laboratory received additional Department of Defense support to expand research programs aimed at developing a greater understanding of the physics of reentry. The programs to monitor reentry vehicles as they descend back into the atmosphere over the Pacific also continued. The information collected with airborne support control equipment is returned to the laboratory for analysis and interpretation. Information gained from both programs is used in connection with developing advanced intercontinental ballistic missiles and an entire missile defense system.

During 1968 plasma physics research continued to expand. Additional support was received from NASA to develop a plasma radiation shielding system to protect future astronauts against interplanetary radiation storms. Additional funds were received from the government to continue work on the Heavy Ion Plasma Accelerator (HIPAC). The HIPAC may enable physicists to perform nuclear experiments beyond the reach of existing particle accelerators, which are capable only of accelerating light elements. The device will enable scientists to explore the mystery of nuclei and could enable them to learn more about the formation of the universe, study radioactive decay properties of nuclei and possibly discover new elements.

AVCO LYCOMING DIVISION

In addition to establishing record increases in the production of gas turbine engines for both fixed-wing and vertical-lift aircraft, Avco Lycoming Division, during 1968, marked several product-performance/"first-delivery" milestones over a wide market area, involving many new power applications.

Engine production, centered on the division's most advanced T53 series power plant—the T53-L-13—again reached an all-time high. Employment at the Stratford, Connecticut, plant climbed to approximately 10,000 persons and the division's new plant in Charleston, South Carolina, also accelerated its growth. The size of the Charleston plant was increased to 800,000 square feet and employment at that facility topped 2,500, with 3,500 expected by mid-1969.

Expansion at the main Avco Lycoming plant in Connecticut brought its facilities to approximately 1,750,000 square feet of floor space.

The course of the year also saw Avco Lycoming deliver its 10,000th T53 engine and its first T55-L-11 engine—most advanced in the T55 series, and flat-rated at 3,750 shaft horsepower.

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 in several military and commercial Bell helicopters.

However, it was not until early 1968 that the effect of large numbers of the Army's new AH-1G Bell HueyCobra gunship, powered by the -L-13, could be fully measured.

Other aircraft powered by the T53-L-13 include the Bell UH-1H, latest version of the famed Huey series of helicopters, and the new 15-place commercial Bell 205A, made available early in 1968.

In connection with commercial operations, Avco Lycoming's foreign licensing commitments continued to grow in 1968 for the assembly and servicing of gas turbine engines, being required in large numbers by private companies and foreign governments which have purchased Avco Lycoming-powered helicopters.

Announced in January were ceremonies conducted within a month of each other at opposite ends of the globe heralding deliveries of foreign-assembled T53-L-11 gas turbine engines both in Italy and in Japan. This was in addition to earlier foreign-assembled deliveries in Germany. All 3 operations entered qualification tests in 1968 for foreign assembly of the more powerful T53-L-13 engines. Late in the year Klockner-Humboldt-

Deutz, German licensee for the T53, achieved its 100th engine delivery milestone.

Meanwhile, Avco Lycoming received FAA certification itself in 1968 for commercial production, in the United States, of the T5313A. This brought to 7 the number of different types of Avco Lycoming gas turbine engines certified by the FAA since 1964.

Initial deliveries for production engines were recorded during 1968 for 2 other advanced Avco Lycoming engines: the T53-L-15 turboprop engine and the T55-L-11 helicopter engine. The T55-L-15, counterpart of the -L-13 helicopter model, was powering the most advanced version of the Army's high-speed observation aircraft, the fixed-wing Grumman OV-1D Mohawk.

First deliveries of the T55-L-11 engine, rated at 3,750 shaft horsepower, took place in September and these power plants were being used in Boeing's twin-engine, tandem-rotor CH-47C Chinooks, latest version of the Army's CH-47 series of prime transport helicopters. The additional power of the higher-rated Lycoming engines provides a 25 percent increase in the Chinook's payload, over an earlier CH-47B model powered by T55-L-7C engines.

Avco Lycoming's shaft turbine aircraft engines alone surpassed the 12,000,000-flight-hour mark in 1968, in little over 10 years since the company's first turbines reached substantial production levels.

Also delivered in 1968 were TF-12 and TF-25 marine and industrial engines for a wide range of new applications, all with high volume potential.

As the result of a Navy testing program started in 1967, a new Avco Lycoming gas turbine marine propulsion system was selected in 1968 as the power plant for 2 new riverine-type assault boats built by the Sewart Seacraft Company.

The TF-12 marine gas turbine, heart of the new propulsion system, has a continuous power rating of 800 shaft horsepower and an intermittent rating of 920 shaft horsepower. The system also incorporates a "Z" strut unit built to Lycoming specifications.

The 2 new 50-foot, shallow draft "Riverine" boats, developed for Navy use, have been given the designations CCB, for Command Control Boat, and ATC, for Armored Troop Carrier.

In the industrial field, production was started in 1968 on TF-25 engines ordered in late 1967 by Delta Projects Limited, Winnipeg, Canada, to be used as a gas burning power source for gas pumping units.

Also recorded in 1968 was the first sale of a TF-25-143 engine to the Oil Industries Company, Odessa, Texas, to be used as the dual pump power source for truck-mounted Oil Fracturing Rigs, operated by the Cardinal Oil Company of Odessa. These rigs feed pressure into "sluggish" oil wells to open cracks in subterranean formations through which oil will then flow more freely, increasing the well's barrels-per-minute performance.

Under a contract for one prototype engine, the TF-25-143 will be evaluated by Cardinal and the Oil Industries Company as the single 2,200 shaft horsepower replacement for 2 much larger diesel engines providing 1,000 horsepower each.

Also developing in 1968 were potential oil industry uses in the areas of drilling (including portable drill rigs), water flooding, and generator sets for remote areas.

Another new application realized in 1968 was the use of twin TF-25-2030 gas turbine engines as the main power source for propulsion of an experimental, 324-passenger hovercraft (air cushion) vehicle designed for regular ferry services across the English Channel.

Under contract to the Vosper Thornycroft Group of the David Brown Corporation, Portsmouth, England, 2 engines were to be delivered for this Vosper VT1 prototype craft by early 1969. Assembly and test of these engines was to be conducted at the Avco Lycoming plant in Charleston, South Carolina.

Lycoming facilities at both Stratford and Charleston were approved in 1968 by Lloyd's Register of Shipping and interim certification was issued, making Avco Lycoming the first U.S. company to be authorized for the production of gas turbine engines as the main propulsion power plant for hovercraft-type vehicles.

Further developments also were recorded during 1968 in the Avco Lycoming test and development program for the Army's AGT-1500 gas turbine engine for heavy land vehicles. Early in the year the new engine was installed in an Army tank (mated with an advanced Army transmission) and it successfully underwent test trials on a specially constructed track at the Lycoming plant in Connecticut.

The AGT-1500 engine with its fuel saving regenerator is installed in the same space in an M-48 tank previously occupied by its normal diesel power plant, yet it provides approximately twice the horsepower. Testing was to continue as part of an Army program aimed at providing an improved power source for tanks and other heavy surface vehicles for the 1970 time frame.

Other Avco Lycoming activities also increased during 1968, notably the production of constant-speed drives. The LD6-10A model, which had already accumulated more than 1,000,000 hours of flight experience by year's end, was to be delivered at an even more accelerated rate during 1969 and used on the Navy's McDonnell Douglas A-4E, A-4F and TA-4F jet fighter-bomber aircraft. Other versions were being used by the Marine Corps and by the Australian, Israeli and British navies.

In addition, a new 40KVA unit, the LD-9 constant-speed drive, was under evaluation by the U.S. Navy.

In the missile area, Lycoming continued production under the Mark I penetration aids program for the Minuteman II and III intercontinental ballistic missiles. Plant facilities for this program were expanded.

The division also continued its highly sophisticated subcontract manufacturing efforts. For example, Lycoming was employing its extensive 3-dimensional milling equipment to produce the main cabin fittings and rotor hubs for the Sikorsky CH-53 helicopter. 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 also engaged in the Deep Submergence Rescue Vehicle Program, producing steel hemispheres which, when welded together, form the vehicle's main operational cabin. 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 inch.

Sales of aircraft reciprocating engines for fixed wing and helicopter aircraft continued at an increased pace during 1968 at Avco Lycoming's Williamsport operation. Indications were that Avco Lycoming unit sales for 1968 would surpass those of 1966, which was the Williamsport Division's best year. Export shipments increased considerably during the year and actual fiscal year period shipments will show a significant percentage increase.

Turbocharging was added to several engine models to meet the increased demand for altitude operation and pressurization of general aircraft. A fully aerobatic, 200-horsepower, 4-cylinder, fuel-injected engine was also introduced during the year because of considerable export interest. This aerobatic engine was the only fully aerobatic FAA-approved engine in the United States. Work continued on the refinement of existing models and on several other new models of higher horsepower up to 520 horsepower for corporate and commuter type airplanes.

In addition, a new family of reciprocating engines was under development. These new engines will incorporate such features as overhead camshafts, higher speeds and improved weight/horsepower ratios.

AVCO MISSILE SYSTEMS DIVISION

Avco Missile Systems Division was developing a new penetration aids system, the Mark I, under a $65,000,000, 20-month contract for the U.S. Air Force Minuteman intercontinental ballistic missile program. Subsequent production was to be at the Avco Lycoming Division, Stratford, and related componentry for the system was being provided by the Avco Electronics and Ordnance divisions.

During 1968 the division significantly advanced the state of the art of missile-borne electronic and electromechanical equipment by developing and testing highly miniaturized and precise components for instrumentation and control. This equipment was used in more than 30 flight tests which yielded a large body of experimental data never before possible.

Other research and development activity centered on analytical and experimental work on new technologies associated with the missile-antimissile engagement problem.

Avco Missile Systems Division established a marketing and business management organization to broaden its existing business base and to develop new business opportunities that will align themselves with the division's experience in defense systems.

AVCO ORDNANCE DIVISION

The Ordnance Division arming and fuzing business line increased in 1968 because of additional production activity on retarded bomb fuzes, Minuteman arming and fuzing systems and rocket fuzes. Development programs on mortar fuzes, proximity fuzes and retarded bomb fuze series contributed to the business line increase.

In the munitions business line, key engineering programs were approved establishing a threshold for increased production activity in the future.

The Ordnance Division's posture in the field of small rocket-propelled extended-range munitions (AVROC) led to 2 contracts with the U.S. Army to develop 2 40-millimeter rounds of ammunition. First, and of highest priority, is an AVROC round to fit the M75 and M129 automatic grenade launchers used so effectively by helicopter gunships in Vietnam. These weapons and the division's AVROC ammunition were planned for use on new helicopters such as the Cheyenne and for use on ground vehicles such as armored personnel carriers. The second program was to develop an AVROC round to fit the hand-held M79 grenade launcher. This weapon proved so effective in Vietnam that "everyone wants one."

Avco Ordnance Division was pursuing expansion of the AVROC concept into other calibers. The division felt it had just scratched the surface of knowledge with AVROC ammunition. Much was learned but much more is to be discovered which will show even greater advantages for the AVROC concept.

Research and development continued to be a major effort. Avco independent research and development included design effort addressing the miniaturization of components and circuitry for future microwave ICBM fuzes, to comply with the severely restricted space which can be made available on advanced reentry vehicles. Miniature components and devices, capable of surviving a severe radiation environment, received extensive appraisal.

Another Ordnance Division independent research and development undertaking was the investigation of fluidics systems and components for ordnance devices. Fluidic circuits were designed and built to perform the functions typical of requirements for a bomb fuze using both conventional fluidic elements as well as turbulence amplifiers. Fluid technology was being explored as a solution to the requirement for a reliable fuze for mortar and artillery use. The requirement that a fuze must sense a second environment after it experiences setback in the gun placed emphasis on fluidics, which will allow the fuze to sense movement through air as the second environment.

The division's Marketing Department was reorganized into 4 separate groups. Respective groups were established to support the military Departments of the Army, Navy (including the Marine Corps) and Air Force. The fourth group was established to support Avco's AVROC programs.

The division's programmed replacement with precision tooling, improved equipment and advanced methods and techniques bore the fruit of higher production rates, lower costs and better quality parts. Included in this program was a unique Bullard Continumatic vertical boring machine, a LeBlond Tape-Controlled Turret Lathe, a classified automatic assembly and brazing system and an automated passivation system for chemically cleaning fuze parts. To meet ever greater user demands, production rates significantly increased in several programs in the order of 150 to 230 percent. Costs on several programs were reduced in the order of approximately 20 percent.

The division expected to spend more than $1,000,000 in 1969 to further improve facilities to accomplish greater precision and accuracy, reduce lead times, and continue to be competitive in the manufacture of the most reliable, high quality and low cost products in the industry.

AVCO SPACE SYSTEMS DIVISION

The Avco Space Systems Division continued to find, during 1968, a broad range of applications for its strong technology base developed in support of ICBM and Apollo reentry systems. The manufacture of heat shield materials for the Apollo vehicles remained a major division activity in the area of thermal protection systems. The successful manned Apollo program attested to the reliability of the Avco-developed heat shield material for the Command Module.

During the year Avco expertise in heat shield materials was applied to the development of low-cost thermal protection systems for tactical missiles to allow survival in the increasingly severe aerothermal environments they must withstand. Quantities of radomes and fins for a new Navy missile system were coated with specially developed Avco ablative materials. In addition, a special Avco material was being provided for the Navy's Poseidon missile.

The conflict in Southeast Asia produced specific needs for vastly improved armor and armor systems to protect personnel and vehicles. The division responded to this problem with the application of some of its specialty materials such as high-density ceramics, newly developed transparent ceramic armor and composite armor systems. Special armor systems were designed for the protection of riverine craft, helicopters and fixed-wing aircraft. The division was providing the prototype armor for the Navy's Assault Support Patrol Boat (ASPB).

Production of high-strength boron filament for the Air Force continued in the division's Boron Pilot Plant at the same time as intensive investigations were made into the use of boron composites as a high-strength material for aircraft structural components. Also, unique composite materials with 3-dimensionally woven reinforcement were produced during the year in a variety of configurations for specific structural applications. These Avco 3-D materials possess significant mechanical and thermal characteristics not attainable in normal reinforced plastic materials. In the non-aerospace field, increasing promise and interest developed for the use of 3-D materials for large gears, bearings and shaft seal applications.

An advanced version of the Avco lightweight Resistojet system, developed as the prime east-west station-keeping unit for NASA's Application Technology Satellite D, was flown in September with unqualified operational success. Avco auxiliary propulsion equipment also was successfully flown in October on the M.I.T. Lincoln Laboratory LES-6 satellite.

Avco software was incorporated by division personnel into the NASA-Goddard Flight Control Center Program. This program successfully controlled the deployment and predicted the dynamics of the 750-foot booms on the Radio Astronomy Explorer satellite.

The division continued to lead in the development of sterilization facilities in support of NASA's space program. A Model Assembly Sterilizer, being built for NASA-Langley, is a trailerized prototype facility for the terminal sterilization of the Mariner Mars '73 probe.

The division devoted increased effort to the investigation and development of infrared systems as an aircraft countermeasure to ground-to-air and air-to-air missiles. High-intensity IR metal vapor lamps were developed, put through extensive flight tests and produced. Complete IR systems were being developed for specific applications to surveillance, reconnaissance and electromagnetic warfare operations.

BEECH AIRCRAFT CORPORATION

In 1968 Beech Aircraft Corporation, for the third successive year, set an all-time record in fiscal year sales. Total sales for the year amounted to $176,803,654, which included $122,368,428 for commercial products, also a record, and employment at Wichita headquarters and 3 divisions reached a 15-year high of 11,600.

In international markets, Beechcraft sales also established a new high, totaling $29,004,401 for the fiscal year. Export sales were bolstered by fleet purchases of Beechcrafts for training purposes: 13 single-engine Beechcraft Bonanza E33s to Japan, 12 twin-engine Beechcraft Barons to England and 10 twin-engine Beechcraft Super H18s to Japan Air Lines.

Sales leader in the 1968 Beechcraft commercial fleet was the turboprop, pressurized Beechcraft King Air. With total deliveries exceeding 410, the King Air, according to the Aerospace Industries Association of America, accounted for nearly 23 percent of all turbine-powered aircraft and 45 percent of all turboprops delivered for corporate use in the United States.

With the introduction of new models during the year, the Beechcraft product line was increased to 20 models, ranging from the 2-place, single-engine Beechcraft Musketeer Sport to the 17-place, turboprop Beechcraft 99 Airliner.

The 250-mile-an-hour Beechcraft 99 Airliner, following FAA certification and first delivery in May, amassed in six months of service a total of nearly 10,000 hours of operation as initial units reached 23 commuter airline operators in the United States.

Production models of the twin-engine, pressurized Beechcraft Duke were delivered to first customers. In June assembly of the Duke was assigned to the Salina (Kansas) Division.

Introduced were the 6-place, single-engine Beechcraft Bonanza 36, largest Bonanza ever produced; the 8-10 place turboprop Beechcraft 99 Executive, corporate version of the Beechcraft 99 Airliner; and the twin-engine, supercharged Beechcraft Queen Air 70.

Also presented for the first time were 4 single-engine Beechcrafts combining business travel and aerobatic capabilities. Licensed for aerobatic maneuvers were the aerobatic Beechcraft Bonanza E33C and Bonanza E33B plus the aerobatic Musketeer Custom and Musketeer Sport.

A $4,300,000 award by the U.S. Naval Air Systems Command continued production of the supersonic, rocket-powered AQM-37A missile target through September 1970 and brought revenue from the program since 1960 to more than $63,000,000 and unit production to over 2,100. Production of the AQM-37A was transferred to the Boulder (Colorado) Division.

Successful testing of the Sandpiper, a missile target which combines the Beech-designed AQM-37A airframe and a newly designed solid-and-liquid propellant engine and which is designed to reach Mach 4 speed and 90,000-foot altitude, was accomplished at Eglin Air Force Base, Florida, for the U.S. Air Force Armament Laboratory.

The Stiletto, a modified version of the AQM-37A missile target ordered by the Defense Ministry of the United Kingdom, was successfully test flown off the coast of Wales in September.

The U.S. Army ordered additional units of the Beechcraft Model 1025 Cardinal missile target, bringing total awards for that program to more than $42,000,000. In June the Salina Division assumed production of the Cardinal.

A follow-on contract by the U.S. Army Ammunition Procurement Supply Agency brought bomb dispenser total production to more than 20,000 units since the first contract in 1962.

Production of subassemblies for the supersonic McDonnell Douglas F-4 Phantom II was extended through December 1969 with receipt of a $6,300,000 add-on contract. The sixth award on F-4 assemblies brought to more than $66,000,000 the total amount received by Beech Aircraft since 1963.

In March the largest subcontract ever awarded by Bell Helicopter Company, approximately $75,000,000, went to Beech Aircraft for manufacture over a 5-year period of more than 4,000 airframes for the commercial Bell JetRanger 206A, the Army's light observation helicopter (LOH) series, and the Navy's light turbine training helicopter. The first airframe for the Bell JetRanger had been delivered by Beech Aircraft just weeks before, under a previous contract for that aircraft.

Under a $6,300,000 award by Bell Helicopter Company, production of panels for the Army's UH-1 Huey helicopter was continued. Awards to Beech for the UH-1, including spares, totaled more than $25,000,000.

Beech Aircraft's Boulder Division, continuing its role in the nation's space program, was awarded a $4,000,000 contract for fabrication of additional cryogenic gas storage systems used aboard the Apollo spacecraft. The Beech system supplies oxygen to the Command Module's environmental system and hydrogen and oxygen to the fuel cells for electrical power and drinking water.

BELL AEROSYSTEMS COMPANY
A TEXTRON COMPANY

For Textron's Bell Aerosystems Company, a research/development and systems engineering pioneer for more than 30 years, 1968 featured the production and deployment of the U.S. Army's first Air Cushion Vehicles (ACVs) to Vietnam, the unveiling of the world's first long-range Jet Flying Belt and the first flight of NASA's Bell-built Lunar Landing Training Vehicle.

Milestones also were reached by Bell on several other advanced systems, including the tri-service X-22A Vertical/Short Take-off and Landing (V/STOL) research aircraft, the Air Cushion Landing Gear and experimental lunar flying vehicles.

The Army's 3 ACVs, first to roll off Bell's production line, were airlifted in May to Southeast Asia, where they participated in several highly successful Allied missions in the swamps and rice paddies of the Mekong River Delta region southwest of Saigon.

The heavily armed and armored 10-ton amphibians were the first combat ACVs built exclusively in the United States to military specifications. The 3 U.S. Navy Patrol Air Cushion Vehicles deployed to Vietnam in 1966 were commercial vehicles modified by Bell to meet Navy needs. The Navy craft were based near Hue for the better part of 1968. Their speed and amphibious capabilities were instrumental in several inland and coastal assault operations in the northern provinces.

The Army ACVs, built under a U.S. Army Aviation Materiel Command (AVCOM) contract, feature a more powerful turboshaft engine, a new low-speed control system, greater firepower and heavier armament.

Bell continued to spearhead a multicompany parametric and conceptual preliminary design study for a 100-ton model test craft of the 4,000-5,000 ton Surface Effect Ship for the Joint Surface Ship Program Office. The SES would incorporate the air cushion principle and reach speeds of 100 miles per hour.

Research continued on development of a 60-ton ACV, the SK-10, designed to carry troops and heavy equipment at speeds reaching 70 miles per hour.

In recent years Bell has conducted parallel development of an Air Cushion Landing Gear (ACLG), a system based upon the ACV principle. An ACLG-equipped LA-4 Lake amphibian aircraft made its first take-off and landing utilizing a new ACLG braking technique in September.

Shortly thereafter, the ACLG began a series of advanced flight and terrain taxiing tests, a portion of which was funded by a new U. S. Air Force contract which included take-off/landing and taxi tests over a variety of surface conditions, including snow, grass, sand and such obstacles as ditches and simulated tree stumps.

Confirming Bell's faith in the long-range potential of air cushion vehicles was the completion in late 1967 of a company-funded $400,000 Air Cushion Technology Laboratory at the main plant adjacent to Niagara Falls (New York) International Airport. The structure, which became fully operational in 1968, includes a 10,000-square-foot pool and a whirling arm rig for testing current and advanced ACV designs over water and other terrain surfaces.

Bell Aerosystems' Air Cushion Vehicle Technology Laboratory at Buffalo, New York, became operational during the year.

In June, Bell unveiled its Jet Flying Belt, a one-man, backpack propulsion system developed for the Defense Department's Advanced Research Projects Agency (ARPA) under an AVCOM contract.

An outgrowth of the company's famed Rocket Belt, the jet-propelled configuration is capable of flight durations and ranges far greater than the 21 seconds of flight time to which its rocket-propelled forerunners were limited. Although specific performance details are classified, the Jet Belt's range and flight duration are discussed in terms of minutes and miles rather than seconds and feet.

Jet Belt tether tests were initiated in September. The scheduled program included manned free flights in late 1968 or early 1969.

Powered by what is believed to be one of the world's smallest high bypass turbojet engines (approximately 1 foot in diameter by 2 feet long), the system is expected to have as many commercial applications, e.g., riot control, rescue, fire fighting, as military uses, which include reconnaissance, counterguerilla and communications missions.

A pioneer in the development of individual mobility systems, Bell also has flown chair and one- and 2-man platform configurations of its rocket-propelled systems.

Applying its small rocket technology to lunar exploration systems, Bell completed the first manned free flight of its Body-Controlled Pogo Vehicle in August. Instead of being controlled manually as were earlier configurations, the new system allows the operator to simply lean in the direction he wishes to go. Known as kinesthetic control, this technique is considered more natural for the operator because it relies almost entirely on his sense of balance.

Bell subsequently received a NASA contract for flight testing a kinesthetically controlled platform much larger than the Pogo originally flown by Bell, and nearer the weight and inertial characteristics of an actual lunar flying vehicle.

Another advanced flight system, Bell's Lunar Landing Training Vehicle (LLTV), made its first manned free flight in October at Ellington Air Force Base, Texas. NASA and the Apollo astronauts were utilizing 3 LLTVs to practice simulated Lunar Module moon landings.

The LLTV is a modified version of the Lunar Landing Research Vehicles developed earlier by Bell for NASA. Both configurations are fitted with a turbofan engine designed to offset 5/6 of the vehicle's weight to simulate the lunar gravitational environment. The operator controls the vehicle by firing small clusters of rockets located around the framework of the vehicle.

The tri-service X-22A V/STOL Research Aircraft completed military preliminary evaluation in early 1968 and in July attained a sustained hover height of 8,020 feet, believed a world's record for V/STOL aircraft. During the maneuver the X-22A was not at full power. Subsequent analysis of flight data confirmed the 12,400-foot hover ceiling projected for the aircraft by Bell design engineers.

Later the X-22A was equipped with the Variable Stability System, a complex electronic control unit which permits the aircraft to automatically vary flight characteristics while airborne to simulate a wide range of V/STOL aircraft for evaluations of potential problems, the principal mission of the program.

The X-22A was scheduled for delivery to the U.S. Navy, administrator of the tri-service contract under which it was developed, in March 1969 for 2 years of extensive research.

In August a highly sophisticated Bell propulsion system helped guide the maiden launch of the U.S. Air Force's Minuteman III ICBM to a bull's-eye in the Ascension Island region, 4,400 miles from the launch silo at Cape Kennedy, Florida.

Bell-built positive expulsion tanks supplied propellants to the Command and Service Module reaction control systems and the Saturn S-IVB auxiliary propulsion system for the year's Apollo spacecraft missions.

Bell's famed Agena rocket engine, known as the "workhorse of the space age," continued to place many payloads in space under NASA and Air Force programs.

In January, Bell was awarded a NASA contract to continue work on a Radar Attitude Sensing System (RASS), an advanced, multipurpose flight control sensor with no moving parts, designed to provide information needed to stabilize an orbiting spacecraft with respect to the earth's surface. Once completed, an engineering model was slated for trials aboard manned aircraft and an orbiting vehicle.

During the year Bell delivered 6 motion-stabilized BGM-2 gravity meters, one to the U.S. Army Mapping Service, 2 to the U.S. Navy's Oceanographic Office and one each to Gulf, Shell and Mobil oil companies, where they were used in conjunction with undersea oil exploration operations.

The U.S. Army Electronic Proving Ground at Fort Huachuca, Arizona, awarded Bell follow-on contracts for continued operation, maintenance and development of the Army's Electromagnetic Environmental Test Facility, where airborne electronic systems are evaluated in manned and unmanned aircraft.

Bell received a contract from the U.S. Naval Ship Systems Command for 5 Bell AN/SPN-42 All-Weather Carrier Landing Systems (ACLS). The new installations brought to 19 the number of ACLS units delivered to the Navy by Bell since 1950. The systems were earmarked for the USS *John F. Kennedy*, the USS *Saratoga*, the USS *Nimitz* and the Naval Air Stations at Lemoore, California, and Oceana, Virginia.

The company continued development of 2 other advanced avionics systems, the Visual Airborne Target Locator System (VATLS) and the Simplified Aircraft Instrument Landing System (SAILS).

Installed aboard a Bell UH-1B helicopter, VATLS pinpoints enemy ground targets and electronically directs artillery fire on them. The system has proved successful in substantially increasing the regularity of first-round direct hits. The second VATLS-equipped helicopter was deployed to Vietnam in September 1968. It features improved maintainability and reliability as well as a greater sensing ability.

The Bell SAILS unit permits low-altitude approaches for landings in remote areas, including a means of accurately determining release points for cargo and/or troop drops. It utilizes an airborne tracker in conjunction with a ground beacon to provide all-weather aircraft guidance information. Test demonstrations of the system were conducted at Bell's main plant, at Wright-Patterson Air Force Base and at Pope Air Force Base.

In July, Bell's modern computer facility in Tucson, Arizona, became the center of a unique automated medical system. Established for the U.S. Department of Health, Education and Welfare, the program provides computerized medical, environmental and sociological records for each of the 8,500 members of the San Xavier and Papago Indian reservations in southern Arizona. The system capitalizes on the computer technology and data-processing technology Bell has developed at the center while designing and implementing management information and simulation systems for the U.S. Army—still the principal mission of the center.

The facility's new medical role is a major step forward in the effort to facilitate treatment and prevention of communicable diseases among these nomadic tribes.

As a result of Bell's materials processing and structural research, a technique for welding heavy gauge Thoria Dispersed (TD) nickel was developed in 1968. Bell's ability to weld this high-temperature aerospace alloy is expected to permit designers to substantially increase the efficiency and operating lives of future rocket and jet engines. The Bell technique involves a low-heat input which minimizes agglomeration, a phenomenon which causes the alloy to become extremely brittle and has plagued previous welding attempts.

The company's efforts in composites research during 1968 led to the fabrication of graphite fiber turbine blades and other aerospace test structures of varying degrees of structural complexity.

At midyear Bell completed construction of a supersonic impact erosion test chamber, first in the free world designed to evaluate the ability of aerospace materials to withstand the impact of rain, snow, dust and ice crystals at Mach 3 speeds.

Built under a U.S. Air Force contract, the whirling arm test chamber is expected to play an important role in achieving breakthroughs in the study of supersonic impact erosion by speeding the development of new and improved materials useful to engineers in designing future erosion-resistant components and structures for supersonic and hypersonic aircraft, as well as for missiles and spacecraft.

The year also marked the completion of a new 12,000-square-foot chemistry building at Bell's main plant. It represented a consolidation of the company's research and development activities in such areas as propellant analysis, metal finishing, fungus testing and quality and contaminant control. All are technologies allied to the rocket engine propellant tanks, rocket engines, space vehicle structures, air cushion vehicles and electronic systems and components designed and developed by Bell.

On August 2, 1968, Textron Inc., parent organization of Bell Aerosystems Company, announced the election of Robert S. Ames of Bell Aerosystems as a Textron vice president. Ames, an executive with 25 years' management experience in the aerospace industry, had been Bell's vice president-manufacturing since September 1964. In his new capacity as a corporate group officer, Ames is engaged in the supervision of a number of Textron divisions. Ames assumed his new duties in Providence, Rhode Island, Textron's corporate headquarters. Succeeding Ames as Bell's vice president-manufacturing was William S. Nochisaki, who had served as executive director of manufacturing since January 1967.

In addition to its main plant near Niagara Falls, New York, and its research facilities at Tucson and Fort Huachuca, Arizona, the company maintained during 1968 an avionics instrument laboratory in Cleveland, Ohio, and a sales/marketing operation, Bell Aerosystems-Canada, in Toronto. President William G. Gisel announced that employment throughout the year averaged approximately 7,200 persons.

BELL HELICOPTER COMPANY

A TEXTRON COMPANY

Expansion and diversification were evident throughout 1968 as Textron's Bell Helicopter Company again achieved new highs in commercial and military sales.

Sizable contracts from the U.S. Army, Navy, Marine Corps and Air Force were divided almost equally between new production aircraft and models well established in the inventories of the armed forces.

While extending its record of on-time deliveries to the U.S. government to 12 years, Bell also had unprecedented success in commercial marketing. The year set records from the standpoints of units sold and dollar volume on both the domestic and the international markets.

Accelerated demand for the 5-place, turbine-powered Model 206A JetRanger, which in 1967 had enjoyed the greatest first-year sales in commercial helicopter history, was the key to a substantial amount of new business again in 1968.

Not only did it far exceed its initial year civil sales, but the JetRanger was selected for observation, trainer and utility roles by armed forces of the U.S. and several foreign nations.

The U.S. Army named the JetRanger winner of its re-opened light observation helicopter competition, awarding Bell a contract for 2,200 of the aircraft to be delivered between 1969 and 1972. The Navy selected the JetRanger as its light turbine trainer and ordered 40 for delivery by the end of 1968. The JetRanger also was the choice of the Brazilian Air Force and of law enforcement agencies in Europe, Asia and Africa.

Introduction of stowed floats capable of full in-flight inflation, and of an ambulance configuration featuring folding litters that can be stored in the baggage compartment when not in use, made the JetRanger increasingly attractive to police, fire and other state and local agencies.

Success of Bell's development efforts on a twin-engine helicopter led to a management go-ahead on production engineering. The company announced that its Model 212, powered by the Pratt & Whitney Aircraft PT6T-3 turbine twin-pac of United Aircraft of Canada, would be delivered to commercial customers in 1970. The airframe is that of Bell's latest commercial model, the 15-place 205A.

Military cognizance of the company's progress in the twin-engine field was evident. The Canadian government approved participation with Bell and United Aircraft of Canada in a development program expected to lead to that nation's equipping its armed forces with the new aircraft. The U.S. Air Force ordered 76 UH-1 helicopters and the Marines contracted for 49 HueyCobras, both utilizing these same twin engines.

Armed forces' selection of the JetRanger and of twin-engine Bell aircraft for combat and training operations shared the spotlight with additional quantity purchases of the Vietnam-famed Huey helicopters. The Army continued its long-lead-time buys of UH-1H utility transports, with orders in 1968 for more than 1,500, and boosted its total production requirement for the 2-man, high-speed HueyCobra gunships. The Navy also ordered more than 50 UH-1s for training and utility missions, giving that series extremely rare 4-service status.

As a result of this contract activity, Bell at year-end had orders from the U.S. military for 11 different model designations ranging from 2-place to 15-place aircraft.

These include the Army's 2-place TH-13T instrument trainer and the AH-1G HueyCobra, 3-place OH-13S observation ship, 5-place OH-58A and 12-15 place UH-1H. Marine models are the 2-place AH-1J and 10-place UH-1E. Navy acquisitions are the 5-place TH-57A and 2 variants of the Marine Huey configuration, the TH-1L and UH-1L; the Air Force twin-engine model is designated UH-1N.

Bell Helicopter Company's AH-1G HueyCobra continued in heavy production for the Army. A twin-engine configuration was ordered by the Marine Corps.

Commercial production models, in addition to the JetRanger and 205A, are the 3-place 47G-4A utility ship, the 3-place turbosupercharged 47G-3B-2 and the 47G-5. The latter is a 3-seater for utility use and a 2-seater for aerial application.

A co-production contract between Bell and the Federal Republic of Germany, designed to provide approximately 350 UH-1Ds to the armed forces of that nation by the end of 1970, was in its third and final stage. Bell was delivering sets of dynamic components for the remaining helicopters. Prime contractor in West Germany was Dornier, GmbH.

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

In February, Bell announced that it would open a facility at Amarillo (Texas) Air Force Base to overhaul and modify airframes of battle-damaged helicopters from Vietnam. The depot was activated immediately. By the end of the first year of operations, employment in Amarillo was expected to be about 650.

Additional facilities expansions in 1968 included a new 200,000-square-foot Customer Logistics Building on company land adjoining the main Fort Worth plant, an 80,000-square-foot addition to an office structure at the main facility, and a 12,000-square-foot building addition to Plant 5A containing 8 new transmission test cells.

Research, development and product improvement activities remained at a high level during 1968.

A powerful new version of the Army UH-1 helicopter, capable of lifting a 3-ton external payload, was flown successfully. Company engineers stated that the retrofitted aircraft, named the HueyTug, is ideally suited as an aerial artillery prime mover in combat operations. The helicopter was demonstrated to the Army, Navy, Air Force and Marine Corps and was undergoing official evaluation.

A practical system for varying the diameter of a rotor was developed and successfully tested with full-scale hardware. The rotor was ready for application to a flight vehicle, and the company was investigating integrating the system into an advanced research flight test program. The variable-diameter rotor has specific applications in a high-speed compound helicopter and the tilt-rotor vertical take-off and landing vehicle.

A heliborne fire suppression system, designed to allow quick recovery of personnel trapped in crashed and burning aircraft, successfully passed Bell and U.S. Army evaluation tests at Fort Rucker, Alabama. During a 3-week period in which 71 experimental fires were conducted, the system consistently allowed aeromedics to remove dummies from fire-engulfed wreckage in about 30 seconds. The tests culminated in purchase of a quantity of the systems by the Army.

Elevated to the rank of full vice presidents by Bell Helicopter Company were William L. Humphrey, general manager of the Overhaul and Modification Center at Amarillo; Dwayne K. Jose, Commercial Marketing; M. R. Barcellona, Management Engineering; John Finn, Industrial Relations; James C. Fuller, Public Relations; Joe Mashman, Special Projects; and Warren T. Rockwell, Director of Washington Operations. During the year the company announced a realignment of its organization to initiate the Project Management Concept. Charles R. Rudning was named Director of Program Management, reporting directly to Executive Vice President J. F. Atkins.

Bell Helicopter was one of 4 companies awarded Army contracts for preliminary design investigations for the proposed Utility Tactical Transport Aircraft System (UTTAS) and completed this concept formulation study. The company was engaged in numerous other new or continuing research and development programs, including several of classified nature. Employment, keeping pace with accomplishments of 1968, was approximately 11,000, including the work force at Amarillo.

THE BENDIX CORPORATION

COMMUNICATIONS DIVISION

The Communications Division, a prime government contractor, was primarily engaged in 1968, as in previous years, in the development and production of communication and radar equipment. Recognizing the demands for advanced communications and radar systems to meet future needs, the division was conducting research and development programs designed to keep the division abreast of the latest state-of-the-art techniques in the general field of electronics.

Production of the AN/APX-72 IFF transponder was under way at the Communications Division. The work being done represented the largest single contract for IFF transponders ever let by the U.S. government. The contract funded for $27,000,000 marked the first time that a major electronics subsystem of this complexity had been procured on a tri-service basis. Considered a universal transponder, the AN/APX-72 will be installed aboard lightweight aircraft, helicopters, jet aircraft and Navy ships. The transponder performs the dual functions of enhancing air traffic control operations and providing friend or foe identification capabilities. Plans called for the units to be installed in most new aircraft configurations and for retrofitting existing aircraft with the transponder. Universal application of this transponder is part of a government program to develop a completely integrated and standardized air traffic control system. Advantages gained from such a program will aid in the solving of technical and logistical problems for the military.

The Communications Division was working on a $7,000,000 contract to build the AN/GRC-147 ground radio communications system. The contract called for construction of 70 radio systems, which are comprised of 5 cabinets containing 3 transmitters and 2 receivers. The AN/GRC-147 provides short-distance, line-of-sight, command post type ground communications over a 35-mile range. Systems are housed in portable shelters which are transportable by land, sea or air. Each system is capable of relaying 96 different messages simultaneously. Teletype and photo transmission capabilities were also being incorporated into the system.

An assembly area at the Communications Division was being used to install the AN/GRC-147 communication systems into portable shelters to bring about the AN/TRC-111 configuration. The work being done was funded under a separate contract for $2,900,000. For the first time in its history, the division will be able to install complex electronics equipment into transportable shelters on a large-scale production basis at its plant in Towson. This is significant in light of the fact that the majority of the systems built for the U.S. Army Electronics Command and Army Signal Corps invariably are enclosed in some type of portable shelter.

The Communications Division completed delivery of 8 Apollo Range Instrumented Aircraft (A/RIA) to the United States Air Force under subcontract to the McDonnell Douglas Corporation. These complex airborne systems consist of automatic acquisition and tracking equipment; a 7-foot antenna; telemetry receiving, recording and processing equipment; and voice communications equipment to relay the astronauts' voices to the worldwide manned spaceflight communications network. The equipment was installed in C-135s and was in operational use on a wide range of support missions, spanning from ballistic reentry missions to voice relay on the Apollo program.

A $3,100,000 contract let by the U.S. Air Force for the construction of 2 transportable torn tape relay centers was completed during the year. The centers are designed to receive and transmit information over 20 separate telecommunications lines. In addition to telecommunications equipment, the centers are equipped to use compatible cryptographic devices. Bendix-built interface or "patching" components are used to provide the crypto-telecommunications interface. Further expansion was made in the division's proprietary line of terminal devices and ancillary items for use in secure communications systems. Eleven items were added to this line during the year.

Among the many specialized electronics systems built by the division was the AN/FPS-100 parabolic radar. A 1968 $2,800,000 contract let by the Iranian government called for the construction of 4 of the radars.

The division was also under contract to build signal marker beacons used by the U.S. Army to mark positions of friendly forces. A dense jungle canopy can often prohibit the transmission of radio signals. To overcome this problem, a marker beacon that can penetrate the dense foliage was developed.

During the year the Fuzing Devices Division in York, Pennsylvania, consolidated with Communications Division. This brought about an increase in the Communications Division's product line. Most notable among the new products added was the fuzing device used to trigger the Phoenix long-range air-to-air missile. The Phoenix was designed primarily for use with the F-111B aircraft.

Production was under way on surface fuzes for the MK12 reentry vehicle at the division's York Plant. This reentry vehicle was destined for the Minuteman III missile system.

A new computer programming center in Colorado Springs, Colorado, was opened by the division during the year. The center was established to provide systems analysis and programming tasks for the AN/FPS-85 radar system.

The computer-based space detection and tracking sensor located at Eglin Air Force Base, Florida, was to enter the operational inventory of the 14th Aerospace Force of the Aerospace Defense Command as the first operational ground-based phased array radar in the United States. Programming techniques developed for this project represented a new capability for the division and promised to have broader applications in the expanding field of computer-controlled radars.

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

The Communications Division has been developing electronically steerable antenna beam radars since 1958. Much of this effort was culminating in the delivery of the AN/FPS-85 radar to the Air Force. From this store of knowledge, the next-generation phased array antenna techniques were being developed. The objective goals of the new antenna systems are to provide fast scan and multiple scan capability in a lightweight, mobile configuration. The novel radar system being developed consists primarily of solid-state components. Maximum utilization is made in the development of microwave integrated circuits and microminiaturized control circuits.

In the field of communications, the division designed and produced satellite and secure communications terminals, range instrumentation communications links, IFF transponders and personal radios. Next-generation systems, it was recognized, will be primarily in a digital format. The division, therefore, was exploring the areas of frequency synthesizers, digital filters, VOCODERS, and spread spectrum. The advantages to military usage of digital communications systems include achievement of a high degree of reliability and maintainability, greater security, multichannel capability, frequency agility and greater adaptability to microcircuitry commonality.

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

NAVIGATION & CONTROL DIVISION

NASA's Saturn-Apollo launches and Apollo Applications Program, U.S. Navy's Poseidon missile, U.S. Army's Pershing missile, USAF's Minuteman missile, McDonnell Douglas' DC-10, Lockheed's C-5A, Boeing's 747, the Concorde SST and Army's AH-56A Cheyenne helicopter—these were but a few of the many aerospace programs with which The Bendix Corporation's Navigation & Control Division was closely linked during 1968.

The division's aviation activities were accelerated by a contract from McDonnell Douglas to provide the automatic flight control system for the new DC-10 trijetliner. The system, scheduled for production delivery early in 1970, will be capable of making fully automatic landings. The system is designed with dual subsystems and separate but parallel installation of redundant components to assure that it will remain operational even in the event of a malfunction somewhere in the system. The wide-body, multirange DC-10 is designed to carry up to 345 passengers on flights of 300 to 3,200 miles; it will enter airline service in 1971.

When Lockheed-Georgia Company's C-5A Galaxy logistic transport made its initial flight on June 30, 1968, Bendix was on board. Compact, lightweight cockpit instruments included vertical scale type indicators for both engine and flight functions, peripheral command indicators and dual bull's-eye attitude flight director indicators, all of which feature integral microcircuit electronics. The 350-ton transport, the free world's largest aircraft, is nearly as long as and spans more than a regulation football field, and its tail is about as tall as a 6-story building.

Division equipment was also ordered for The Boeing Company's giant 490-passenger Model 747 transport. Besides developing the central air data computer, the division was contracted to supply automatic throttle, yaw damper and Mach trim systems and RDMI and RMI as standard equipment. In addition, a number of 747 airline customers ordered the division's vertical scale engine instruments—the first time this type of instrumentation has been specified for a commercial aircraft—and dual bull's-eye attitude director and horizontal situation indicators.

Additional Boeing Company contracts were received by the division for automatic flight control systems (AFCS) and the Boeing-Bendix Precision Approach and Landing System (PALS) for use on 707 and 720 aircraft. The PALS system, in 1965, became the first to win Federal Aviation Administration certification for use in making fully automatic landings under Category II weather (100-foot ceiling and one-quarter mile forward visibility). History was again made on May 28, 1968, when a Bendix system landed a Pan American 707 aircraft at Milwaukee for the first U.S. public demonstration of an automatic landing by a 4-engine aircraft. Again, in September, it helped achieve a significant milestone when Pan Am became the first U.S. airline to be certified by the FAA to have any plane in its fleet land during Category II minimums. In addition to airlines that will be getting PALS-equipped aircraft, Northwest Airlines contracted to procure PALS to retrofit its 707 fleet for Category II operations.

The division also received follow-on contracts for automatic flight control systems and all-weather landing equipment for Lockheed-Georgia's U.S. Air Force C-141 cargo transport. Equipped with this gear, the C-141 became the first military transport qualified to make automatic all-weather landings. During its association with the C-141 program over the past 7 years, the division has also supplied vertical scale indicators, yaw damper systems and vertical navigation systems.

The U.S. Navy awarded additional contracts for PB-20 AFCSs for the P-3C antisubmarine patrol aircraft and the A-4E attack aircraft.

Overseas orders for Bendix AFCS systems were placed by the Nihon Aeroplane Manufacturing Company of Japan for its short/medium-range YS-11 commercial transport and by the British Aircraft Corporation for its BAC One-Eleven short-haul commercial transport. The division also continued to support development of the Anglo-French Concorde supersonic transport's AFCS.

During 1968 the division's general aviation program expanded as the Fairchild Hiller FH-227 and the Hawker Siddeley DH-125 3A/RA aircraft were added to the growing list of executive aircraft for which the FAA has approved the PB-60 AFCS. In addition, the PB-60 AFCS and the FD-60 Flight Director System were granted FAA certification for use by the Lockheed JetStar to make landings in Category II weather conditions.

During the year a contract was awarded the division by the U.S. Air Force for the manufacture of dead reckoning navigation computer systems. Intended for use on the F-4 Phantom fighter aircraft, these systems continuously compute, transmit and display information needed by the pilot for the navigation of his aircraft. The Air Force also ordered compass components and directional gyros for the T-38/F-5A fighter trainer aircraft.

Follow-on contracts were awarded for vertical scale flight instruments for the USAF's F-111/FB-111 aircraft, and engine vertical scale instruments were ordered by Grumman Aircraft Engineering Corporation for the U.S. Army's OV-1C Mohawk observation reconnaissance airplane.

Additional contracts were awarded for the Bendix weapons release system for the U.S. Navy's A-4, A-7 and F-100 aircraft. The system permits the pilot to program the automatic release of stores from the weapons stations in whatever quantity, mode and drop intervals he desires.

Production orders were awarded by Lockheed-California for a dual-control version of the system for the U.S. Army's 2-man AH-56A Cheyenne helicopter, which made its first flight December 12, 1967. Also ordered for the AH-56A were computer control panels which enable the pilot to enter navigational data into the helicopter's on-board central computer complex.

In the field of automatic check-out equipment for military applications, the versatile AN/GSM-133 general-purpose programmer comparator was ordered for use with the giant C-5A transport. New in test equipment for commercial use was the Model 200 computer-controlled automatic test station, which was ordered by Continental Airlines to check out avionics equipment on its fanjet fleet. With the equipment, Continental will become the first U.S. airline to use such equipment in an airline maintenance program. In October, TWA also placed orders for customized versions of the computer complex that not only will check out equipment on its jet fleet but will also meet the additional test requirements of avionics equipment on the company's upcoming fleet of 747, 1011 and American SST aircraft.

Navigation & Control's space activities during 1968 included additional contracts on NASA's Apollo Applications Program (AAP) from the Martin Marietta Corporation, with whom the division was teamed as principal subcontractor. The program includes planning for continuous occupancy flights of up to 56 days in earth orbit and extended duration flights up to 1 year using a resupply spacecraft, as well as lunar orbit flights and lunar surface operations up to 14 days. The division is responsible for communications, displays and controls, and portions of experiments analysis and other electronics.

NASA follow-on contracts were awarded for control moment gyros to provide accurate and continuous attitude control and stabilization for the Apollo Telescope Mount (ATM). The ATM is slated for use during an Apollo Applications 56-day experiment to study the sun in its most active stages. The division was also contracted to provide roll position indicators for the ATM.

Other NASA contracts were awarded to the division for inertial guidance platforms for the Saturn launch vehicle. The platform performed perfectly on all Saturn I, Saturn IB and Saturn V flights through 1968 and was scheduled for all future Saturn launches. The platform, in conjunction with a launch vehicle data adapter and launch vehicle data computer, is the active guidance system that maintains the preset course of Saturn from the launch through space orbit injection as predetermined by the mission requirements.

The division was awarded a contract by the U.S. Navy to provide 2 vital units in the Poseidon missile's inertial guidance system. The units are known as IRIG (Inertial Reference Integrating Gyroscope), a precise liquid-floated gyroscope which stabilizes the missile's inertial guidance system in flight, and PM PIP (Permanent Magnet Pulsed Integrating Pendulum), an acceleration-sensing device that helps determine the missile's flight position. The contract was awarded for winning a competition based on the research and development phase of the Poseidon program conducted for the U.S. Navy by the Massachusetts Institute of Technology. The 34-foot long, submarine-launched Poseidon will be able to reach any spot on earth from its submerged nuclear-powered nesting place.

For the 11th consecutive year the division was awarded contracts from the U.S. Army for supplying inertial guidance systems for the Pershing missile program. The supersonic, selective-range missile is completely mobile and is operational with the U.S. Army at home and with NATO forces abroad.

The division moved into its 12th year of production on Hawk missile antenna bases and pedestals. The Hawk missile defense system is employed by the U.S. armed forces in the U.S., Panama, Europe and Asia. It has also been bought by such foreign countries as Sweden, Israel and Saudi Arabia.

In June 1968 the division shipped its 1,000th PIGA (Pendulous Integrating Gyro Accelerometer) to North American Rockwell's Autonetics Division for installation in USAF's advanced Minuteman II missile. PIGAs are key acceleration-sensing units in the missile's guidance and control system.

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

During 1968 the division undertook one of its largest facility remodeling programs in history and extensive updating was done throughout the 6 plants. The entire 170,000-square-foot engineering building, for example, underwent interior remodeling that included new floors, walls, ceilings, lighting and air conditioning.

A 14,400-square-foot hangar to house the division's aircraft was constructed adjacent to the division's general aviation facility and bordering on Teterboro Airport. The 120-foot by 120-foot hangar is an insulated, metal, rigid-frame structure that includes galley and crew facilities and can house 4-5 aircraft depending on size. The hangar features infrared heating, mercury vapor lighting and 6 24-foot-high hangar doors that move on heated tracks and can withstand 100-mile-per-hour wind loads. As part of the overall improvements, new landscaping was done throughout much of the 140-acre facility.

AEROSPACE SYSTEMS DIVISION

A scientific experiments package designed and developed for placement on the lunar surface was delivered in the summer of 1968 by Bendix Aerospace Systems Division to the NASA Manned Spacecraft Center. This system, known as ALSEP (Apollo Lunar Surface Experiments Package), will be transported to the lunar surface on an Apollo flight and will then be deployed by an astronaut. ALSEP will sense, collect and transmit scientific and engineering data to earth for 1 year.

Included in the data collected are scientific phenomena such as solar wind, seismic activity, magnet fields, lunar soil composition, etc. This program will provide the scientific community with unprecedented data concerning the formation of the earth. ALSEP represents a meaningful stepping stone toward the scientific exploration of space and the planets.

The conversion of the Local Scientific Survey Module from an unmanned to a manned mode of operation added a new dimension to the operational capabilities of the Bendix lunar vehicle. After completion of a long, remote traverse of 1,000 kilometers or more, the vehicle can be quickly outfitted for manned operation by modular interchange of the crew station and remote control package. Compared to a manned mode only, this conversion capability permits 90 percent of the extended lunar module payload to be allocated to science, thus increasing the potential scientific return.

Significant achievements were also realized in the commercial products market. For example, the Bendix Thermal Mapper is an unclassified airborne infrared imaging system first introduced by Bendix Aerospace Systems Division in March; it proved its value in water pollution tracing and forest fire detection.

The system comprises 4 basic components: scan head; control console; vertical reference; and a 28-vdc, 10-ampere power supply. It operates with off-the-shelf, 70-millimeter, TRI-X film, and the only moving components are the scanning shaft and the film drive.

A new Transportation Systems Department was formed to apply aerospace capabilities to transportation problems. During 1968 a contract was received to determine the composite transportation system for the new town of Columbia, Maryland. The Columbia Transit Program encompasses the analysis of transportation demand and requirements, application of advanced technology for the movement of people and goods, determination of innovative means of revenue production, financial packaging, and the writing of specifications for the transit system design.

ELECTRIC POWER DIVISION

During the year the Electric Power Division supplied initial electric power systems for Boeing 747 superjets. The electric system, rated at 360,000 watts of electric power, consists of brushless generators and solid-state control components.

In line with the 747 program, the division received orders for solid-state power inverters and alternator-drive units. These latter units will supply aircraft-type electric power to operate and check equipment being installed in 747 aircraft.

A complete line of test and check-out equipment for the 747 electric system was also developed. Both portable and console-type equipment was made available for checking system components.

The division continued to supply electric power systems for other commercial aircraft during the year. For the military, Electric Power Division continued to supply electric systems for such applications as the F-4 Phantoms, A-4D Skyhawks and HueyCobras.

Also during the year, prototypes of oil-cooled, integrated drive-generators were completed and tests started. These new, compact generators are extremely small and compact for their rating and initial tests show very high reliability, low operating life and low maintenance costs. The small generators are unique since they are integrated with the constant-speed drive to make a compact assembly. The entire assembly utilizes engine oil for cooling. Oil supplied at 120 degrees Centigrade and 230 pounds per square inch pressure permits a generator output of 2,000 watts per pound of generator weight, more than double the output per pound of weight of conventional generators.

Other major programs under way at the division included the development of a family of transformer-rectifiers which convert AC electric power to DC electric power at high efficiencies and development of environment-free DC generators. These DC generators will be cooled with engine oil to withstand tough, rugged operating conditions at extreme hot and cold temperatures.

During the year Electric Power Division continued installation of modern manufacturing equipment to speed up production operations. Included in the new manufacturing equipment was a unique wire-coating machine developed by the division. The machine wraps a tough, insulating material around copper wire automatically at high speeds. Also included in newly installed manufacturing equipment was a 4-axis, tape-controlled drill press which operates at extremely close tolerances and high production speeds. This new production equipment was part of Electric Power Division's cost-reduction program initiated several years ago to increase production efficiency and pass the savings on to customers.

Total employees at the division at year-end numbered 1,100 with about 25 percent working in engineering and other technical assignments.

ENERGY CONTROLS DIVISION

The Energy Controls Division of The Bendix Corporation, South Bend, Indiana, experienced another year of rapid sales growth and facilities expansion during 1968. This continued growth was also reflected by the appointment of the general manager, H. G. Tarter, to the position of corporate vice president and group executive. S. B. Smith, Jr., was appointed the division's new general manager.

The Boeing 747 airplane was rolled out September 30 on Bendix wheels and brakes. The development of this equipment and initial production of the flight test program requirements were on schedule. Initial equipment deliveries to Boeing were completed 2 weeks in advance of schedule. Laboratory qualification testing continued throughout the year with completion scheduled for November. The last tests were to be dynamics simulation in advance of the first airplane flight, which was scheduled for late December.

October 11, 1968, was an unusual day for The Boeing Company at Seattle, Washington, because the 100th aircraft of both the 737 and the 727-200 was rolled out that day. It was also significant for the Bendix Energy Controls Division since it is a major supplier for the jetliners. Both aircraft are equipped with Bendix wheels and brakes as standard equipment; Bendix also supplies the nose strut for the 737.

The DC-8-63, latest of the McDonnell Douglas Super Sixty aircraft to enter airline service, uses new-design Bendix wheels and brakes. Following qualification and flight test certification, aircraft delivery to customers was expanding.

During 1968 the Bendix Energy Controls Division developed techniques for design and manufacture of wheels and brakes from new alloys. Test programs were conducted which verified both experimental and analytical results. A wide spectrum of materials and alloys was the subject of intensive investigation for use in both current and advanced designs. These developments were further assisted by the addition of an electron probe microanalyzer. This equipment is an integral part of the expansion of the division's capability in the scientific development of new composite materials. With this instrument it is possible to make direct chemical analysis of a sample which is 1 micron in area and 1 micron in depth, representing 1 micro-micro gram of material.

The market for Bendix helicopter tie bar programs broadened during 1968. Bell incorporated the Bendix tie bar in the basic design of several new models. The advantages and performance achieved on the earlier models led to adoption of the unit by Bell. The tie bars for the Lockheed AH-56A moved forward into a production category. This was done after extensive research and development programs pointed at achieving extended life under extremely difficult environmental conditions.

A pattern was developing which indicated that all the next generation of light-to-medium helicopters in Europe probably will incorporate the Bendix tie bar. A favorable reaction to the incorporation of this unit was received from France, Germany and England.

The first landing gears were delivered on time to meet the scheduled roll-out and start of the flight test program of the C-5 during 1968. This year also saw completion of drop test programs for both the main and nose landing gears of the world's largest airplane. Flight testing confirmed anticipated results developed from both analytical and laboratory testing. Manufacturing underwent a broad expansion during the year, moving from prototype into the production phases of fabrication. New machine tools were brought "on stream" to keep pace with the buildup in delivery requirements.

The extremely large and sophisticated drop test laboratory constructed in South Bend was put into full operation during the year. With this added capability for development and qualification testing, Bendix was prepared for the era of million-pound and larger aircraft of the future.

Extensive development work was under way to determine design and fabrication techniques for the use of filament structures in landing gear systems. In addition, advanced techniques were developed for stress analysis and determination of fatigue characteristics in these types of structures.

The division continued a major production program for landing gears on all models of the highly successful McDonnell Douglas F-4 aircraft.

The need for expanded production capacity was relieved by the construction of 48,000 square feet of floor space to be used for in-process stores and production offices. A further increase in capacity and capability was achieved by bringing a number of new machines on line during 1968, including many N/C types. Plans were made for further expansion of the manufacturing capacity with additional N/C machines.

The enormous gantry heat treat facility established new highs in output several times during the year. Associated with the large heat treat facility is a mammoth wheelabrator shot or sandblast machine. This machine has the capability of precisely controlled inside diameter shot peening as well as the OD. The 15-foot-diameter work table will handle the very large size parts being developed for the new generation of jumbo aircraft.

Additional manufacturing capability was provided for the landing gear product line by a new Michigan spline grinder which can handle ID or OD splines up to 15 inches in diameter and 40 inches in length. A Heald planetary grinder also was added, one of the largest in the country and specifically designed for Bendix. It will grind holes from 2 to 36 inches in diameter.

Continuing efforts in the field of spacecraft landing systems led to successful completion of several programs during the past year. Of major significance was the development of a semi-empirical LM footpad soil/interaction model for the NASA Manned Spacecraft Center. This model was incorporated by NASA into the Lunar Module landing dynamics computer program, and, using soil characteristics established for the lunar surface, permits real-soil landing simulation of the Lunar Module.

The interaction model was adapted by Bendix to the previously developed Surveyor spacecraft landing dynamics computer simulation for the Jet Propulsion Laboratory. This simulation was being used by the Jet Propulsion Laboratory for analysis of the telemetered data from the various successfully landed Surveyor spacecraft.

Additional studies pertaining to the landing characteristics of the Bell Aerosystems/NASA Lunar Landing Training Vehicle were performed for the Manned Spacecraft Center. This astronaut training vehicle uses landing gear equipment developed earlier by the division.

Landing dynamics analysis and preliminary design studies of a potential landing system for a proposed unmanned Mars soft-lander were continued during the year, and effort was reoriented from a Voyager-type vehicle to a smaller, less sophisticated lander. In addition, computer programs developed earlier for performance and preliminary design studies were considerably refined during 1968 to permit both a more flexible and a more detailed study of landing system designs.

Since a portion of the landing impact energy can be absorbed by footpad penetration into the soil, minimizing the energy absorbing requirements of the shock strut, 1968 efforts also were directed toward application of the soil interaction model as a spacecraft landing system design tool.

The division was awarded a contract to build a hydromechanical control system for Pratt & Whitney Aircraft's Model JTF22 demonstrator engine program involving the FX/VFX-2 aircraft.

A microelectronic engine control system, designed and built by the division and Navigation and Control Division, was tested on Pratt & Whitney Aircraft's Model JTF20 Advanced Manned Strategic Aircraft (AMSA) demonstrator engine. Further, on this program, a contract was received for the initial phase of the continuing AMSA engine demonstrator program.

Planning was being finalized to supply initial control systems for Pratt & Whitney Aircraft's TF30 engine powering the VFX-1 aircraft.

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

A main fuel control system was under development for the demonstrator General Electric GE12 engine competing for the Army 1,500 horsepower aircraft engine program. Possible programs that could involve this engine were UTTAS and LAAV.

A contract was awarded to the division to build initial engine control systems for the UACL PT6-T4 engine which will power both the U.S. Marine Corps Bell AH-1J twin-engine HueyCobra and the USAF Bell UH-1N twin-engine rescue helicopter. Production of this control system was planned for a Bendix subsidiary, Aviation Electric, Limited, in Canada.

Engine control systems for the T63 engine powering the military Hughes OH-6A helicopter and commercial helicopters were in production at this division.

Production of engine control components for the T56 turbopropeller engines powering the P-3B and C-130 aircraft continued.

The initiation of delivery of engine control systems for the AiResearch TPE 331 engine late in the year was to increase the division's general aviation business.

INSTRUMENTS & LIFE SUPPORT DIVISION

A major milestone was achieved at Instruments & Life Support Division during early 1968 with receipt of a multimillion-dollar contract from the National Aeronautics and Space Administration to design, develop and produce the cryogenic gas storage systems for the first 56-day mission of the Apollo Applications Program. Receipt of this contract culminated a concentrated research and development effort put forth by the division during the last 5 years. Designed for long-duration storage of cryogenic hydrogen, oxygen and nitrogen, the systems will support the spacecraft electrical power generating equipment as well as the crew compartment atmosphere control system.

To meet future cryogenic gas storage system requirements, Instruments & Life Support Division was in the final stages of completing a modern, 24,000-square-foot facility. The building will devote a 16,000-square-foot, extremely clean, temperature- and humidity-controlled area to production and the remainder to engineering design and development.

In the area of flight instruments, the year saw several new products introduced for both commercial and military applications, as well as for spacecraft use. Special flight instruments produced by Instruments & Life Support Division for NASA's Apollo program and put to use in 1968 included a longitudinal accelerometer, which displays fore and aft acceleration forces during all phases of orbital and suborbital flight, and a barometric altimeter, which indicates the proper altitude for parachute deployment during manual reentry into the earth's atmosphere. Soon another Bendix-built instrument will be called upon to aid the first U.S. astronauts to land on the moon's surface. Called the thrust-to-weight-ratio indicator, the instrument, simply by measuring lunar g's, will reveal the rate at which the engine slows down the Lunar Module as it descends toward the surface.

Several study and development programs were successfully carried out on fluid measurement techniques. Particularly significant were the 2 study programs the division successfully completed for NASA's Manned Spacecraft Center, Houston, and Marshall Space Flight Center, Huntsville. Both programs were concerned with a technique of measuring fluid quantity in an all-attitude, zero-g environment.

In addition to the flight instruments provided for the 1968 Apollo flights, the division provided systems for precisely monitoring propellant tank loading, as well as optical point sensors which initiate shutdown of the 5 engines on the S-1C stage of Saturn V. The prism-shaped glass tip of the sensor protrudes into the small river of liquid oxygen flowing from the tank to one of the 5 1,500,000-pound-thrust engines. A narrow beam of light passes through the shank of the prism and impinges on one surface of the glass wedge. As long as the tip is covered with fluid, the beam passes through the surface and is dispersed. The instant the level of liquid oxygen drops below the tip, the beam, instead of being dispersed, bounces from one surface of the wedge to the other and back through the shank. The reflected beam is electronically detected, and an output signal is conveyed to the engine shutdown mechanism.

One of many significant accomplishments during the year in the area of life-support equipment was a uniquely designed backpack for storing and converting liquid air to gaseous breathing air for personnel working in a toxic environment. The backpack features a slim profile vacuum-insulated storage container that is only 4 inches thick yet contains more than a 2-hour supply of air. The backpacks will be used initially by persons engaged in the loading of highly toxic engine propellants aboard the Lunar Module spacecraft at Cape Kennedy. Other promising applications include mine rescue, fire fighting and long-duration underwater operations.

THE BOEING COMPANY

On September 30, 1968, the first model 747 superjet, largest commercial airliner in the world, rolled from The Boeing Company's new Everett, Washington, manufacturing facility. This event, heralding the arrival of a new era in aerial transportation, was the dramatic highlight of a year in which the company acquired a new president, accepted new responsibilities in the United States' space program, delivered the new twin-jet Model 737 to airlines, commenced work on the new Minuteman III intercontinental ballistic missile and set new records in the rate of deliveries for commercial aircraft.

Unfilled orders at September 30, 1968, were $5.464 billion, including $4.702 billion for commercial aircraft, $392,000,000 for military aircraft and $370,000,000 applicable to missile and space programs.

Well before year-end, the company delivered its 1,500th commercial jet airliner from an order book showing 1,957 sales by October 30. Rate of delivery was 96 airplanes in 64 working days during the third quarter of the year. Company employment remained relatively stable at approximately 140,000 persons.

Roll-out of the 747 was a milestone in a program which had its formal beginning in 1963 when a Boeing engineering group was formed to plan an airplane to meet travel increases expected in the 1970s. Tentative decision to proceed was reached by the company's directors in March 1966, and options for land on which to build a final assembly plant to produce the airplane were obtained in June 1966. Since that time, the factory has been built, including a main structure which, containing approximately 160,000,000 cubic feet, is the world's largest volume building.

Assembly of the first airplanes, along with construction of engineering mock-ups, began in the building long before it was complete. A work force of approximately 15,000 occupied the Everett facility by year-end. By the time of the roll-out, Boeing had announced orders from 26 airlines for 158 of the big airliners.

In 1969 the first 5 completed 747s were to enter a 10-month flight test program, the most extensive ever undertaken in the industry; 2 additional airframes were to be used for static and fatigue testing.

While the 747 attracted the most public attention during the year, Boeing devoted much more of its total effort toward other programs. The company is weapon system integrator for the Minuteman ICBM, with responsibility for assembly, test, launch control and ground support systems. Many Minuteman components are manufactured in Seattle, and missile assembly is carried out at Boeing-operated Air Force Plant 77 near Ogden, Utah. Approximately 1,000—mostly Minuteman I versions—are on alert in several states. The early versions gradually were being replaced by Minuteman II, and Boeing was working on the still larger and more advanced Minuteman III.

A second missile, SRAM (Short-Range Attack Missile), was being built for the U.S. Air Force by Boeing. This is a supersonic air-to-ground weapon with nuclear capabilities, to be carried both by late model B-52 bombers and by the FB-111 fighter-bomber.

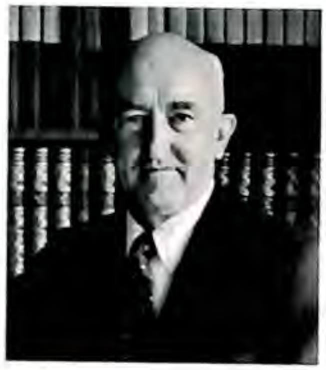
By year-end the company had delivered more than 1,000 Chinook and Sea Knight twin-rotor helicopters to the U.S. armed forces from its Vertol Division factories near Philadelphia. Most of these are in service in Vietnam. A water-jet-propelled hydrofoil gunboat, the *Tucumcari*, was delivered to the U.S. Navy at Seattle during the year, was voyaged to San Diego and was undergoing competitive testing there.

In space activities, Boeing's attention centered on the Apollo/Saturn program. The first stage for the Saturn V booster was being produced by Boeing at Michoud, Louisiana, and proved at the Mississippi Test Center. The company is under contract with the National Aeronautics and Space Administration also for systems engineering and integration of the entire launch vehicle, as well as for ground support and testing. In May the company was assigned the responsibility by NASA for technical integration and evaluation (Apollo/TIE) for the Apollo/Saturn moon program. Company staffs for Apollo/Saturn are located at Houston, Texas; Huntsville, Alabama; Cape Kennedy, Florida; and Washington, D.C.

Two United States supersonic transport prototypes were under development in Seattle in a cooperative nationwide program involving the federal government and private industry. The prototypes will be assembled at the Boeing Developmental Center (which was being enlarged for that purpose) from parts provided by subcontractors and suppliers throughout the nation under a contract administered by the Federal Aviation Administration. In studying more than 500 configurations since 1952, Boeing has devoted more than 20,000 hours of wind tunnel testing to developing the U.S. SST. The company was incorporating improvements in its design before starting construction, to insure that the prototypes will provide a sound foundation for follow-on, commercially successful SSTs.

The company was involved in a number of research and development efforts, both in its various divisions and in the Boeing Scientific Research Laboratories, devoted principally to pure scientific disciplines not directly connected to present products.

In 1968 William M. Allen, president of Boeing since the end of World War II, became chairman of the board of directors and chief executive officer for the company. T. A. Wilson, executive vice president, was elected president.

T. A. Wilson (left), formerly executive vice president, was elected president of The Boeing Company in 1968, succeeding William M. Allen (right), who became chairman of the board and chief executive officer.

Late in the year, the company announced a reorganized Aerospace Group, tailored to cut costs and seek new business. In the new organization, 6 product management divisions and branches report to group headquarters and a new Aerospace Operations unit provides support for Aerospace Group activities in the Seattle area. Leading elements of the reorganized Aerospace Group include the Aerospace Systems Division, responsible for new products development, some product management and engineering-oriented functional support; the Missile Division, responsible for the company's missile product line; Southeast Division, established according to geographical considerations; Aerospace Operations; ASMS Branch, responsible for the Navy's Advanced Surface Missile System program; Spacecraft Branch, which oversees work on the Burner 2 and such advanced programs as the Mars '71 and '73 probes; and Marine Branch, responsible for the company's work in hydrofoil programs.

THE BUNKER-RAMO CORPORATION AMPHENOL CONNECTOR DIVISION

Amphenol Connector Division, now a part of The Bunker-Ramo Corporation, has long been a leader in complex interconnection systems for the aerospace industry. The division's engineers worked closely with several major aerospace prime contractors to develop umbilical and interstage connectors and cable assembly systems.

For example, engineers at the division's Space and Missile Systems operation in Chatsworth, California, completely value-engineered the cable assembly for the Sea Sparrow missile, the ship-carried adaptation of the proven Sparrow air-to-air missile. The result was a redesigned cable assembly system with greater reliability at a cost saving over the existing system. Amphenol also provided special connectors for the program.

The division won the design competition for the umbilical connectors to be used on the Poseidon missile, a Lockheed Missiles & Space Company project. The Amphenol design provides the utmost in reliability. Not only were typical design problems encountered and solved but an exhaustive analysis was conducted to develop materials that would meet the stringent performance requirements.

Amphenol Connector Division continued to supply the cable assemblies used in the Minuteman guidance control system and it obtained a contract for the development and production of a new high-performance cable assembly for the Minuteman III program.

Astro/348, the division's high-density miniature circular connector which meets MIL-C-81511, was selected for the Navy's A-NEW antisubmarine system. The connector was also slated for use in other aerospace/aircraft projects. The year saw further development of a 500 F connector for the Boeing SST.

CESSNA AIRCRAFT COMPANY

For Cessna Aircraft Company, 1968 was a record growth year with total consolidated sales for the company at an all-time high.

During the year Cessna maintained its top position among manufacturers of general aviation aircraft with sales of commercial aircraft setting a record dollar volume over any previous year in the company's history. Cessna again led the industry in unit sales for both single- and multi-engine aircraft. A total of 7,003 commercial airplanes were delivered during the company's fiscal year, which ended September 30.

Total consolidated sales exceeded $264,000,000, an increase of more than $50,000,000 over 1967, with commercial aircraft accounting for a record of approximately $164,000,000.

A significant increase in dollars resulted from the acceptance of "400" series twin-engine executive aircraft, led by the pressurized Model 421 which accounted for 161 deliveries during the fiscal year. Following the Model 421's introduction, acceptance climbed steadily and at year-end it was the top-selling pressurized twin on the market.

Offering the broadest line of commercial airplanes in the industry, Cessna recently further expanded by announcing the Fanjet 500, a "new generation" of corporate jet aircraft. Del Roskam, company president, said the 8-place jet culminates a decade of research by Cessna before venturing into the market. The company announced a guaranteed price of $590,000 on orders placed early for the aircraft. At this price, it was expected to be the lowest-priced business jet on the market when first customer deliveries are made in early 1972.

The company announced plans to establish a separate Marketing Division for the Fanjet 500 that will operate independently from the present commercial marketing activities. The division will handle sales and service of the new aircraft.

The company established a new record for monthly unit deliveries of commercial aircraft during the fiscal year by delivering 830 commercial airplanes during September 1968. This surpassed Cessna's previous record total of 828 units delivered in October 1967.

During the year several delivery milestones were passed including the 10,000th Model 150, 10,000th Model 182/Skylane and 1,000th T-37 military twin-jet trainer. More of the 2-place Model 150s are flying than any other 2-place aircraft in production; the 10,000th was delivered to the Longhorn Aero Club, largest flying club in the world. The 10,000th single-engine, 4-place Model 182/Skylane went to an Ohio businessman. The 1,000th T-37 jet trainer went to the U.S. Air Force Air Training Command.

Cessna's 10,000th Model 150 was delivered early in the year and the model topped 11,500 deliveries by year-end.

Government business for Cessna showed a sharp increase, rising to $72,000,000 in sales for 1968. In addition to the T-37 jet trainer, which is being produced for the USAF and the air forces of 12 other nations, Cessna continued deliveries on the A-37 attack jet, the O-2 tandem twin, the T-41 single-engine piston trainer and the U-17 single-engine utility aircraft.

Other military production included ordnance dispensers and subassembly work on the Bell UH-1D Huey helicopter and the McDonnell Douglas F-4B Phantom jet fighter.

Six different Cessna military airplanes were flying with the USAF in Vietnam. In addition to the A-37 and U-17, 2 versions of the O-2 were being used for forward air control and psychological warfare duties. The U-3, a military version of the commercial Model 310 twin, was being used for utility missions, and the O-1 Bird Dog was in wide service for forward air control.

Deliveries were begun during the year on the A-37B attack jet. The B version has air-to-air and single-point ground refueling capabilities. Orders were placed for 228 A-37Bs.

The O-2, a military version of the twin-boom, tandem-engine commercial Super Skymaster, continued in production. The USAF had on order 268 of these airplanes.

The company's efforts in learn-to-fly programs, responsible for generating many new airplane sales and student pilot starts, produced significant achievements in air-age education. A highlight was a cooperative program announced jointly by the company and American Airlines to promote aviation education in elementary schools. In the program, considered a first between an airline and a general aviation manufacturer, Cessna and American make available classroom material that can be used in aviation courses in elementary schools.

Cessna also announced its "PAVE" program to furnish assistance to vocational technical schools which are training young people for careers in aircraft maintenance fields. "PAVE," or Programmed Assistance to Vocational Education, includes the offering of the latest factory training packages to schools on a free-loan basis. The packages, identical to those Cessna service personnel receive from factory schools, include filmstrips, disc records and video tape segments.

With the added importance of aviation in the lives of every citizen and the current growth in flight training, the company predicted that 1,500,000 new student pilots over the next 5 years are an attainable goal for the industry. Company president Roskam stated, "Using 1968 as the base, we expect to double our unit business during this 5-year period in the learn-to-fly category, greatly expand our dealer organization and significantly increase the percentage of students being trained by Cessna dealers."

Worldwide facilities of the company and its affiliates will cover more than 3,245,000 square feet of floor space when construction initiated in 1968 is completed. Typical of the expansion is a $1,600,000 engineering and research center under way for the Commercial Aircraft Division in Wichita, Kansas.

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

An affiliate company, Reims Aviation in Reims, France, was manufacturing 3 Cessna airplanes for European and United Kingdom markets. These were the Models F150, F172 and the Reims Rocket.

The company was operating an assembly plant for its Model 150 at Strother Field-Kansas, in the Winfield-Arkansas City area.

Employment at the various worldwide Cessna facilities totaled over 12,500 at year-end.

CHANDLER EVANS CONTROL SYSTEMS DIVISION OF COLT INDUSTRIES INC.

Chandler Evans continued during 1968 the expansion in volume and diversification of products which had been evidenced over several previous years. In addition to accelerated production of unitized controls for the Lycoming T53 power plant utilized in the Bell Iroquois and HueyCobra helicopters, a unit exchange overhaul program was initiated for the Army Aviation Systems 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. Positive displacement fuel pumps were produced for the Pratt & Whitney Aircraft engine-equipped Lockheed SR-71, LTV A-7 Corsair II, General Dynamics F-111, Sikorsky CH-54 Skycrane, Lockheed C-141 StarLifter and Boeing KC-135 tanker and B-52, as well as the McDonnell Douglas DC-8 and Boeing 707-320 commercial transports. Chandler Evans pumps were also manufactured for use on 4 business jets: the North American Jet Commander, the Learjet, the French-built Dassault Fanjet Falcon and the German-produced Hamburger HFB 320 Hansa, all employing General Electric engines.

By year-end a total of almost 30,000 Chandler Evans pumps had accumulated more than 100,000,000 service hours on military and commercial aircraft.

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

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

A substantial commitment in the field of 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 McDonnell 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. Work continued in the development of hydraulic and stored gas systems, and the preproduction phases for the Hughes TOW program were completed.

Major developments initiated in 1968 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.

New research and development programs were initiated for advanced vehicular turbine controls, a control/pump for a General Electric 15,000-kilowatt power plant, and fuel pumps for the Pratt & Whitney Aircraft JTF22 engine being developed for the FX and VFX aircraft and the General Electric CF6 engine for the McDonnell Douglas DC-10.

The Chandler Evans facilities located at West Hartford, Connecticut, consisting of a modern unilevel plant occupying over 310,000 square feet, were being expanded to incorporate new engineering labs and production test facilities. The company employed at year-end more than 1,900 people and had field offices in Dayton, Ohio; Los Angeles, California; Seattle, Washington; and Munich, Germany.

CONTINENTAL MOTORS CORPORATION

The healthy demand for Continental aircraft engines and spare parts continued through 1968 with Continental Motors Corporation again supplying a large portion of the total engines delivered to the general aviation industry.

Continental's major customers in the general aviation field were Cessna Aircraft Company and Beech Aircraft Corporation. Continental Motors was also powering models of aircraft built by numerous other companies throughout the world including Beagle Aircraft Ltd., Bolkow Entwicklungen, Britten-Norman Ltd., Reims Aviation and Sud Aviation. These aircraft covered a wide range of uses, from single-seat agricultural models to aircraft used for commuter airlines, personal transportation, cargo, corporate and private travel and similar activities.

The demand for Continental's 375-horsepower geared turbocharged GTSIO-520-D engine, utilized in Cessna's pressurized Model 421 introduced in

1967, and the company's 300-horsepower TSIO-520-E, installed in Cessna's Model 401 and Model 402 aircraft, was significant. Also noteworthy was the demand during 1968 for Continental's IO-520-C engine which powers the twin-engine Beechcraft Baron, and the IO-520-B utilized in the new larger version of the twin-engine Beechcraft Bonanza.

Continental-powered Cessna and Beech general aviation type aircraft continued to serve American armed forces for forward air control missions, pilot training programs, aerial supply, photoreconnaissance and other purposes. Typical were the military version of the Cessna Super Skymaster, designated by the military as the O-2 series, and the T-41 series, basically Cessna Model 172s.

Continental Motors' Zero Time remanufactured aircraft engine program, under which owners of Continental-powered aircraft can exchange their original engine for a like model factory-remanufactured power plant that has been restored to new engine standards, also made a significant contribution to total business volume. Work conducted under this remanufactured engine program was accomplished at Continental's Mobile, Alabama, facility.

Continental Motors' successful licensing agreement with Rolls-Royce of Crewe, England, was in its eighth year. Under this arrangement, Rolls-Royce manufactures and sells certain Continental aircraft engines used by airplane producers in Europe and elsewhere in the eastern hemisphere.

Continental's extensive aircraft engine design and development program continued during the year. One particularly significant new program was expected to provide aircraft engines featuring a substantial improvement in weight-to-horsepower ratio.

CONTINENTAL AVIATION AND ENGINEERING CORPORATION

Government contracts for production of Continental Aviation and Engineering's J69 series gas turbine engines and spare parts, for related overhaul and retrofit, and for component improvement programs accelerated significantly during 1968, accounting for the major portion of new business received.

Orders for J69-T-29 and J69-T-41 engines, which power Ryan Aeronautical Company's tri-service subsonic Firebee jet targets and drone systems, were particularly noteworthy. The J69-T-29 engine has a rated thrust of 1,700 pounds and the J69-T-41 has a thrust of 1,920 pounds.

Also significant were orders during the year for the company's J69-T-25 engine with rated thrust of 1,025 pounds. This power plant is utilized in Cessna's T-37 twin-jet military trainer aircraft.

Three important milestones were achieved during the year by CAE's advanced 1,840-pound-thrust YJ69-T-6 engine, designated by the military as the YJ69-T-400, which powers prototype models of Ryan Aeronautical Company's supersonic Firebee II jet target drone system. The Firebee II made its first supersonic flight in June, reaching speeds in excess of 800 miles per hour. In September the Firebee II reached its design speed of Mach 1.5 (1,000 miles per hour). In both of these test flights, the Firebee II was air-launched from a modified Navy patrol bomber.

Also in September, the third major milestone for the Firebee II was reached when the successful first ground-launch of the supersonic aerial target was achieved. The pilotless jet aircraft was launched from a standard Firebee short-rail ground launch pad with assistance of an 11,000-pound-thrust JATO bottle. Ryan was flight testing 14 prototypes of the supersonic Firebee II under contract to the Naval Air Systems Command.

Continental Aviation and Engineering was also actively engaged in designing new turbine engine gas generator concepts for the Air Force. These developments in sophisticated advanced design were expected to enhance CAE's present series of turbojet engines and to represent significant advances in the state of the art. Additionally, CAE entered into several new system concept studies with the Air Force and industry and was actively pursuing the power plant requirements of these projects in their earliest stages.

Continental Aviation and Engineering announced in December 1967 that it would establish a turbine engine manufacturing activity at a government-owned plant in Neosho, Missouri. Following start of operations in March 1968, this facility was involved with turbine engine overhaul, the manufacture of turbine engine spare parts, and the production of turbine engine gears for use in CAE's J69 series gas turbine engines manufactured in Toledo, Ohio. The 350,000-square-foot Neosho facility possesses considerable turbine engine manufacturing and test capability, plus the potential for future expansion.

CURTISS-WRIGHT CORPORATION

Curtiss-Wright Corporation is a first-tier supplier of a wide variety of aerospace components. Corporate headquarters are in the Wood-Ridge (New Jersey) Facility at One Passaic Street.

Other facilities are located in Caldwell, New Jersey; East Paterson, New Jersey; Buffalo, New York; Cleveland, Ohio; Long Island City, New York; Hempstead, Long Island, New York; Toronto, Canada; St. Louis, Missouri; Carlstadt, New Jersey; Jersey City, New Jersey; Smithtown, New York; Addison, Illinois; Los Angeles and Vernon, California; and Windsor, Connecticut.

Curtiss-Wright completed 2 significant acquisitions in 1968. The Comet Tool and Die Company of St. Louis, Missouri, and the Metal Improvement Company (New Jersey) were purchased and were being operated as wholly owned subsidiaries.

Comet is a leader in the profile milling of airframe parts in the Midwest, providing a supplement to Curtiss-Wright capabilities in this field provided by the Zarkin Machine Company, which was acquired in 1967.

Metal Improvement Company was engaged in shot peening and the manufacture of shot-peening equipment. Shot peening is a process employing fine round shot to work the surface of metals and improve their fatigue life. MIC was operating plants in Carlstadt and Jersey City, New Jersey, Windsor, Connecticut, and Addison, Illinois. Its subsidiaries are Metal Improvement Company, a Delaware corporation, of Los Angeles, California, and Bo-Chem Corporation of Vernon, California. The company was in the process of establishing a new facility on Long Island to serve customers in that area. Its principal customers are industrial companies and major airframe manufacturers engaged in the design and manufacture of advanced commercial and military jets.

During 1968 the Wood-Ridge (New Jersey) Facility shipped the first production landing gear components for the Boeing 747 jumbo jet, under contract to Cleveland Pneumatic Tool Company, a subsidiary of Pneumo Dynamics Corporation, prime contractor for the landing gear system. Produced at the Wood-Ridge Facility, the parts comprising one shipset include one nose steering collar assembly; 8 main axles and one nose axle; and 8 tow fitting assemblies, which are used for handling the aircraft on the ground.

Wood-Ridge was performing work under a contract from General Electric to manufacture major pressure vessels and head assemblies for naval propulsion systems. An existing building at Wood-Ridge, formerly used for the manufacture of rocket cases for the Titan III, was being renovated and expanded to accommodate this work.

Wood-Ridge also delivered the first of 2,000 turbine engine discs being made by Curtiss-Wright for the Avco Lycoming Division's T53-13 twin gas turbine engine.

The Caldwell (New Jersey) Facility received an order to engineer and fabricate landing gear actuation systems for the U.S. Air Force C-5 transport. These systems transmit power and actuate landing gear and landing gear doors. They include actuators, gear boxes, shafting and hydraulic and electric drive units.

Curtiss-Wright was selected by Lockheed-California to design and produce the trailing edge flap actuation system for the Lockheed L-1011 air bus jetliner. The system, which operates the inboard and outboard flaps, consists of power drive units, gearboxes, shafting ball screw actuators and related controls. The work will be done at the Caldwell Facility.

The electronics capabilities of the East Paterson (New Jersey) Facility were being employed in a major U.S. Army contract for surveillance equipment. The contract was for a Tactical Imagery Interpretation Facility (TIIF). A prototype was delivered to East Paterson. It is housed in an expandable van-type truck and is composed of a viewer computer, a Field Artillery Digital Automatic Computer (FADAC) and numerous stereoscopic and optical elements. It is used for photographic interpretation to furnish tactical information to military intelligence. It will perform numerous missions, such as updating of maps, surveying troop movements, new installations and fire control missions.

The Buffalo Facility continued to specialize in extrusions, forgings, castings and precision engineered products. Development of the extruded titanium, integrally stiffened wing panel sections continued, in conjunction with the USAF and Lockheed program for subsonic and supersonic aircraft applications.

Buffalo embarked on a major expansion program involving the machine and forge shop areas of the Turbo Products Operation and the foundry. Improvements include additional forge and machining equipment and construction of a new building to expand the machine shop area.

On order were new machine tools, including the latest profile milling units and tape-controlled milling and drilling machine tools. The forging capability at Buffalo was to be enhanced by the addition of a 1,000-ton and a 2,500-ton forging press, a 6,000-pound forging hammer, and related support equipment such as furnaces. Additional electrical discharge machines were to be put into operation.

An additional contract from General Electric for vane platforms for the TF39 turbofan engine which powers the U.S. Air Force/Lockheed C-5 was to be filled at Buffalo. The facility also received an additional contract to make parts and components for other GE engines.

Marquette Metal Products Company, Cleveland, Ohio, continued to produce compact precision spring clutches for appliances, marine equipment, 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.

Zarkin Machine Company, Long Island City, New York, broke ground for a new 100,000-square-foot building. It was to have 5- and 10-ton capacity cranes running the length of the manufacturing area. Automatic chip conveyors, which collect cuttings from the machines and convey them out of the plant, were to be installed. Twelve numerically controlled profile millers were to be purchased and installed, along with 8 or 10 other machines transferred from the Long Island City Facility. The new facility will be capable of performing profile milling of steel, aluminum, magnesium, and titanium forgings or castings for major aerospace structural elements.

In 1968 Zarkin delivered the first numerically machined F-111 bulkhead to McDonnell Douglas Corporation for use in the crew escape module of the aircraft.

Target-Rock Corporation, of Hempstead, New York, continued to produce specialized valves and fittings for nuclear marine, petrochemical and industrial applications.

Canadian Curtiss-Wright, Ltd., Toronto, acquired Design Team Leasing Ltd., and subsidiaries, also of Toronto. DTL, through its offices in Toronto, Montreal and Detroit, makes available designers, engineers, and draftsmen on a leased basis for special projects for temporary assignments to clients in a variety of technical fields.

Canadian C-W has also signed a contract to market an air-cooled, 2-stroke gasoline engine of Japanese manufacture for use in snowmobiles and for other recreational and industrial uses.

Development of the Curtiss-Wright Rotating Combustion Engine continued. RC engines manufactured by Fichtel & Sachs of West Germany were being marketed by Curtiss-Wright for use in snowmobiles. Three major snowmobile manufacturers were offering the 20-horsepower engine as an option and over 4,000 units were expected to be sold in 1968.

FAIRCHILD HILLER CORPORATION

The development of a gunship for close troop support, the successful deployment in space orbit of an antenna system taller than the Empire State Building, and the winning of an award to compete for the design of Applications Technology Satellites F and G were among the highlights of 1968 at Fairchild Hiller Corporation.

The gunship was actually a modification of the Fairchild Hiller C-119 Flying Boxcar, a Korean War transport. The modification, by Fairchild Hiller's Aircraft Service Division, was, the Air Force reported, one of the quickest such efforts in Air Force history.

The huge antenna array was but one of 4 major systems designed and built by the company's Space and Electronics Systems Division for the National Aeronautics and Space Administration's Radio Astronomy Explorer satellite, RAE-1. Stored in containers about the size of a woman's purse, the antennas were deployed on signal from earth to their 750-foot length, forming a giant X 1,500 feet from tip to tip. Launched in July, they picked up low-frequency radio waves—normally blocked from the earth by the ionosphere—from deep space and were expected to give scientists clues to the sun's role in the earth's radio storms and to enlarge man's understanding of radio noises in our galaxy. Besides the antenna array, the division developed the RAE's structure, its solar array paddles, and the 630-foot-long libration damper boom.

In the competition for the Applications Technology Satellite, NASA selected Fairchild Hiller to head one of the 2 teams to propose a design for 2 satellites which will be placed in stationary orbit and will carry out a number of communications and scientific experiments. On the Fairchild Hiller team are IBM, Honeywell and Philco-Ford.

The company's Space and Electronics Systems Division also designed and constructed for NASA's Lewis Research Center the Space Support Unit of the Space Electric Rocket Test satellite. The Support Unit contains the "brains" of the satellite: the telemetry, command, power, data storage, and attitude control systems. SERT will be a 6-month-long test of a mercury bombardment ion thruster system.

Fairchild Hiller was active in other space activities, including the design of a waste management system for the Manned Orbiting Laboratory, thermionic energy converters, and electrical propulsion systems; the design and manufacture of thermal louvers for the Orbiting Astronomical Observatory; solar cell arrays; and pressure regulators, pressure switches, cryogenic valves and disconnect couplings for a variety of satellites, rockets and boosters. In addition, the company's quick-response Technical Services Division continued to provide scientific, engineering and technical support to NASA's Spaceflight Integration and Sounding Rocket Division and to other NASA facilities for special programs.

In aircraft, the company marketed the FH-227, a 55-passenger propjet used by the nation's regional airlines, its smaller sister, the F-27, and the newer, pure-jet F-28, and was cooperating with Swearingen Aircraft, San Antonio, Texas, in a proposal to build the Metro, a 20-passenger airliner designed especially for the air commuter.

Besides transport aircraft, the company manufactured helicopters and STOL aircraft. To its line of turbine jet executive and utility FH-1100 helicopters, Fairchild Hiller in 1968 added an ambulance configuration, enabling the aircraft to carry 2 litter patients plus medical attendant and pilot. Its STOL aircraft, called the Heli-Porter, can take off in as little as 150 feet and land in 100 feet and can carry 6 passengers or a ton of cargo.

Fairchild Hiller served as a major subcontractor in aircraft manufacture.

For Boeing, the company was manufacturing wing control surfaces and air turbine drives for the 747 superjet. In addition, the company was assigned a major role in the manufacture of the U.S. supersonic transport to be manufactured by Boeing. In military aircraft, the company continued into its fourth year the manufacture of tail assemblies of the McDonnell Douglas F-4 and started to produce T-Stick II, an all-weather bombing system for the F-105.

Several of the company's other divisions were manufacturing products related to aircraft/space activities. For example, Stratos Division was producing environmental control systems for the Army's AH-56A Cheyenne; vapor cycle cooling systems for the Navy's E-2A Hawkeye; energy conversion systems for the C-130 and 747; temperature control systems for the F-111, RF-4, F-106 and F-105; and ground support environmental systems for all U.S. military services. Stratos-Western was manufacturing flare launchers; sonobuoy launch systems; radar, radio and infrared markers; fire and smoke grenades; and underwater sound source dispensers. The Space and Electronics Systems Division was producing information management systems for various military aircraft. Among such systems were the stores management set for the F-111D, Auxiliary Data Annotation Systems, Code Matrix Readers, film titlers, film continuous enlargers and film destructors and silver recovery systems. Burns Aero Seat Company, a Fairchild Hiller subsidiary, continued as one of the largest manufacturers of aircraft seats.

The company's Aircraft Service Division, a 4-facility operation based in Florida, continued to maintain, repair, modify and redesign aircraft; it is capable of handling anything that flies. Among its capabilities are fuel cell reconditioning, electronics repair, corrosion control and original design and engineering. Besides the C-119 gunship, the division handled 14 other kinds of aircraft in 1968, including the C-123, C-130, F-102, F-105 and DC-9.

Fairchild Hiller's Aircraft Service Division developed a gunship modification of the C-119 Flying Boxcar, shown here in ceremonies marking delivery to USAF.

Another Florida facility, Air Carrier Engine Service, Inc., a subsidiary, services and repairs Pratt & Whitney engines. During 1968, ACES installed a Pratt & Whitney jet engine test cell in preparation for servicing the JT8D engine.

Fairchild Hiller's corporate headquarters is at the Sherman Fairchild Technology Center, Germantown, Maryland. There, too, the company's Space and Electronics Systems Division maintains its headquarters as well as its research and development facilities. The division's manufacturing plant is at Winston-Salem, North Carolina, and its Technical Services Division is at Riverdale, Maryland.

Republic Aviation Division, which in 1968 added a helicopter development center to its plant, is located at Farmingdale, Long Island, New York. The locations of other divisions and plants: Aircraft Division, Hagerstown, Maryland; Aircraft Service Division, St. Augustine (headquarters and plant), St. Petersburg, Bayard and Crestview, Florida; Stratos Group headquarters and Stratos Division, Bay Shore, Long Island, New York; Stratos-Western, Manhattan Beach, California; Stratos-Industrial Products Division, Winston-Salem, North Carolina; Burns Aero Seat, Burbank, California; Air Carrier Engine Service, Miami, Florida.

THE GARRETT CORPORATION

The most significant achievement of the Garrett Corporation in 1968 was its entry into the jet engine manufacturing field. For Garrett, the announcement that the company's new ATF 3 fanjet engine would be used to power the North American Rockwell Sabreliner not only signaled its intention to build jet engines for aircraft but also marked the largest single production contract in the 30-year history of the company. North American Rockwell said the value of its contract with Garrett for 300 ATF 3s was $59,000,000. Garrett has been developing the 4,000-pound-thrust engine at its AiResearch Manufacturing Division in Los Angeles for the past 3 years.

Though overshadowed perhaps by the significance of the new engine announcement, the other 1968 activities of The Garrett Corporation were by no means inconsequential.

In November it was announced that The Garrett Corporation would expand its marketing interest in the growing field of electronics by forming a major new company named Garrett Micro-Circuits Corporation.

The new company will manufacture microelectronic components and circuits for commercial, industrial and aerospace applications. Initial investment in Garrett Micro-Circuits Corporation will total $3,500,000 for facilities and production equipment. The new 50,000-square-foot facility will be located in Torrance, California, and will eventually employ approximately 400.

Overall sales and production for Garrett's 8 divisions and 2 subsidiaries were headed, at year-end, toward a record level. Employment, too, was up appreciably from 1967, stabilizing at the 13,500 level.

Garrett-AiResearch announced in October that it would start production of the new ATF 3 turbofan engine for aircraft applications.

Through year-long emphasis on reducing costs without affecting quality, Garrett's ability to compete successfully in all major product lines continued to gain strength. More than 4,000 different products for commercial, industrial and military customers comprised Garrett's 1968 product list.

From this broad product diversity, which has traditionally been associated primarily with the aerospace industry, Garrett made substantial inroads in non-aerospace fields. High-speed ground transportation, power generation for the oil industry, and microelectronics are a few of the programs in which the company was actively applying its aerospace knowledge.

GARRETT-AIRESEARCH LOS ANGELES

In October 1968 the first manned flight of Project Apollo was accomplished with "101 percent success." For AiResearch Manufacturing Division, Los Angeles, this perfect flight marked a significant milestone by further establishing the company's leadership in environmental control systems for manned space vehicles. In every manned U.S. space flight, AiResearch ECS life-support systems have played the vital role of keeping the astronauts alive and comfortable in space.

The Apollo 7 mission logged several ECS firsts. It was the first spacecraft to have a truly "shirt-sleeve" environment which permitted the crew to spend extended periods of time unsuited in living-room comfort. It was the first to provide the crew with hot and cold water for food preparation, and, by means of the flexible ECS, Apollo 7 was the first American manned spacecraft launched with a mixed cabin atmosphere of oxygen and nitrogen while the astronauts breathed pure oxygen in their suits.

With the successful conclusion of Apollo 7, AiResearch environmental control systems had logged 2,769 hours in space including Projects Mercury and Gemini.

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

Under contract to McDonnell Douglas, the division continued development of life-support systems for Gemini B, an integral part of the Air Force Manned Orbiting Laboratory, and for Airlock, a NASA 3-man space experiment. Development also continued on a second-generation life-support system for NASA's Apollo Applications Program, which will extend the ECS capability well beyond the present 14-day missions.

In addition to accelerated development of the new turbofan aircraft engine, AiResearch-Los Angeles conducted advanced work in other propulsion methods. Under NASA contract, research and development of a hypersonic research ramjet engine capable of operating between Mach 3 and 8 (2,000-5,000 miles per hour) progressed. Engine technology developed from this program will have application in future hypersonic transports, missiles and spacecraft operating within the atmosphere.

Development of a radically different electric motor for the U.S. Department of Transportation proceeded on schedule. Called a Linear Induction Motor (LIM), this device is expected to produce speeds up to 250 miles per hour for ground vehicles. When perfected, the LIM could propel tracked air cushion vehicles between cities at speeds competitive to air transportation.

First tests of the LIM on a tracked wheeled test car, also being designed and built by AiResearch, were to begin in 1969.

In other ground transportation systems, AiResearch's electric propulsion system developed for the San Francisco Bay Area Rapid Transit District successfully completed a stringent test program in 1968. If selected by BARTD, the system was to go into production in 1969.

Another program, to demonstrate the feasibility of a gas turbine engine for propelling a railroad passenger car, was successfully completed on the Long Island Railroad. This has been extended to demonstrate a dual-mode gas turbine-electrical propulsion system. The AiResearch system will be tested by the Budd Company for the New York MTA.

Military and commercial airframe builders and the airlines were major customers for AiResearch in 1968. A major contract was awarded to the division by McDonnell Douglas for development and production of the environmental control system for the DC-10 trijet.

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

In its expanding electronics activities, AiResearch began in 1968 to develop an all-digital central air data computer. By year-end the system was being demonstrated in breadboard form to airlines. As a result of this development, the division was selected by American Airlines to build 2 prototype systems for flight testing aboard a 707 jetliner. The solid-state system is expected to afford a higher degree of reliability and accuracy than present analog systems, yet be lighter and smaller. AiResearch has produced more than 7,000 central air data systems for numerous high-performance aircraft.

Another electronics product, Aircraft Integrated Data Systems (AIDS), was in full production. American, Alitalia and CP airlines were using versions of the AIDS. The AIDS automatically monitors selected engine and aircraft systems performance and records the data for later analysis by ground computers. The system is an invaluable maintenance tool for assessing systems performance and physical condition.

Under USAF contract, AiResearch was developing an advanced airborne AIDS for present and future bomber-type aircraft. This system, which may use an on-board computer, will afford real-time assessment of subsystem health in addition to long-term trend analysis.

Other notable highlights for AiResearch in 1968 included delivery of the first central air data computer for the advanced version of the A-7 Corsair II. Eventual production of this system could total more than 1,100 units. AiResearch's first turbogenerator installation on an offshore oil production platform was completed in 1968; a new cryogenic refrigeration system for commercial airliners was installed and flown on a Western Airlines Boeing 737; and the company announced development and first orders for a new all-plastic cabin pressure system for light aircraft.

GARRETT-AIRESEARCH PHOENIX

The Garrett Corporation's second largest division, AiResearch Manufacturing Company of Arizona, Phoenix, continued a spiraling growth cycle which saw previous production highs exceeded month in and month out.

Pacing the growth was an increasing sales backlog which at year's end stood at record level. All major production lines, gas turbine engines, air turbine starters and motors, and pneumatic valves and controls, shared in the expanding sales market.

In the gas turbine market, AiResearch reinforced its position as the major U.S. manufacturer and supplier of small turboprop aircraft engines for business/commercial and military applications with the addition of an 840 shaft horsepower option to its TPE 331 family of turboprop engines. Horsepower options to meet varying customer needs are now offered in a range from 575 to 840 shaft horsepower, and higher horsepower ratings are being readied. The 840 shaft horsepower TPE 331 turboprop engine powers the USAF C-10A version of the Handley Page Jetstream.

In the military prime mover field, AiResearch continued producing a military version of its TPE 331 commercial engine, the 715 shaft horsepower T76, which powers the North American Rockwell tri-service OV-10A Bronco light multimission aircraft. The OV-10A entered combat service in Vietnam in July 1968 with the U.S. Air Force and Marine Corps. Orders placed for additional T76 engines in 1968 boosted to more than $28,000,000 the total value of AiResearch engines delivered or on order for the OV-10A.

Broadening its role in the prime propulsion engine market, AiResearch in July announced its entry into the small helicopter turbine engine field with a new 220 shaft horsepower turboshaft engine, the TSE 36-1. An initial order for 500 of the new engines was placed by Enstrom Corporation for its new T-28, 2-3 place version of its piston-powered F-28A. The TSE 36 marks the lower end of the AiResearch prime mover power spectrum, which is anticipated to extend eventually upward to 2,000 horsepower.

Following the pattern of 1967, AiResearch extended its earlier lead in airborne auxiliary power units beyond the huge new Boeing 747 and Lockheed C-5 aircraft to the new McDonnell Douglas DC-10, which can accommodate well over 300 passengers. AiResearch was also providing APUs for McDonnell Douglas' highly successful short-to-medium-range twin-jet DC-9, purchased by more than 30 airlines around the world.

In the field of pneumatic-powered actuator and control systems, AiResearch during the year was awarded contracts in excess of $22,000,000 for The Boeing Company's new 747 superjet. Under the contracts, AiResearch will supply air turbine motor powered wing leading edge flap actuators and actuators for main engine fan turbine thrust reversers. The fan thrust reverser system embodies a newly developed, lightweight, positive displacement air motor and a new concept of high-speed drive through lightweight flexible power shafts. An air turbine motor also drives an electrically synchronized, pneumatic-mechanical kneeling drive system for the giant Lockheed C-5. Installed on each of the C-5's 4 main landing gears, it permits the C-5 to kneel to ideal cargo-handling height. Within 2 minutes a fully loaded 769,000-pound C-5 aircraft can be raised or lowered 39 inches.

AiResearch continued development of MUST hospital components as additional MUST hospitals were deployed to Vietnam in support of Army and Marine units. Under test were X-ray, food service, pharmacy and dental units; prototype water recycling and waste disposal systems were scheduled for delivery to the Army by year's end. Within the next 5 years, the Army plans to have equipped all active field medical units with MUST (Medical Unit, Self-Contained, Transportable) portable hospitals.

In the advanced power systems field, AiResearch remained active in 1968. Delivered to the NASA Lewis Research Center, Cleveland, was the first of 4 Brayton rotating units. Consisting of a compressor, turbine and high-speed alternator, all mounted on a single shaft and supported by gas bearings, the Brayton rotating unit is the heart of an electrical power generating device being investigated by NASA. The hermetically sealed system generates power outputs of from 2.25 to 1.5 kilowatts at a consistently high level of efficiency. In addition to space applications, a Brayton power system offers possibilities for silent power generation for military applications; as source of deep ocean electrical power for underseas vehicles, habitats and commercial underseas endeavors; and for long-duration unattended terrestrial power generation.

GARRETT-AIRESEARCH AVIATION DIVISION

The year 1968 was another growth year for Garrett's AiResearch Aviation Division, with business reaching a new high. With deliveries of the Grumman Gulfstream II coming off the line, both the Los Angeles and Long Island completion centers were operating to heavy schedules. In addition to Gulfstream II completions, a record volume of DH125, JetStar and Falcon interior and avionics completions was set during the year. Helping to make this possible was an unprecedented contract for 10 Falcon completions, signed with Pan Am. The majority of these Falcons were being completed at the Long Island MacArthur Airport facility.

The highly successful Merlin program continued to gain momentum with the new Merlin IIB. The latest version is equipped with Garrett-AiResearch TPE 331-1-151G turboprop engines, resulting in a significant increase in performance. To keep pace with the program, AiResearch established a national sales force devoted entirely to the Merlin program. The addition gave AiResearch Aviation a total of 3 sales groups: one selling custom interior and avionics completions; one selling the Hawker Siddeley DH125 and the Grumman Gulfstream I and II; and one selling Merlins. Most recent addition to the Merlin group was a Dallas sales office. In addition, a network of Merlin service centers was established across the country.

During the year AiResearch Aviation introduced an innovation in business aviation marketing: a whirlwind tour around the country to give corporate operators an opportunity to see some of the latest concepts in corporate aircraft equipment. Shown, for the first time in most places, was the Gulfstream II. In addition, a DH125 with a new interior concept and a Merlin were displayed. By combining the great amount of interest generated by the Gulfstream II with the wide spectrum of business flying requirements covered by all 3 airplanes, the display drew wide attention among top level executives and aviation personnel.

GARRETT-AIR CRUISERS DIVISION

During 1968 the Air Cruisers Division continued its expansion in production volume which has been occurring over the past few years. Employment reached a new high, and a new factory building scheduled to be in operation before the end of the year was started in midyear. Sales and backlog for the year were expected to surpass all previous years despite a steep increase in competition throughout the industry.

Air Cruisers is engaged primarily in the design and manufacture of inflatable survival equipment for the air transportation industry and various military agencies. It is the largest producer of air-inflated shelters in the country. Volume production on the famous MUST hospital shelters (Medical Unit, Self-Contained, Transportable) continued at an increasing rate. The shelters have been widely used as field hospitals in Vietnam in conjunction with other types of equipment produced by AiResearch Manufacturing Company of Phoenix and Los Angeles. These field hospitals have been described by the Surgeon General of the U.S. Army as the greatest forward step in combat field medicine in 100 years.

The year marked the first time that the MUST concept developed by Garrett was sold for applications other than field hospitals. Air Cruisers was supplying to Philco-Ford Corporation a modified design for use as tactical air communication centers. This breakthrough added to the potential utilization of this new product line of Air Cruisers.

Again in 1968, as in the year before, Air Cruisers participated in keen competition for the inflatable survival gear furnished by the Lockheed-Georgia Company to be carried aboard the new Air Force troop carrier, the C-5A, and won each of these competitions with resultant contract awards for all life rafts and evacuation systems utilized on this aircraft.

Air Cruisers' expanded engineering department accomplished additional development work for the new giant aircraft, such as the Boeing 747, McDonnell Douglas DC-10 and Lockheed L-1011. A significant result of this development work was a demonstration in May at Barbados, B.W.I., for the Technical Committee of the International Air Transport Association, of a new concept for passenger aircraft evacuation. Custom models for each of the major aircraft utilized by the world's airlines today, as well as for the future giant sky carriers, should result in a continuing high rate of activity for the Air Cruisers Division.

Of significant note in 1968 was a change in the foreign representation for Air Cruisers' products. Airsupply International, a subsidiary of the Airsupply Company (another Garrett division), now provides this service in 26 countries.

GARRETT MANUFACTURING LIMITED

Garrett Manufacturing Limited, Rexdale, Ontario, the Canadian subsidiary of Garrett, experienced continued growth in 1968. Both sales and backlog increased, as did employment, which exceeded 500 early in the year.

Major elements in the expansion were the setting up of a thin film microminiature electronics research and development and production capability, and the expansion of traditional product areas into a wider range of applications and markets. The microelectronics facility should assist GML in continued advancement of state-of-the-art development in all areas.

Significant product developments included a downed aircraft locator emergency beacon; both digital and cam driven programmable pneumatic signal generators, for which major contracts were received; and static inverters for Army vehicle land navigation systems and the general aviation market.

Other areas of interest included weather data acquisition systems for airport installations and horizon bar equipment for helicopter assist in landing on a carrier.

Garrett Manufacturing marine activity expanded with the addition of new deck machinery products such as towing and mooring winches.

Diversification of product line activity continued not only in development and manufacturing but also in the overhaul area.

GARRETT-AIRESEARCH INDUSTRIAL DIVISION

AiResearch Industrial Division of Los Angeles enlarged its facility for the second time in 2 years. The addition of 20,000 square feet of manufacturing space was the result of increased demand for aircraft and industrial turbocharger systems, each of which is designed for a specific engine application.

Popularity of these systems for general aviation continued to grow and several new applications were undergoing test and FAA certification. In 1968 Piper introduced its popular Navajo, equipped with an AiResearch turbocharger system. A number of models offered by Cessna, Beech and Mooney have comparable installations. Some include cabin pressurization, a bonus benefit provided by turbocharging.

After one year of operation, the remanufacture-exchange program for system components demonstrated its merit in fast, economical service to aircraft distributors and owners.

GARRETT SUPPLY DIVISION

Garrett Supply Division, which has been serving industry in southern California and in Arizona for more than 30 years, added new lines and greater inventory to handle growing customer sales. New automated material handling equipment greatly increased efficiency in the number of orders handled per day.

Garrett Supply had well over a hundred of its customers on the data phone purchasing system, adding more each month. This system lowers the cost of purchasing for the customer, eliminates errors and has been a time- and cost-saving innovation.

With the Arizona industry moving forward, the Phoenix branch of Garrett Supply also added people and inventory.

Early in 1969 the firm planned to open an East Coast operation.

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

GARRETT-AIRSUPPLY DIVISION

The Garrett Corporation's Airsupply Division, headquartered in Santa Monica, California, furnishes sales engineering and distribution services on a nationwide basis for suppliers of aircraft and aerospace equipment.

In 1968 the division extended its area of sales coverage into western Europe. Airsupply International, a new Garrett subsidiary, was formed to handle the European operations. The subsidiary will establish offices in all key European cities, utilizing the established facilities of Garrett International S.A., another Garrett subsidiary. The new firm's headquarters are in Plainview, New York.

GENERAL DYNAMICS CORPORATION

With military and space work accounting for approximately 85 percent of more than $2 billion in sales, General Dynamics Corporation in 1968 marked new successes in several major aerospace programs and in space exploration.

More than 100 F-111 variable-sweep-wing aircraft had been produced by General Dynamics by the end of the year and had accumulated more than 15,000 flight hours in test, training and combat. Early in the year United States Air Force F-111As were ferried to Thailand and flown in combat for the first time. In July the first production version of the Strategic Air Command's FB-111A strategic bomber made its first flight. Two months later the first of 24 F-111C strike aircraft was formally accepted by the Royal Australian Air Force.

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 60 National Aeronautics and Space Administration and USAF vehicles from the pad by the fall of 1968. Manufacture of the advanced versions of the SLV-3—SLV-3A and SLV-3C—began late in 1967 and continued into 1968. The SLV-3A and SLV-3C, developed for more demanding future missions, were assigned for Orbiting Astronomical Observatory (OAO), Applications Technology Satellite (ATS) and Mariner Mars 1969 flyby missions.

In August, General Dynamics received an estimated $500,000,000 order from McDonnell Douglas to build the major portion of the fuselage for the DC-10 trijet commercial transport.

In missilery, production continued on the U.S. Navy's Standard missile and the U.S. Army and U.S. Marine Corps' Redeye shoulder-launched antiaircraft missile. Redeye production reached a rate of 1,000 missiles per month. General Dynamics also was awarded a contract by USAF to begin testing an air-launched version of Redeye called RAM. Production of an improved version of the Standard Antiradiation Missile (ARM) was started for the Navy and USAF. In addition, the company was named by the Navy as one of 3 industrial team leaders to compete for the engineering development phase of the billion-dollar Advanced Surface Missile System (ASMS) fleet air defense program.

By year-end, 5 Canadair CL-215 twin-engine amphibious water-bombers were in flight testing. The airborne fire fighter, already purchased from General Dynamics' Canadian subsidiary by Canadian and French governments, was scheduled for certification in December. Production of 115 CF-5 tactical support fighter aircraft for the Canadian Armed Forces and of another 105 NF-5 aircraft for the Royal Netherlands Air Force proceeded on schedule in 1968. Also on the production line, the first of 3 CL-84 V/STOL aircraft being manufactured for the Canadian Armed Forces neared completion in December.

For NASA's Project Apollo, 3 22,000-ton instrumentation ships built by General Dynamics played key roles in the successful first flights of manned Apollo spacecraft. Floating tracking stations in NASA's round-the-world network, USNS *Vanguard*, *Redstone* and *Mercury* were positioned in the Atlantic and Pacific to track Apollos 7 and 8, communicate with the 3 astronauts and relay information between the spacecraft and Houston. The sea-going tracking stations were also scheduled to be "on track" for the manned lunar landing mission expected in 1969.

In other electronics programs, General Dynamics delivered the first production microelectronic tactical air navigation (TACAN) systems for installation in F-106 aircraft and the first aerospace ground equipment (AGE) stations in support of the strategic bomber version of the F-111. Deliveries of AGE stations in support of the F-111A had begun in 1967.

A major milestone was passed in the development of the Navy's A-NEW advanced antisubmarine warfare system in October when a YP-3C Orion made its maiden flight carrying the AN/ASA-70 Tactical Display System developed by General Dynamics' Stromberg Datagraphics Inc., subsidiary.

FORT WORTH DIVISION

F-111 versions coming off the assembly lines at the Fort Worth, Texas, plant at year-end were the F-111A tactical fighter-bomber for the Tactical Air Command, the FB-111A strategic bomber for the Strategic Air Command and the F-111C strike aircraft for the Royal Australian Air Force. USAF's RF-111 reconnaissance aircraft was engaged in extensive flight testing throughout the year.

At the start of 1968, F-111As were being flown by Tactical Air Command pilots at Nellis Air Force Base, Nevada, for combat training. In February 1968 the first F-111A detachment at Nellis successfully completed all required testing and training. This detachment exceeded its programmed flying time and achieved the highest level of blind-bombing proficiency in Air Force experience with an accident-free safety record.

Throughout the training program, aircraft utilization was approximately 50 hours per month per aircraft. This utilization rate was unprecedented for such an early stage of aircraft development and was higher than the utilization rates of units flying other types of aircraft within the United States. Before deployment, Air Force crews had accumulated 3,382 hours during the flight training program. Approximately 60 percent of all aircrew training was conducted at night and included low-altitude training.

Operational F-111As were deployed first to Southeast Asia. They arrived at Takhli Royal Thai Air Force Base, Thailand, on schedule, March 17, 1968. They flew more than 50 combat missions, most of them at night and in bad weather, within about 2 months.

The first production version of the FB-111A strategic bomber made its first flight July 13, 1968, at the Fort Worth division plant. It was in July 1967 that the development version of the aircraft made its first flight.

The FB-111A's fuselage is the same length as the F-111A, but its wing span is 7 feet greater to provide added range and to permit a higher gross weight. It also has a strengthened landing gear for heavier loads and is equipped with advanced electronic systems for SAC missions. FB-111As were scheduled to replace C through F series of the B-52 used by Strategic Air Command.

The F-111C strike aircraft for the Royal Australian Air Force took the spotlight in September. At Fort Worth on September 4, the Royal Australian Air Force formally accepted its first F-111C from the U.S. government. The Honorable Allen Fairhall, MP, Australia's Minister for Defence, accepted the aircraft.

The F-111C is essentially the same as the F-111A, except that the wing span is 7 feet greater for longer ferry range and the landing gear is strengthened to carry heavier gross weights.

Forty-eight RAAF crew members undertook F-111 flight training during 1968 at Nellis Air Force Base, Nevada.

CONVAIR DIVISION

Early in 1968 the Convair division's Centaur 2-burn upper stage with the Atlas booster completed a highly successful performance in Project Surveyor with 7 consecutive flawless launches for the 7 Surveyor missions. For 1968 missions, NASA chose Atlas-Centaur to launch Orbiting Astronomical Observatory (OAO) and Applications Technology Satellite (ATS) vehicles. The ATS mission in August was unsuccessful. Although the Atlas portion of the flight was flawless, Centaur failed to restart its engines for a second burn following a long zero-g coast.

In addition to boosting Centaur upper stages, Convair division's Atlas vehicles launched other payloads with a high degree of reliability. Through mid-October there were 18 launches, 17 successful. Atlas reliability as a space booster is 91 successes out of 94 missions, with a 1968 year-end string of 42 consecutive successful launches.

Recycled Strategic Air Command (SAC) Atlas missiles were used as boosters to launch several Advanced Ballistic Reentry Systems (ABRS) and 4 Orbiting Vehicle 1 (OV1) scientific satellites. Dual OV1 satellites were launched in 2 separate missions. On a 20-missile average, recycled Atlas reliability was 90 percent.

The uprated, more powerful Atlas SLV-3A and -3C replaced the SLV-3 completely in 1968. The SLV-3A can be used with an Agena upper stage and the -3C with Centaur. The first SLV-3A early in 1968 successfully launched NASA's Orbiting Geophysical Observatory (OGO-E); another successfully launched a USAF payload. By mid-October, 4 SLV-3Cs had been launched, all successful.

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 Convair division was chosen in August 1968 to manufacture a major portion of the fuselage for the new advanced technology DC-10 trijetliner.

The contract, awarded by McDonnell Douglas, will have a value of approximately $500,000,000 by 1975. An estimated 4,000 Convair division employees will be assigned to the DC-10 program when production reaches its peak. Convair will build all of the fuselage except the nose and tail sections at the division's Lindbergh Field plant at San Diego. Delivery of the first complete fuselage package to McDonnell Douglas will be in late 1969.

Deliveries of empennage sections for the Air Force C-5 jet transport continued. The sixth and seventh empennages were scheduled for delivery to the Lockheed-Georgia Company late in 1968, on schedule.

Modification kits to convert 340/440 piston-powered Convair Liner aircraft to turbine power were sold to overseas operators during the year. Four kits were sold to Lufthansa German Airlines, which then sold converted aircraft to Air Algerie, the national airline of Algeria. One kit was sold to S.A. de Transport Arien (SATA), an air charter firm in Geneva, Switzerland. A second kit was scheduled for delivery to SATA late in the year.

POMONA DIVISION

Diversification of existing tactical guided missile programs and concepts highlighted work at the Pomona division in 1968. A contract to begin testing of an air-launched version of the Redeye missile (RAM) was awarded by the Air Force, and production of an improved version of the Standard ARM was started for the Navy and Air Force. In addition, the Pomona division was named one of 3 industrial team leaders to compete for the engineering development phase of the Navy's billion-dollar Advanced Surface Missile System (ASMS) fleet air defense program. Production of the Standard missile for the Navy and the Redeye missile for the Army and Marine Corps continued, with the latter reaching the 1,000-missile-per-month production rate.

The shoulder-fired Redeye missile, designed to protect infantrymen from low-flying enemy aircraft, was deployed in Europe by the Army. The 4-foot-long, heat-seeking missile was also supplied to

Marines at Twentynine Palms, California, and Army personnel at Fort Bliss, Texas, for training purposes. The air-launched version will be tested by the Air Force for use in air-to-air operations.

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

Two versions of the Standard missile—extended range and medium range—continued in production. Interchangeability of hardware between the 2 models is a key feature of the missile, 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. The Standard missile system will eventually replace the Terrier and Tartar missiles for shipboard fleet air defense. Production of the 2 latter missiles was completed in 1968, but they will continue to arm some 70 Navy ships for several years.

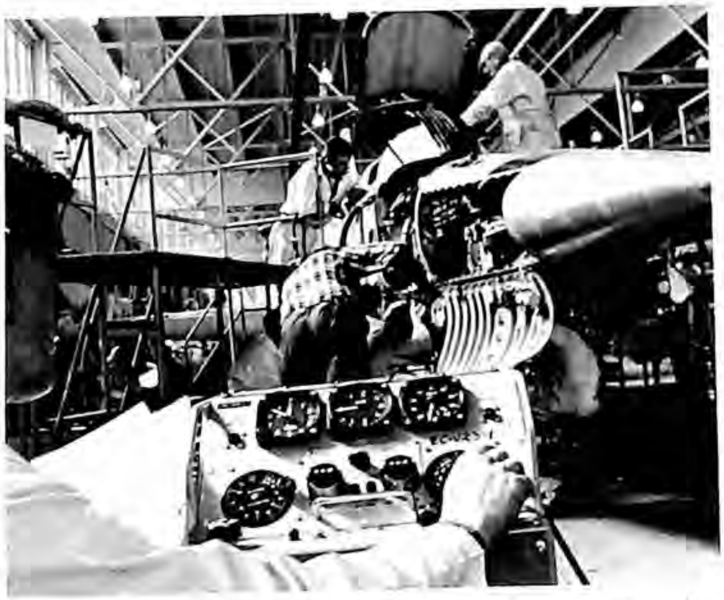
Contract definition for ASMS was awarded to the Pomona division as program manager of an industrial team that includes Hughes Aircraft Company's Ground Systems Group, Sperry Rand Corporation's UNIVAC Federal Systems Division and Sperry Gyroscope Division and Northrop Corporation's Nortronics Division. ASMS was expected to become operational by 1975.

CANADAIR LIMITED

The first of 3 CL-84 V/STOL aircraft which Canadair is manufacturing for the Canadian Armed Forces took shape on the production line as 1968 ended.

The CL-84, a tilt-wing vertical and short take-off and landing (V/STOL) aircraft, is the first of its kind to be developed in Canada. In a year-and-a-half of flight testing, the prototype CL-84 accumulated 405 operating hours in 305 flights. Powered by 2 gas turbine engines, it can take off, hover and land vertically like a helicopter or fly as a conventional airplane at a cruise speed of more than 300 miles per hour. This is faster than the cruise speed capability of contemporary helicopters.

Production of 115 CF-5 tactical support/fighter aircraft for the Canadian Armed Forces and of another 105 NF-5s for the Royal Netherlands Air Force was on schedule through 1968. Two single-seat fighter versions and one tandem-seat training version had flown successfully. Delivery schedules called for 4 per month starting in November 1968. The first NF-5 was slated to reach the final line in December 1968. After flight testing of the first 2 NF-5s, which was to be completed in March 1969, 9 airplanes per month will come off the production line and deliveries will be divided between the 2 countries. Final delivery to Canada will be in October 1970, and to the Netherlands in September 1971. The CF-5 and the NF-5 are Canadian versions of the basic Northrop F-5 fighter.



Technician checks out flight instruments on a Canadair CF-5 tactical aircraft; the General Dynamics division was building 220 of the planes for the Canadian and Netherlands governments.

Canadair was also manufacturing the rear fuselage section for all F-5s built by Northrop Corporation in California.

Members of the armed forces of Canada, Britain and the Federal Republic of Germany concluded service performance trials of the AN/USD-501 Airborne Surveillance System (started by Canadair in 1959 as the CL-89 drone). The test firing was carried out at Canadian Armed Forces Base, Shilo, Manitoba, by a tri-nation group. The cost of design, development, test and evaluation was shared by the 3 governments participating and, with trials completed, production was under way at Canadair.

The AN/USD-501 is a reconnaissance drone system designed to provide tactical intelligence in the forward battle areas. The drone design emphasizes small size and high speed and uses a rocket motor for initial boost and a turbojet engine for inflight power. After launch the drone accurately follows a preselected course, takes photographs as it flies over the target area and then returns to a predetermined recovery point, where it lands by parachute. The 8½-foot-long drone is reusable. The sensors are 2 70-millimeter cameras equipped for day and night operation. Other types of sensors were being evaluated.

The AN/USD-501 system can be operated under adverse battle conditions and, because of its small size and high speed, it has a particularly high probability of surviving against a strong enemy air defense.

Twenty CL-215 twin-engine amphibious aircraft in fire fighting water-bomber configuration were in production for the Province of Quebec in Canada and 10 for the Republic of France. Deliveries of the aircraft were scheduled to start in the spring of 1969, just prior to the start of the forest fire season in both countries. As a water-bomber the CL-215 loads up 6 tons of water in just 12 seconds by opening its hull tanks as it skims the surface of a lake or river. In an average day's fire fighting, it can dump 45 tons of water in round trips from water source to fire without refueling.

Canadair recently completed an order for 20 trainer tactical support versions of the CL-41 jet trainer for the Royal Malaysian Air Force. The company has built 190 of the side-by-side seat training versions of the aircraft and they are now in service with the Canadian Armed Forces.

Canadair has designed and built 2 ground-based satellite antennas: one is in service for the Defence Research Telecommunications Establishment near Ottawa, and the other is to be in operation soon at Bouchette, Quebec. The latter was built for Northern Electric Company and Bell Telephone of Canada and will be used in satellite communications tests. It may become part of the central station in a complex Arctic communications network.

With design and engineering capability gained from the satellite antenna work, Canadair joined a group including Northern Electric Company of Canada and Hughes Aircraft Company of California to develop, manufacture and arrange for the launching of satellites to meet Canadian communication requirements.

In a major move to continue its program of diversification and expansion, Canadair acquired in May 1968 the shares of Flex-Track Equipment Limited, which, in turn, acquired the tracked vehicle assets of Robin-Nodwell Manufacturing, Ltd., both of Calgary. The combined unit operates as a wholly owned Canadair subsidiary under the name of Flextrack-Nodwell Limited, in Calgary.

ELECTRONICS DIVISION

Three Apollo Instrumentation Ships (AIS) laden with complex electronics systems provided by the Electronics division of General Dynamics moved out on station in the Atlantic and Pacific oceans in December 1968 to carry out key assignments in the United States' first manned Apollo lunar mission.

The 3 "moonships," each carrying about 445 tons of electronics, are the USNS *Vanguard*, *Redstone* and *Mercury*. The division was prime contractor for the Apollo Instrumentation Ships program and supplied 8 of the 12 major electronics systems aboard each ship.

The division completed the AIS program early in 1968 with installation of a SATCOM (Satellite Communication) system aboard the *Vanguard* at the shipyards of the corporation's Quincy division. The 275-ton, 30-foot-diameter dish antennas aboard the 3 ships enable them to receive and transmit data from Apollo spacecraft to land-based mission control centers via earth-orbiting communications satellites.

The *Vanguard*, *Mercury* and *Redstone* are seagoing platforms which form the midocean links in NASA's world-circling tracking, data acquisition and command control network for the Apollo program.

The division's computer programming and systems design and analysis center in San Diego, which played a major role in the Apollo ship program, received a NASA commendation for its development of the programming for real-time displays of raw data transmissions from the ships to NASA's ground stations in earlier Apollo missions.

Under contract to the Naval Air Systems Command, the division also improved the capability of another tracking ship, the USNS *General Hoyt S. Vandenberg*. The division modified the ship's radar system to double its tracking ability and permit independent operation of 2 existing tracking radars. The improved tracking radars were equipped with automatic target acquisition and reacquisition, data processing and recording and visual display systems for identifying and tracking reentry and near-earth orbiting vehicles.

Also in 1968, the first system capable of performing, in a single receiver, the functions of automatic antenna tracking, telemetry data acquisition and ranging to a satellite was developed and produced by the Electronics division for the Satellite Tracking and Data Acquisition Network (STADAN) of the Goddard Space Flight Center. Until development of the new Multifunction Receiver (MFR), these functions required 3 separate receivers. The first MFR was produced for installation at NASA's STADAN station in Rosman, North Carolina. Others were being installed at primary STADAN stations in Alaska, the Malagasy Republic and Australia.

The division's San Diego operation was carrying out another NASA contract to expand the capabilities of 4 STADAN stations that support earth-orbiting satellites. The 2-year program, begun late in 1967, will extend the operational range of the stations from 100,000-200,000 miles to more than 1,000,000 miles.

The first MISTRAM-B transponder to be carried aloft on a missile flight was used for ground station tracking of the successful Minuteman III flight from Cape Kennedy on August 16. The new transponder aboard the 60-foot-long Minuteman III was a compact radio receiver and transmitter package which received signals from the ground station on 2 channels and transmitted corresponding signals back to the cooperating MISTRAM station on earth.

The frequency and wave forms of the signals were used to provide trajectory data on the missile. MISTRAM is a U.S. Air Force missile trajectory measurement system. MISTRAM-B transponders are produced by General Dynamics under Air Force contract in support of the Minuteman III program.

Another advanced microcircuited transponder was being produced by the division for use in Air Force satellite programs. A half-dozen other major electronics programs for aerospace systems application were under way, including production of terrain-following radar and a dual-mode radar for use on operational military jet aircraft. In development was a lightweight, multifunction airborne radar for close support and counterinsurgency aircraft.

At the Electronics division's Dynatronics operations in Florida, work centered on an advanced, solid-state automatic telemetry tracking receiver for use in STADAN operations.

To accommodate the steady growth of the division's activities, a new 100,000-square-foot assembly plant was completed in the latter part of 1968 on a 217-acre site about 12 miles north of Orlando, Florida, near the existing Dynatronics operation.

The Electronics division, a pioneer in tactical air navigation (TACAN) development, delivered in 1968 the first production units of microelectronic TACAN for use in the Air Force's F-106 interceptor. The division has a multimillion-dollar contract to manufacture 350 micro-TACAN systems, the first solid-state, microcircuited TACAN ever flown. By year-end, the Electronics division had supplied over 10,000 airborne TACANs for military use.

Much of the division's activity during the year involved work on aerospace ground equipment (AGE) for the F-111 program. The first AGE FB-111A strategic bomber test station was shipped from the division's main plant in Rochester, New York, to Fort Worth in May. The multimillion-dollar AGE program involves design, development and manufacture of integrated test equipment for more than 200 types of airborne communications, radar, navigation, flight control and weapons penetrations aids for a variety of F-111 configurations.

The division's antisubmarine warfare operation in Rochester, New York, continued deliveries to the Department of Defense of airborne AN/ARR-52A radio receiving sets. These sets, carried in a wide variety of ASW aircraft, detect and track underwater targets by the reception of signals from sonobuoys. The latest generation of the division's sonobuoy receivers, the microelectronic AN/ARR-72, was being supplied for use aboard the Navy's new P-3C Orion antisubmarine warfare aircraft.

STROMBERG DATAGRAPHICS INC.

Early in 1968 the Data Products division of General Dynamics' Stromberg-Carlson Corporation subsidiary was established as Stromberg Datagraphics Inc., a separate corporate entity within General Dynamics' Electronics group. A major market for Stromberg Datagraphics products is the military services, to which it sells command and control and airborne display systems.

A milestone in the development of the Navy's A-NEW advanced antisubmarine warfare system was passed in October when the YP-3C Orion ASW aircraft made its maiden flight carrying a preproduction AN/ASA-70 Tactical Display System, designed and built by Stromberg Datagraphics under contract to the Naval Air Systems Command.

Quantity production of the AN/ASA-70 Tactical Display System was begun in 1968 following completion of its development phase.

Stromberg Datagraphics display units were completed and installed in an A-3B aircraft engaged in the Navy's VS A-NEW Mod 5 airborne ASW development program. Mod 5 is the Navy's first VS avionics flight test system and will be used to demonstrate the feasibility, practicality and performance of advanced A-NEW techniques in a carrier-based aircraft system. Flight test of the Mod 5 A-NEW system was under way.

A Mobile Tactical Exercise Control and Evaluation System (MOTECS) was developed by Stromberg Datagraphics for the Naval Research and Development Laboratories and evaluated by the U.S. Marine Corps during amphibious exercises at Camp Pendleton, California. The system contained an advanced version of Stromberg Datagraphics' SD 1090 display console.

Late in 1968 Stromberg Datagraphics delivered a flexible display control simulator system to The Boeing Company's Aerospace Group for use in study programs directed toward determination of optimum display parameters required on future Airborne Warning and Control System (AWACS) missions.

GENERAL ELECTRIC COMPANY

AEROSPACE GROUP

Aircraft Equipment Division

The beginning of 1968 saw the formation of GE's new Aircraft Equipment Division, which was announced as a part of the General Electric Company reorganization in late 1967. Charles W. George was appointed vice president and general manager of the new division; prior to the appointment, he was the company's vice president and general manager of the Defense Electronics Division. Growth of the former division necessitated a reorganization into 2 new divisions—the Aircraft Equipment Division headquartered in Utica, New York, and the Electronic Systems Division with headquarters in Syracuse, New York.

The Aircraft Equipment Division increased its contribution to the defense and commercial aerospace markets. A leading worldwide supplier of aerospace electrical and electronic equipment, the division during the year made application of new technologies—such as fly-by-wire flight control, lasers, low-light-level television, computed displays, and solid-state rate sensors—which have opened new fields for product development and growth.

Employing more than 16,000 people at year-end, the division is comprised of 4 product departments and an advanced systems department. The departments and locations are: Aerospace Electrical Equipment at Erie, Pennsylvania, Lynn, Massachusetts, and Waynesboro, Virginia; Aerospace Electronics at Utica, New York; Armament at Burlington, Vermont, and Springfield, Massachusetts; Avionic Controls at Binghamton, New York; and Advanced Systems and Planning at Utica, New York.

The Advanced Systems and Planning operation saw its first full year of operation and markedly strengthened the division's contribution to military and commercial contracts for aerospace equipment.

The Aerospace Electrical Equipment Department has product responsibility for the development, design and production of instruments and electrical equipment for aircraft and space applications. These equipments include navigation systems, fuel management systems, engine instruments, and electrical systems.

The department continued production of various equipments for commercial and military aircraft, as well as for certain space programs such as the Lunar Module and SNAP-8.

Electrical systems were delivered for the C-5A Galaxy cargo aircraft, which made its first flight in 1968. The C-5A electrical system consists of 5 generating channels, is capable of producing 400 kva, and weighs approximately 400 pounds. This compares with earlier systems weighing as much as 50 percent more per kva.

The department introduced a new oil quantity indicating system. GE developed a simple, lightweight, highly reliable electric dipstick with appropriate readout that provides a direct measurement of the quantity of oil contained in the tank being measured.

Development work started on a self-contained oxygen system for use on high-performance military aircraft. Such a system will eliminate the need for liquid oxygen facilities at remote bases. The key element in the system is an "oxygen concentrator" that will extract oxygen from jet engine compressor bleed air and will deliver pure oxygen to the pilot's face mask on a continuous demand basis.

The department began work on the development and manufacture of the main electrical power generating system for the SST. General Electric over the past 10 years has been developing and testing a variable-speed, constant-frequency (VSCF) electrical system for aircraft application. The Boeing SST is the first aircraft to call specifically for a VSCF system. The SST's electrical facilities include a 4-generator 60 kva variable-speed, constant-frequency electrical system.

A number of 1968 developments at the Aerospace Electronics Department highlighted the division's activity in the area of lightweight electronic systems and equipment which GE develops and manufactures for a wide variety of mission requirements covering detection, guidance and data processing.

Production of attack radar systems for the F-111A and of new AN/APQ-114 radar systems for the FB-111 fighter-bomber version continued. The F-111A aircraft was introduced into the U.S. Air Force's operational inventory in Southeast Asia during the year.

The AN/APQ-113 and the AN/APQ-114 became the latest production systems in a long line of radars developed and manufactured by the division. Microelectronics and solid-state circuitry were used extensively in the new radar systems to meet stringent size, weight and reliability requirements.

Delivery of production quantities 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 missile's sophisticated heat-seeking sensor automatically guides the missile after launch to the point of interception. This equipment contains some of the most advanced infrared techniques available for production today.

Significant electronic warfare hardware of the barrage and deception type continued to flow from the division to the Air Force in 1968. Other high-activity programs were satellite command systems, developmental work on the airborne early warning radar for the Navy's new E-2C aircraft, and significant production effort on the data processing system for the Navy's P-3C antisubmarine warfare aircraft.

In conjunction with GE's work on military applications of low-light-level television, the division delivered 2 1,000-line-resolution TV cameras for NASA's Marshall Space Flight Center. 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. Another LLLTV system underwent development and testing for use on the P-3C aircraft.

To meet the demands of the Vietnam conflict, production was stepped up at the Armament Department on the 20-millimeter Vulcan cannon and 7.62-millimeter 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.

Initial deliveries of 20-millimeter Vulcan Air Defense Systems (VADS) were made to the U.S. Army by the Armament Department. The Vulcan fires up to a rate of 3,000 shots per minute in its air defense role and the same ground vehicle weapon system can fire at 1,000 shots per minute in a role against ground targets.

The VADS system was being produced in 2 versions: a self-propelled, amphibious version and a towed version.

In new armament roles, the 20-millimeter Vulcan gun appeared on the HueyCobra helicopter and, with the 7.62-millimeter Minigun, on the newly operational AC-130 troop-support gunship. In addition, a contract was awarded for a heavy weapons turret to appear on the HueyCobra in 1970.

Production continued on armament systems for LTV's new A-7 series of lightweight fighter aircraft and the McDonnell Douglas F-4E fighter.

Major research and development effort was continued on the revolutionary concept of caseless ammunition.

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 fuzes.

Within the Avionic Controls Department at Binghamton, New York, are consolidated the division's technologies, capabilities and facilities for the design, development and production of commercial and military avionic control systems.

The product scope of the department includes flight controls, aircraft engine controls, weapon delivery control systems, displays, 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 rotorcraft.

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 help achieve high reliability, low cost and ease of maintenance. The experience gained in the technology and design of the F-111 automatic flight control system is being applied to commercial supersonic aircraft.

The swiveling gunner's station provides the gunner on 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 flyby 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 1968 avionic development activities included a new long-life solid-state rate sensor for both aircraft and space use, a large control moment gyroscope and associated computers for space vehicle stabilization and attitude control systems, and flight control work for the SST program.

A microelectronic digital computer underwent operational testing with an SST aircraft simulated on an analog computer. The solid-state rate sensor underwent flight, operational and evaluation testing at Boeing on a 707 for application on the commercial supersonic transport.

A major development milestone was reached by the Avionic Controls Department when the XV-4B Hummingbird, a VTOL aircraft, was successfully test flown, demonstrating the capability of the GE electronic fly-by-wire system to eliminate mechanical linkages to an aircraft's control surfaces.

The multiweapon fire control system program encompassed design and development of analog and microelectronic digital computers, manufacture of engineering prototypes, and their installation on the UH-1B helicopter.

Electronic Systems Division

A major contributor to the Navy's Polaris and Poseidon Fleet Ballistic Missile program, the General Electric Company's Electronic Systems Division continued development and made first production shipments of the Mk 3 inertial guidance system, the Mk 88 fire control system, and support equipment for the Poseidon program. Deliveries were also continued on Mk 492 module test sets used for testing electronic components of the Poseidon and Polaris guidance systems. First test firing of the Poseidon missile from Cape Kennedy in August 1968, termed a "complete success" by the Navy, was followed by a second firing in November.

Production continued on swiveling gunner's stations for the Army's AH-56A Cheyenne helicopter, an attitude control system for the Air Force's reentry measurement vehicles, a mortar locator for pinpointing enemy mortar emplacements with the first shot fired, and airborne personnel detectors for use by the Army in Southeast Asia in detecting concealed personnel.

Development work continued on advanced microminiature circuit technology and packaging concepts for weapon control and guidance applications of the future; on a servo turret drive for Army tracked vehicles that permits accurate "fire on the move" capability through 2-axis stabilization of the gun; on a new solid-state drive for Navy guns and launchers that operates directly from digital commands fed directly from a computer; on condensation nuclei techniques for personnel detection; on a carbon dioxide laser spectrometer for detection of chemical agents; and on boundary layer control techniques for low-drag, high-speed underwater vehicle configurations.

The Electronics Laboratory announced a new microelectronic technique early in 1968 for use in hybrid microelectronic circuits. Called STD for Semiconductor on Thermoplastic on Dielectric, the process eliminates the "flying lead" and permits batch fabrication of circuit interconnections. Further development of the process was continuing.

New approaches to solid-state displays through electroluminescence, magneto-optics, and light-emitting switches were being investigated. Thermoplastic and oil film techniques were being used to develop large-area projected displays.

The Electronic Systems Division continued to serve as GE's competence in land and sea-based electronic systems and equipment. With headquarters in Syracuse, New York, ESD at year-end had a total employment in excess of 12,000 people in 4 major organizations: Ordnance Systems in Pittsfield, Massachusetts; Heavy Military Systems, the Electronics Laboratory, and the Advanced Systems and Requirements Operation, all in Syracuse, New York.

Dr. R. H. Beaton was appointed general manager of the division in January 1968, and during the year the systems engineering capabilities were significantly strengthened. The division's competence is in radar, sonar, weapon control, and associated electronic technologies in the land and sea-based electronic systems area.

Missile and Space Division

The Missile and Space Division maintained its status as a major contractor in the space program in 1968, while broadening its horizons into new and promising fields of space spin-offs.

Starting its second decade of operation, the division began 1968 with almost 20,000 employees and over 5,000,000 square feet of research and development facilities. Headquartered in Valley Forge, Pennsylvania, the division conducted development and test activities at all the primary U. S. missile and space operation centers and at some overseas locations.

The division's Re-entry Systems organization in Philadelphia continued to maintain General Electric's responsibility for research, development, and production of vehicles and systems that can survive reentry into the earth's atmosphere or entry into the atmosphere of other planets.

These efforts included work on such strategic systems as the Mark 12 reentry system for the Minuteman III intercontinental ballistic missile and the Mark 6 system for the Titan II; reentry research and test vehicles such as NASA's Reentry F program; scientific recoverable satellites such as Biosatellite; and lifting entry and planetary entry system programs.

The Re-entry Systems organization also continued studies of nondefense applications of space technology. Notable among such applications is the organization's work in the field of housing research and development. The organization was investigating new concepts of residential construction for the development of high-quality, lower-cost military family housing for the Department of Defense. Teamed with the architectural firm of Hugh Gibbs and Donald Gibbs, AIA, Re-entry Systems was providing architectural and manufacturing engineering services for a 200-unit project at George Air Force Base, California. Construction will be included in a subsequent phase of the project, and significant cost savings were predicted when the mobile factory concept begins producing prefabricated building sections on the site.

Another major area of space technology application is in the field of oceanics. Project "Bottom-fix" is a Re-entry Systems concept for a future manned deep ocean station. Technology and system studies of potential military significance in high-strength materials and nuclear power are being conducted. A titanium-pyro ceram model of the Bottom-fix module underwent preliminary pressure tests during 1968, and additional tests at the Navy's Research and Development Center were to take place in 1969.

Another Missile and Space Division oceanics program, Tektite I, was begun in 1968. This program, jointly sponsored by the U.S. Navy, the Department of the Interior, NASA, and General Electric, will involve 4 marine scientists living at a water depth of 50 feet for 60 continuous days. In and around an underwater habitat designed and constructed by the division, the aquanaut-scientists will conduct exhaustive and comprehensive marine geological and biological experiments. While the 4-man crew is conducting its underwater research mission, it will be continuously observed by Navy and NASA behavioral and biomedical teams. The objectives will be to identify man's psychological and physiological reactions to a long-term mission performed in an isolated, hostile environment common to undersea and space missions. The Tektite I mission was expected to begin in February 1969 at a location in the Virgin Islands.

The division's Space Systems organization, a consolidation of 3 previous GE operating departments —Spacecraft, Manned Orbiting Laboratory, and

Special Military Projects—was established in 1968. Daniel J. Fink, former Deputy Director of Defense Research and Engineering for Strategic and Space Systems was named its general manager. Located at the GE Valley Forge Space Center, the 5,800-man organization had both manned and unmanned space programs under way. Typical programs included Nimbus, Orbiting Astronomical Observatory, ATS-F&G, Apollo color TV transmission system, Integrated Medical Behavioral Laboratory Measurement System, broadcast satellites and earth resources satellite studies.

Four key events in Space Systems programs took place in 1968, with 2 very successful performances. The GE-designed OAO stabilization and pointing system worked perfectly after the spacecraft was launched in December and continued to meet all of its stringent requirements. Also successful was the portable color TV transmission system developed by Space Systems to provide a means for television coverage of the Apollo program. In October the system transmitted the Apollo 7 recovery operation from the USS *Essex;* and in December, the Apollo 8 recovery in the Pacific from the USS *Yorktown.*

Launch of the GE-built Nimbus B weather satellite in May was unsuccessful because of failure of the booster, and the ATS-4 launch later in the year resulted in a very poor orbit. The GE-designed gravity gradient stabilization for the ATS satellite thus did not receive a full chance to work, though the system was tested and did operate. The very elliptical orbit, however, prevented successful stabilization.

As a result of the booster failure on Nimbus B, NASA ordered another, identical spacecraft. This spacecraft will have been built in the record-breaking time of 9 months when launched in the spring of 1969.

ATS-E, the fifth of the ATS series, will also carry a Space Systems-produced stabilization system. This spacecraft was also scheduled for launch in 1969.

The Application of Remote Manipulation to Space Maintenance was the subject of a feasibility study by the Space Systems organization. For the study, SSO was investigating the feasibility and economics of performing in-orbit maintenance of unmanned satellites using a ground-controlled manipulator. SSO engineers were examining in-orbit repair and refurbishment missions, determining manipulator system requirements, evaluating system performance, defining standardized satellite design practice which would facilitate future repair and refurbishment, and defining an orderly development program, as well as system costs.

A very-high-resolution closed-circuit camera system was developed in 1968 by SSO. The new GE TV system has the capability of projecting for astronauts a scale model of the lunar surface in sufficient detail to identify the hazard of 3-foot-wide craters at a simulated altitude of 1.6 miles. The simulated conditions teach astronauts to identify and avoid obstacles in sufficient time to insure a safe landing on the moon.

A 275 percent improvement in television picture detail over other similar available systems is expected from the GE camera.

At the National Aeronautics and Space Administration's Mississippi Test Facility (MTF), huge first and second stages of Apollo/Saturn V launch vehicles were being given critical preflight testing, including static test firings, to prove their flightworthiness. General Electric's Mississippi Test Support Department (MTSD) continued to provide the management, engineering, technical, logistic and operational services required for functioning and maintenance of the 25-square-mile proving ground.

The check-out, modification, test and certification of 6 Saturn V first and second stages involved full attention and effort at MTF during 1968. GE-MTSD provided a wide spectrum of range, base and special services to NASA; to the 2 stage contractors, Boeing and North American Rockwell; and to other tenants.

During 1968 the department increased its involvement in and its pursuit of new business, particularly in those commercial and government fields where its management and technical skills and aerospace know-how are most applicable. These included socioeconomic projects associated with Office of Economic Opportunity and Community Action Program operations of rural, urban and regional scope; operation of training centers; and special studies. During the year, MTSD also did technical work on GE's Tektite and Sea Robin oceanographic projects and began designing a procedural management system for the Iowa Power and Light Company.

During 1968 the Apollo Systems Department, headquartered in Daytona Beach, Florida, continued to support NASA on Project Apollo, chiefly in the areas of engineering services and check-out.

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 check-out equipment, electrical support equipment and electrical launch support equipment, ASD developed major data management services and engineering services for the U.S. 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, working with the Atomic Power Equipment Department, completed design and fabrication of a nuclear power plant simulator being used for training operators of nuclear power plant stations. This system, an integral part of the world's first boiling water reactor training center, electronically simulates the entire operation of a nuclear power plant and represents ASD's first major spin-off into a growing non-aerospace and defense customer area.

As General Electric's center for basic research and exploratory development in space-related sciences and technologies, the division's Space Sciences Laboratory at Valley Forge continued work in reentry physics and hypersonics, magnetohydrodynamic power, composite materials and structures, ballistic missile defense discrimination research, space experiment design, optical structures, and nondefense applications.

In advanced materials and structures for aerospace application, emphasis was placed on the development of fiber-reinforced metal and plastic composite material, radiation-resistant polymers, dry film lubricants for high vacuum, electronic materials, structural ceramics, bearings, and space processing of materials.

Magnetohydrodynamic power generation, plasma diagnostics, plasmamicrowave interaction and laser light scattering continued to be the subject of experimental and theoretical research. A major new MHD shock tunnel experimental facility was brought into operation in 1968 and nonequilibrium powers above ½ megawatt were obtained. The effects of plasma sheaths on antenna resonance were studied experimentally and work was initiated on an RF method of gas laser pumping. In addition, the construction of a laser air pollution probe was initiated.

In space and planetary physics, studies proceeded on the space environment, new methods for micrometeoroid detection, free molecule interactions with surfaces, and applications of polarimetry to meteorology and earth resources experiments.

Also, a new technique for detecting meteoroids and space contaminant particles and measuring their relative velocity was investigated and should soon be flown on rockets or satellites. Studies of techniques for making significant air pollution measurements from satellites were conducted. Work continued on the kinetics of normal atmospheric constituents and pollutants.

In applied physics, investigations continued on infrared detectors, optical communicators, reentry technology, and the dynamics of moored surface vehicles. Studies of ground-based and ocean-based optical and electronic data collection systems were conducted.

Extensive theoretical and experimental research proceeded on reentry technology and observables with data on vehicle radiation signatures obtained by ground stations at White Sands Missile Range and the Western Test Range and from analysis of vehicle on-board data. Work continued on sensor technology for specialized field missions including development of imaging radiometers, optical communicators, a video tape analysis and display station, and a variety of high-speed optical detection and tracking systems.

Theoretical and experimental studies were concerned with the thermal degradation, oxidation and off-gassing of various polymeric and polymer-related materials in connection with R/V design and observables, and with spacecraft contamination. Other theoretical and experimental research related to upper atmosphere phenomena, including electron cloud formation and nuclear fireball modeling, was conducted.

Mechanics investigations continued on hypervelocity impact; the failure mode of composites; the control and optimization of directional, specific, and bulk properties of composites; and the effect of parametric variations on their performance. The role of mechanical forces on the functioning of fibrous biological structures was studied.

AIRCRAFT ENGINE GROUP

The dramatic growth pattern of General Electric's Aircraft Engine Group continued through 1968, particularly in its commercial aircraft engine market.

On January 1, 1968, the Aircraft Engine Group became one of the company's 10 major operating organizations, having previously been the Flight Propulsion Division. Within the group are 5 divisions with clear separation between military and commercial business.

AEG is one of the company's largest groups, with 28,000 employees at 2 major plant locations (Cincinnati, Ohio, and Lynn, Massachusetts) and satellite facilities at Hooksett, New Hampshire; Rutland and Ludlow, Vermont; Albuquerque, New Mexico; and Everett, Massachusetts. The group also has 4 service shops, located in Ontario, California; Seattle, Washington; Arkansas City, Kansas; and Cincinnati, Ohio, plus a flight test center at Edwards AFB, California.

The major commercial success of 1968 was the selection of the commercial CF6 turbofan engine for the McDonnell Douglas DC-10 trijet by American Airlines and United Air Lines. A total of 110 orders and options for trijets was made. The 40,000-pound-thrust engine first ran on October 21 and exceeded its guaranteed thrust level by 5 percent on October 27, less than a week after it first went on test. The CF6 is designed for low sound, long parts life and a high degree of maintainability. It will enter commercial airline service in late 1971.

The testing program on the engine for the U.S. supersonic transport continued on schedule during 1968. The GE4 was tested at more than 63,000 pounds of thrust in September, making the SST turbojet the most powerful engine in the world. By year-end, more than 600 hours of testing had been accumulated on 7 engines in 2 configurations.

As part of GE's investment in commercial engine activities, a new $12,000,000 Altitude Test Facility went into operation in Cincinnati. The facility simulates speeds up to Mach 3 and altitudes over 80,000 feet. This facility is part of the group's 3-year $100,000,000 investment in plant modernization and construction of new facilities.

On another commercial engine front, AEG counted more than 500 GE-powered business jet aircraft flying by the end of 1968. This total constituted more than 50 percent of the worldwide turbojet and turbofan business jet aircraft fleet. The GE business jet engine family includes the CJ610 turbojet series (Jet Commander, Learjet and Hansa 320) and the CF700 turbofan (Fan Jet Falcon).

By year-end, well over 800,000 engine flight hours had been logged by GE business jets since first entering service in 1964. In 1968, production began on a higher-powered CF700-2D which offers 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 1968 to Sikorsky for its S-61 and S-62. GE engines power all scheduled U.S. commercial helicopter aircraft.

General Electric's military engine activities were highlighted by the winning of the U.S. Navy's VSX antisubmarine warfare aircraft engine power plant competition with the TF34 high bypass turbofan entry and the successes of the TF39 development and flight test program.

The 41,000-pound-thrust engine had logged more than 10,000 running hours, including flight test in 2 U.S. Air Force C-5 logistic transports, built by Lockheed, and in a modified B-52 flying test-bed. Approximately 300 engine flight test hours had been accumulated. The C-5 first flew on June 30, 1968, and through the first series of 8 flights engine operation was flawless.

In addition, the TF39 completed the 150-hour endurance portion of its Formal Qualification Test for the U.S. Air Force. This rigorous test helps ensure that the TF39 will be a reliable power plant that meets all performance criteria. The TF39 will enter operational service with the Military Airlift Command with a Time Between Overhaul (TBO) of 1,000 hours. This TBO will grow to 5,000 hours in service.

The C-5 power plant was in full production. The first 4 production engines were accepted by the U.S. Air Force on October 6, 1968.

One of the Aircraft Engine Group's small engines, the J85, continued in production for the Northrop T-38 trainer and F-5 Freedom Fighter and the Cessna A-37 attack aircraft for the U.S. Air Force as well as for various nations throughout the free world. In addition, the Lockheed XV-4B Hummingbird II V/STOL experimental aircraft began flying in 1968, powered by 6 J85s. The modified XV-5B, built by Ryan, began an experimental flight test program under the direction of NASA. This aircraft is powered by a lift-fan system driven by 2 J85 engines.

At the Cincinnati plant, the 10,000th J79 for U.S. military aircraft was delivered to the Air Force on October 29. The first J79 was built and tested in 1954. In 1968, it was being produced for the twin-engine McDonnell Douglas F-4 and the twin-engine North American Rockwell RA-5C. Other operational aircraft powered by the J79 are the single-engine Lockheed F-104 and the 4-engine General Dynamics B-58. Production of J79 engines will continue into the 1970s.

GE was proceeding on its initial $11,000,000 development contract to build and test a high-performance afterburning turbofan engine for the FX/VFX-2 aircraft. GE was in competition with Pratt & Whitney Aircraft for this engine contract. Earlier, GE announced that the GE1/10 engine, forerunner of the FX/VFX-2 power plant, had exceeded all Air Force contract commitments. Well over 100 hours of testing on this augmented turbofan were accumulated during the program.

This new engine, as well as several others, is a derivative of GE's GE1 basic core engine. The GE1 is a highly flexible engine that can be transformed into an afterburning turbojet, a turbofan, an augmented turbofan, a turboshaft or a turboprop as well as into the lift-fan or lift/cruise configuration.

The T58 turboshaft engine continued in production for a wide variety of applications. The -16 version, which generates 1,870 shaft horsepower, was unveiled in 1968. Production engines deliver up to 1,500 shaft horsepower and the -16 adds to this performance improvement pattern of the T58 family. The T58 began life with a power output of 1,050 shaft horsepower in 1959.

In Lynn, the T64 turboprop/turboshaft production rate began to climb rapidly in 1968. The -16 version, which is capable of 3,925 shaft horsepower, was in production for the U.S. Army AH-56A Cheyenne helicopter, built by Lockheed. The -16 was one of 3 advanced T65 engines being produced for aircraft of all 3 U.S. military services. Two T64-12 engines power the Marine/Sikorsky CH-53D heavy assault helicopter, and 2 -7 engines are installed in the U.S. Air Force/Sikorsky HH-53C air rescue helicopter.

GE marine and industrial gas turbines include the LM100, LM300, LM350, LM1500 and LM2500. These engines range in power from 1,000 to 25,000 horsepower. They are used as power plants for hydrofoils, air cushion vehicles, displacement marine vessels, electrical power generation, pipeline pumping, and locomotive boost propulsion.

The 2 newest entries in the Marine and Industrial Department product line are the LM300 and LM2500 gas turbines. They are derived from the T64 and TF39 aircraft engines, respectively. Both engines were unveiled in 1968 at the 13th Annual ASME Gas Turbine Show in Washington.

The LM2500 is an advanced technology marine gas turbine in the 25,000-horsepower-class, boasting the lowest fuel rate and best marinization materials of any production marine gas turbine in its power class. The engine was being offered as main propulsion for advanced commercial and military shipbuilding programs such as the Navy's new DX destroyer project.

Other GE gas turbines in marine service included the LM1500 in the Navy's new aluminum-hulled PG patrol gunboats for high-speed operation, and the LM100 for emergency power generation and take-home power aboard commercial cargo carriers and the Coast Guard Hamilton class cutters. LM100 gas turbines also power air cushion vehicles for both the Army and the Navy.

LM1500 industrial gas generators were in widespread use for liquid and gas pipeline pumping. One such unit went more than 12,000 hours before overhaul. In 1968 a unique 3-jet LM1500 unit went into operation at Pennsylvania Power and Light, making that company the third major electric utility to install General Electric jet gas turbines.

B. F. GOODRICH AEROSPACE AND DEFENSE PRODUCTS

The year 1968 was an eventful one for B. F. Goodrich Aerospace and Defense Products, a major producer of tires, wheels and brakes and many other diversified products for the nation's defense establishment, aircraft manufacturers and commercial airlines.

A contract to supply Lockheed with main landing gear wheels and brakes for its trijet L-1011 luxury airliner was signed. The agreement called for 350 shipsets of 8 main landing gear wheels and brakes per aircraft, including spares, to be delivered beginning in the first quarter of 1970.

B. F. Goodrich will manufacture the wheels and multiple-disk brakes in its plant at Troy, Ohio, where production capacity has been doubled since 1966.

B. F. Goodrich is also producing wheels and brakes for the U.S. Air Force C-5 aircraft, built by Lockheed-Georgia. Brake disks for the 24 main wheels of the C-5 are made of beryllium and weigh about 35 percent less than comparable steel disk brakes. This saves approximately 1,500 pounds in the gross weight of the aircraft.

B. F. Goodrich is also supplying Lockheed-Georgia with tires, load-rated at 40,000 pounds, for the giant aircraft.

In addition to filling its role as major supplier of tires for all types of aircraft—military, commercial and general—in regular service, the company opened 3 new aviation products service centers, at New York City, Kansas City and Los Angeles. Aircraft tire retreading, using latest equipment and procedures, is already established for all popular airline sizes.

Special applications were made with a unique anti-fouling rubber, called "Nofoul," used to protect underwater surfaces from the harmful effects of barnacles and other marine organisms. The sheet material, which can be applied with special adhesive to ship hulls, buoys, pilings and other underwater structures, keeps surfaces free of marine life at least 4 times longer than other protective coatings.

Nofoul rubber was cited in 1968 by Industrial Research, Inc., as one of the 100 most significant technical products of the year.

B. F. Goodrich is a leader in many other specialty rubber products for the aerospace industry. The company continued to produce emergency evacuation slides for Boeing's 747 commercial jetliner. The slides, made of a lightweight, coated fabric, are capable of being inflated in seconds.

Other products made by the B. F. Goodrich division include electrical and pneumatic de-icing systems, erosion shoes, rocket motor case insulators and liners, ablative and reinforced plastic structures and tanks and pressure sealing zippers. It also manufactures inflatable seals, "Rivnut" fasteners, rigid structural foam material, called "Rigicell," and sonar components including domes, transducer boots and hydrophone tubes.

GOODYEAR AEROSPACE CORPORATION

A dynamic new management team began guiding Goodyear Aerospace Corporation in 1968.

Morris B. Jobe, vice president of sales, became president on July 1, succeeding Loren A. Murphy, who retired after 43 years' service.

Named vice presidents in the new management were E. A. Brittenham, Jr., vice president of engineering; James A. Keenan, vice president of manufacturing; and Willis S. Zeigler, vice president of marketing.

Jobe, a 1938 graduate of the University of Akron, also attended the Institute for Management at Northwestern University and has done postgraduate work in industrial management. He joined The Goodyear Tire & Rubber Company in 1938 after receiving his bachelor's degree and joined Goodyear

Aerospace in 1951. He is a trustee of the National Security Industrial Association and in 1968 was elected to a 3-year term on the NSIA Executive Committee. He was general manager of GAC's Arizona Division from March 1966 to June 1967, when he was named vice president-sales.

Significant scientific and technological advances in systems, electronics, airframes and plastics activities, plus continuing diversification, were accomplished by Goodyear Aerospace in 1968.

Production levels increased at the headquarters plant in Akron, Ohio, at the Arizona Division in Litchfield Park, and at the Jackson, Ohio, commercial plastics plant.

The Subroc antisubmarine missile, for which GAC is prime contractor, remained at the top of the production list. 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.

Contracts for more than $40,000,000 for continuing production of the underwater-to-underwater missile were awarded GAC in 1968 by the Naval Ordnance Systems Command.

Associative and parallel computer processors that can process more data, faster, were under development by Goodyear Aerospace.

The computer system may be able to direct 2,000 aircraft a second and help unsnarl congested aircraft traffic along the nation's airways and on the runways. The firm believed the system could speed up flight operations and detect possible in-air collisions in time to prevent them from happening.

An experimental unit programmed for electronic warfare control was delivered to the Air Force at the Rome (New York) Air Development Center.

The company continued to develop and manufacture sophisticated weapons systems and flight simulators to train military pilots.

A contract was awarded by the U.S. Navy for 8 training devices to be used to train pilots to fly TA-4F advanced jet trainers. Each device can train 4 pilots simultaneously.

The Fleet Training Center in San Diego officially accepted GAC's unique emergency ship handling trainer to be used to familiarize naval personnel with ship maneuvering techniques under numerous operational conditions. As the student stands at the bridge mock-up, the movements of his ship and other ships and buoys are presented by means of a visual display. In this simulated environment, projections of harbors and shorelines are superimposed by means of a split-beam optical system and a digital computer.

Complete mobile color photography labs capable of rush processing aerial reconnaissance film in forward areas of Vietnam were unveiled in November. Color photos produced are similar to those which pinpointed Russian missile sites in Cuba during the 1962 crisis.

Color printing equipment included can process and dry 3,200 feet of 5-inch-wide color aerial reconnaissance film in an 8-hour period. It also can duplicate standard 70-millimeter, 5-inch and 9.5-inch reconnaissance film in continuous lengths up to 1,000 feet at rates from 20 to 60 feet per minute.

By adding 2 computer-filled data processing labs to 7 photo processing and support modules, GAC made it possible to determine immediately whether the photos and data gathered during a day's aerial photographic mission are suitable for map-making.

The 9-lab WS-430C System is the first air-transportable and relocatable facility equipped to support aerial mapping projects.

Also in 1968, GAC produced a "petal" antenna that will "bloom" in space. It is a huge radio antenna for spacecraft that folds into a small package for launching, then opens to its full 30-foot diameter in space. The largest antenna ever designed for orbiting spacecraft, it was built for the National Aeronautics and Space Administration. It can be used to receive and transmit signals on satellites under consideration by NASA as possible second-generation spacecraft in the Applications Technology Satellite (ATS) Program.

Goodyear Aerospace was closely tied to the Boeing 747. Its Arizona Division produced the 747 center wing section, landing gear doors and cabin windows.

Reaching nearly 2 centuries into the past, GAC revived the ancient art of hot air ballooning to develop a system for snatching pilots to safety after they have bailed out over enemy territory.

The principle was incorporated into a system called PARD (Pilot Airborne Recovery Device) which aims at allowing the ejected pilot to remain aloft until a rescue plane can reach and retrieve him in midair.

A Ballute (a contraction of balloon and parachute) at the top of the deployed main parachute is inflated as air rushes through its vent. A burner, suspended below the Ballute and fed from a tank of propane gas strapped to the pilot's back, ignites. This heats the air flowing into the Ballute. The heated air gives the Ballute sufficient lift to halt the pilot's descent and permit him to rise and float high above the ground. He can then be snatched into the rescue plane or towed to friendly territory and released to descend by his regular parachute.

Parawing gliders, remotely resembling a parachute, that can deliver high-priority cargo to troops in remote or hostile areas with pinpoint accuracy were developed by GAC during the year.

A delta-shaped glider that is steerable, the parawing homes in on friendly troops, guided by a ground-based transmitter the size of a GI walkie-talkie. It can be released from altitudes as high as 30,000 feet and at distances up to 12 miles from the target.

Goodyear Aerospace also used gold in a new process for making heated acrylic windows and windshields to prevent airplane icing and fogging. The windows are coated with a transparent metallic film that can be heated electrically. Gold was used because it is one of the best conductors of electricity and because its atomic structure renders it transparent when in a thin state.

The Akron and Arizona plants continued to produce canopies, windows and windshields for several types of aircraft, including helicopters. The Akron plant also received several additional contracts for aircraft wheels and brakes.

Goodyear Aerospace took the first steps toward breaking the "baggage barrier" for the superjets under a major contract to supply 708 baggage containers to Pan American World Airways. Other airlines also were expected to order cargo and baggage containers.

The containers, about 5 feet high, 5 feet wide and 7½ feet long, are contoured to fit the plane's cargo compartment. Each can hold about 55 pieces of passenger luggage. They can be loaded into and unloaded from the aircraft as units, eliminating the need for handling individual suitcases.

Goodyear Aerospace continued its high production schedule and received more contracts in 1968 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.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION

In 1968 Grumman entered its 39th year with continued growth, increased sales and additional expansion of its facilities. Research and development played an increasingly important part in the corporation's growth, and Grumman continued work on several new aircraft.

At year-end, Grumman employed 35,000 people in over 30 plants. Production of the corporate Gulfstream II was changed over to the newly opened Savannah, Georgia, facility. Grumman acquired a machine shop facility at Glenarm, Maryland, adding 56,000 square feet of property to its assets. The test facility at West Palm Beach, Florida, is the home base of the hydrofoil gunboat *Flagstaff* and the submersible *Ben Franklin;* the facility is the Grumman corporation's center of activity for oceanology.

The corporation produced a variety of military and commercial aircraft, the NASA/Grumman Apollo Lunar Module flight and test spacecraft and the second of the series of Orbiting Astronomical Observatories, and it remained extremely active in ocean technology. Ten model types of aircraft were in production and in service in Southeast Asia.

The A-6A Intruder, built for the Navy and Marine Corps, remained the mainstay of the all-weather attack effort in Vietnam. With a load capacity of almost 18,000 pounds, the A-6A operates from either advanced forward air bases or off the attack aircraft carriers on station in the South China Sea.

The EA-6A tactical countermeasures aircraft, in service with the Marine Corps, was placed in production again. A 4-place version of this aircraft, the EA-6B, made its first flight in May, paving the way for the Navy to expand its electronic warfare capability.

The TC-4C, a Gulfstream I-based A-6A bombardier/navigator trainer, entered service with the Navy and Marine Corps. The contract for 9 of these highly specialized aircraft was completed and all aircraft were delivered on schedule.

While the E-2A Hawkeye continued in active service with Navy fleet units, Naval Air Systems Command awarded Grumman a contract to initiate development of a successor. Known as the E-2C, this new version of the E-2A early warning aircraft will feature greatly improved and more reliable avionic systems. The aircraft, like the E-2A, will carry its detection antenna in a large-diameter rotodome atop its fuselage.

The Army's OV-1 Mohawk battlefield surveillance aircraft continued in production, and a continuous modification program paralleled the effort. Work continued on the OV-1D. All 3 versions of the OV-1 were in service in Vietnam as the "eyes in the sky" of the Army.

With deliveries of 14 S-2 Tracker antisubmarine aircraft to Australia, production of this type, which had been continuous since 1952, came to an end. Over 1,500 of the aircraft had been delivered. Proposals for a modification program were prepared.

The C-2A Greyhound carrier on-board delivery aircraft supported the ships of the Seventh Fleet with deliveries of vital supplies ranging from typewriter ribbons to jet engines. Several of these aircraft were also assigned to units of the Sixth Fleet in Europe.

With 6 model types no longer in production (E-2A Hawkeye, C-2A Greyhound, C-1A Trader, E-1B Tracer, S-2 Tracker, HU-16 Albatross), the company nevertheless had 10 different types of aircraft operating in 1968 in Southeast Asia.

Production of aft fuselage sections for the Air Force F-111 aircraft series continued at the company's Garden City factory.

The turboprop-powered Gulfstream I corporate aircraft was in production with deliveries averaging one per month. The company was exploring additional military markets for this aircraft.

Over 30 turbofan-powered Gulfstream II aircraft were delivered to customers. In May one of these aircraft was flown nonstop from New York to London, and nonstop back, marking the first such trip for a jet-powered corporate aircraft. In October a Gulfstream II made a transpacific crossing from Tokyo to Atlanta, Georgia, with an intermediate stop at Anchorage, Alaska.

The newly certificated Super Ag-Cat continued to be a high seller in the agricultural crop-dusting market. More than 500 have been produced since 1958.

The Apollo Lunar Module (LM) program made great strides in 1968. In January LM-1 was launched into earth orbit and successfully completed all planned tests and maneuvers. Lunar Modules 2, 3 and 4 were completed and shipped.

The second Orbiting Astronomical Observatory arrived at the Goddard Space Flight Center and was launched successfully on December 7.

In the Ocean Systems Department, the mesoscaph *Ben Franklin*, built in cooperation with Dr. Jacques Piccard, was launched and christened at Grumman's West Palm Beach, Florida, facility. The submersible was undergoing tests in preparation for the Gulf Stream drift mission, which was to start in 1969. The U.S. Navy hydrofoil PGH-1 *Flagstaff* was also launched and christened. After undergoing preliminary tests, the hydrofoil gunboat will be evaluated by the Navy off the coast of California. 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.

Grumman continued to work in the area of advanced materials, with emphasis on improved titanium manufacturing and further development of techniques involving the use of boron and graphite filaments.

GYRODYNE COMPANY OF AMERICA, INC.

During 1968 Gyrodyne continued to produce QH-50D pilotless helicopters and supporting DASH equipment for the U.S. Navy and the Japanese Maritime Self-Defense Force. Also, a limited number of QH-50s, modified to perform surveillance, reconnaissance and other tactical missions, were produced for the Advanced Research Projects Agency of the Department of Defense. Multimission flight test programs were conducted to determine the drones' capabilities to perform high-risk missions. Armed with a variety of weapons such as miniguns, rockets, grenade launchers and multibomb racks, successful "attack" flight tests were performed. The installation of sonobuoy racks and other sensing devices was utilized to prove out the drones' detection capabilities. Day and night television cameras, laser rangefinders and covert illuminators were used to ascertain the feasibility of utilizing the remotely controlled vehicle for target detection, gun laying and enemy troop movements.

Further advances were made in utilizing sea-ground-air control stations to vector the drone in its flight regimes and provide "hand-off" control from one command station to another. The utilization of auxiliary fuel tanks provided the capability to extend the QH-50's flight endurance from 1.5 to 6 hours, depending upon the payload trade-off between weapons and fuel supply.

In 1967 and 1968 the Atomic Energy Commission utilized the QH-50 as a sensing device to hover over the sites of underground nuclear explosions and collect real-time scientific data and, by means of a TV camera, record ground zero effects. The success of these projects resulted in further planned use of the system.

The company continued to forge ahead in other important areas. Gyrodyne Petroleum, Inc., a wholly owned subsidiary, reported that at year-end it held vested interests in more than 300 producing gas and oil wells.

Its most interesting program was the Rulison Field Project whereby the Atomic Energy Commission and private enterprises planned, in 1969, by means of an underground nuclear explosion, to create a deep chimney to economically release the vast reserves of natural gas known to exist in this field. Gyrodyne will realize 16 percent of the gas production sales that result from the program.

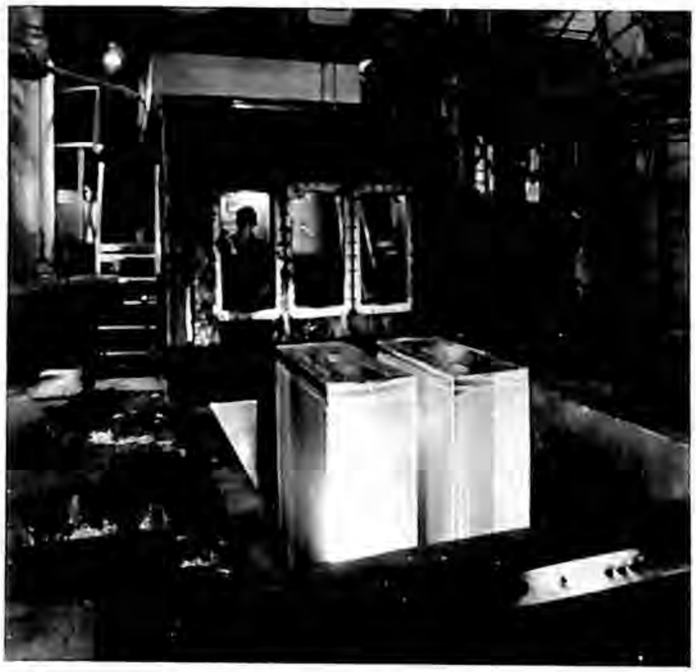
Flowerfield Properties Inc., another wholly owned subsidiary, had a participating interest in the development of a large citrus grove in Florida. Started in 1966, there were at year-end more than 400,000 trees planted and expansion was continuing.

HARVEY ALUMINUM

The year 1968 was a significant period for Harvey Aluminum. Initial shipments of sheet, plate, forgings and extrusions were made for the DC-10 and prototype materials for the L-1011 undertaking. Shipments of Harvey components, including ultrasonic quality aircraft plate, were made for the 747, SST, C-5A, MOL space program, helicopters and Poseidon missile system.

The newly expanded 14,500-ton press at the Extrusion Division, Torrance, California, substantially increased capacity, product and shipment of goods. This powerful press provides proficiency in the manufacture of large structural shapes required by the aerospace industry. AM-2 Mat, the all-weather portable aluminum runway, product of imaginative and inventive company research engineers, was supplied in record amounts from this large extrusion press. These unique extruded aluminum planks, capable of handling the fastest and heaviest aircraft, can be readily transported and installed in remote locations from package to landing strip in 72 hours.

An aerospace depot was expanded during the year to provide prompt delivery of customer-specified stock. Also, new finishing and casting facilities became fully operational at the all-purpose rolling mill at Lewisport, Kentucky. Expansion continued in these facilities and will result in substantial output of coil and flat stock.



Sheet ingot is removed from the casting pit at Harvey Aluminum's Lewisport, Kentucky, facility.

In the Corporate Research and Development Center, Harvey engineers worked on the development of the various alloys, product applications and special programs of ordnance and armament systems. Harvey materials engineers made important progress in the field of composite materials. Company improvement in manufacturing techniques has been steady, and size capabilities have been enlarged enough to produce boron aluminum composite sheets 16 square feet in area. Because of the incredible strength-to-weight ratio in metal matrix composites, they are of considerable importance in the aerospace industry. Use of composite metals in supersonic aircraft could reduce weight substantially if composites of boron fibers and aluminum were used throughout the structure. Methods for making well-bonded titanium matrix composites have been developed, and demand for experimental quantities of this material for higher temperature applications is starting to appear.

A project to develop a welding technique for the control of distortion and reduction of residual stresses in the welding of aluminum plate was brought to successful conclusion. This technique will be used in welding strong aluminum alloys for space vehicles and other critical airplane and aerospace applications. Harvey's position as a leading producer of aluminum ingot and mill products kept pace with the skyrocketing growth of the aircraft industry. Titanium strength-to-weight ratios will place it in top priority in the unfolding air bus and superjet 747 programs. Jet engine manufacturers continued to be the foremost users of Harvey titanium because of its high tensile and fatigue strength-to-weight ratios and extraordinary corrosion resistance.

A fully integrated producer of aluminum mill products, Harvey was producing titanium from sponge to finished mill product under one roof and one mill management, thereby eliminating confusion and shipping problems.

Harvey Aluminum's principal products are aluminum ingot, billet, casting alloys, rod and bar, pipe, tube, irrigation tubing, hollow sections, press forgings, forging stock, hand forgings, rings, impact extrusions, electrical bus bar, rigid electrical conduit, structurals, special shapes, light and heavy press extrusions, sheet, plate, strip, foil, wire rod, screw machine parts, containers, skids; ore and chemicals, bauxite, aluminas; titanium ingot, billet, rings, forgings, rod, bar, extrusions, tubing, pipe, strip, plate; zirconium ingot, billet, slab, bar, plate, sheet, strip, foil, rod, wire, extrusions, tubing, forgings; steel alloys, ingot, billet, slab, bar, plate, rod, extrusions, tubing, forgings; brass, plumbers brass goods; special metals; exotic alloys of various types.

HERCULES INCORPORATED

The most dramatic highlight of the aerospace year for Hercules Incorporated was the successful first flight of the Navy's Poseidon Fleet Ballistic Missile on August 16 from a launch pad at Cape Kennedy. Hercules is propulsion system manager for the 30-ton, MIRV-capable missile. The first-stage motor case is fabricated of Spiralloy® fiberglass at the company's Bacchus Works near Salt Lake City, filled with composite propellant by Thiokol at the latter's Wasatch plant a few miles away, then returned to Bacchus for final production, check-out and inspection. The second-stage motor for Poseidon is made entirely by Hercules. The motor case, like that of the first stage, is made of Spiralloy fiberglass, is filled with Hercules double-base propellant, then is finished, tested and inspected at Bacchus. Additional flight tests of the submarine-launched missile were scheduled.

Exotic fiber structures were investigated further by the company in 1968. Work went forward on government contracts for development of improved structures using boron and graphite fibers in resin matrices, and Hercules planned to develop design and production techniques for fabrication of airframe structures and jet engine components using the new strong, lightweight materials.

Application of aerospace technology and materials to water purification and sewage treatment occupied the attention of a number of Hercules researchers at the company's Allegany Ballistics Laboratory near Cumberland, Maryland. The work completed in 1968 under government research and development contracts showed much potential for expanding the company's environmental systems effort.

Hercules worked closely in 1968 with arms manufacturers in the development of guns capable of firing the firm's caseless ammunition. Of particular concern was development of an automatic aircraft weapon for which the reduced weight of the caseless ammunition would provide particular benefits. Caseless ammunition weighs about 30 percent less than conventional ammunition.

Successful development of an improved Sparrow missile for the Air Force was completed in 1968 by Hercules. Propellant for the missile is Hercules' composite "Hercopel," produced at the Allegany Ballistics Laboratory. Sparrow is the first application of Hercopel.

Firings at White Sands of the Sprint missile (Hercules is its propellant manufacturer) continued to be successful. Sprint-type rocket motors are available for other high-speed applications.

HONEYWELL INC.

More than 10,000 of the 20,000 employees in Honeywell's Aerospace and Defense Group worked during 1968 on space and aircraft programs for the United States and the free world. Major events of the year are described by location in the following summary.

AEROSPACE DIVISION-FLORIDA

Successful flights of Honeywell inertial guidance systems on 3 Centaur rockets, first flight tests of an advanced aircraft navigator, new missile inertial components contracts and developments in plated-wire computer memories marked the year for the Aerospace Division in St. Petersburg, Florida.

An 80,000-square-foot plant was begun to accommodate increased communications systems and devices activities as well as expanded aerospace and defense production. The center was to be ready for occupancy in the spring of 1969.

A Honeywell-guided Centaur sent the seventh Surveyor spacecraft on its way to the moon; and for the first time since becoming operational in 1966, Centaur boosted payloads other than Surveyors into space. One was an Applications Technology Satellite (ATS-4) in July. The second was an Orbiting Astronomical Observatory (OAO-2), launched in early December to get better ultraviolet data on the stars. A $4,500,000 contract for continued engineering and maintenance was received from NASA's Lewis Research Center, for which Honeywell acts as associate prime contractor for Centaur guidance.

In other missile developments, the division won Navy contracts totaling $7,000,000 for initial production of inertial guidance components for the Poseidon fleet ballistic missile and for Polaris component repairs. The submarine-launched Poseidon is to be 8 times more effective than its predecessor. Production of inertial components continued for Minuteman, the Air Force intercontinental ballistic missile.

An approximate $4,000,000 award from Philco-Ford's Aeronutronic Division for Shillelagh missile gyros established Honeywell's leadership in this Army antitank program. The work represents the first increment of a program continuing through 1971.

On the aircraft front, the Air Force began flight tests of a new kind of inertial navigator using body-mounted gyros rather than a complex gimbaled platform. The C-130 flights took place at Holloman Air Force Base, New Mexico, to provide data on the new and potentially more economical navigation concept.

Rugged computers whose memories will not forget information when power is shut down were made possible for the first time with the entry into production of plated-wire (rather than ferrite-core) memories. Contracts totaling several million dollars for plated-wire stacks were received for several ballistic missile and spaceborne telemetry programs, including Poseidon. Honeywell's ALERT digital airborne computer met success in a number of experimental military applications.

AEROSPACE DIVISION-MINNEAPOLIS

Resumption of the United States' manned space flight program in spectacular fashion with successful Apollo 7 and 8 missions highlighted the year. The spacecraft's stabilization and control system, built for North American Rockwell, performed well throughout the 11-day test flight around the earth in October and the first manned lunar mission in December.

Following their check-out on the Apollo 7 and 2 earlier unmanned 1968 missions, the Apollo controls were declared ready for lunar flights as NASA moved closer to the national goal of putting 2 men on the moon and returning them before the end of the decade. During the year a $6,600,000 order for an additional 8 control systems was received from North American.

Fuel probes on the Douglas-built S-IVB stage flew during the 1968 Apollo missions. Hand controls and other cockpit instrumentation were made ready for the first manned test flight of the Grumman-built Lunar Module in 1969.

Elsewhere on the space front in Minneapolis, activity was varied. In systems work, division scientists and engineers started studying attitude-determination and infrared radiometer problems considered critical to the worldwide mapping of a more stable reference horizon in the earth's atmosphere by satellite in the 1970s. The project was initiated by a Honeywell-led team, also consisting of Lockheed Missiles & Space Company and Control Data Corporation, for NASA's Langley Research Center. Definition of the design of an active control system for the ATS F and G satellites to be flown in 1972-73 began under a subcontract from Fairchild Hiller Corporation.

Working with Nippon Electric Company, Honeywell began defining guidance and control concepts for the launch vehicle for a Japanese scientific and communications satellite program. The first vehicle would be flown in 1971.

Aero engineers completed delivery of the attitude control and scan platform control subsystems for 2 Mariner spacecraft slated to fly past Mars in 1969 on scientific missions. The 2-year, $6,000,000 project was performed for Jet Propulsion Laboratory, Pasadena, California, which is directing the Mariner program for NASA.

Deliveries commenced on cockpit displays and switches for the modified Lunar Module that will serve as the spaceborne observatory for the Apollo Telescope Mount, a post-Apollo project sponsored by NASA's Marshall Space Flight Center.

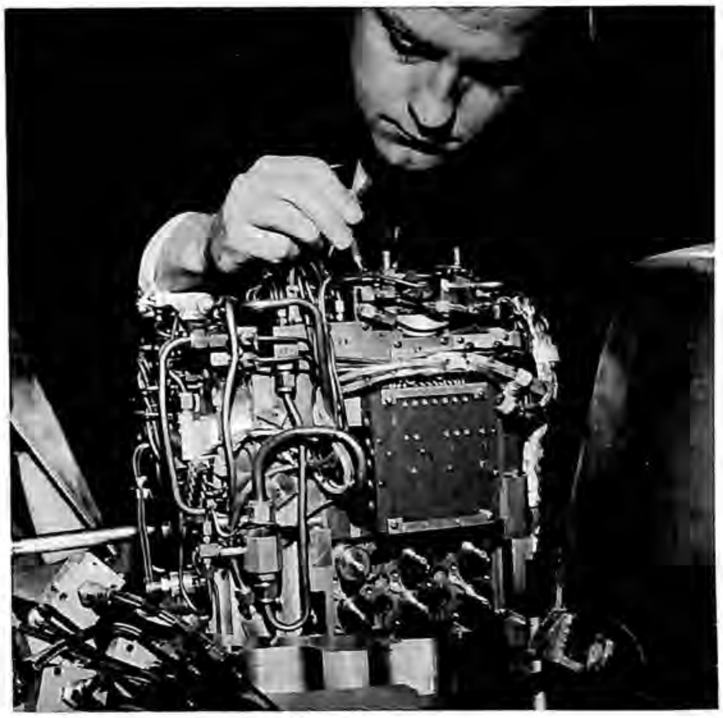
Honeywell-built inertial reference equipment was in production for or flew on 5 NASA and Air Force booster rockets, including Athena, Agena, Burner II, Thor-Delta and Scout, and the Sprint defense missile.

Military aircraft and helicopter avionics developments were numerous. The division-built automatic flight control system, engine pressure ratio instruments and fuel measurement equipment flew on the Lockheed C-5 Galaxy's maiden flight in June. The first 5-axis automatic pilot for helicopters was delivered to Lockheed-California Company for the Army AH-56A Cheyenne, and additional pilot's helmet sights were shipped under the development phase of the Cheyenne program.

Radar altimeters were sold for the first time on 6 U.S. and 8 foreign vehicles. Among the U.S. aircraft were the Army UH-1D and Navy UH-1E helicopters, Army OV-1 Mohawk, Air Force C-130 transport, Coast Guard HH-3F search and rescue helicopter and Navy P6 Porter. Overseas, altimeters were sold for the Fiat G91Y Italian fighter and G222 transport, Piaggio 808 executive jet, Italian Navy UH-1B ASW helicopter, Agusta-built UH-1D helicopter, German UH-1D helicopter and Boelkow-Nord AS-34 missile, Spanish Navy UH-1B helicopter and British Shackleton ASW patrol plane.

Growing out of the radar technology was a proximity warning device enabling helicopter pilots to avoid midair collisions during training. First units were flight tested by the Army at Fort Rucker, Alabama. A low-cost terrain avoidance and warning concept also was defined.

In the commercial aircraft field, the company passed in June the 1,000 mark in air data computers produced for jet transports. Fifty-seven airlines were using Honeywell units on Boeing 707s, 727s and 737s, Douglas DC-8s and Sud Caravelles. Production started on fuel measurement systems for the Boeing 747 and engine pressure ratio devices were turned out in continuing volume for commercial jets.



Honeywell Aerospace Division engineer inspects world's first fluidic 3-axis helicopter flight control system prior to its first successful flight test aboard a Navy CH-46A.

Flight control research and development progressed on a number of fronts, including direct lift control, electronic "fly-by-wire" and fluidic systems, load alleviation and mode suppression to extend the fatigue life of large aircraft, and automatic recovery of downed pilots. A hydraulic-fluidic yaw damper was successfully flight tested on an Army UH-1B helicopter, and a pneumatic-fluidic 3-axis stability augmentation system flew on a Navy CH-46 helicopter. Several contracts from NASA and the military brought the laser gyro a step closer to realization as an attitude sensor in aircraft and missile flight control systems.

Also in fluidics, the company completed successfully a 3-year research and development project on fluidic jet engine controls for the Air Force Aero Propulsion Laboratory and launched an important new development project with a major engine manufacturer.

SYSTEMS AND RESEARCH DIVISION

Technical centers exploring new aerospace and defense products and markets for Honeywell in Minneapolis and producing electrooptical devices and systems in Lexington, Massachusetts, made important contributions in 1968. The Honeywell Radiation Center moved into a new 85,000-square-foot laboratory in Lexington specially designed for infrared, laser, radar and other electrooptical research and development.

The first fine sun sensors for the experiment pointing control system of the Apollo Telescope Mount were delivered to NASA-Marshall under a $2,000,000 contract. On another NASA project, the Canopus star tracker, planet sensor and Mars gates—key electrooptical elements of the 2 Mariner 1969 spacecraft experiment platform controls—were completed.

In the aircraft reconnaissance field, engineers conducted first flight tests of a high-speed aerial reconnaissance mapper with good results, and work began on the display portion of a helicopter-borne real-time surveillance system.

For the Army, the center continued development of passive far-infrared rifle-mounted sights and tank-mounted sights employing Honeywell-produced detectors sensitive to radiation at 10.6 microns. The detectors were offered to the commercial market for the first time, especially for carbon dioxide laser communications systems.

Honeywell's simplified tactical approach and terminal equipment (STATE) completed operational evaluation for the Marine Corps at Quantico, Virginia, and was undergoing evaluation by the Army at Fort Rucker, Alabama. The radar landing system provides angular terminal guidance both in azimuth and elevation and accurate range and range-rate information.

Laser scientists at the Minneapolis-based Systems and Research Center demonstrated a highly stable CO_2 voice laser system built for space communications experimentation by NASA-Marshall, and showed TV transmissions with a similar system in the laboratory. Other research moved forward in fluidic temperature sensors, flight controls, computer technology, signal processing, automatic imagery processing and life sciences.

Studies of future systems requirements of the military were initiated in several new areas, including airborne antisubmarine warfare (ASW), fighter avionics, rotary-wing avionics, tactical reconnaissance-strike equipment, manned vehicle control display technology, area security and control and remote earth surveillance.

In ongoing development programs, the company's helmet sight was successfully flight tested by the Air Force as the visual sensor in a tactical reconnaissance systems research project, and an electronic programmer that helps Army helicopter pilots learn to keep station while in formation was made ready for test flight.

HUGHES AIRCRAFT COMPANY

For Hughes Aircraft Company, the year 1968 began with the end of an "old" space program and drew toward an end with the start of a new one.

In January, Surveyor 7, last of the breed of unmanned soft-lunar-landing spacecraft, successfully set down on the moon to score the fifth success in 7 launches.

And in October Hughes received a $72,000,000 contract from the Communications Satellite Corporation and its 63-nation consortium to build 4 Intelsat 4 communications satellites with 25 times the capacity of any satellite in service to provide worldwide communications for the 1970s.

The new Intelsat 4 spacecraft, the world's largest commercial satellite, will be nearly 18 feet high and 8 feet in diameter. It will be designed to carry more than 5,000 2-way telephone calls, or transmit 12 color television programs simultaneously, or carry any combination of different types of communication transmissions.

A unique feature of the Intelsat 4 will be its ability to focus power into 2 "spotlight" beams and point them at any selected areas, thus providing a stronger signal and more channel capacity in areas of heaviest communications traffic. For transatlantic transmission, for example, the beams could be aimed at western Europe and eastern United States, or they could link South America with Europe or North America.

The Hughes contract with Comsat Corporation, manager for the International Telecommunications Satellite Consortium, provided extensive participation as major subcontractors by companies from 10 nations: United Kingdom, Canada, West Germany, Switzerland, Belgium, Japan, Italy, Sweden, Spain and France.

The Intelsat 4 family will be the fifth generation of Hughes satellites to see service since the launch of tiny Syncom 2 in 1963 and marks a dramatic illustration of the progress in satellite technology during the past 5 years. Each of the huge new spacecraft will have more capacity than all of the currently operating communications satellites combined, and each will have an operational lifespan of 10 years to cover the world's communications needs of the next decade.

With more and more nations acquiring ground stations (at year-end there were 22 earth terminals in 17 nations and this figure should rise to 40 stations by 1970), it was expected that the new satellites will help carry live color television coverage of the 1972 Olympic Games in Munich to more viewers than have witnessed all previous Olympiads.

However, the world need not await the 1972 games for convincing proof that satellite technology has taken many giant steps. This fact was supplied dramatically during 1968 by 2 news events that captured worldwide attention—the visit of Pope Paul to Bogota, Colombia, in August and the Olympic Games in Mexico City in October. Each event was telecast live and in color to millions of viewers around the globe via Hughes-built satellites and Hughes-built ground stations.

The XIX Olympiad TV coverage was brought to European screens via a tricky bit of teamwork. The color pictures of the sports events were sent from Mexico's ground station direct to the ATS-3 satellite which Hughes built for NASA, then transmitted down to the earth terminal at Goonhilly Downs, England. The voice commentary of the games, in a dozen languages, was sent by microwave from Mexico to a station at Mill Village, Nova Scotia, then up to the Early Bird satellite which Hughes built for Comsat, then down to a terminal at Pleumeur Bodou, France. In Europe the pictures and commentary were matched and the coverage appeared on TV screens in the native tongue of each nation—all in split-second "real time."

For viewers in Japan and Hawaii, the picture and voices went by microwave from Mexico to a ground station that Hughes built and installed near San Jose, California, then through the Intelsat II satellite over the Pacific.

For the papal visit to the Eucharistic Congress, Hughes built a unique air-transportable "quickie TV" satellite ground station—the only one of its kind in the world—and flew it aboard a single cargo plane to Bogota where it was installed within 24 hours from its Los Angeles departure. TV coverage of the Pope's activities was sent from the ground station—an electronics-stuffed hut and a 16-foot antenna—to the same NASA/Hughes ATS-3 satellite that 2 months later carried the Olympic telecasts.

The small earth station, like the larger one installed at San Jose for the Olympics, was assembled by a new subsidiary, Hughes Communications International, which the company formed in January to design and construct international earth terminals for satellite communications. HCI designed a large international ground station to be erected at Itaborai, Brazil, 30 miles from Rio de Janeiro, under a contract with EMBRATEL, the Brazilian government-owned communications carrier.

Another major 1968 satellite program at Hughes was the giant experimental tactical communications satellite built for the Department of Defense under a $30,000,000 contract to link military units in the field, aircraft and ships at sea. The 2-story-high, 1,600-pound spacecraft, about the same size as Intelsat 4 but with a communications capacity comparable to 10,000 2-way telephone channels, was scheduled for delivery late in the year for launch aboard a Titan III-C booster into a synchronous orbit 22,300 miles high.

It will carry a cluster of antennas whose powerful signals can be picked up by all types of terminals, even those with antennas as small as 1 foot in diameter. Thus even small Army units in the field could communicate through the satellite with each other and with their headquarters.

Another interesting project of the company's space systems division is the $67,000 5-month feasibility study being carried out for the National Science Foundation to define and design a single-mission satellite which would carry a coronagraph to photograph the solar corona, the circular crown of light around the sun. After centuries of "working in the dark" from mountaintops during rare total eclipses of the sun, scientists are seeking a satellite that could snap pictures of the sun's glittering crown continuously for 9 months from a 300-mile-high earth orbit. Hughes engineers proposed a cigar-shaped satellite 8 feet 7 inches long and 30 inches in diameter, weighing 230 pounds in orbit, that would draw its power from the sun through 2 solar panels.

Also, on the rooftop of the space division's 12-story building at El Segundo, California, adjacent to Los Angeles International Airport, is a 30-foot parabolic antenna that was used during much of the year to "see" the weather by receiving signals from 2 Applications Technology Satellites (ATS) and converting them into pictures of the earth's cloud formations. The picture reception is part of a research program being conducted under direction of the Environmental Science Services Administration (ESSA), an agency of the U.S. Department of Commerce. ESSA, in cooperation with NASA, is obtaining the weather data via satellites for study in the development of improved local and long-range weather forecasting systems.

The company's aerospace group at Culver City, California, and its missile systems division at Canoga Park, California, were deeply immersed in new and continuing missile development. In midsummer the firm received a $95,000,000 U.S. Air Force contract to develop, test and produce the Maverick missile, a TV-guided air-to-ground weapon designed to knock out enemy tanks, armored vehicles and field fortifications. In operation, the pilot selects a target on a television screen in the cockpit, locks the missile's guidance system on it and launches the missile. The pilot then can leave the area while the missile continues to the target, guided by an electrooptical TV homing device in its nose.

Work continued on the long-standing TOW, a Tube-launched, Optically-tracked, Wire-guided missile that makes "instant marksmen" out of untrained troops by receiving steering signals through 2 hair-thin wires that unreel in flight, electronically "slaving" the missile to travel along the gunner's line of sight. TOW, developed as an antitank weapon under contract with the U.S. Army Missile Command, Redstone Arsenal, Alabama, was tested in the summer of 1968 by the U.S. Marines at Twentynine Palms, California. The Marines fired 20 TOW missiles and literally ran out of targets after blasting concrete fortifications, sandbag bunkers, tank hulls and moving targets.

Nearly 100 high-ranking military representatives from 11 foreign nations got a firsthand look at TOW's tank-killing capability during a late-summer firing demonstration at the U.S. Seventh Army training center at Grafenwoehr, Germany, where TOW scored 4 hits out of 4 tries against moving tank-size targets at ranges from "extremely short" to more than a mile.

In October the Army's Frankfort Arsenal awarded Hughes a $2,700,000 contract as initial funding to produce 243 laser rangefinders for the M-60 battle tank in a move aimed to make U.S. tank commanders the first in the world to be able to pinpoint their targets at the speed of light. The rangefinder bounces a ray of laser light off a target, then calculates the precise distance by measuring the time required for the light to travel (at 186,000 miles per second) to the target and back. The Hughes rangefinders will represent the first completely militarized laser placed in production.

The world's first laser action was achieved at Hughes Research Laboratories, Malibu, California, in May 1960.

In 1968 scientists at the Malibu research labs announced another scientific advance of far-reaching importance when they demonstrated a new method of sensing the presence of matter by detecting and measuring minute changes in the nearby gravitational field. The new flyable mass sensor is claimed to provide the first practical technique for making detailed gravity surveys from a moving vehicle such as an aircraft or spacecraft. Its first application could be to map the mass distribution of the moon from a satellite. An airborne version could make rapid gravitational field surveys of the earth which might detect mineral deposits, such as oil fields.

Hughes' ground systems group at Fullerton, California, announced in early January that it had teamed up with Bath (Maine) Iron Works and other industrial specialists to compete for a contract to design and build a new fleet of U.S. destroyers for the 1970s. Six months later the Bath-Hughes organization was one of 3 teams selected to conduct an initial contract definition study, receiving a $10,-500,000 9-month pact as its share of a $30,000,000 funding for the preliminary phase of the project. The new destroyer program is a potential $2 billion effort to replace World War II destroyers and to augment vessels being built.

In late January a 2.2-mile scale duplicate—the first in the U.S.—of the famous 9-mile military vehicle test course at Aberdeen Proving Ground in Maryland was opened by Hughes-Fullerton to any company or agency in the nation wishing to test any type of vehicle. The course was used during the year to prove the reliability, durability and mobile suitability of new transportable tactical air operations centers (designated 407L), being built by the company under an Air Force contract.

Hughes-Fullerton announced delivery early in the year of the 14th and last of its air-transportable Mark 1B satellite ground-link terminals—the world's largest—to join the first global military satellite communications network. The terminals were being operated by the 3 military services at sites around the globe as part of the Initial Defense Satellite Communications System (IDSCS), which uses near-synchronous communications satellites.

Hughes Aircraft technicians make final test of a Mark 1B satellite communications ground-link terminal at the company's Fullerton plant, where 14 of the stations were built.

A sales milestone was achieved in midyear when the 11-year-old Fullerton facility announced its cumulative product sales had topped the $1 billion mark, with a sales mix about equally distributed between the U.S. Army, Navy, Air Force and foreign governments.

In July the company announced it was building a prototype of what could be the world's most powerful long-range radar system, planned for split-second defense of cities against attack. The system, called ADAR (for Advanced Design Array Radar), is designed to pinpoint and identify targets accurately and quickly.

Another milestone was achieved in 1968 when the company announced in August that it had surpassed the $125,000,000 mark in the value of computerized shipboard command, control and communication display systems built and delivered to the U.S. Navy. The seagoing units, designated NTDS (for Naval Tactical Data System), were operating on scores of U.S. and foreign naval warships.

Work continued on air defense ground environment (ADGE) projects for the defense of entire free world countries.

A new Hughes-designed computerized air defense system, BADGE, that gives Japan umbrella protection against aerial attack was accepted in March by the Japanese government. BADGE covers Japan and the surrounding Pacific area with an electronic network that detects, tracks and identifies airborne targets automatically, evaluates and compiles incoming data and provides to-the-target control of Japan's modern fighter interceptor aircraft and surface-to-air defense missiles.

In April a new 3-nation air defense programming and training center was unveiled in Belgium as the first operational link in NADGE, a complex electronic air defense project for the NATO nations of Europe. Unveiling of the center, to be used in conjunction with command and reporting centers being installed in the Netherlands, West Germany and Belgium, marked the successful conclusion of a 10-year effort by the 3 nations that banded together in 1957 to develop a mutual air defense system. Eventually the 3-nation system will be phased into the $300,000,000 NADGE (NATO Air Defense Ground Environment) project being built from Norway to Turkey.

The first electronic hardware forming the heart of NADGE—a complex computer subsystem—was accepted in May by the corporation building the European project. A total of 37 subsystems will be built at the Fullerton facility and installed at NADGE sites.

In July, under a 1966 multimillion-dollar Swiss contract, Hughes-Fullerton shipped the last equipment for Project FLORIDA, an advanced air defense control network for Switzerland, to that nation for installation and on-site testing. FLORIDA is designed to provide a network of air defense centers that will work with Switzerland's modern aircraft and surface-to-air missiles to protect the country's historic neutrality.

Other major activities at Hughes-Fullerton in 1968 included design and construction of 30 new seagoing command and control display systems that will completely automate combat information centers aboard naval ships of France and the Federal Republic of Germany by the early 1970s, and installation of experimental research radar equipment on Kwajalein Atoll to help the Department of Defense develop technology for protection against ballistic missile and satellite attack.

The year brought Hughes Aircraft Company several important awards and honors, particularly for the highly successful Surveyor program.

On May 7 Vice President Hubert Humphrey presented the Robert J. Collier trophy to Lawrence A. Hyland, Hughes vice president and general manager, who accepted on behalf of "the tens of thousands" who participated in the complex task of making Surveyor spacecraft land gently on the moon and send back more than 86,000 photographs of the lunar surface. It was the second time around for Hughes with the coveted Collier trophy. Howard Hughes, president of the company, and his associates won it for their round-the-world flight in 1938.

The Surveyor feats also won the company the Nelson P. Jackson aerospace award of the National Space Club, which Mr. Hyland accepted at the 11th annual Robert H. Goddard memorial dinner at Washington, D.C., in March 1968.

Mr. Hyland also was the recipient of the distinguished service gold medal awarded annually by the Armed Forces Communications and Electronics Association.

The American Meteorological Society presented its 1968 award for outstanding service to meteorology to Hughes Aircraft and its subsidiary, the Santa Barbara Research Center, for building a spin-scan camera that has made high-resolution photographs of the earth's cloud cover from ATS satellites.

After the final Surveyor was launched in January, bringing the program to an end concurrent with government cutbacks in space activities, Hughes' total employment gradually was reduced by about 5,000 from its total of 31,500 of late 1967. However, with the award of new contracts for such programs as the Maverick and TOW missiles and, later, Intelsat 4, the company, in July, organized "Operation Build-up," a major recruitment effort to acquire qualified engineers and support personnel for an expanded number of openings in its aerospace group engineering divisions. As the year neared an end, employment was again on the upswing and was expected to climb further in the following 6 months.

The firm was operating 11 facilities at Culver City, Fullerton, El Segundo, Canoga Park, Los Angeles, Malibu, Santa Barbara, Torrance, Oceanside and Newport Beach in California, and Tucson, Arizona. The company's gross sales exceeded $500,000,000 for the third consecutive year.

HUGHES TOOL COMPANY

Hughes Tool Company continued its upward production trend during 1968 in the areas of military and civilian helicopters as well as military gun ordnance systems.

Activities at the company's main plant in Culver City, California, were highlighted by accelerated deliveries of the OH-6A Cayuse to the U.S. Army under contracts calling for deliveries of 1,415 of these light observation helicopters. The rugged ship started its second year of combat in Vietnam, where it has earned widespread acceptance from pilots and ground troops alike.

During its initial 12 months of operation, the Cayuse flew in excess of 100,000 combat hours, considered by the military a remarkable feat for a first-year aircraft.

Production was under way on the company's commercial 500 helicopter series with deliveries scheduled for April 1969. The 500 models, which are versions of the OH-6A, include a deluxe executive, a standard utility and an international military model.

Hughes Tool initiated production of the 500 helicopter series, commercial versions of the Army's OH-6A light observation helicopter.

Four international military models were delivered to the Colombian Air Force in April 1968, and 3 were delivered in November to the Kawasaki Aircraft Company of Japan as part of an initial 25-ship delivery program. The Japanese firm has entered into a licensing agreement with Hughes to build and market the turbine-powered helicopter in Japan, Korea and Okinawa.

In early September a 500 international military model left on a 2-month demonstration tour of Australia, the Philippines, Japan and India. The tour included operations in the Himalayas at heights of more than 20,000 feet. (The OH-6A holds the world's light helicopter altitude record of 26,448 feet.)

Demand for the company's Model 300 helicopter showed a marked increase in 1968, particularly in the field of law enforcement. The year began with Lakewood, California, purchasing 3 of the Hughes ships following the success of an 18-month, federally sponsored experiment called "Project Sky Knight."

Use of the specially equipped Hughes police helicopter in a concentrated program of day-night surveillance resulted in an 8 percent reduction of crime in Lakewood in 1967, as compared with a national crime rate rise of 9 percent during the same period. The ships are flown by the Los Angeles County Sheriff's Department.

Following the Lakewood purchase, Kansas City, Missouri, bought 3 Model 300s and became the first city police department in the world to utilize helicopters as a round-the-clock deterrent to crime.

Before the year was over, 17 American cities were using Hughes law enforcement helicopters as part of their regular police patrol system.

In August, Rea E. Hopper, vice president and general manager, announced the promotion of Jack E. Leonard to the post of vice president of marketing. Mr. Leonard had been serving as assistant vice president and director of military marketing.

At the same time, it was announced that Carl D. Perry had been appointed to the newly created post of assistant vice president and director of governmental relations. Mr. Perry had been serving as assistant to the vice president and general manager, and as director of the communications division.

A significant announcement in November revealed that the company planned to move ahead with the development of a new heavy-lift helicopter system. The system will be based on 2 decades of heavy lift and "hot cycle" research by Hughes, which produced the first helicopter to lift twice its own weight.

The HLHS aircraft will be designed to have a net payload of 3 to 5 times the 10-ton lifting capacity of the best U.S. helicopter now in service.

Hughes also was working on an Army contract calling for 396 TH-55As, the Army's primary helicopter trainer. The ship is used to train more than 500 pilots a month at Fort Wolters, Texas, the world's largest helicopter school.

Assembly of the TH-55A and the Model 300, as well as fabrication of major subassemblies for the OH-6A, was being carried on at the company's Rose Canyon facility near San Diego.

Another San Diego area facility, at Palomar County Airport, was being utilized for all production flight testing of the company's military and commercial helicopters.

In the area of ordnance, Hughes produced for the U.S. Navy more than 800 of its Mark IV gun systems using the Mark 11 20-millimeter twin cannon. Slung beneath the fuselage of an attacking aircraft, the weapon can fire 4,000 rounds per minute.

Hughes also was producing the XM-27E1 armament subsystem, utilizing a high-rate-of-fire machine gun, which arms the Cayuse helicopter.

In the development stage were several Army-funded projects, including a high-velocity, 350-shot-per-minute, 40-millimeter grenade launcher which can arm the Cayuse.

Total employment increased during the year to slightly over 5,000 at the 4 Hughes facilities in Culver City, El Segundo, Palomar and Rose Canyon, as compared to fewer than 650 only 3 years earlier.

INTERNATIONAL BUSINESS MACHINES CORPORATION

FEDERAL SYSTEMS DIVISION

IBM people and computers played an important role during 1968 in advancing the nation's space and defense programs through new and continuing government contracts.

At Huntsville, Alabama, Cape Kennedy, Florida, and Houston, Texas, IBMers continued their support of the National Aeronautics and Space Administration's Saturn/Apollo moon program. During the first manned flights of Apollo in 1968, the Instrument Unit, Saturn's smallest "stage," guided and controlled the launch vehicle from lift-off until the Apollo spacecraft and the S-IVB second stage of Saturn separated in orbit. The Instrument Unit, a 3-foot-high by 21.7-foot-diameter ring, contains 60 electronic, electrical and mechanical units and is the nerve center of Saturn. It is assembled, programmed and tested by IBMers at Huntsville.

Also supporting the 1968 missions was the Real-Time Computer Complex in Houston. During the flights of Apollos 7 and 8, System/360 Model 75s performed billions of calculations a day to provide flight controllers with the information needed—in real time—to support the mission.

At the Cape Kennedy launch site, hundreds of IBM specialists assisted in the electronic check-out of the rocket and in operating the launch support complex.

Another Huntsville-developed system will soon be helping commuters in California's Bay area travel faster and more efficiently. The San Francisco Bay Area Rapid Transit District (BARTD) is building a 75-mile, all-electric transit system that will include an automatic fare collection system developed by IBM. The system includes a coin/bill-operated ticket vending machine that issues magnetically encoded tickets, an add-fare machine that will permit a ticket's value to be increased, and commuter passenger gates designed to accept the magnetic tickets and deduct fares from the magnetically recorded values.

The first en route air traffic control system underwent extensive testing during 1968 at the Air Route Traffic Control Center, Jacksonville, Florida. IBM was responsible for integrating the system and for writing the more than 160,000 computer instructions required for operation. This system and others that are planned for major cities throughout the country will help the Federal Aviation Administration's flight controllers keep track of hundreds of aircraft simultaneously while they are en route from one location to another.

A computer at Eglin Air Force Base, Florida, is helping to train combat soldiers by simulating many of today's modern air and ground-based weapons and missiles during war-game exercises. An IBM System/360 Model 65 and a series of specially developed programs simulate weapons fired from aircraft and from the ground, and keep track of "hits" and "misses" in real time during the war games.

At White Sands, New Mexico, another System/360 Model 65 is converting raw telemetry data from missile flights into information suitable for recording or display. Range users will be able to analyze data during and immediately following a flight instead of waiting anywhere from a few days to several months for complete telemetry data reduction results. The Telemetry Data Center was completed and turned over to the Army in 1968.

In 1968 IBM put a ruggedized System/360 Model 30 on wheels for the first time. The system, known as CS3 for Combat Service Support System, is capable of moving when and where today's field Army moves. CS3 pools logistics and personnel records in a central computer that supplies field commanders with instant information on their troops and supplies. The systems are mounted in 4 35-foot vans, and in 2½-ton trucks. Six of the data processing and communications systems have been successfully completed and delivered to the Army.

IBM's System/4 Pi, a space-hardened computer that fits in a suitcase, was in use for a number of land, sea, air and spaceborne applications.

System/4 Pi was being used in the A-6 and A-7 aircraft for navigation and weapons delivery. Flight tests of System/4 Pi computers for use in the new improved Mark II avionics system for the Air Force FB-111 strategic bomber and the F-111D tactical aircraft were under way.

On the A-7D (Air Force) and A-7E (Navy) programs, for which IBM has avionics subsystem integration responsibility, a prototype system was delivered in March and flown in June, the same month the first production hardware was delivered. IBM produces the navigation and weapons delivery panel for the A-7D and has responsibility for integrating these units with other avionics system elements.

New technologies in the field of lasers and communications played a major role in IBM in 1968. Development of a new dye laser that can be tuned with a knob over a range 4 times wider than that of other lasers was announced in May. IBM was using the tunable laser as a laboratory tool to investigate other laser dyes.

The division made a major move into the field of digital communications with the introduction of special devices to speed the transmission of errorless digital data from computer to computer. Further developments were under study for Project Mallard, a mobile digital communications system intended for field armies in the 1970s.

IBM's Federal Systems Division, headquartered in Gaithersburg, Maryland, concentrated on advanced technology and special systems for the ground-based, airborne and spaceborne requirements of military, scientific and civil government agencies. The division employed at year-end 13,000 people and had 5 operating centers including the Electronic Systems Center, Owego, New York; the Federal Systems Center, Gaithersburg, Maryland, with operations at Houston, Texas; the Space Systems Center, Huntsville, Alabama, with operations at Cape Kennedy, Florida, and Los Angeles, California; the Communications and Engineering Sciences Center, Gaithersburg, Maryland; and the Center for Scientific Studies, Gaithersburg, Maryland.

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 1968, 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.

ITT Avionics Division has the distinction of being the only supplier of the entire TACAN system. TACAN is comprised of airborne interrogators, ground beacons and antenna systems, indicators and test equipment. Hyperbolic systems included Loran-C ground stations, Loran-C/D airborne receiving systems, Loran-C/D navigation systems, Omega shipboard navigation equipment 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.

During 1967 the Avionics Division's Hydro-Acoustic Laboratory became operational. The facility, a research and development laboratory constructed above a 200,000-gallon aboveground water tank, is 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, provides 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 communications satellites, first of which was launched on December 18, 1968, by the Communications Satellite Corporation. (TRW Systems Group, TRW Inc., is program manager for the Intelsat III satellites.) An 85-foot-diameter commercial satellite communication earth terminal built for Spain by ITT Defense Communications Division was situated 40 miles north of Madrid. A dual satellite communication earth terminal built by the division was 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.

A message-switching communication center was built by the division for the Department of State. Called the Automated Terminal Station, the new communication center is located on the fifth floor of the State Department building in Washington, D.C.

The division held contracts with the U.S. Army Electronics Command for tactical tropospheric-scatter radio sets and antennas, as well as line-of-sight radios and antennas. Both versions will be packaged in mobile shelters.

Federal Electric Corporation

Starting in 1952 with a nucleus of 3 people, ITT's Federal Electric Corporation had grown in 1968 into a worldwide organization with some 8,000 employees performing a diversity of aerospace services.

Since 1956 Federal Electric has operated, maintained and supplied for the U.S. Air Force the famed Distant Early Warning (DEW) Line, the 3,600-mile Alaska-across-Canada-to-Greenland network of radar surveillance and communications stations.

Expanded work requirements in the 1968 contract covered the operation and maintenance of the BMEWS (Ballistic Missile Early Warning System) submarine cable terminal at Thule AFB, Greenland, as well as logistics support functions at Sondrestrom AFB and other rehabilitation and reinforcement of various outdoor structures to withstand the savage Arctic wind and weather.

A major Federal Electric responsibility is the DEWLine sealift which takes place each year during the few short weeks of Arctic summer. In all, some 37,000 tons of cargo, including 10,000,000 gallons of diesel fuel as well as aviation and motor gasoline, are delivered each summer by sealift ships.

In 1968 the U.S. Defense Communications Agency honored the FEC-operated DEWLine by selecting the Dye Main station at Cape Dyer as "the outstanding communications station" in the U.S. military global defense network.

Federal Electric was also operating and maintaining the North Atlantic Radio System which extends the DEWLine's communications links to Iceland and the United Kingdom.

At the U. S. Air Force Flight Test Installation at Palmdale, California, ITT's Federal Electric Corporation, through its subsidiary ITT Technical Services, Inc., performs a wide variety of support services.

At this famous "cradle of tomorrow's military aircraft," ITT's service associate manages security patrols and the cleaning, repair and maintenance of 17 miles of runways and taxiways, 23 miles of operational roads and 15 miles of security fences and gates; preventive and corrective maintenance of all ground and airborne radio and telephone communications equipment; and the operation and maintenance of crash-rescue helicopter service. Other services range from fire protection and safety and medical first aid to the procurement of all needed supplies and materials.

An important new assignment at Palmdale in 1968 called for the ITT service team to conduct a massive runway modernization program that will enable the installation to handle heavy jumbo jets and supersonic transport planes, some of which weigh as much as 500 tons.

As prime contractor at the U.S. Air Force Western Test Range, the world's most active missile and space experimental center which extends from California across the Pacific to the Indian Ocean, ITT's Federal Electric Corporation performs a host of operational, maintenance and technical support services both ashore and afloat, ranging from communications, tracking, instrumentation and telemetry to data storage, retrieval and reduction, logistics, timing and quality control.

At the range, Federal Electric engineers and technicians operate and maintain instrumentation facilities at Vandenberg AFB and Pillar Point, California, as well as Hawaii and Eniwetok in the Marshall Islands. FEC specialists also man the radar, optical, telemetry and communications equipment aboard 10 ocean-going range ships operating in the Atlantic, Pacific and Indian oceans. Three of the larger so-called Apollo ships, assigned to support the manned lunar program, are equipped to provide not only radar, telemetry and communications but also command and control, satellite communications, timing, and data computation and data reduction.

Federal Electric provides range safety and instrumentation support in the launch area and handles inflight and trajectory information as well as impact scoring, recovery data and data reduction on all missile and space shots launched from the Western Test Range.

A new responsibility assigned to Federal Electric in 1968 was the maintenance and operation of a new automated telemetry system (AFWTR-VADE) which forms a vital communications link to support Apollo and other space programs now being developed.

Besides operating and maintaining the Western Test Range's technical facilities, ITT's Federal Electric Corporation maintains another team of engineers at Vandenberg Air Force Base; this team is involved in various other Air Force contracts ranging from the implementation of communications and switching systems to a diversity of ground support systems and the operation of communications systems for the Air Force's recently established Space and Missile Systems Organization. In 1968, the Federal Electric Vandenberg projects group engineered, furnished and installed technical communications and electronic systems for Vandenberg's test management center and implemented a new communications switching and display system for the range.

During the year the same FEC group won a contract to engineer, furnish, install, operate and maintain a technical communications and electronics system for the Ballistic Missile Reentry System (BMRS) launch facilities at Vandenberg. The system embraces closed-circuit television, microwave, administrative telephones, direct lines, networks, public address systems and other communications required by the Air Force Systems Command's 659th Aerospace Test Wing.

Under another contract, FEC's Vandenberg group was expanding the area frequency monitoring capability at the Frequency Control and Analysis (FCA) facility at Vandenberg. The monitoring capability will be modernized to meet the increased work load of the frequency spectrum as more sophisticated electronic devices are adapted to missile and space requirements.

Another Federal Electric implementation achievement was the engineering design, supply, installation and activation of a 72-channel tropospheric-scatter communications system between Berlin and Breitsol. Linking U.S. armed forces in West Berlin with other military centers in western Germany, the new system can provide for further extensions to connect it with other U.S. military communications systems in Europe.

In 1968 ITT's worldwide service associate started to implement for the U.S. Army Electronics Command the European Wideband Communications System (EWCS), a new microwave network in the Federal Republic of Germany.

Federal Electric also implemented a new segment of the NATO Signal Communications System which became part of the U.S. Army's European Tropospheric Scatter System (ET-A). The new segment, bypassing France, became necessary when NATO relocated its headquarters from France to Belgium.

ITT's Federal Electric Corporation, systems implementation contractor for the European Mediterranean Tropo Scatter Communications System (Project 486L), continued its interest in this vast system which extends from Spain across the Balearic Islands, Sardinia, Italy, Greece and Crete to Turkey. In a new contract awarded in 1968, the U.S. Air Force Communications Service entrusted ITT's service associate with the responsibility for training Air Force technicians to operate and maintain the sophisticated electronic equipment of this network, which Federal Electric completed in 1966.

Throughout the year ITT's Federal Electric Corporation played a major role in NASA's space programs at the Kennedy Space Center, the Marshall Space Flight Center and the Manned Spacecraft Center.

At the Kennedy Space Center, Federal Electric is prime contractor for communications and instrumentation support services. It conducts a beehive of activities ranging from timing, tracking and telemetry to environmental measurements, calibration, computer programming and data reduction.

Before each launch at the center, Federal Electric workers are busily installing, maintaining and operating communications systems. FEC's communications and timing department is responsible for the operation and maintenance of KSC's operational television setup, a space-center-wide, closed-circuit system; its operational intercom system, which carries voice and data transmissions throughout the center; the central timing area, which provides split-second timing references for the entire KSC area; and intercom and signal circuits ranging from fire alarms to press conference broadcasts.

Federal Electric's communications and timing department maintains the OIS (operational intercommunications system), which ties together the basic parts of the huge launch complex 39. OIS "broadcasts" on a cable, much in the same way a radio transmitter broadcasts through the air. The use of a cable provides absolute dependability, and the use of radio frequency signals allows the cable to carry many times the number of messages a normal telephone-type cable would handle.

Some 60 closed-circuit television cameras are operated and maintained about the launch pad by this department. They are remote controlled as they turn, focus and peer intently at critical connectors, valves and other equipment. These cameras take the place of human eyes in areas too hazardous or difficult to reach for humans. Some, for instance, stare up into the rocket motors as the steel-melting exhaust flame starts. Pictures from the cameras are transmitted over 10 video channels to selected monitor screens throughout the center.

At KSC, FEC's measurements department handles the maintenance of measurement standards, including temperature, voltage, mass weight, dimensions and others, to assure consistency in measurements throughout KSC. It also works to calibrate and maintain the 42,000 precision measurements instruments used at the center, and makes vital measurements for NASA concerning such things as weather, acoustics, vibration, pressures and fuel flow rates.

At KSC, Federal Electric's telemetrics department gathers and retransmits electronic data from the launch vehicle and displays the data for engineering and management use. In addition, the department tracks launch vehicles while they are within range of KSC and looks for interference which could adversely affect electronics at the space center.

Federal Electric's computation department handles NASA's scientific computation chores having to do with launch vehicle, spacecraft and mission performance.

At the Kennedy Space Center, Federal Electric's data retransmission branch sends data to other NASA centers. It also maintains and operates the Apollo launch data system, Apollo mission simulator data transmission system, launch information exchange facility system and the meteorological radar recording system which records radar weather balloon data.

In 1968 NASA awarded ITT's Federal Electric Corporation a citation in recognition of the company's cost reduction achievements at the Kennedy Space Center.

At the Manned Spacecraft Center in Houston, ITT's service associate is prime contractor for logistics and technical information support services.

At Houston, Federal Electric performs such functions as technical writing, editing, report preparation and test documentation as well as data storage and retrieval, microfilming and graphic arts and warehousing and the procurement of supplies.

Material receiving, processing, shipping and storage are managed by the FEC logistics support department at Houston. This group also performs for NASA such services as the maintenance of catalogs listing some 20,000 separate items, and the operation of the Manned Spacecraft Center logistics library.

One of the functions of Federal Electric at Houston is to translate telemetered information and computer data on flight and ground tests into maps, charts, pictures and graphs for use by astronauts in orbit as well as by scientists at the Manned Spacecraft Center. At Houston, FEC specialists handle technical documentation in 22 different test categories ranging from space environment to simulation laboratories.

At the Marshall Space Flight Center, ITT's service associate is prime contractor for reliability support services covering research and development, advanced studies, analysis and documentation. Federal Electric also monitors other NASA contractors to assure the highest levels of reliability in the manufacture and assembly of the Saturn launch vehicles and associated systems.

At Huntsville and at other contractor locations, Federal Electric engineers and specialists perform reliability assessments on critical hardware, systems, and stages of the giant Saturn launch vehicle, identifying problem areas and recommending appropriate corrective action. They also generate the mathematical modeling capability for NASA's use in evaluating the individual stage contractors' reliability performance. In another support area, the failure analysis and evaluation group performs the investigation and evaluation of all significant failures that occur on the Saturn vehicles.

FEC evaluates prime contractor reliability programs and testing procedures to determine if the contractual specifications established by NASA are met. Programs and tests that do not conform are brought to NASA's attention, along with recommendations for corrective action. Various tests are also analyzed by FEC to determine if the actual testing is conducted properly and if the tests accurately assay the ability of each component to perform its intended function.

ITT's Federal Electric is one of a dozen aerospace companies that run Job Corps Centers for the Office of Economic Opportunity. The systems management approach developed by the aerospace industry is 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. Essentially, the Kilmer program is a total community and real-life experience comprising academic, vocational and moral education, spiritual guidance and counseling, meals and clothing, housing and logistics, medical and dental care and, most important of all, job placement and the ability to function as a productive member of our free society.

More than 4,000 Kilmer corpsmen have been graduated from the center; most of them have been placed in jobs earning a minimum of $2 an hour.

Federal Electric was adapting its Kilmer experience and systems management techniques to other social problems. For example, in 1968 the company embarked on an educational program to train corporations cooperating with the National Alliance of Businessmen in the techniques of hiring, training and working with the hard-core unemployed.

Another landmark event in 1968 was the launching by ITT's Federal Electric Corporation of a mammoth management safety program for the U. S. Post Office. More than 37,000 postal supervisors in 82 cities throughout the nation will attend the courses, developed and conducted by ITT's service associate for the Postal Training Institute.

ITT Industrial Laboratories Division
ITT Federal Laboratories

ITT's experienced team of technologists in Fort Wayne, Indiana, continued its impressive record of successful aerospace developments throughout 1968, placing special emphasis on spaceborne optoelectronic cameras for meteorological and earth sciences programs, specialized visual and audio information systems for air traffic control and data management, ordnance and fuzing products for missilery, night vision and light amplification equipment and systems, and related componentry.

An image dissector camera system developed for NASA's Applications Technology Satellite (ATS-III) completed a full year of operational space use in November 1968. As a reliable working unit, the space camera continued to take clear pictures of the western hemisphere from the ATS synchronous orbit over 22,300 miles in space. Showing clearly the intensity and location of storm centers and cloud formations, pictures taken by the camera were utilized to track troublesome weather movements such as Hurricane Gladys and to provide constant review of other storm centers, including those related to Apollo 7 recovery areas.

Other successful spaceborne instruments designed and developed by ITT's Fort Wayne laboratories include infrared nighttime cameras aboard NASA's Nimbus I and II weather satellites, star-tracker sensing modules serving as "eyes in space" for all 5 Lunar Orbiters, a photoelectric camera to photograph a deep space light reflection phenomenon from the Orbiting Geophysical Observatory (OGO) satellite, spacecraft guidance sensors for Orbiting Astronomical Observatory (OAO), and guidance and precise measurement sensors for balloon experiments investigating the atmosphere of Venus.

Scheduled for launch in early 1969, the Nimbus B2 weather satellite is equipped with both daytime image dissector and nighttime infrared space cameras developed by ITT's Fort Wayne team of scientists and engineers to provide 24-hour-a-day, pole-to-pole weather and cloud cover photo coverage to meteorologists.

An ITT-developed daytime space camera for gathering meteorological information will be aboard Nimbus D, targeted for 1970; important measurements of atmospheric water vapor content and distribution will be accomplished from this same space vehicle by a filter wedge spectrometer developed at ITT-Fort Wayne.

High-resolution cloud cover photos like this one were taken by an image dissector camera system developed for NASA's ATS-III satellite by ITT's Fort Wayne laboratories.

Additional space projects under way included a very high resolution radiometer for Tiros, advanced camera systems studies for future applications technology and earth resources space programs, and numerous components and subsystems for Solar Year experiments in the Apollo Telescope Mount Program.

ITT-Fort Wayne was also contributing to improved weather forecasting through installations of radar telephone transmission systems developed for the U.S. Weather Bureau to permit remote user viewing of weather radar data. The system has gained wide acceptance as a significant advance in providing visual availability of current weather data from remote weather sites, greatly extending the usefulness of weather radar itself.

Another system utilizing the same optical conversion techniques was delivered to the Federal Aviation Administration for display of radar information to air traffic controllers with significantly improved brightness and contrast in the very high and variable light levels of airport control towers. Airport tower controllers praised the new bright display, which permits easier viewing of radar air traffic information.

Modern, solid-state ground-to-air communications equipment provided by ITT in Fort Wayne was also being used for air traffic control, particularly where conditions require collocation with other equipment.

In mid-1968, ITT-Fort Wayne was selected to develop and manufacture advanced design solid-state radio receivers and transmitters for ground-to-air communications at more than 200 military air traffic control centers located throughout the world. Typically installed in remote control site facilities, the equipment will replace present tube-type communication apparatus.

Other specialized high-performance radio frequency communications products for aerospace include satellite receivers, astronaut communications systems, aerospace ground equipment, and complete microwave receiving systems, including associated major components.

Missile fuzing and ranging applications involve special RF and electrooptical short-range sensing systems manufactured at ITT-Fort Wayne. Airborne night vision systems utilize sensing equipments and infrared illuminators developed and produced by the Indiana-based operations.

ITT Gilfillan, Inc.

During the first part of 1968 ITT Gilfillan consolidated its activities at a new $10,000,000 headquarters complex in Van Nuys, California, and at the company's original Los Angeles plant. At year-end, ITT Gilfillan occupied a total of about 500,000 square feet of development, engineering, manufacturing and testing space and had more than 2,300 employees. The consolidation was effected to provide for increased efficiency and anticipated growth.

Best known as the builder of more than 90 percent of the free world's military ground controlled approach radar, Gilfillan also has been a primary supplier of several other types of military radar for years. The company is engaged in 4 principal product areas: air defense radar, air traffic control radar, combat surveillance radar and electronic warfare systems.

Throughout 1968 Gilfillan was engaged in developing a quick-reacting omnidirectional mortar-locating radar for the U.S. Army. Termed AN/TPQ-28, it uses computers for almost instant data on target fixes. An advanced feasibility development model of the radar was tested by the Army in 1968. A feasibility hardware model of the radar subsystem underwent field tests and demonstration at the Yuma Proving Ground, Arizona, in January 1967.

Gilfillan continued production of AN/SPS-48 long-range shipboard radar systems for the U.S. Navy under a multiyear procurement contract signed in late 1965. An order for 3 additional systems, representing the final increment in the contract, was received in September. The radar provides improved range performance for target designation to the Terrier, Tartar and Talos surface missile systems.

Under service evaluation in 1968 was the AN/TPS-32, a 3-dimensional tactical radar which automatically feeds digital data to the Marine Tactical Data System. The system was developed by Gilfillan under contract with the Naval Electronic Systems Command (Marine Corps and Amphibious Electronics Division) for the U.S. Marine Corps.

The system completed rigorous reliability tests demonstrating a high MTBF. Extensive flight tests and several thousand hours of operation were conducted to demonstrate the radar's combination of 3-dimensional accuracies, data rate coverage and ECCM capability.

Gilfillan continued development of a new precision approach radar for helping to land aircraft in adverse weather. Unique rain tests were conducted to determine how well the circularly polarized, high gain pencil beam radar "sees" through the monsoon-type rain of Southeast Asia. The tests verified the circular polarization technique which consistently gives more than 20 db of improvement in rain backscatter.

Also in the air traffic control field, the company received a definition phase contract from the Air Force Systems Command, Electronic Systems Division, for development of a new lightweight Landing Control Central for use at tactical air bases. The equipment would consist of an airport surveillance radar, a precision approach radar and an operations shelter housing radar scopes and UHF, VHF and HG radio equipment. It will replace the heavy AN/CPN-4 and the AN/MPN-11 equipment currently in the Air Force inventory.

Gilfillan was working on a contract awarded by the Air Force to supply 12 AN/FPN-16 ground controlled approach radar systems for assisting in landing aircraft under adverse weather conditions. The radars will be used at naval air stations. The company previously built 75 of the systems for the Air Force and one for the Navy.

Three Gilfillan-produced radar systems were aboard the USS *John F. Kennedy* when the nation's newest aircraft carrier was commissioned in September. They are the AN/SPS-48 long-range air search and designation radar, the AN/SPN-43 surveillance radar and the AN/SPN-35 precision approach radar.

The SPS-48 provides data for carrier aircraft interceptor control and for direction of shipboard missile systems. The SPN-43 is an air traffic control radar which is operated in conjunction with the SPN-35 carrier controlled approach radar. Together, they provide positive radar air traffic control of aircraft departures and landings in all types of weather.

ITT Industrial Products Division

The Industrial Products Division of International Telephone and Telegraph Corporation, located at San Fernando, California, has been engaged in the design and manufacture of electronic equipment and systems for the military, aerospace and industrial market for the past 10 years.

Included in this unit's product line are hand-held and vehicular mounted night vision devices, rocket and gun weapon control systems for close-support aircraft and helicopters, and precision visual display equipment.

Based on an Industrial Products Division design for a weapons control system for armed helicopters, the unit was awarded a contract by the U.S. Army Weapons Command for an advanced rocket control and display system. The award was an outgrowth of the division's intervalometer (electronic rocket-fire sequencing device) program developed for combat helicopters.

The unit continued to gain prominence for its scientific computer display systems, and orders were received from several leading universities, including Texas A&M, M.I.T. and Johns Hopkins, and from the Federal Aviation Administration.

Night vision equipment design, development and manufacture were an important part of IPD's effort in 1968. Voltage multiplier components were supplied to other ITT units cooperating in night vision research. An order for electronic night vision binoculars was placed with IPD by the U.S. Army Electronics Command.

ITT Aerospace Division

The Aerospace Division of the International Telephone and Telegraph Corporation's Defense-Space Group continued as one of the world's most advanced laboratories engaged in the design and development of space-oriented products and systems.

In 1968 technical contributions were made by the division 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 advanced NASA missions in the post-Apollo phase. In 1968 the unit received contracts from the space agency to define flight hardware and to design a prototype for an advanced electrooptical system.

The California-based unit of ITT entered into preliminary production of satellite navigation equipment using the Navy's spaceborne satellite receiving system. Designated AN/SRN-9, the navigation equipment provides position location accuracies for ships to approximately 1/10 of a nautical mile in all types of weather and on a worldwide coverage basis. A nonmilitary version of the same system was developed for merchant fleets, for oil exploration companies and for geodetic survey teams.

Another aspect of the division's space capability is the tracking receivers it is providing for use in Comsat stations located around the world.

Electrooptical 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 emphasis on acquisition and tracking techniques. Special low-light-level television cameras were developed in response to military requirements in Southeast Asia.

Exploratory and advanced development work continued for the Navy in a unique tactical missile guidance system employing the latest advances in pseudo-noise technology. Test results are proving the effectiveness of pseudo-noise techniques in comparison with current tactical missile guidance systems.

Multi-altitude transponders and SECOR Type II satellites were delivered for use on the Army's geodetic satellite program. These transponders were designed to operate at altitudes of 2,400 nautical miles as opposed to previous designs which operated under 1,000 miles altitude. Applications of an ITT small scientific satellite were also pursued.

ITT Aerospace continued to be a principal supplier of electrooptical sensors on a classified USAF satellite program, and the unit remained active in pursuing solutions to undersea requirements in secure communications, telemetry, tracking and surveillance.

ITT Electron Tube Division

ITT Electron Tube Division is a dynamic growth organization devoted to the development, manufacture and marketing of a wide range of components across the entire field of special purpose electron tubes—electrooptic tubes and tubes for the communications, industrial and microwave equipment market. The division is responsible for ITT's tube business in the United States and operates facilities in Easton, Pennsylvania, Roanoke, Virginia, Fort Wayne, Indiana, and San Fernando, California.

In 1968 the Easton plant became an important source for a variety of rugged xenon short arc lamps by developing lamps rated from 1 to 20 kilowatts. The spectrum of light from these lamps is very close to natural daylight since they possess visible IR as well as ultraviolet energy. The devices play an important role in solar simulators, and they are also utilized in jeep and tank-mounted searchlights for battlefield and target night illumination. Future commercial applications include use in a variety of projection systems, stadium lighting, and large-area city illumination.

Significant achievements were made in the TWT product line in 1968 with the development and manufacture of the F2085 TWT, a high-power, pulsed, broadband output device rated at 1 kilowatt and having a frequency range of 7 to 11 GHz. In addition, the development in 1968 of the F2577 TWT, a sister tube of the F2085, was considered to be an excellent entry into the S-band field. It is a high-powered, pulsed, broadband output tube rated at 1 kilowatt, with a frequency range of from 2 to 4 GHz.

In the power tube field, Easton possesses excellent capabilities for the development and manufacture of a full line of high vacuum power tubes—water, air, or vapor cooled diodes, triodes and tetrodes. These power tubes have a variety of applications in commercial broadcast transmitters, military communications transmitters, industrial oscillators for induction and dielectric heating, linear accelerators, radar modulators, Loran navigation equipment and vibration equipment for environmental testing. Typical of ITT's response to customer needs was the development in 1968 of type F1091 superpower triode. Tests of the first F1091 prototype at High Voltage Laboratory of the Rome Air Development Center proved that the tube is capable of delivering 40 megawatts of peak power at 1 percent duty. During these tests, the tube also operated at plate voltages of 65,000 volts and at pulse widths of 1,000 microseconds. Another power tube development in 1968 involved the engineering of the 1086V high-power hard tube modulator which possesses outstanding high voltage hold-off characteristics and secondary grid emission suppression. This tube has excellent applicability in new-generation accelerators requiring high power input as well as pulse coding and shaping capabilities.

The Roanoke plant is a major center for the engineering and production of electrooptic tubes. In 1968 Roanoke's production and engineering facilities were doubled, and the plant became a leading supplier of Generation I image intensifier tubes to the armed forces. The tube is the "heart" of the U.S. Army's night vision combat equipment, able to amplify the dim glow of the moon, stars, or faint sky glow and intensify the available light many thousands of times. Most important of all, Generation I tubes do not emit an infrared light of their own which can be detected by the enemy, as was the case with the older infrared scopes. The plant was also an important producer of direct view storage tubes utilized in a variety of radar display indicators, both in military aircraft and in civilian aircraft.

Fort Wayne's Tube and Sensor Laboratories were engaged essentially in applied materials research, product development, custom device fabrication and pilot production of advanced special-purpose electron tubes and sensors—photo, camera, storage, image intensifiers and image tubes. A unique combination of capabilities led to the establishment of an exclusive and broadly based line of specialized photo tubes, which are incorporated in tracking, mapping, laser detection, night vision equipments and other electrooptical subsystems needed for many important space experiments and military applications. The rapid expansion of laser optical sources in particular brought a sharply increasing demand for new electrooptical devices of the type under development at the laboratories.

During 1968, 2 new lines of specialized camera tubes were introduced: missile guidance vidicons for the Walleye and Maverick programs and ultra-high-resolution image dissectors for hard copy readers and space reconnaissance systems. In 1968 the Walleye vidicon tubes were qualified for missile application, making ITT the only manufacturer which has qualified the potted Walleye assemblies, and image dissectors were developed which are capable of resolving over 4,000 TV lines while operating unattended in space for multiyear periods at high light levels. The laboratories' unique line of image correlation (pattern recognition) tubes has also been made more rugged (ceramic construction) and substantially miniaturized. ITT is the sole supplier of these devices which are capable of recognizing, tracking and manipulating complicated optical images. Excellent phosphor output screens were developed in 1968 for image intensification, photo, and night viewing applications. The screens are capable of 140 line pairs per millimeter without loss of conversion efficiency.

The Advanced Electro-Optical Laboratories in San Fernando were engaged in the development of image intensifiers in a multitude of sizes, low-light-level pick-up tubes, proximity focused image converters, channel plate, solid-state imaging systems, externally processed photocathodes, and special processes, techniques, and components to advance the state of the art in the night vision field. The devices developed at the laboratories are utilized in sophisticated equipments which enable man to dramatically extend his capacity to see under extremely low light-level conditions. During 1968 the laboratories developed a remote view camera tube oriented toward guidance systems for missile tracking and completed development work on a microchannel plate product line; it was expected to further this area of technology in 1969 by additional advancements in processes, techniques and fabrication methods. Further, the San Fernando Laboratories made outstanding advances in night vision technology in 1968 with the development of highly sophisticated future-generation direct-view image intensifiers, enabling ITT to capture the first significant procurement in Generation II night vision technology.

KAISER AEROSPACE & ELECTRONICS CORPORATION

The business of Kaiser Aerospace & Electronics Corporation continued during 1968 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® navigational aid and community antenna television (CATV) equipment.

The corporation had a backlog of orders totaling $32,500,000 as of September 30, 1968, compared with $44,431,000 as of September 30, 1967, and the volume of sales during 1968 was about the same as in 1967.

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 and Minuteman.

At Palo Alto, California, manufacture of the Kaiser Flite-Path system and the associated Kaiser Radar Data Converter for use by the Navy in the Grumman A-6A aircraft 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 electromechanical systems for the aircraft and aerospace industry.

In Phoenix, Arizona, the company was designing and manufacturing military electronics support equipment. Kaiser CATV Division of Kaiser Aerospace & Electronics Corporation, also located at Phoenix, produced CATV equipment for sale throughout the United States. Kaiser Aerospace & Electronics is a wholly owned subsidiary of Kaiser Industries Corporation.

KAMAN CORPORATION

Kaman's aerospace, technology and aircraft-related businesses continued strong in production, research and new products in 1968, and backlogs remained high.

KAMAN AIRCRAFT DIVISION

In prime helicopters, Kaman's production aircraft, the USN/USMC UH-2 Seasprite and the USAF/MAP HH-43 Huskie, were delivering outstanding performance in all corners of the globe.

In Southeast Asia, the HH-43 Huskie helicopters continued to bear the brunt of air rescue missions. In its 10th year of service, the Huskie continued to have the highest availability record of USAF aircraft.

Huskies were produced in limited quantity during 1968 for the Imperial Iranian Air Force, bringing Iran's Huskie fleet to 26 aircraft.

Kaman's UH-2C Seasprite, a twin-engine version of the original single-engine Seasprites, was delivered in increasing numbers to the U.S. Navy and made operational in Southeast Asia for utility, search and rescue operations. Several Navy contracts were received by Kaman extending the number of twin-engine Seasprites on order.

Aircraft improvements flight tested during the year included an uprated transmission, 4-bladed tail rotor and dual landing wheels. These product improvements were extending the Seasprite's capability in expanded Navy programs.

A gunship version of the UH-2 was ordered by the U.S. Navy for search and rescue missions. The armed UH-2s will have chin- and waist-mounted machine guns, armor protection and other features.

Additionally, a stub-wing UH-2C entered flight test as a flying platform for external stores. A wide variety of antisubmarine weaponry can be carried beneath the wings of the modified UH-2.

A company record for aircraft gross weight was set by a UH-2C in May at the company's test flight facility in Bloomfield, Connecticut. A Seasprite with an uprated transmission flew at 13,600 pounds gross weight, 3,600 pounds above the design gross weight of a standard twin-engine UH-2C. With a useful load of 7,000 pounds, the record-setting aircraft had a useful load greater than its empty weight.

Other Navy contracts included selection of Kaman for overhaul of UH-2A/B and -C models of the Seasprite.

Kaman Aircraft Division obtained additional follow-on contracts for production of wings and empennage for Grumman's OV-1 Mohawk, and major components for Grumman's A-6 Intruder.

Other large subcontract production included work for the McDonnell Douglas DC-8 and the Lockheed C-5A, and for General Electric (Cincinnati and Philadelphia) and Perkin-Elmer.

Kaman's "Sweet Chariot" forest penetrator rescue seat, hailed for its major contributions in facilitating helicopter rescues in Southeast Asia's jungles, was delivered in large quantities to all military services. Fire Suppression Kits, used for crash rescue work, were in production for U.S. and foreign governments.

In aircraft equipment, Kaman produced complete galley systems for McDonnell Douglas and for Eastern Airlines.

Basic research extended Kaman's acknowledged leadership in rotor design. Notable was a Controllable Twist Rotor (CTR) system which would vary its pitch or angle of attack over its length, offering potential for increased lift and speed in pure helicopters, as well as improved performance for heavy lift machines.

In the developing field of vibration research, Kaman undertook development of a 3-dimensional vibration isolator that eliminates nearly 100 percent of vibrations fed into it, particularly at low frequencies. Feasibility studies were in progress to isolate rotor and transmission systems from helicopter fuselages.

Expansion of existing facilities and construction of new buildings gave the Aircraft Division a plant capacity of more than 1,300,000 square feet in 1968.

KACARB PRODUCTS DIVISION

Kaman's growing bearing business moved into new facilities in Bloomfield, Connecticut, in 1968 and doubled production. The KAcarb bearing is a unique self-lubricating bearing developed by the company; it features extremely long life and high resistance to corrosion. Bearings were in volume production for use on Army and Navy helicopters.

KAMAN SCIENCES CORPORATION

Kaman's 4 science and technology divisions were organized in 1968 into a newly formed subsidiary, Kaman Sciences Corporation.

Kaman Nuclear, Colorado Springs, Colorado, attracted several new contracts from the Department of Defense and Atomic Energy Commission for theoretical studies and laboratory experiments concerning nuclear weapons, nuclear safety and reliability, antennas, fallout and pollution.

Science Engineering Associates, San Marino, California, Kaman's oceanography division, was under contract to several government agencies and private companies for mooring studies, pollution studies, wave oscillation studies and designs of manned underwater stations.

Kaman AviDyne, Burlington, Massachusetts, was engaged in theoretical research for the major military services and NASA on such subjects as nuclear blast effects, guidance and control of lifting reentry vehicles, SST avionics and collision avoidance systems for aircraft.

Kaman Systems Center, Bethesda, Maryland, was furnishing systems analysis, systems engineering, operational analysis and systems effectiveness studies to several government agencies and other prime defense contractors.

AIRKAMAN INC.

AirKaman Inc., Kaman's subsidiary in general aviation, grew from one operation in 1967 to 3 operations in 1968. The original AirKaman at Bradley International Airport, serving Hartford-Springfield, was joined by AirKaman of Omaha Inc., serving Omaha Municipal Airport and Millard, Nebraska's industrial airfield, and by an AirKaman operation at Jacksonville's new International Airport.

All AirKaman locations have service and storage operations for general aviation, sell fuel to scheduled airlines and general aviation, and offer repairs.

At Bradley, AirKaman is a franchised dealer in Beechcraft, has a Jet Maintenance Center and operates jet charter service.

At Omaha, AirKaman is a franchised Beechcraft distributor to 4 midwestern states and is a dealer as well.

Jacksonville, opening late in 1968, together with Bradley and Omaha established AirKaman as one of the larger general aviation businesses in the U.S.

KOLLSMAN INSTRUMENT CORPORATION

Kollsman Instrument Corporation continued in 1968 as the major supplier of air data instrumentation to the commercial airlines and military services. The company's optical programs, associated in recent years principally with the nation's space programs, found increasing application in military and other nonspace markets.

AVIONICS DIVISION

Kollsman's KS-200 central air data computer, certificated for use on the Douglas DC-8-60 series and Boeing 737 commercial jet transports, reached volume production. Flight tests for certification of the computer aboard the Grumman Gulfstream II executive jet transport were scheduled for completion at year-end.

New flight instrumentation developed during the year included a servo-pneumatic altimeter and a 4-inch Mach/airspeed indicator for the Boeing 747 jumbo jet transport.

The division continued to supply altitude reporting equipment for the commercial airlines in anticipation of the expected Federal Aviation Administration regulation requiring the equipment for aircraft in major traffic control areas. Altitude alerting equipment was under development by the division.

A $4,000,000 contract was negotiated under which more than 60 Kollsman aircraft instruments, including Kollsman Integrated Flight Instrument Systems, were to be supplied to Douglas Aircraft Company for DC-8 and DC-9 jet transports through 1970.

The division established during the year a sales and service facility at Wichita, Kansas, to market and support the Garda line of 6 basic flight instruments for light aircraft. The instruments were being produced by Salmoiraghi, pioneer Italian instrument maker and licensee of Kollsman.

For the military services, Kollsman began deliveries late in the year of AAU/21A altitude reporting equipment, AAU/19A servo-pneumatic altimeters and TTU/229 test equipment. Development of the CPU-46 central air data computer for military aircraft continued, looking toward deliveries of the initial production quantity in 1969.

Considerable progress was made in the development of solid-state pressure transducers for advanced flight instrumentation. The new transducers, able to sense both static and dynamic pressures, are expected to be applicable to industrial requirements also.

ELECTRO-OPTICS DIVISION

The Apollo Optical Unit, a combination sextant and telescope, was used successfully during the Apollo 7 and 8 space missions to track stars for alignment of the inertial guidance platform of the Command Module. Produced as the optical subsystem of the Apollo guidance and navigation system, the Optical Unit also will be employed on NASA's manned lunar landing missions.

The Alignment Optical Telescope built by Kollsman to align the inertial platform of the Lunar Module will also be used on manned Apollo missions to the surface of the moon.

Spaceborne Kollsman star trackers were employed in the spacecraft attitude control system of the 1968 Orbiting Astronomical Observatory.

The star trackers will be employed also in a subsequent OAO mission designed to orbit the Kollsman-built Goddard Experiment Package, a 38-inch reflecting telescope and spectrometer designed to measure the ultraviolet radiation of distant stars. Star trackers also were being developed for the Air Force's Manned Orbiting Laboratory.

Kollsman's optical capabilities were applied increasingly to other military and nonspace programs, particularly in the area of night vision equipment, both in head-up displays and in stabilized sights. Optical components and equipment were being produced by Kollsman for naval rangefinders, alignment telescopes and weapon sights, including the Dragon antitank missile.

Development continued in optical fuzing, grazing incidence optics (for detecting invisible light), ion beam figuring of optical surfaces and laser systems for underwater ranging and detection and for communication from the air to underwater.

SYSTEMS DIVISION

Category II flight testing of the AN/USQ-28 aerial mapping system continued with Kollsman support at Forbes Air Force Base, Kansas, headquarters of the Air Force's 1370th Mapping Wing.

The bulk of the Kollsman-produced ground support equipment for the system was delivered to the Air Force and work was continuing on the technical manuals and handbooks. The Geocon IV lens, heart of the mapping system, was being considered at year-end for other high-precision metric camera systems such as those required by lunar orbiting spacecraft.

Development of the Night Observation Device Long Range (NODLR) for the U.S. Army was begun in 1968 and system tests of the prototype equipment were scheduled for early 1969.

CORPORATE TECHNOLOGY CENTER

Under Navy contract, production of a large-screen real-time operations display system was begun in 1968 for use at the Barking Sands Underwater Range at Kauai, Hawaii. The display system, fed by computers currently in use at the naval range, will incorporate the Kollsman Delphic II projectors, a digital computer and control console. The system will be able to display numerous trajectories in 5 different colors over varied reference charts and backgrounds.

Other applications of the Delphic system being explored by Kollsman concern the computer retrieval and graphic display of financial and industrial management information, computer-directed classroom instruction and large-screen display of vital patient functions during surgical operations.

A sonar Doppler docking and navigation system was developed during the year for use by supertankers and other ocean-going vessels.

LEAR JET INDUSTRIES, INC.

As the first full year of operations since The Gates Rubber Company, Denver, Colorado, acquired controlling interest (58 percent ownership), 1968 served as an important pivotal year for Lear Jet Industries, Inc.

Sales volume for fiscal 1968, ended April 30, 1968, was $34,500,000, an 11 percent increase over the previous year. Net operating loss before extraordinary items was $3,800,000, a reduction of 70 percent from fiscal 1967.

More significantly, the company reported at its annual meeting of shareholders in September that August 1968 represented a trend-setting month of profitable corporate operations. Charles C. Gates, Jr., president and chief executive officer, said Lear Jet's first 6 months of fiscal year 1969, ending October 31, 1968, would be profitable, leading to a year-end modest profit on anticipated record sales in excess of $60,000,000.

Election of Lieutenant General Hewitt T. Wheless, USAF (Ret.), as a director completed the corporation's 9-member board of directors. His most recent position prior to retirement in July 1968 was as Assistant Vice Chief of Staff, U.S. Air Force.

AIRCRAFT DIVISION

In November 1968 the 200th Learjet aircraft was rolled from production lines in Wichita, Kansas. Lear Jet led in delivery of corporate jets again in 1968, marking the fourth consecutive year it held leadership in total worldwide delivery of business jet equipment. Cumulative flying by the Learjet fleet exceeded 100,000,000 miles by the end of 1968.

Some 20 units of the new 10-place Learjet 25, certificated late in 1967, were delivered by the end of 1968. The "25" measures 4⅓ feet longer than its sister ship, the 8-place Learjet 24, and features a number of performance advances, including extended range to more than 1,800 miles with 8 passengers and 45-minute fuel reserve. Added interior conveniences, such as a private, fully enclosed lavatory, further enhanced the Learjet 25's acceptance within the corporate aviation community.

On February 20, 1968, a standard, production Learjet 25 established a new world "time-to-climb" record for business jets, flying to 40,000 feet in 6 minutes 19 seconds, breaking by 1 minute 2 seconds the previous mark set in December 1965 by a Learjet 23. The achievement was significant in that it demonstrated the high performance of the "25" in rapid and direct climb to high, over-the-weather, economical cruise altitudes—as well as highest margin single-engine safety operations.

Improvements to the basic Learjet 24 were listed late in 1968 in a company announcement of the new Learjet 24B, scheduled for initial deliveries in January 1969. The 24B features an increase of 500 pounds useful load and more powerful General Electric CJ610-6 engines, identical to those powering the larger, heavier Learjet 25.

A new warranty program introduced in 1968 covers both models. It is applicable for 4 years or 2,000 flying hours, whichever comes first, and is unmatched in the business aviation industry. Lear Jet officials said the extended warranty was made possible after detailed surveys of service records of Learjets already in fleet use.

The company's Aircraft Division continued its constant product improvement program during the year. Most significant were greatly reduced balanced field lengths (minimum authorized take-off/landing distances) for both the "24" and the "25."

The Learjet 24 has a balanced field length of 3,775 feet, lowest by 1,000 feet of any turbojet business aircraft. The "25's" new runway distance is 5,186 feet. Both new distances open up several hundred additional airports to each model, further adding to flexibility of owner operations.

In 1968 Lear Jet management made the key decision to specialize exclusively in design, production and marketing of corporate aircraft. To complement its 2-model line of executive turbojet equipment, the company began preliminary design of a true corporate helicopter which will offer twin-turbine power and a seating capacity comparable to today's modern business jets.

A task force advanced design group, comprised of highly skilled and versatile engineering personnel, was established in the Los Angeles area to spearhead preliminary design of the new helicopter as well as to handle advanced technical assignments on other divisional projects.

Concurrent with the new helicopter announcement, Lear Jet said it was disposing of its Brantly helicopter interests since the 2- and 5-place Brantly models are designed and marketed primarily for training and utility requirements.

A new customer service center, at extreme left in photo, doubled Lear Jet's aircraft service facilities in 1968.

Wichita facilities were further expanded with occupancy in June 1968 of a 30,000-square-foot building which doubled the company's customer service center complex.

Sales, both domestic and export, rose to new levels. Factory production rates were increased from 3 per month in late 1967 to one unit per week in 1968. Aircraft Division employment increased from 850 to 1,400, and personnel by late 1968 had achieved 3,000,000 consecutive man-hours without a disabling injury, over a 12-month period.

JET ELECTRONICS & TECHNOLOGY, INC.

Formerly known as the Avionics Division of Lear Jet, this newly established subsidiary was reorganized and renamed in 1968 to more clearly identify its current and planned future activities in the airborne electronics field as well as to provide greater marketing and financial flexibility.

Based in Grand Rapids, Michigan, J. E. T. continued its pursuit of military and commercial business, which at year-end accounted for more than 60 percent of its volume. The balance goes to the Lear Jet Aircraft Division for installations aboard Learjet 24/25 aircraft.

Developmental and production contracts from the U.S. Air Force, U.S. Navy and commercial customers such as King Radio Company were in excess of $1,000,000. The firm's Model 803 gyro indicator is now flying aboard 2 types of combat aircraft in Southeast Asia.

The same basic instrument, coupled with J. E. T.'s emergency power supply system, has created considerable interest among operators of all makes of business jet aircraft as a high-reliability third backup to primary and secondary instruments.

Two newly developed instruments were delivered late in 1968 to airframe manufacturers and government agencies, to undergo flight test programs in high-altitude, high-performance aircraft.

To meet expanding production requirements, J. E. T. in December 1968 occupied a new 57,000-square-foot facility.

STEREO DIVISION

Based in Detroit, Michigan, this non-aviation-oriented phase of Lear Jet's operations continued to enhance its position as a leader in 8-track tape stereophonic player/cartridge systems. It expanded its player line to 15 home, automobile and portable models and remained top producer of 8-track tape cartridges for the entertainment industry.

Acquisition in May 1968 of Avsco, Inc., Excelsior Springs, Missouri, a leading manufacturer of plastic products, including tape cartridges, further secured the company's leadership position in the magnetic tape cartridge field.

RESEARCH & DEVELOPMENT LABORATORIES

A product offering multimillion-dollar potential was under detailed development at Lear Jet's research and development laboratories in Santa Ana, California.

The new LearVerter variable-speed, constant-frequency (VSCF) AC electric power system has attracted wide industry attention for its greater reliability and many other advantages over the hydraulic systems now universally used. In 1969 the U.S. Air Force and a major airframe manufacturer were to conduct formal flight evaluations of the LearVerter system, which converts turbine engine shaft power into constant alternating current.

In addition to development of the LearVerter and other new products, the research and development facilities support continuing product improvement of other Lear Jet electronic products.

LEAR SIEGLER, INC.

While increasing its diversification to cover other markets, Lear Siegler, Inc., maintained its position among the leaders of the aerospace industry and deepened its penetration of commercial and general aviation markets. Virtually every major commercial air transport relies on LSI products of one kind or another, and significant awards for advanced avionics, power equipment, display instrumentation and a variety of new airborne and ground-based systems and components were received during 1968.

One of the most important commercial aviation contracts ever awarded was received by LSI in mid-year from Lockheed for its L-1011 trijet airliners. Collins Radio Company and LSI, working as a team, were awarded a $40,000,000 avionics contract. During the summer LSI also received a significant contract for development and production of the L-1011's electric generating system.

LSI products also bolstered the nation's defenses and aided in scientific research from space to the sea. These products and services for government programs, which accounted for 38 percent ($181,000,000) of the company's fiscal 1968 sales volume, ranged from automatic flight control and navigation systems to electric propulsion motors for deep submergence vehicles and advanced instruments vital to manned space flights.

LSI AVIONICS GROUP

Astek Division

Located in Armonk, New York, LSI's Astek Division enhanced its position as a leader in the development and manufacture of pressure sensing and servoed flight instruments by capturing approximately 90 percent of the domestic and 85 percent of the world market for overspeed limit sensors. A minimum of one instrument, which is the primary warning device to signal the pilot of overspeed, is required on all turbine-powered commercial aircraft using U.S. controlled air corridors. With the selection of this device by Boeing for the new 747, the Astek instrument became a standard item on every commercial jet manufactured in the United States.

The division also received a contract from Douglas specifying Astek's Airspeedata instrument as standard equipment for DC-9 aircraft. This instrument combines the display of indicated airspeed, Mach number and maximum allowable airspeed in one instrument.

The division's digital counter pointer drum altimeter was specified as standard for the Boeing 737. Introduced late in 1967, with improved presentation of altitude, this altimeter represents a significant advancement in the state of the art in pneumatic air data instrumentation.

Production programs at the division included overspeed limit sensors and command Mach airspeed indicators and altimeters for such aircraft as the A-7A, Fan Jet Falcon, and the Boeing and McDonnell Douglas commercial jet families.

Astronics Division

The Astronics Division of LSI, teaming with Collins Radio Company, scored a major breakthrough in the commercial aircraft avionics market in 1968 when it was selected by Lockheed to provide the avionic flight control package for the L-1011. The contract for approximately $40,000,000 is one of the largest initial commercial avionic systems contracts ever awarded.

The complete avionic package for the luxury transport will include 4 basic systems: the autopilot/flight director system, stability augmentation system, the flight control electronic system, and the speed control system, including Mach trim and stall warning.

With the Collins/LSI Astronics system, the L-1011 will be the first commercial airliner delivered to the airlines with a fail-operative avionic flight control system as part of its original equipment. The fail-operative capability will allow the L-1011 to complete a normal landing even though a component malfunction occurs during final approach. Present fail-safe systems require a go-around and second landing attempt when a component in the automatic system malfunctions. The fail-operative automatic landing system for the L-1011 will have the potential to permit routine airline operation regardless of weather conditions, even to zero-zero visibility.

The Astronics Division was also developing an advanced automatic flight control system for Navy P-3C Orion aircraft. Under contract to Lockheed, the LSI division will develop a dual-channel, 3-axis system as a replacement for the present single-channel autopilot on the P-3.

Prominent in the development of VTOL aircraft flight controls, the Astronics Division was providing additional electronic systems for the integrated VTOL flight control system installed in a CH-3C test-bed and delivered to the Air Force Dynamics Laboratory in 1967. With the additional equipment, the investigation of low-visibility VTOL operations, using the CH-3C as an inflight simulator, will continue with emphasis on letdown, hover and landing modes.

The LSI division will also install a variable stability system in an X-14 VTOL aircraft for a NASA program related to the advancement of technology in the handling characteristics of this type aircraft.

Major continuing production programs at the division included dual flight control systems for the A-7A and A-7D Corsair II aircraft used by the Navy and Air Force and flight control systems for the BQM-34A Firebee target drone.

Instrument Division

Work was completed on a 92,000-square-foot addition to the Instrument Division's manufacturing facility during the spring of 1968. With this addition, floor space of the division's 3-building complex totaled more than 500,000 square feet.

During the year the Instrument Division also placed its new magnetic azimuth detector facility in operation. Designed to measure attitude and heading reference system accuracy, the new facility provides a stable, nonshifting magnetic field for these systems being built for the C-5A aircraft.

The division developed a new "canted T" attitude indicator which features a unique indicator mechanism that permits both roll and pitch servos of the mechanism to be contained inside the sphere of the indicator. Direct-drive DC torquers are used in lieu of conventional AC servos with resultant advantages of simplicity and reliability. An improved, highly reliable horizontal situation indicator was developed through the utilization of this technique.

As part of the Instrument Division's internally sponsored radio navigation program, a unique approach to Loran signal reception was developed. This "total energy concept" makes use of all the transmitted energy from the Loran transmitters, improving both accuracy and operating range of the Loran system.

In addition to the division's radio navigation development activities, the Instrument Division in conjunction with ITT had the only tactical Loran-C/D system in production. Designated the AN/ARN-92, the system provides the pilot with instantaneous and continuous solutions to navigational problems, enabling him to fly his aircraft to the target without visual contact. The division's Loran-D computer subsystem was successfully flight tested in both C-130 and F-4 aircraft during 1968 as part of a weapons delivery system.

The Instrument Division increased its penetration of the commercial airline market in 1968. The division's total air temperature/engine pressure ratio (TAT/EPR) has been selected by 14 airlines for their 737 jetliners, and 15 airlines have selected LSI attitude indicators for their Boeing 747s on order.

Major continuing production programs at the Instrument Division, in addition to those previously mentioned, include precision attitude reference (PAR) systems for the C-5A, AN/AJB-3 and -7 bombing systems, ASN-73 heading reference systems, ASN-70 vertical reference systems, gyros and other gyro systems.

LSI POWER EQUIPMENT GROUP

Power Equipment Division

Contributing greatly to LSI's substantial advances in the field of aircraft systems and components, the Power Equipment Division recorded an important expansion of its nonmilitary aviation markets during 1968.

In addition to the continuing production of the completed electric generating system for the DC-8 Series 60 commercial jet aircraft, the division was selected to develop and manufacture the electric generating system for the new Lockheed L-1011 luxury jetliner. While the DC-8 system represents the most advanced electrical system components flying on a commercial airliner today, the L-1011 system will reflect a completely new concept in aircraft electric systems.

The result of a development program initiated in late 1967 with Sundstrand, the L-1011 system is designed to combine the constant-speed drive and generator into one package called the integrated drive generator. This advancement will make approximately a 50 percent reduction in weight possible and, with other innovations, will provide greater reliability and ease of maintenance.

During the year the division developed various other generators, voltage regulator and control units, and related equipment to meet present and future general, commercial and military aircraft requirements.

New applications for existing products were also developed by the division. PED's frequency controlled drive system was successfully adapted to the Navy's mobile TACAN antenna; a portable solid-state power supply for space use was adapted for the Navy shipbuilding and maintenance brazing operations; and a solid-state laser power supply, developed for NASA, was under evaluation for a classified Army program.

Production programs included throttle actuators for the Chinook helicopter, stabilizer trim servos and spoiler mixer box assemblies for the Boeing 727, stabilizer trim servo actuators for the Boeing 737, fin control servos for the Mark 45 torpedo, DC generators and starter-generators for the UH-1 helicopter and 300-ampere generators for the M-60 tank.

Romec Division

One of the leading manufacturers of hydraulic and pneumatic systems, the Romec Division of LSI produces more lube pumps for jet engines and more fuel booster pumps for helicopters than all other pump manufacturers combined.

To increase its share of the rapidly expanding civil and small commercial market, the division developed a new, low-cost hydraulic power package. This unit is designed especially for actuating smaller aircraft's landing gear, flap and steering systems.

Representative of products that the Romec Division developed for the large commercial jet market are an electric-driven auxiliary power unit start pump, fuel scavenger pump and windshield de-icing pump for the 747.

In contrast to its products for aerospace applications, such as a self-sealing quick disconnect coupling used in the pressurization of fuel tanks for check-out and operation of the Lunar Module, was a highly accurate, lightweight, fluid metering medical pump. This unit, developed early in 1968 for intravenous, constant-flow injection of medication into the human body, allows the patient to remain mobile during treatment.

Transport Dynamics Division

A leader in the field of self-lubricated and metal-to-metal spherical, journal and rod end bearings, Transport Dynamics manufactures bearings for major commercial and military aircraft as well as for missile and space programs.

Primary applications for the division's bearings are related to landing gear, hydraulic actuators, thrust reversers, valves, manual flight controls and other high-load, low-speed bearing surfaces.

During the year Transport Dynamics supplied various types of bearings for a wide variety of applications, including Boeing 707, 720, 727, 737 and 747 transports and CH-46 and CH-47 assault transport helicopters, McDonnell Douglas DC-8s and -9s, Lockheed C-141 and C-5A military transports and the AH-56A attack helicopter.

SYSTEMS AND SERVICES GROUP

Cimron Division

Primarily a manufacturer of digital voltmeters, the Cimron Division expanded this product line and broadened its product base in the printed circuit manufacturing equipment market during 1968.

Two improvements to the division's Hydro-Squeegee solder leveling machine were introduced in 1968. Added to the device developed by Cimron and used by a large number of circuit board manufacturers were filtering and washing systems to increase the economy and efficiency of the machine's overall operation. Also introduced for this general market was a low-priced, single-hand drill and eyelet inserting machine.

In addition to its production of test instruments for laboratory and industry applications, the division supplied environmental instruments for the F-111 ground support test equipment.

Component Services Division

LSI's Component Services Division, headquartered in Harrisburg, Pennsylvania, with facilities at Oklahoma City and Los Angeles, performs instrument and equipment overhaul and repair services on a wide variety of airborne and ground-based systems and components.

Representative of the division's activities during the year were repair and overhaul of CH-3 automatic flight control systems, APS-31 radar systems, and IRAN of McDonnell Douglas (Long Beach, California) company-owned photographic projectors, and rebuilding and repackaging of 40-millimeter booster assemblies for the Navy.

Data and Controls Division

To augment its prominence in aerospace power conversion and distribution equipment and weather radar systems, the Data and Controls Division increased its emphasis on inner space, or undersea, systems.

During the year the division developed a solid-state sonar transmit/receiver switch incorporating proprietary features that provide higher reliability, greater stability and greatly increased operational life over the currently used electromechanical-type switch.

A significant improvement over existing sonar transmitters was made by the division with its development of a new transmitter (power amplifier). Incorporating 7 proprietary features, the transmitter is smaller, lighter, more efficient and 4 to 5 times more reliable than earlier units.

Included in the division's significant production programs are ignition inverters for the firing mechanisms in submarine Polaris launch systems and power supplies for the airborne receiver of the ITT/LSI Loran-C/D system.

Electronic Instrumentation Division

After its first full year of operation in a new market, the Electronic Instrumentation Division was firmly established as a manufacturer of artillery fuzes and booster assemblies. To accommodate this and other engineering and production activity, the division acquired and added more than 73,000 square feet of floor space.

In the field of data acquisition and communications, the division provided systems for space, ground and undersea applications. They included a closed-circuit target acquisition and telemetry system for Cape Kennedy, closed-circuit television systems for ground-based and underwater programs and a secure communications system for a classified government program.

The division also marketed its first frequency multiplier, which was previously developed for a data acquisition system. This device, which puts out the product of 2 inputs, accepts inputs that may vary in frequency up to 2.5 megahertz each.

Hokanson Division

While established as a leader in ground support air-conditioning equipment for commercial and military aircraft, missiles and spacecraft, the Hokanson Division solidified its position of prominence in the aircraft galley and interior furnishings field in 1968.

The division's airline galley business gained major impetus with orders for more than 100 units from Japan Air Lines, United Air Lines and Alitalia. In addition, 64 galleys were part of the equipment for the division's Air Force C-9A aeromedical evacuation transport program. In related work, the division developed for commercial aircraft a forced-convection oven that will reconstitute frozen meals in 20 minutes, compared to the 30 to 50 minutes required by present units. Weight was also sharply reduced. The Hokanson dual compartment oven weighs only 60 pounds, compared to the single-cavity ovens that, with equal capacity, weigh 100 pounds.

For its basic product line, the Hokanson Division developed a new heater for airline support equipment. Utilizing an entirely new concept, the HH-1000 heater has a minimum of moving parts and requires no combustion, electricity or reverse refrigeration to augment the system.

Management Services Division

The variety of management and technical services which the Management Services Division provided experienced a substantial increase in 1968. To accommodate its need for larger facilities, the division's administrative staff occupied a new 30,000-square-foot building in Oklahoma City.

Operations of the division were conducted in virtually every state of the union and in more than a dozen other nations. Services ranged from providing air traffic controllers at bases in Vietnam to overhaul and repair of communications, radar and armament systems and aircraft and helicopter airframes. Designated the "field team concept," this type of aircraft and avionic service capability was expanded under a contract from the Army to include diesel generators and heavy mobile vehicles such as cranes, graders and shovels.

Other programs received or in progress during 1968 at Management Services included engineering support for C-5A, C-141, A-7A and PIFACS programs, field-team modification related to the AIMS program and field-team maintenance and modification for the F-4 aircraft in the Far East.

LING-TEMCO-VOUGHT, INC.

Ling-Temco-Vought, Inc., added 3 nationally known companies, Braniff Airways, National Car Rental and Jones & Laughlin Steel Corporation, to its roster of subsidiaries during 1968.

With these additions, the corporation totaled 10 publicly held subsidiaries going into 1969 and employed approximately 130,000 persons.

The subsidiary roster was as follows: LTV Aerospace Corporation; LTV Electrosystems, Inc.; LTV Ling Altec, Inc.; The Okonite Company; Jones & Laughlin Steel Corporation; Braniff Airways, Incorporated; Wilson & Company, Inc.; Wilson Sporting Goods Company; Wilson Pharmaceutical & Chemical Corporation; National Car Rental System, Inc.

In the aerospace field, 2 subsidiaries, LTV Aerospace Corporation and LTV Electrosystems, Inc., marked up a highly successful year.

The A-7A Corsair II, manufactured by LTV Aerospace's Vought Aeronautics Division, proved itself in combat, operating from aircraft carriers in the Gulf of Tonkin. Returning A-7 pilots lauded the aircraft as the new, versatile workhorse of the fleet.

In the space field, Aerospace's Missiles and Space Division's Scout rocket served as a launch vehicle 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).

Keeping pace with its expansion program, LTV Aerospace's Missiles and Space Division dedicated a new 1,000-square-foot office, laboratory and manufacturing complex, valued in excess of $20,000,000, in June, and the Vought Aeronautics Division dedicated a $4,000,000 satellite machine shop at the Gregg County Airport near Longview, Texas, in October.

At year's end a new San Antonio, Texas, training and manufacturing facility, to be operated by Vought Aeronautics, was set for operations. The facility will train more than 150 hard-core unemployed and will employ the trainees in small detail fabrication for the A-7 and F-8 aircraft. In addition, Vought Aeronautics contracted for an additional new building near the company's main plant in Grand Prairie, to be occupied in early 1969.

Backing up its subsidiaries, Ling-Temco-Vought, Inc., dedicated in September the Robert McCulloch Research Center, a $2,500,000, 97,000-square-foot headquarters for the company's research activities and home for its Dallas research division.

Turning to production, Vought Aeronautics' more powerful A-7B, a follow-on version for the Navy with the higher thrust TF30-P-8 engine, was the major aircraft on the division's assembly line.

The division also completed and flight tested the Air Force's A-7D with an even more powerful power plant, the Allison/Rolls-Royce TF41 engine. In its first flight at Edwards Air Force Base, California, September 26, the new engine sped the camouflaged aircraft to Mach .94 at 20,000 feet.

The A-7D and the newer Corsair for the Navy, the A-7E, are equipped with state-of-the-art avionics systems, using digital computers and a head-up display, to provide much more accurate navigation and weapon delivery in all weather conditions. LTV Aerospace expected to manufacture between 1,500 and 3,000 A-7s before the program is completed.

Vought Aeronautics continued the remanufacturing of the F-8 Crusader series, modernizing the B, C, D and E aircraft as well as the RF-8A. The F-8 remained the fastest single-engine Navy fighter in the world and continued making a mark for itself as a MiG killer. At year-end, the Crusader was credited with more than half the Navy victories over the MiGs in the Vietnam war.

The XC-142, the division's tri-service experimental aircraft and the world's largest vertical short take-off and landing aircraft, was entered in the LIT competition, while concurrently being tested by NASA. NASA's program will provide data on problems of operating commercial V/STOL aircraft in and around commercial airports during periods of low visibility.

As a subcontractor to The Boeing Company, the Vought Aeronautics Division was building the empennage and aft body section for the 747, and was named to fabricate the horizontal stabilizers for the McDonnell Douglas DC-10. The company is also part of the Boeing team for the SST.

LTV Aerospace and Lockheed announced a long-term agreement under which the 2 firms would cooperate in the bidding for and manufacture of Navy and Air Force fighter aircraft. Under the agreement, the LTV, Inc., subsidiary would act as prime contractor for Navy aircraft and Lockheed would bid on Air Force contracts, with the other acting as subcontractor. First fighter effort under that agreement was the LTV Aerospace bid for the Navy's VFX. The Texas firm also made a long-term cooperative agreement with Marcel Dassault of France under which it received technical data concerning the Mirage III-G, the successful French swing-wing aircraft. Certain Mirage technology was used in the Vought Aeronautics VFX proposal.

Vought Aeronautics was also teamed as a subcontractor with Lockheed in a VSX proposal to the Navy.

Missiles and Space Division's 4-stage, solid-propellant Scout performed 7 launches in 1968 and achieved a success ratio of 100 percent. Continuing a performance growth program which has enabled the Scout to more than triple its payload capability in less than a decade, work was under way on a standard fifth stage, an option which will increase hypervelocity reentry performance, make possible highly elliptical deep space orbits and extend the vehicle's probe capabilities to the sun.

A unique, company-designed space radiator system, designed to maintain the proper temperature for the astronauts and their equipment inside the Apollo lunar spacecraft, made its first flight into space on Apollo 7 and operated flawlessly. Apollo 7 also capped off a production program in which the Missiles and Space Division supplied huge fuel and oxidizer containers for the first stage of the Saturn IB rocket. Nine of these containers, each more than 62 feet long, are clustered in each launch vehicle to provide 850,000 pounds of propellant for the first-stage motors. A total of 189 containers was delivered.

Still other contributions to the Apollo program included space mission studies and astronaut training in the company's unique Manned Aerospace Flight Simulator, the testing of space suits and other equipment in its Space Environment Simulator and the performance of spacecraft thermal analyses on all Apollo missions using company-developed computer routines and real-time monitoring by company personnel.

In missile activities, the division's Michigan facility near Detroit made excellent progress on the Army Lance missile system, for which it is prime contractor. The Army's newest surface-to-surface missile is being developed to fill requirements for a highly mobile, versatile and accurate weapon system to replace the Honest John and possibly Little John rockets. Lance, which uses a simplified inertial guidance system and is capable of carrying conventional or nuclear warheads, is the first Army missile to use prepackaged, storable liquid propellants. Test firings of advanced missiles were being conducted at the White Sands Missile Range.

In the surface vehicle field, the Michigan facility continued work on its small, 8-wheeled multipurpose vehicle, called the MACV in a military version and the Kid in a utility version designed to replace the water buffalo as a "beast of burden" in areas such as Southeast Asia. Tests on the highly simplified carrier indicate it can traverse more than 90 percent of the jungle and mountain terrain in Vietnam. Two prototypes of the MACV (Multipurpose Airmobile Combat-support Vehicle) were undergoing tests by the U.S. Marine Corps. The Kid version of the 1,000-pound-payload vehicle was demonstrated in Thailand early in the year and was greeted with enthusiasm.

The Missiles and Space Division was actively engaged in programs in the fields of defense systems, ducted rockets and advanced guidance systems, and was a subcontractor for the 747, DC-10 and SST.

In August a new company, Computer Technology, Inc., was formed by Ling-Temco-Vought, Inc., and LTV Aerospace Corporation and was chartered to offer the rapidly expanding computer industry a diversified range of computer-related products and services. The new company is a subsidiary of LTV Aerospace Corporation. LTV Aerospace holds approximately 70 percent ownership; the remaining stock interest is owned by the parent corporation, LTV, and by management.

Computer Technology, Inc., combines the Dallas-based facilities, resources, personnel and business backlogs of 3 going businesses: LTV Computer Center, the Aerospace Computer Science Services of LTV Aerospace, and Service Technology Corporation, a wholly owned subsidiary of LTV Aerospace which will operate as a subsidiary of Computer Technology, Inc.

Service Technology Corporation, originally formed as a wholly owned subsidiary of LTV Aerospace Corporation, is made up primarily of the resources and activities of the former Range Systems Division. It is composed of 3 operating divisions: Test and Operations Division, Technical Services Division and Engineering Systems Division. Service Technology Corporation (STC) concentrates its business interests in the services field with technical support services conducted at various NASA and DoD sites across the nation and engineering services performed for a variety of customers by its in-house engineering staff in Dallas.

The Air Force contract for the Conversion of Range Telemetry Systems (CORTS) was awarded to STC for improving range facilities at 3 Air Force test centers, Edwards AFB, California; Eglin AFB, Florida; and El Centro, California. The company also received the first major award made by the NASA Electronic Research Center, Cambridge, Massachusetts, for Automatic Data Processing Services to support the center's computer and data activities. The new service company also received a contract to provide documentation services to the Army Electronic Command, Fort Monmouth, New Jersey.

In the Pacific, Kentron Hawaii, Ltd., another segment of LTV Aerospace, 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.

LTV Electrosystems, Inc., made steady progress in electronic systems development, with technological achievements balancing growing sales and continued construction of new facilities.

Corporate headquarters was moved at midyear from Greenville, Texas, to the LTV Tower in Dallas for "more efficient direction of our 4 major operating units, which have 14 facilities in 6 states," to quote President E. F. Buehring.

Largest of these operating units is Greenville Division, with headquarters facilities in Greenville, Texas. At the headquarters plant a 70-kilowatt airborne illumination system was developed to provide with one unit approximately the same ground lighting as the 28-light AGIL and BIAS system; called AGIL II, it was being produced for helicopter installation and use in both military and civilian applications.

Still in research and development, the 70-kilowatt system is reported to be operating for extended periods and promises lighter weight and simplicity of installation.

In the tactical warfare area, Greenville Division was producing the Gunship II modification, arming C-130 aircraft with miniguns and 20-millimeter cannon and "other sophisticated systems."

Although unable to discuss more complex programs because of their security restrictions, Greenville Division was rapidly expanding facilities to meet requirements of growing sales. A multisensor test facility was under construction for completion in March 1969. An additional 74,000-square-foot engineering/administration building went to the site preparation stage. Two new production buildings and an aircraft preparation area went into detailed planning for 1969 construction, along with a 25,000-square-foot engineering lab facility, additional maintenance building and chemical waste facilities.

At Donaldson Facility in South Carolina, aircraft maintenance and modification programs expanded to include the F-101 and work on F-102 aircraft continued. Crash damage repair of C-7A aircraft began in 1968 and was continuing.

At Garland Division, the AN/AYA-7 Digital Communications System was delivered to the Air Force for evaluation tests in both airborne and jeep-mounted configurations.

Automatic controls continued to be a major product line with a contract for a pilot's "feel" system for the Lockheed L-1011 trijet transport. The "feel" system provides a force in the pitch axis to the pilot's control column and simulates various air loads on the aircraft during flight. Such systems were being produced for Boeing 727, 737 and 747 transports. Work was in progress at the Arlington, Texas, automatic controls plant, where construction of a new 60,000-square-foot assembly building neared completion.

Garland Division added new equipment to make its environmental test laboratory the most complete of its kind in the Southwest. A new thermal vacuum chamber can simulate a space environment with a temperature range of 100 degrees below zero Fahrenheit to 250 degrees above zero Fahrenheit. Also added were a shock spectrum synthesizer/analyzer that simulates and then analyzes the effects of blast-off, missile stage separation and normal engine vibration on electronic missile components, and 5 thermal vibration chambers capable of testing up to 15 small missile components simultaneously.

Garland Division completed installation of 2 precision parabolic antennas for satellite communications (in Panama and Brazil) and had 3 others under contract (in Peru, Iran and Lebanon).

Memcor Division moved into production of the AN/VRC-12 vehicular-mounted radio transceivers at its Huntington, Indiana, facilities and introduced an improved version of the AN/PRC-25 backpack radio. In Salt Lake City, Memcor Division's Montek Operations continued work on an Air Force contract for TMC-212 TACAN test monitor and control units and introduced a man-portable TACAN.

Continental Electronics acquired Pickard & Burns Electronics early in 1968 and operated the 2 Massachusetts facilities of this company as the Pickard & Burns Electronics Division of Continental Electronics Manufacturing Company. Pickard & Burns has specialized in radio engineering and consulting and has performed fundamental work in propagation, in navigation systems and in the design and manufacture of specialized receivers, multicouplers, receiving antennas and measuring instruments. At year-end Pickard & Burns Division was producing shipboard antenna couplers for the Omega System. Continental Electronics, the free world's most experienced producer of superpower transmitters, built the 2,000,000-watt NATO VLF station in Norway, which at year-end was in test status, and VLF Mediterranean, where work on peripheral systems, acceptance test and proof of performance was to continue into 1969. In progress were contracts for high-frequency 40 and 200 ISB transmitters for the Naval Electronics System Command (NESC) and a 1-megawatt broadcast transmitter for the Broadcast Corporation of China. Deliveries were made on a contract from the Research and Development Command (RADC) and the Navy Research Laboratory (NRL) for VHF radars. A contract for OTH (over the horizon) radar was in work, and a contract was received early in 1968 for design, manufacture and installation of a VLF transmitter at Annapolis, Maryland, from the Naval Electronics Systems Command. During the year Continental Electronics received a contract and completed delivery of transportable LF transmitters to the Navy, marking the first known installation of such high-powered equipment in transportable configuration.

The year was one of continued advancement and change for LTV Ling Altec, Inc. Acquisition of Escon, Inc., in March 1968, following close on the heels of the acquisition of Allied Radio Corporation in October 1967, substantially enlarged and further diversified the operations of the company. LTV Ling Altec at year-end had 6,500 employees and annual sales in the $160,000,000 range. Headquartered in Dallas, the company has 14 major operating entities, with facilities located from coast to coast, and 3 foreign subsidiaries. Ling Altec has 3 publicly owned subsidiaries, Tamar Electronics Industries, Inc., and Whitehall Electronics Corporation, which are listed on the American Stock Exchange, and Staco, Inc., which is traded over the counter.

LTV Ling Altec, Inc., is a highly diversified company serving primarily the consumer and industrial electronics markets, but it also has a large number of products and services in support of aerospace efforts. The Altec Lansing Division manufactures Giant Voice high-level voice warning systems which can be used at airfields and launch sites; it shipped many of these systems to Vietnam in 1968.

Altec Lansing was also manufacturing public address systems, intercom systems, noise canceling microphones, and telephone amplifiers for aerospace applications. Ling Electronics Division was continuing the research and development effort required to keep it in a leadership position in both vibration and high-intensity sound test systems, required in the development of all aerospace vehicles. University Sound Division was manufacturing speakers used in a variety of aerospace applications, including air-to-ground voice communications. Tamar Electronics, Econolite Division, a pioneer in automotive traffic control, proposed a system for ground control of aircraft traffic to the New York Port Authority employing its newly introduced special-purpose digital traffic control computers. It also developed a ground traffic simulation technique for analysis of traffic problems. Presentations on this new simulation technique, which appeared to have application to new airport design as well as to design of traffic control systems at existing airports, were made to the New York Port Authority, the FAA and the Department of Transportation in October. The Stoddart Division of Tamar Electronics introduced in August a new acquisition system. The Aero Corporation, a subsidiary of Whitehall Electronics, continued to overhaul and repair aircraft. It was expanding facilities at Lake City, Florida, in preparation for increased activity resulting from a recent P2V award. Existing programs included the C-121 and C-124. Staco's subsidiary, Standard Electrical Products Company, was producing miniature illuminated switches used in cockpit controls; it introduced a new generation of switches of this type, designated the Model 40 Matrix Switch.

LOCKHEED AIRCRAFT CORPORATION

The year 1968 saw Lockheed Aircraft Corporation return to the front ranks of U.S. passenger airplane manufacturers, make progress in other lines of commercial business, and record significant milestones in its government programs.

The company began 1968 with a firm backlog of \$2.27 billion, including only \$55,000,000 of commercial orders. As it neared year-end, it had a backlog of \$4.94 billion, including \$2.2 billion in commercial orders. Eight of its 9 operating companies recorded significant increases in commercial business.

With sales close to its 1967 total of \$2.33 billion, 1968 brought Lockheed a record high in sign-ups that affected virtually all of its major government work—some \$700,000,000 for the Navy's fleet ballistic missiles, \$250,000,000 for Air Force and NASA space launches and flights, more than \$300,000,000 for the Air Force C-5 Galaxy transport, over \$100,000,000 for the Army's Cheyenne helicopter, millions for Navy deep submergence programs, and additional orders and funding for other projects.

Major technical achievements included first flight of the Navy's Poseidon strategic missile, roll-out and first flight of the Galaxy and first flight of the P-3C A-NEW Orion antisubmarine warfare plane.

Overall areas of interest included, in addition to Lockheed's traditional air vehicles and support market, missile and propulsion systems, orbital vehicles and missions, undersea and ocean surface research and vehicles, land vehicles, electronics ranging from communications to radar and information systems, housing and construction, and overseas operations and investments.

Pacing Lockheed's resumption of large-scale commercial aircraft activities was its L-1011 advanced technology trijet. Orders starting in March had passed the \$2 billion level by midyear. Designed for the world's highest-density travel markets in the 1970s and beyond, the L-1011 will carry from 250 to 345 passengers and can use intermediate-size airports. Its 3 Rolls-Royce RB.211 engines, embodying a 3-shaft principle, make improved use of fuel, reducing smoke and noise annoyance and enabling growth versions of the L-1011 to fly transatlantic routes and major legs of Pacific crossings. Provisions for passenger comfort outdate all previous concepts of airliner luxury.

Work was well under way on an extensive L-1011 subcontracting activity, a large-scale facilities and equipment program, and detailed design, development, planning, tooling and production to assure start of deliveries to airlines by 1971.

Three C-5 Galaxy heavy logistics transports, world's largest airplanes, flew for the first time. Eight of the giant 728,000-pound aircraft, being built under a \$1.4 billion Air Force contract for the Military Airlift Command, will be in the air by mid-1969, when the Air Force will receive its first plane for transitional training.

The computer-based A-NEW submarine detection system carried by the advanced P-3C Orion antisubmarine patrol plane enables retrieval, transmission and display of tactical data with unprecedented speed and accuracy. About 100 P-3Cs were to be built under the present program, with delivery rates reaching a high of 3 per month for assignment to the Atlantic fleet in late 1969 and the Pacific fleet in the mid-1970s. More than 250 P-3s were in fleet service.

In the vertical-lift field, the Army awarded Lockheed a contract to begin production of 375 AH-56A Cheyenne compound aircraft, the first rotorcraft designed specifically as an aerial fire support system. Incorporating the rigid rotor principle that provides greater stability, speed and flying ease, the Cheyenne has a 50-foot rotor, fixed wing, turbine engine, and propeller for forward flight. At year-end it was successfully undergoing inflight firing tests. The 2-man craft will fly helicopter escort and fire suppression missions at speeds up to 250 miles per hour. Army service evaluation was to continue through 1969.

In other vertical-lift activities, the XV-4B Hummingbird II flew for the first time. A modification of the earlier XV-4A augmented jet thrust vehicle, the XV-4B incorporates a new direct-lift system with 6 jet engines, 4 for vertical take-off and 2 lift-cruise units. It was serving as a key tool in a long-term Air Force vertical take-off research and development program.

Logistics transport developments included delivery in May of the last of 66 C-130K Hercules to the United Kingdom, whose Royal Air Force was operating the largest fleet of military Hercules outside the U.S. In nearly 40 versions, more than 1,000 C-130s serve the Air Force, Navy, Coast Guard and Marine Corps and the governments of 16 other nations. Military and commercial Hercules production was continuing at a 5-per-month rate.

September marked certification by the Federal Aviation Administration of the stretched Lockheed 100-20 commercial cargo carrier Hercules air freighter, accompanied by sale of 3 of the new models and one standard version. Commercial Hercules were in service with 6 airlines and 3 airfreight contractors. Nearly all of 34 Electras being modified as freighters for 4 airlines, some of which contract services to the Military Airlift Command, were delivered.

Flight of a C-141 StarLifter by General Howell M. Estes of the Military Airlift Command from Travis AFB to Scott AFB marked the 1,000,000th flying hour recorded by MAC's C-141 fleet, which consists of 14 squadrons with a capacity of more than 595,000,000 ton-miles per month.

A new market opened for Lockheed's JetStar executive jets with purchase of 2 by a major airline for use in inflight training of pilots for large passenger transports. The JetStar's flight control response and cockpit arrangement favored it in an evaluation by the airline of 7 aircraft in its class. A 2-phase program followed, in which 203 pilots trained in the JetStar did as well or better than those using the large transports, which were freed for revenue service. Fifteen JetStars were delivered during 1968's first 10 months, for a total of 125 in service.

Highlight of Lockheed activities in missiles and propulsion was the successful first flight in August of the Poseidon, eventual successor to Polaris as the Navy's fleet ballistic missile, with double the payload and accuracy of the Polaris A3. Firings at sea will follow pad firings, and the first of 31 nuclear submarines due to carry 16 Poseidons was to start launch tube modification early in 1969. Thereafter up to 5 boats will be converted yearly until all are fitted and deployed by 1975. Lockheed's 12-year missile partnership with the Navy marked another milestone with delivery of the final production line Polaris A3. Production of modification kits continued for a fourth Polaris version. Lockheed will continue to update Polaris missiles, including repair, modification and inventory management, and to provide Polaris missiles as targets in tests of the Sentinel antiballistic missile system.

Lockheed's Agena second-stage booster and satellite continued as the reliable workhorse of the Air Force and civilian space programs; its military uses are classified. Of the 669 space launches on both sides of the Iron Curtain since 1959, 493 were by the U.S., of which Agena participated in more than half. Military and civilian launches scheduled through 1972 include the POGO project for NASA at year-end 1968, placing a polar orbiting geophysical observatory in elliptical earth orbit, complementing the geophysical observatory injected into eccentric orbit by another Agena in March 1968.

Agena was to have 2 new NASA launches in early 1969. It was to perform a dual role in a Nimbus weather satellite mission, placing the satellite in a circular orbit and, on a second trip around the earth, putting a small Army satellite into an orbit of its own. The other task will be the test of a new mercury ion engine in the space electric rocket test (SERT) program, aimed at proving the new power plant's usefulness for long space missions. Lockheed also designed, developed and tested SERT's solar array deployment mechanism. Other NASA work includes study of space devices for possible use in post-Apollo programs, design and installation of a computer-based information retrieval system, and a follow-on test demonstration contract related to an orbiting primate experiment. Lockheed also supplies rocket control systems in NASA sounding rockets to study solar flares near the sun's surface.

Displayed at the Tokyo Air Show in October was Lockheed's Starlet-Starlite concept, a proposed low-cost, compact, lightweight cryogenic booster and spacecraft, which would be capable of extremely high speeds for ranging far out into space to collect and send back scientific data from the sun, the planets and the asteroid belt.

Fortunately not needed, Lockheed's escape rocket rode along on the history-making launches of the Apollo 7 orbital and Apollo 8 lunar missions. The escape rocket's motors were prepared to loft the spacecraft away from danger in event of a booster malfunction during early phases of the launch.

Lockheed's leading position in undersea systems was reinforced with a Navy award to develop and build the deep submergence search vehicle (DSSV), capable of descending 20,000 feet to locate and recover small objects. The prototype, marking the first phase of an operational deep ocean system, will be able to remain submerged with a 4-man crew for up to 40 hours.

In another major undersea system program placed with Lockheed by the Navy, construction was under way on 2 deep submergence rescue vehicles (DSRV's) designed to rescue crews of disabled submarines and to be air transportable in the Lockheed C-141. The DSRV's will operate to depths of 5,000 feet.

In a third undersea system project, the Deep Quest research submarine, funded and built by Lockheed, completed a series of dives to depths of more than 8,000 feet preparatory to certification for use by Navy personnel. Under a lease arrangement, Deep Quest was expected to make 12 to 15 dives as part of a Naval Undersea Warfare Center program.

Significant growth came in electronics, a major field of Lockheed activity. A wide range of electronic products and services included gunfire control systems for Army and Navy use, development of a rotor blade for helicopters, computer memory systems and circuit boards and a family of tape recorders. Lockheed continued as a leading producer of airborne flight and maintenance data recorders and as a specialist in aircraft electronic modifications and installations, and made a significant entry into the commercial field late in 1968 with its multiple applications computer (MAC), offering large-scale capability at low cost, and designed for a wide variety of uses.

In the field of land vehicles, Lockheed was awarded an Army contract to build 3 prototypes of its 8-wheeled Twister. Under development with Lockheed funding since 1964, Twister has demonstrated ability to travel through ravines, dikes, high grass, rubble, mud and desert. Traction is provided by an arrangement in which 4 wheels attached to each of its 2 yoke-joined bodies are driven by an engine in that body. A commercial demonstration model of Lockheed's TerraStar amphibious vehicle began a series of extensive field tests.

Operations at Lockheed's Seattle shipyards included conventional and foilborne tests of the 300-ton *Plainview* research hydrofoil, built of aluminum and the largest vessel of its type, due for delivery to the Navy, and several conventional ship completions and overhauls. These included the commissioning in May of the USS *Schofield*, last of 3 guided missile destroyer escorts built for the Navy, and the launching in August of a 16,550-ton amphibious landing platform dock, sixth of 7 Navy ships in this class, followed by its delivery in October along with 2 other Navy craft.

Significant progress continued for Lockheed's patented Panel Lock low-cost housing system, using preformed wall and roof panels erected by low-skill labor at building sites. Construction projects included dams in Colorado and Oregon, a water project tunnel in California, and joint venture participation in a tunnel near Los Angeles as part of a water system linking northern and southern California.

Lockheed's information system work continued its national growth with added penetrations into 3 areas of specialization: aid to state and local governments, systems for hospital records, and aids for educational systems. Under a long-term contract with a leading Midwest medical clinic, it is working out the basis for optimum use of aerospace-based systems technology by the medical profession. It performed successful cost-savings studies for several state governments and was continuing development of systems to improve motivation and training of elementary school underachievers.

Lockheed maintained customer service and marketing representatives in many parts of the world and its international activities included joint venture developments and licensed manufacturing programs. Lockheed's group of international companies directs electronics assembly operations in Hong Kong and manufacture of arc welding equipment in Mexico, and represents Lockheed's interests in such diverse investments as a finance company in Australia, a tin mine in Bolivia, and a manufacturer of aircraft, ships and motorcycles in Italy.

In 1968's first 9 months Lockheed reported sales of $1.57 billion, net earnings of $36,000,000 and a record high backlog of $4.9 billion, compared respectively with $1.55 billion, $38,000,000 and $2.6 billion for the same 9-month period in 1967. Employment totaled more than 94,000.

THE MARQUARDT CORPORATION A SUBSIDIARY OF CCI MARQUARDT CORPORATION

The Marquardt Corporation established significant milestones in precision rocket technology during 1968 as a result of its continuing highly successful record of space service on the NASA Apollo program.

Produced by Marquardt's Rocket Systems Division under contract to North American Rockwell Corporation, 16 reaction control rockets, mounted in clusters of 4 on the Apollo service module, serve as part of the spacecraft's stabilization and control system. Each rocket generates 100 pounds of thrust and can be operated automatically and manually to accomplish various maneuvers scheduled for the mission. The rockets are designed to provide precise directional thrust to control the spacecraft's roll, pitch and yaw, as well as trajectory corrections, orbital changes and spacecraft separation maneuvers. A total of 96 engines were used on the first 6 Apollo missions and they accumulated approximately 113,000 separate firings and more than 116 minutes of burn time in space.

The R-4D engines are also used for attitude control on the Apollo Lunar Module and on the Air Force's Manned Orbiting Laboratory. The technology in the development and operational success of the R-4D engine served as the basis for the company's development of a broad product line of space rockets ranging in thrust from .5 pound to 5,000 pounds.

Marquardt's air-breathing technology continued to progress in the area of Prepackaged Liquid Air-Augmented Rockets (PLAAR), Supercharged Ejector Ramjets (SERJ), composite rocket-ramjets, and slurry-fueled systems.

Marquardt's activities were further characterized by a broadening of product lines and manufacturing services, particularly in the ordnance and munitions field, in controls and accessories for military and commercial aircraft, and in the development and production of Doppler sonar navigation systems for application to geophysical survey, deep ocean navigation, and supervessel docking.

At year-end Marquardt's activities were supported by approximately 1,200 personnel at Van Nuys, California, and Westbury, New York, and by an array of high-performance propulsion test facilities for space and high-Mach-number environmental testing. The company also maintained district offices in Washington, D.C.; Dayton, Ohio; Houston, Texas; and Van Nuys, California.

MARTIN MARIETTA CORPORATION

BALTIMORE DIVISION

The Martin Marietta Baltimore Division, a major aircraft modification and production center, continued to move ahead in those areas and in advanced manufacturing technologies.

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 VSTs duplicate the flight characteristics of the F-105, F-111, X-15 and X-24A. The F-106/VST marked the first time a variable stability aircraft had been developed for routine training operation; prior craft of this type were used exclusively for research.

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 F-101, B-57, EC-121 and RC-135.

A major award during 1968 was from the U.S. Navy for design assistance and fabrication of the ZAP. Value engineering studies were under way at year's end to produce ZAP as a high-quantity, low-cost weapons systems. ZAP is an acronym for zero antiaircraft potential. It is a hypervelocity solid-fuel rocket designed to detonate with a special high fragmentation effect.

Production of horizontal stabilizers for McDonnell Douglas DC-8 jet transports continued. Major tooling work was performed under a number of contracts. Tooling for the C-5A and F-111 was completed.

For NASA, the Baltimore Division delivered the first Apollo Lunar Service Drill (ALSD). 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.

DENVER DIVISION

Operations at Martin Marietta's Denver Division were concentrated on 2 primary lines of activity: Titan III launch vehicles and spacecraft and their systems.

The Titan III-C flight test program included 2 launches in 1968. On September 26, a Titan III-C placed 4 satellites, weighing a total of more than 900 pounds, precisely into predetermined orbits.

An OV5-2 satellite, carrying compact equipment for detection and monitoring of radiation in the synchronous corridor, was released into an elliptical orbit (perigee, 98 nautical miles, apogee, 19,340 nautical miles). Two other satellites—an OV5-4, carrying heat transfer experimental equipment, and LES-6, an experimental tactical communications satellite—were placed in a true-synchronous circular orbit at 19,306 nautical miles altitude. An OV2-5 satellite, designed to gather information about the characteristics of high-energy particle radiation in the celestial sphere about the earth, was dispensed on a slightly elliptical pattern at synchronous altitude.

In the earlier 1968 Titan III-C launch, on June 13, 8 satellites were placed precisely in circular, near-synchronous orbits to complete for the U.S. Air Force the first military global communications network in space. Eighteen other such satellites, part of the U.S. Defense Department's Initial Defense Satellite Communications System, earlier were lofted into the synchronous corridor by Titan III-C.

The 2 1968 flights from Cape Kennedy, Florida, brought to 33 the number of communications and research satellites that Titan III and its upper stage, Transtage, had delivered to the synchronous corridor during the research and development phase. This total represented nearly 80 percent of all satellites and about 60 percent of all payload weight carried there since the inception of the U.S. space program.

Additional Titan III-Cs were being built under a follow-on contract.

The Titan III-B, using the first 2 liquid-propellant stages of the Titan III core vehicle, and equipped with an Agena upper stage, was flown in a series of continuing missions from Vandenberg Air Force Base, California. The Titan III-B supports a wide variety of Air Force unmanned research and development programs.

Advanced development and early production phases of the Titan III-D and Titan III-M were under way at the division. The Titan III-D configuration is similar to the III-C, except that Transtage has been replaced with a payload. The Titan III-M will be the booster for the Air Force's Manned Orbiting Laboratory.

Titan III vehicles ordered but not yet delivered during 1968 totaled about 40.

Titan III-C also was included in the National Aeronautics and Space Administration's 1969 fiscal budget plans. It was chosen as the booster for an unmanned spacecraft that would be used to explore the surface of Mars during the early 1970s.

As part of the division's continuing program to develop other new applications for Titan III, a contractual study was performed for NASA's Lewis Research Center to investigate requirements for mating an Improved Centaur high-energy upper stage with the Titan III family of space launch vehicles.

The Titan III/Improved Centaur vehicle is a candidate for a variety of unmanned space missions, including planetary exploration.

Other growth elements under investigation by the division, combinations of which could increase Titan III's near-earth payload-carrying capability to over 100,000 pounds, included increasing the diameter of one or more of the core vehicle's liquid-propellant stages from 10 to 15 feet (referred to as the "large diameter core"); increasing the diameter of the 2 Stage Zero solid-propellant motors from 10 to 13 feet, or using 4 solid motors of the current 10-foot diameter, in conjunction with the large-diameter core; and a new main engine for Transtage, pump-fed rather than pressure-fed, providing substantial weight savings as well as more payload-carrying capability.

The division continued its contractual work for NASA's Manned Space Flight and Manned Spacecraft centers, involving payloads integration of the cluster configuration and other special studies for the Apollo Applications Program.

Hardware tasks included development and fabrication of the controls and displays console planned for the Apollo Command Module, which would be one element in the cluster of space modules. The console would be used in connection with the pointing and attitude-maintaining mechanism for a major AAP experiment utilizing the Apollo Telescope Mount, another cluster element.

Other, analytical tasks performed in connection with the AAP contract included systems engineering, involving thermal and structural analyses of the cluster and its major elements; interface definitions between cluster modules; experiments analyses, involving studies of how to achieve maximum utility from experiments and defining requirements of the individual systems as they impact on common sources of supply or origin, and on the entire cluster configuration; and special studies involving such items as crew habitability requirements, training, crew motion, and logistics requirements of the cluster's Orbiting Workshop module.

In August the division was selected by NASA to perform feasibility and preliminary design studies of an unmanned, automated soft-lander spacecraft, with a support module, for the 1973 Mars mission opportunity. The study identified critical long lead items associated with a soft-lander plus a support module to fly by Mars and relay entry data to earth.

Also for NASA, the division completed a study investigating the feasibility of using a buoyant station for the 1972 or 1973 Venus mission opportunities. The study culminated with a wind tunnel test of the balloon deployment system. The Buoyant Venus Station, weighing approximately 200 pounds, would contain about 60 pounds of instrumentation designed to take measurements while floating in the atmosphere of Venus.

The Meteoroid Penetration Detector Development project, which began in 1967, was extended through mid-1969 by NASA. The work is intended to determine the feasibility of attaching meteoroid detectors to the exterior of the Saturn S-IVB stage and to develop a radiation-resistant thermal control coating material for spacecraft.

Work under this project includes the design, development, fabrication and test of various types of detectors which could be used to provide data about the characteristics of the meteoroid environment and meteoroid penetration in space. The information is critical to the design of deep space manned and unmanned spacecraft.

Other advanced technological studies under way at Denver included:

- Investigation and demonstration of noncontaminating 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; 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 intravehicular activity, special maneuvering units such as backpacks and handguns, crew activity as affecting the attitude control of in-space hardware and problems in attitude control while conducting orbital tracking operations.
- Development of advanced materials for integrated tank insulation system for the long-term storage of cryogens in space.
- Analysis of lunar surface density of contaminants from an extravehicular astronaut.
- Design, construction and test of an on-board check-out system for airborne and spacecraft applications.
- Design, construction and test of glass-filament-wrapped tanks for use as fuel or pressurization containers during space missions.

The division's new electronics manufacturing facility became operational in 1968, and construction began on a new 6-story space support facility.

The 50,000-square-foot electronics facility is designed for manufacture, assembly and test of electronic components, subsystems and systems used in aerospace vehicles and spacecraft systems.

Its features include an 8,000-square-foot clean room fed by horizontal airflow and dual filtering systems; a Digital Acquisition and Test (DIGIDAT) system, developed by the division and equipped with computerized controls to permit extremely rapid testing of components and completed packages; special contiguous laboratories manned by advanced electronics manufacturing technology personnel; and environmental functional testing facilities.

Completion of the space support facility was scheduled for spring of 1969. The lower 2 floors will provide some 60,000 square feet of floor space for fabrication and assembly of spacecraft subsystems. The remaining space will be equipped for engineering and support offices and for smaller laboratories and test equipment.

ORLANDO DIVISION

In 1968 Martin Marietta's Orlando Division continued work on 5 major tactical missile systems: the Army's Pershing, Shillelagh, SAM-D and Sprint ABM and the Navy's Walleye glide bomb.

In addition, the division entered a new phase of its work on RADA, an advanced tactical communications system under development for the U.S. Army. RADA is a mobile, wireless digital communications system that provides secure division-level field communications without central switching. The new phase included the building of advanced development units of RADA equipment for further testing and a study aimed at determining how RADA can be adapted to Project Mallard. Mallard is an international communications system under development by the U.S., Canada, Australia and the United Kingdom.

Martin Marietta's Orlando Division was testing this advanced development model of the Army's RADA communication system, designed to put automatic dial radio in the battlefield.

In April 1968 DoD awarded production contracts for the Sentinel system, which includes Martin Marietta's Sprint antimissile missile.

The Orlando Division 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.

In late 1968 the Orlando Division was completing hardware for NASA to conduct the first space-to-earth millimeter wave communication experiment aboard the ATS-E satellite. The division was also building for NASA the Control Signal Processor used on Saturn IB and Saturn V launch vehicles, as well as the gyro processor for the Apollo Telescope Mount program.

Improved ground support equipment for the Pershing system went into full production in 1968. In process under the Pershing 1-A system, as the program is known, were several changes to the ground support equipment used in counting down and launching the missile. The biggest outward change is the switch from tracked to wheeled vehicles for transporting firing units. Increased mobility and reliability, less vibration, lower maintenance costs and an increased rate of fire will result from the improvement program. Other major Pershing 1-A system advances center in a new programmer test station, fast-reacting erector-launcher, and a new battery control central to serve as a unit command post.

Annual practice test firings from off-range missile sites in southeastern Utah into White Sands Missile Range, New Mexico, continued. 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.

Development work on the Sprint antimissile missile, slated to be one of the major components of the Sentinel Ballistic Missile Defense System, continued under a contract with the Bell Telephone Laboratories. After 5 years of the development effort, the Orlando Division had received a total of $353,808,000 for research and development activities, and $6,849,873 for production activities under its incentive contracts with BTL and the Western Electric Company. Flight test of the missile continued at White Sands Missile Range, and later tests were scheduled for Kwajalein Atoll in the Pacific, where Sprint will be integrated with other elements of the Sentinel System.

During 1968 the Orlando Division began mass-producing Shillelagh antitank missiles at its small weapons manufacturing facility. Contracts won in December 1967 and March 1968 brought to $34,000,000 the total awards to Martin Marietta for production of this weapon.

Shillelagh is a lightweight, surface-to-surface guided missile system designed as main armament for armored combat vehicles. A direct fire missile that is launched from a combination gun-launcher, Shillelagh will be effective against tanks, troops and field fortifications. Its 152-millimeter gun-launcher can fire either missiles or conventional ammunition. The system provides high accuracy against moving or stationary targets.

Production of the Walleye glide bomb continued, along with transmitting and launching equipment for the Bullpup air-to-surface missile. Bullpup was operational with both Navy and Air Force fighter aircraft and with aircraft of the NATO nations. Walleye, a highly accurate weapon with no propulsion, is television-guided to the target. Developed by the Navy, it is operational with both Navy and Air Force fighter units.

At the beginning of 1968, heavy production operations were transferred to the division's new manufacturing facility. This building is the largest factory structure in Florida to use prestressed concrete for all beams, walls, and roof slabs; it adds 102,000 square feet of floor space to the facilities at Orlando. Simultaneously, the main plant was revamped in accordance with latest concepts and standards for production of electronic equipment and for other light manufacturing.

RESEARCH INSTITUTE FOR ADVANCED STUDIES

The Research Institute for Advanced Studies (RIAS) near Baltimore City performs basic research in physics, fluid sciences, materials science and biosciences. Its work is funded by Martin Marietta Corporation and by contracts with various U.S. government agencies, including the Air Force, Army, Navy, Advanced Research Projects Agency, Atomic Energy Commission, Department of the Interior and National Aeronautics and Space Administration. RIAS also has a Charles F. Kettering Foundation grant to perform research in photosynthesis.

During 1968, RIAS had approximately 90 professional staff members, more than a third of whom held doctorates. This staff included scientists from many foreign countries as well as the United States and was augmented by visitors from universities and other research centers who presented seminars or participated in regular RIAS research programs. Results of RIAS research are published in the leading science journals and in symposia papers.

The physics group carried out research in metastable compounds, charge transport in semiconductors, quantum chemistry and ion transport. Research into the physical mechanisms involved in the decomposition of high-energy crystals suggested techniques for modifying and controlling the decomposition rate of these compounds, some of which are used as explosives and solid rocket oxidizers.

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.

The fluid sciences group continued its programs in hypersonic blunt body aerodynamics, 3-dimensional laminary boundary layers and low-speed lifting aerodynamics. Emphasis in these external aerodynamics programs was on those aspects peculiar to truly 3-dimensional flow.

This group also conducted studies of unsteady boundary layer transition, coupling of propellant lines and structural oscillations (the so-called POGO instability), and chemical non-equilibria on the numerical analysis of high-speed flow.

The RIAS materials science group continued its ceramics studies. Titanium carbide, vanadium carbide and their alloys were investigated in a combined theoretical and experimental program that encompasses electron microscopy, mechanical behavior, band structure and bonding studies. This program is intended to provide structural materials with combined ductility and high-temperature strength surpassing any materials used today. Work dealing with surface-sensitive environmental effects on material behavior of many structurally important metals, such as titanium, aluminum, copper and their alloys, continued. These materials may embrittle and fracture under relatively low stresses in selected environments. Objectives included both elucidation of the mechanism of this type of failure (stress corrosion) and 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 scientists were seeking to prevent this type of failure by both chemical and electrochemical means.

Under a NASA contract, the RIAS biosciences group resumed research on an extraterrestrial life detection experiment. The technique rests on the detection, by mass spectrometry, of the enzyme-catalyzed exchange of oxygen-18 between water and labeled oxyanions. This exchange appears to be common to all forms of observed life.

The RIAS extraterrestrial experiment is heat sterilizable and makes minimal assumptions about the nutritional requirements of organisms that might be found on other planets.

In 1968 this work concentrated on simplifying the detection procedure, increasing the number of applicable oxyanions and continued laboratory studies to verify the concept.

Work in photosynthesis—seeking a better understanding of the mechanism by which living plants convert light energy to chemical energy—focused on the role played by manganese in oxygen evolution.

Chemosynthesis research centered on the cultivation of a hydrogen-oxidizing microorganism and studies of its potential contribution to a closed ecological system, such as a manned spacecraft on an extended voyage.

MARTIN METALS DIVISION

The 2 product lines of this division are superalloys and investment castings. Martin Metals Division is a recognized leader in the research, development and production of high-temperature superalloys. These exotic metals, many containing as many as 10 to 15 different elements, must withstand the 2,000 degree Fahrenheit temperatures and high corrosive environments and pressures of advanced jet engines.

MAR-M alloys are serving jet power requirements in vehicular, marine and industrial power plants throughout the world. Experimental engines for the power needs of the future will contain these alloys and the new ones developed by Martin Metals researchers.

Vacuum melted investment cast turbine blades and vanes are the second product line. These airfoils are used in jet engines such as Pratt & Whitney

Aircraft's JT3D. P&W's JT9D engine has Martin Metals castings in the blades of the second, third and sixth stages. Other engines containing Martin Metals parts include the JT12, J52, JT8D, TF30 and FT4, and the General Electric TF39.

Airplanes flying on these engines include Boeing's 707, 720, 727, 737 and 747; McDonnell Douglas' DC-8, DC-9 and F-4; General Dynamics' F-111; Boeing Vertol's CH-47A; Grumman's OV-1 Mohawk; and Bell helicopters.

Significant technical gains have come from the metallurgists at Martin Metals. For example, during the past 10 years 10 new alloys have been invented, developed, produced and marketed by this division.

The new alloy of 1968 was MAR-M alloy 432. This high-strength, high corrosion-resistant alloy has special properties specifically designed for integrally cast turbine wheels. This is especially significant since a problem with these wheels in the past has been the inability of any one alloy to combine ductility in the center of the hub with high tensile strength in the outer rim. MAR-M alloy 432 is the first such alloy to combine these 2 physical characteristics and, at the same time, provide outstanding high temperature creep properties.

McDONNELL DOUGLAS CORPORATION

The McDonnell Douglas Corporation, with world headquarters in St. Louis, began its second year of operations on April 28, 1968, as one of the world's leading aerospace firms, and by midyear had begun to realize the potential of its synergistic merger.

The decision to produce the DC-10 advanced technology trijetliner was the most significant event in the company's commercial aviation programs during 1968.

Initial orders and options for a total of 110 of the wide-body luxury jetliners were received from American Airlines and United Air Lines. American placed orders in February for 25, with options for an additional 25, and United ordered 30, and optioned another 30, in April. Northwest Airlines ordered 14 DC-10s and took options for another 14 on October 29, bringing to 138 the total of DC-10 orders and options.

The Northwest orders were for an intercontinental DC-10 designated the Series 20, with 3 Pratt & Whitney Aircraft JT9D-15 engines, each producing 45,500 pounds of thrust.

The DC-10 Series 20 complements the domestic Series 10 DC-10 ordered by American and United and using 3 General Electric CF6 high bypass ratio jet engines in the 40,000-pound-thrust class.

McDonnell also announced a DC-10 Series 30 for intercontinental operation using an advanced version of the GE CF6 which will develop 45,600 pounds of take-off thrust. The Series 30 will be capable of operation up to 4,900 statute miles carrying 270 passengers. It will operate from 10,000-foot fields at maximum gross take-off weight of 490,000 pounds.

The "full speed ahead" commitment to build the DC-10 was announced April 25 by James S. McDonnell, corporation chairman.

Scheduled to enter airline service in 1971, the multirange trijet will accommodate 270 passengers in mixed-class seating and will carry up to 345 passengers in an all-economy configuration.

It will be 179 feet long and will have a maximum gross weight of up to 490,000 pounds, and its 20-foot-diameter fuselage will permit new standards of comfort and convenience for air travelers.

The DC-10 will operate economically on flights from 300 to 4,900 statute miles and will carry its full passenger capacity on nonstop coast-to-coast flights in the United States and on intercontinental flights.

Douglas Aircraft Company will assemble the DC-10 at its extensive facility in Long Beach, California. Other McDonnell Douglas divisions producing major DC-10 assemblies include McDonnell Douglas Astronautics, Santa Monica, California, the nose; McDonnell Aircraft, St. Louis, Missouri, design and development of the wing and production of certain control surface components; and Douglas Aircraft Company of Canada, Ltd., a McDonnell Douglas subsidiary, manufacturer of the wing structure in Malton, Ontario.

A team of experienced, reliable subcontractors from the United States, Canada and Europe was assembled by McDonnell Douglas to produce other major subassemblies and components for the DC-10.

McDonnell Douglas advanced into the DC-10 program while producing its 4-engine DC-8 jetliners and DC-9 twin-jets at a combined rate higher than that for any comparable period in its lengthy commercial aircraft history.

During the first 9 months of 1968, the Douglas Aircraft Company delivered 77 DC-8s and 153 DC-9s for a total of 230 jetliners, a company record.

Since the beginning of the 2 programs, a total of 396 DC-8s had been turned over to 32 airlines through September 30, 1968, and the same number of carriers had received a total of 378 DC-9s.

Additional orders for the various versions of the 2 aircraft were booked during the year, bringing total orders for the DC-8 Super Sixty Series to 230 as of October 24 and to 558 for the DC-9. In addition, 12 C-9A models of the DC-9 were ordered by the U.S. Air Force, of which 4 had been delivered by September 30.

During 1968 4 models of the DC-8 came off the production lines at Long Beach. They were the basic Series 50 model and the larger Super Sixty Series, including the Super 61 transcontinental model, the Super 62 ultra-long-range model and the Super 63 intercontinental model. These models included all-passenger, convertible passenger-cargo and all-cargo versions.

Another milestone in the 10-year life of the DC-8 family occurred in 1968. This was the certification and first delivery of the DC-8 Super 63F, an air freighter capable of hauling a larger payload a greater distance than any other commercial jet in airline operation.

The giant transport, in convertible passenger-cargo versions, can carry a maximum payload of nearly 110,000 pounds over transcontinental ranges. In an all-freight configuration, the DC-8 Super 63F can have more than 115,000 pounds of cargo. The convertible Super 63F was the 20th DC-8 model to be certified by the Federal Aviation Administration.

The DC-9 likewise was produced in 4 models: the Series 10, Series 20, Series 30 and Series 40, including all-passenger, all-cargo and convertible passenger-cargo versions.

The Series 20, a high-performance version of the DC-9, made its first flight on September 18. Combining the fuselage of the Series 10 with the high-lift wing of the Series 30, the newest of the DC-9s is designed for service on commercial air routes between cities with smaller airfields previously accessible only to propeller-driven transports. On its initial take-off, the Series 20 dramatically demonstrated its quick lift-off capability by using only 2,700 feet of runway to become airborne. The Series 20 will carry up to 90 passengers over ranges of more than 1,800 statute miles. It is equipped with either the 14,500-pound-thrust Pratt & Whitney Aircraft JT8D-9 jet engine or the 15,000-pound-thrust version of this power plant. First delivery of this new model of the twin-jet was scheduled for December 1968.

The year also marked the initial delivery of the Series 40 model of the DC-9. It was turned over to Scandinavian Airlines System on February 29. Biggest of the twin-jets, the Series 40 will accommodate a maximum of 125 passengers in its 125.6-foot fuselage, about 21 feet longer than that of the Series 20. The Series 40 was the third DC-9 model to be certified for commercial operation.

Two other noteworthy events occurred in the DC-9 program during 1968. The first executive jet version of the DC-9 was delivered in April, and the first all-cargo version was delivered shortly thereafter.

Another important first delivery was that of the military version of the DC-9, the C-9A Nightingale aeromedical airlift airliner, turned over to the Military Airlift Command of the U.S. Air Force at Scott Air Force Base, Illinois, on August 10. Delivery of the fully equipped flying hospital ward occurred less than a year after McDonnell Douglas received a contract for the C-9As from the Air Force Systems Command's Aeronautical Systems Division. The C-9A provides jet speed and comfort for wounded or sick patients on flights between military hospitals in the United States. It will accommodate more than 40 ambulatory patients, 30 to 40 litter patients or a combination of the 2.

In June the McDonnell Astronautics Company and Douglas Missiles and Space Systems Division were merged to create the McDonnell Douglas Astronautics Company, responsible for all corporate efforts in space, science and exploration, and for a wide variety of spacecraft, launch vehicle, missile and related programs. Headquartered in Huntington Beach, California, this new company consists of 2 major components, a Western Division and an Eastern Division in St. Louis. The company's projects include the Air Force's Manned Orbiting Laboratory, NASA S-IVB upper stage, the second stage for Saturn IB and third stage for the Saturn V lunar vehicle, Thor and Delta launch vehicles, development of the Spartan missile long-range interceptor for the U.S. Army's Sentinel ballistic missile defense system, development of the Dragon antitank missile for the Army, production of the Genie air-to-air missile for the Air Force, and pioneering work on many classified programs.

The McDonnell Douglas Corporation was organized in September into 4 major components, each operating under its own president: the McDonnell Aircraft Company, St. Louis; Douglas Aircraft Company, Long Beach; McDonnell Douglas Astronautics Company, Huntington Beach; and McDonnell Automation Company, St. Louis. Plans for the construction of a new corporate headquarters building in St. Louis were announced, as well as new manufacturing facilities in St. Louis and Long Beach.

At year's end, F-4 Phantoms were still in demand for U.S. armed forces and internationally, and production continued at a high rate. On September 5 the company delivered its 3,000th Phantom, a Navy F-4J.

In late April, 3 F-4Ks were delivered to the Royal Navy in Yeovilton, England, where the first Royal Navy Phantom squadron will be based, after a 4,700-mile transatlantic flight. The first 2 Royal Air Force F-4Ms were flown from St. Louis to Aldegrove in Northern Ireland by McDonnell flight crews on July 20.

Deliveries of F-4Ds to the Iranian Air Force began in September.

West Germany's Bundestag defense committee on October 24 approved purchase of a reported 88 RF-4E reconnaissance aircraft to equip its Air Force.

The Japanese defense agency selected the F-4E interceptor Phantom on November 1 as the mainstay fighter of its defense arm.

The company continued to modify and improve the Phantom. On May 15 an F-4 was flown with a beryllium rudder, the first time an aircraft was flown with a major load-carrying component fabricated of this material. On September 10 an RF-4C was flown with a boron composite rudder, the largest aircraft component of composite construction yet flown. The first flight of boron composite wing flaps took place on an A-4 Skyhawk in California in August. This material has a strength and stiffness comparable to steel, yet is lighter than aluminum.

In preparation for next-generation aircraft, the company was competing for both Navy and Air Force programs, especially the Navy VFX-1 and Air Force FX. On July 19, McDonnell was selected by the Naval Air Systems Command as one of 5 funded contractors for the contractor definition phase of the Navy's VFX-1 program and was working on a proposal for Air Force FX replacement.

On June 20, Eastern Airlines and McDonnell Aircraft Company announced a joint operational project to demonstrate the feasibility of using McDonnell's Model 188 STOL aircraft for city center to city center passenger service, the first practical on-location test of this aircraft and its supporting equipment. This 7-week demonstration program in Washington, Boston, New York and Newark began in September, and was followed by 3 weeks of evaluation at the Federal Aviation Administration's National Aviation Facilities Experimental Center. The Model 188 takes off in less than 1,000 feet, lands in less than 500, and cruises at about 250 miles per hour. It carries up to 64 passengers, and is the forerunner of larger, more advanced STOL aircraft being designed by McDonnell Douglas.

Military aircraft programs at Douglas included production of the A-4 and TA-4F Skyhawk. The A-4F attack bomber was delivered to the U.S. Navy and Marine Corps and was in service in Vietnam. The Navy also received additional TA-4F advanced jet trainers. More than 2,000 of the various versions of the Skyhawk had been produced by year-end.

On June 7 the New Zealand government announced selection of the Skyhawk to replace its Canberra jets in the Royal New Zealand Air Force's primary combat role. Placed through the United States government, the order included 10 single-seat Skyhawks and 4 Skyhawk trainers, with deliveries scheduled to be completed early in 1970.

Skyhawks also were produced for Israel and were in service with the Royal Australian Navy and the Argentine Air Force.

In the space field, the newly organized McDonnell Douglas Astronautics Company concentrated its activities on such launch vehicle programs as the Saturn S-IVB, Thor and Delta and such spacecraft programs as the Saturn I Orbital Workshop and the Manned Orbiting Laboratory.

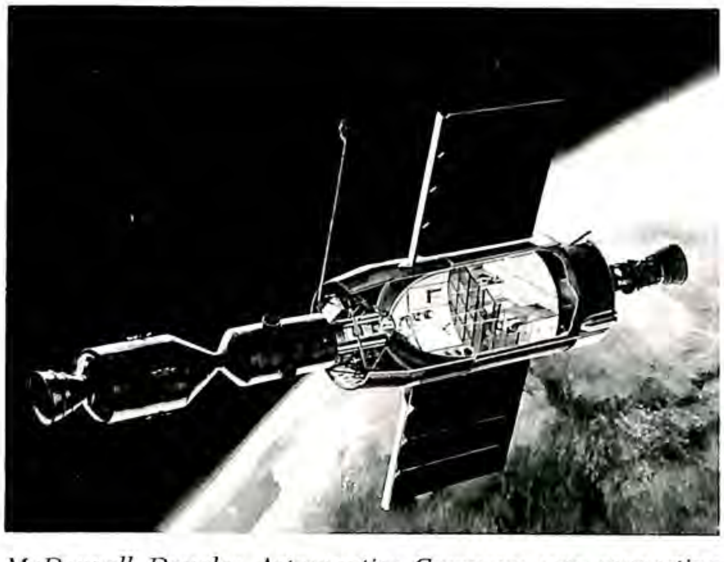
The 10th and 11th S-IVB rockets were delivered to the National Aeronautics and Space Administration's Marshall Space Flight Center for use as upper stages on either the Saturn IB or the Saturn V launch vehicles.

In January NASA announced an order for additional S-IVBs, increasing to 29 the total of the liquid hydrogen/liquid oxygen-powered stages it has ordered from McDonnell Douglas.

During the year the Delta established a new record of 25 consecutive launch successes. Through September 30, as the chief United States launch vehicle for research satellites, it had orbited payloads in 55 of 59 launches.

In July NASA announced the awarding of a $9,700,000 contract to McDonnell Douglas for 10 Long Tank Deltas, increasing to 88 the number of Deltas ordered since the beginning of the program. In addition, NASA and McDonnell Douglas signed a contract for more than $26,000,000 for Delta launch and related support services at Cape Kennedy and the Western Test Range.

The Air Force continued its utilization of the Thor as booster stage for classified launches from Vandenberg Air Force Base. The Long Tank Thor, only version of the rocket being manufactured, is 14½ feet longer than a standard Thor, permitting it to carry more propellants and thus extending its burn time and increasing its earth-to-orbit performance. Contracts were received from the Air Force during the year for production of additional Long Tank Thors and for launch services.



McDonnell Douglas Astronautics Company was converting an S-IVB stage to an Orbital Workshop (cutaway), to be flown in the Apollo Applications Program.

The company has a major role in NASA's Saturn Orbital Workshop program. Part of NASA's Apollo Applications Program, the workshop project involves the conversion of the empty liquid hydrogen tank of an S-IVB stage into a spacious experimental laboratory for a 3-man crew after the fuel is consumed in attaining orbit.

At the company's Space Systems Center in Huntington Beach, modifications and fixtures necessary for use of an S-IVB as a workshop are installed in the stage. A full-scale mock-up of the Orbital Workshop was built for NASA's Marshall Space Flight Center.

Testing performed as part of the workshop program included a series of airborne zero-gravity experiments using mock-up sections of the workshop in an Air Force KC-135. Purpose of the tests was to measure the ability of engineers and astronauts to work in hard-to-reach sections of the workshop during the brief periods of weightlessness achieved during the roller-coaster maneuvers in the jet aircraft.

The company's space-related research included a successful and productive experiment in which 4 crewmen spent 60 days in a simulated space chamber in a significant test of advanced life-support systems.

In the missile field, McDonnell Douglas Astronautics has a major role in the U.S. Army's Sentinel Ballistic Missile Defense System, established to counter the Communist Chinese missile threat. As a major subcontractor to Bell Telephone Laboratories and Western Electric Company, McDonnell Douglas is developing the Spartan, a 3-stage missile designed to intercept intercontinental ballistic missiles at long range.

During the year the Army announced 2 successful test firings of the Spartan at the Kwajalein Missile Range in the Pacific.

Another missile project of McDonnell Douglas Astronautics is the design, development and flight test of an experimental missile configuration known as Project UPSTAGE. Selection of the company for the program was announced in June by the Advanced Research Projects Agency. At that time the company was awarded the first increment of a planned $25,800,000 contract for the work. UPSTAGE is a follow-on to earlier programs conducted as part of Project Defender, a continuing series of research experiments in ballistic missile defense systems. Work on UPSTAGE was under way in Santa Monica.

Astronautics was also producing the Genie air-to-air missile for the Air Force's Air Defense Command. Genie has been in continuous production in Santa Monica and Sacramento for the Air Force since it first became operational in 1957.

Early in 1968 the company signed an agreement with Mitsubishi Heavy Industries, Limited, under which the Japanese firm will produce Nike Hercules air defense missiles under license from McDonnell Douglas. The agreement permits Mitsubishi and its subcontractors to produce the 2-stage missile with technical assistance from McDonnell Douglas.

Other missile and space programs of McDonnell Astronautics included research in such areas as solar physics, materials, reentry, electronics and biotechnology. In the latter field, for example, the company developed an engineering model of a lightweight undergarment designed for efficient removal of excessive body heat from astronauts during space missions. The work was done under a joint NASA-Air Force contract.

At the company's Donald W. Douglas Laboratories in Richland, Washington, scientists and engineers were developing 2 tiny atomic batteries, designated the ISOMITE and the BETACEL.

Both are long-life batteries designed to produce electrical power for such uses as operation of pacemaker devices implanted in heart patients, remote-site instrumentation or spacecraft self-powered devices.

Other projects of the Donald W. Douglas Laboratories include development of miniature engines which someday may be capable of implantation in the human body to operate heart-assist devices. Contracts for this work were received from the National Heart Institute and the Atomic Energy Commission (AEC).

Scientists there also developed the first heat pipe "space radiator," a unique spacecraft cooling system. Initial installation will be in NASA's Applications Technology Satellite (ATS-E).

McDonnell Douglas programs in the nuclear field also included participation in Douglas United Nuclear, a joint subsidiary of McDonnell Douglas and the United Nuclear Corporation. At the AEC's Hanford, Washington, facility, the firm operates reactor and nuclear fuel fabrication equipment under contract to AEC.

Research projects at Astropower Laboratories, a McDonnell Douglas Astronautics facility in Newport Beach, California, included development of heat-resistant, long-life chemical batteries for use in spacecraft, and investigations in such fields as pattern recognition, materials and desalination of sea-water.

At the corporation's basic research facility, the Advanced Research Laboratories in Huntington Beach, investigations in mathematical sciences, environmental sciences, materials sciences and life sciences were under way. Projects included research in acoustical holography and lunar geology.

The McDonnell Automation Company expanded its services to business, science and industry across the nation. At year-end there were offices in St. Louis, Denver, Houston, New York, Washington, D.C., Columbia, Missouri, Chicago and Los Angeles.

McDonnell Automation Company is one of the largest commercial utility companies in the world, and a service facility with large-scale computers available to many customers through the use of remote terminals. It operates 673 terminals in various cities in the United States, which transmit data to computers in St. Louis.

In June it began for the U.S. Department of Agriculture a sophisticated computer study of the potential of agricultural production in the entire Missouri River Basin—285,000,000 acres—for 20-

year periods: 1980-2000 and 2000-2020. The study evaluates the costs and benefits of irrigation, drainage, and flood protection projects. This analysis is one of the largest ever solved by computer, but McDonnell is capable of solving problems almost twice as large.

In July it received a study contract from the Army to develop a master plan for use in designing numerical control manufacturing facilities for spare and repair parts at the Edgewood Arsenal, Maryland, as part of a broad manufacturing methods technology program. Numerical control is a computerized technique that automatically directs a machine tool in fabricating metal parts. McDonnell Automation Company has performed numerous similar studies for industry, and the parent corporation has extensive numerical control experience. It is one of the world's largest users of NC equipment.

McDonnell Douglas Corporation is concerned with the problems of hard-core unemployed and, through the National Alliance of Businessmen, was attempting to do something about it.

On January 23, 1968, President Lyndon B. Johnson named James S. McDonnell, chairman and chief executive officer of McDonnell Douglas Corporation, to an executive board of 15 of the nation's leading businessmen from the nation's largest cities to attack the problem of hard-core unemployment. Mr. McDonnell is national director and chairman of the 10-state Region VII. Called the National Alliance of Businessmen, or NAB, this is a working group concerned not only with the policy but also with the operation of the program. It is a partnership between business and government to train the hard-core unemployed in a program called JOBS, or Job Opportunities in the Business Sector.

McDonnell components in 4 of the nation's 50 metropolitan areas were included in NAB's hard-core unemployment program and were participating in NAB's JOB pledge campaign.

In St. Louis, during 1968, the company began a 2-year training program for 90 hard-core unemployed in clerical and food service skills, and a 10-week summer training employment program, STEP, for 100 needy high school male students.

In Los Angeles the corporation established a 44-week program on job instruction in a production environment. In July, as part of JOBS, and NAB, it established an aircraft parts and assembly plant in Los Angeles to train and employ up to 500 hard-core jobless persons.

MENASCO MANUFACTURING COMPANY

Menasco in 1968 produced approximately 30 percent of the total United States requirement for aircraft landing gear, retaining its position as the largest volume producer.

The major contract award received by the company was an $87,500,000 contract from Lockheed-California Company in September, for design and manufacture of main and nose landing gear and retraction actuators for the Lockheed L-1011 luxury trijet, newest entrant in the commercial aviation field.

The contract followed an earlier announcement by President Gerald J. Lynch that Menasco would set up a separate organization for actuator design and production. In October he confirmed the announcement by revealing that a facility would be activated in the Los Angeles area for actuator production during the company's 1969 fiscal year ending June 30, 1969. Menasco had previously produced actuators as an adjunct to production of landing gear.

The president also announced plans for establishment of a new facility at Palmdale, California, primarily for the assembly, test and logistics support of the L-1011 landing gear. These installations are in addition to a 30 percent plant and facilities expansion scheduled for completion by January 1969, in both the Burbank, California, and Fort Worth, Texas, divisions of Menasco.

A $6,000,000 capital expenditure program for new machine tools and related equipment was authorized in September 1968 for the 1969 fiscal year. It followed an earlier $7,200,000 capital expenditure program announced in November 1967, and was part of a planned $25,000,000 investment for the years 1968 to 1971.

During 1968 Menasco participated in the following programs: Bell UH-1B helicopter program; Boeing 707, 720, 727 and 737 aircraft programs and CH-46A helicopter program; General Dynamics-Grumman F-111A and FB-111 programs; General Dynamics F-102, F-106 and B-58 programs; Ling-Temco-Vought A-7A and F-8U programs; Lockheed L-1011 trijet, C-5A military transport aircraft, C-130, C-141, P-3 and JetStar programs; McDonnell Douglas DC-9, F-4K and Saturn programs; North American Rockwell Apollo program; NASA Centaur, docking and reentry training programs.

Initial delivery of the first increments of bogie beams for the Lockheed-Georgia Company C-5A Galaxy transport was scheduled by Menasco for January 1969. Produced in the California Division, the bogie beams are being manufactured with several significant innovations in machining techniques. Program commitments were on schedule.

Menasco's backlog at the close of its fiscal 1969 first quarter was $139,000,000. Year-end financial results for the fiscal year ended June 30, 1968, set all-time highs for Menasco in shipments, earnings, assets and backlog.

Shipments were $44,462,673; earnings were $3,185,572, or $2.03 per share on average shares outstanding; and corporate assets increased from $25,639,890 to $30,973,054.

In 1968 President Lynch activated a Planning and Corporate Development Division headed by vice president J. Dean Meyer to implement Menasco's forward planning for new programs, new products, research and development and long-range facilities and employment growth.

NORTH AMERICAN ROCKWELL CORPORATION

North American Rockwell Corporation, formed by the merger of North American Aviation, Inc., and Rockwell-Standard Corporation, ended its first year of operation in September 1968, with sales of $2,639,784,000 placing it among the top 30 industrial firms in the United States. Net earnings totaled $73,750,000 for the year, with the backlog of unfilled orders totaling $3.49 billion.

The company's product line at year-end included aircraft, nuclear energy, missiles, electronics, space vehicles, rocket propulsion systems, automotive products, agricultural and industrial equipment, textile machinery and yachts.

The company was serving as prime contractor on the Apollo spacecraft command and service modules, the second stage of the Saturn V launch vehicle and the engines in all 3 launch stages. Its Tulsa Division was building the adapter housing the Lunar Module in which 2 astronauts will descend to the moon's surface and return; the auxiliary rocket motors for the second stage and the small thrusters for the command module are also NAR products.

This combination of activities made the company the leading industrial organization in the nation's lunar landing program.

During the year, major deliveries to the National Aeronautics and Space Administration included the first 3 Apollo spacecraft for manned missions and 4 S-II flight stages for the Saturn V launch vehicle.

The company played a key role in the historic Apollo 7 11-day earth-orbital flight of astronauts Walter Schirra, Donn Eisele and Walter Cunningham and in the 147-hour Apollo 8 lunar mission, crewed by astronauts Frank Borman, James A. Lovell and William A. Anders.

Apollos 7 and 8 used Command and Service Modules virtually the same as those that will be used during lunar landing missions in 1969 and 1970. The H-1 first-stage engines and the J-2 engines on the second stage of the Saturn IB booster were also identical to those to be used in lunar landing missions.

Successful completion of the flights, together with preceding flights in the Apollo series, was more than tacit evidence that North American Rockwell has met and overcome the technological problems of the program.

Concurrently, the company's Space Division continued to look ahead. Division scientists and engineers were preparing studies, designs and experiments for future ventures into space and for interplanetary flights, both manned and unmanned.

A major effort concerned NASA's immediate Apollo Applications Program, the national space effort which will follow the lunar landing. Related activities include the Astronaut Maneuvering Unit, which will be used to assist astronauts in movement during space flight or within space stations. A test vehicle of this unit was built, as was a Remote Maneuvering Unit designed to operate and perform varied functions in space while being controlled from a base station.

NASA had invited the division to make a proposal on a one-man flying platform that will skim over the moon's surface. A test platform was flown in the earth's atmosphere and a simulation program was being conducted.

As the nation's principal designer and builder of large liquid rocket engines, the company has supplied propulsion for several of the nation's large ballistic missiles and for more than 800 U.S. military and civilian space launches. In 1968, company-produced engines were used in 34 successful space vehicle launches.

Generating 1,522,000 pounds of thrust, the F-1 is the most powerful liquid propellant rocket engine in the free world. It is clustered in a group of 5 to provide 7,610,000 pounds of thrust, or 160,000,000 horsepower, for the first stage of the Saturn V launch vehicle. The F-1 was in regular production for the Apollo/Saturn V program.

With the initial Saturn V boost already provided by the F-1s in the first stage, the second stage is powered by 5 J-2 engines. Each generating up to 225,000 pounds of thrust, they achieve high efficiency by using liquid hydrogen as fuel. The J-2 engines, the nation's largest operational liquid hydrogen engines, were also in production.

Eight H-1 engines, each generating 200,000 pounds of thrust, provided the first-stage power for the Apollo/Saturn IB flights.

During the year the company's plant at McGregor, Texas, delivered solid-propellant rocket motors under accelerated schedules for the Sparrow, Phoenix and Shrike missiles, and gas generators were provided for the Navy's Tartar and Terrier missiles and the Army's Shillelagh missile.

Rocketdyne was selected to provide the rocket engines for the Navy's Condor air-to-surface missile. A Rocketdyne-developed injector was selected for use on the Apollo Lunar Module ascent engine which will boost astronauts off the moon and back to the orbiting Apollo command module during the lunar landing mission.

The division's jet engine components operation during the year made deliveries on afterburners for aircraft jet engines.

In June the SNAP-8 (Systems for Nuclear Auxiliary Power) developmental reactor sustained nuclear chain reaction in ground tests at the company's Atomics International division. This was an advanced test version of a compact reactor being developed to provide auxiliary electrical power for future earth-orbital, lunar and deep space missions. It also has potential application as a source of power in remote terrestrial and offshore areas.

The nation's most complete aerospace electronics center in one geographic location is in Anaheim, California, where the company's Autonetics Division complex covers 267 acres. Here, more than 3,000,000 square feet of facilities are devoted to research, design, development, test and fabrication of electronics products.

In 1968, Autonetics continued production on the Minuteman II intercontinental ballistic missile program. The division is associate prime contractor for Minuteman II guidance and control equipment and is responsible for 99 percent of the missile's electronics.

Test flights were begun on the Minuteman III with the first research and developmental system successfully launched down the Atlantic Missile Range from Cape Kennedy in August.

The nation's most advanced all-digital computer-controlled avionics systems for the Air Force's new FB-111A strategic bomber were flight tested and F-111D advanced tactical fighter bomber preproduction systems were delivered.

Avionics systems for the FB-111A were in production as flight tests continued on development models. F-111D system development tests and production continued. Both versions use microelectronic circuitry to improve performance while reducing size and weight and increasing reliability.

Modification continued on Ship's Inertial Navigation Systems (SINS), which are guiding the U.S. nuclear-powered submarine fleet armed with Polaris and Poseidon ballistic missiles. The extreme navigation accuracy of SINS enables a submarine to launch its missiles while submerged because SINS continually updates the submarine's exact position. Nearly all United States and British submarines armed with Polaris missiles are equipped with Autonetics' SINS. The new Poseidon missile and modified SINS will be aboard 31 of the 41-vessel nuclear fleet.

Maintenance and repair of inertial navigators continued for the Hound Dog air-to-surface nuclear missile carried by the B-52 strategic bomber.

Autonetics, the world's largest producer of military airborne digital computers, neared the milestone of producing its 4,000th airborne computer. In production were 2 types of Minuteman computers and a navigation computer for the F-111 program. Aircraft navigation and launch computers for the Short-Range Attack Missile (SRAM) and Condor missile were under development and test.

Along with the F-111D attack radar, Autonetics was producing the radar-equipped navigation system for the Navy's RA-5C Vigilante tactical reconnaissance aircraft manufactured by the Columbus Division. Columbus also was working on associated carrier-based intelligence systems for use with the RA-5C.

Autonetics was updating the series of radars for the F-104 NATO aircraft and the U.S. Air Force F-105s. Additionally, prototypes of an improved radar for the Italian Air Force's F-104 aircraft were built. Research on advanced radars such as electronic phased-array models was continuing.

The division developed such off-the-shelf advanced microelectronic circuitry as metal oxide semiconductors (MOS) and silicon-on-sapphire (SOS) micromemories. Applications are in such rapidly growing fields as computers, calculating, and the conversion, processing and transmission of digital data. This technique, which Autonetics is preparing for aircraft and ships, enables one or 2 lightweight coaxial cables to do the work of much heavier, complicated wiring. As an example, Autonetics was manufacturing and delivering MOS devices for use in the music and film system installed in the Boeing 747 and was manufacturing other advanced circuitry for sales off the shelf.

Advanced research and development of microelectronic circuitry and materials for microwave application were being pushed vigorously. This technology represents important breakthroughs, with promise for advanced radars and other microwave equipment.

In other areas Autonetics was manufacturing electronic support equipment for the Apollo spacecraft and Saturn automatic check-out equipment for aircraft and missiles; developing and producing antisubmarine warfare equipment; and pursuing research and development of advanced lasers, optical star trackers and infrared sensors.

The division was conducting advanced, government-funded avionics studies for new aircraft programs, including the Advanced Manned Strategic Aircraft (AMSA) and advanced tactical aircraft (FX) for the Air Force and the carrier-based air superiority aircraft (VFX) for the Navy.

Production of second-generation integrated circuit devices began in a new 40,000-square-foot, $1,600,000 microelectronics facility at the division's Anaheim complex. Autonetics previously had produced these critical integrated subsystems on a pilot-line basis for use in advanced systems. The new facility is a part of Autonetics' long-range plan to manufacture this advanced circuitry for its own use and for sale on the open market.

Also at the Anaheim complex, the division completed and occupied during 1968 a new 270,000-square-foot systems engineering building. The division's Minuteman program office is housed in the $5,000,000 structure.

Construction began in October on a new 1,000,000-square-foot electronics center on a 92-acre site, part of the company's 1,300 acres at Laguna Niguel, California. It will be the world's largest single electronics engineering and manufacturing facility under one roof. Initial occupancy was scheduled for late in 1969 for manufacturing, engineering and support operations for computers, data processing and life science systems.

During 1968 aircraft sales increased over the previous year. The Los Angeles and Columbus (Ohio) divisions were combined organizationally into a single aircraft group with a common advanced engineering organization to insure the most effective utilization of research and manufacturing capabilities.

The Columbus Division produced 3 different types of aircraft under Navy contracts.

By year-end all of the Navy's A-5A attack aircraft had been converted to the RA-5C tactical reconnaissance version and a contract for additional RA-5Cs was being fulfilled.

New orders for a substantial number of OV-10A light armed reconnaissance aircraft were received from the Navy during the year and the Columbus Division was producing them at the rate of one each working day. The OV-10A entered operational service with the Marine Corps in July.

In the T-2B/C twin-jet Navy trainer program, orders for many additional aircraft were received during the year. The latest aircraft ordered were of the new T-2C configuration which features lighter-weight engines for improved performance.

T-28 trainer aircraft were being modified to an attack configuration for deployment to countries around the world. Additional modification effort for the T-28 was planned by both the Navy and Air Force.

Development of the Navy's Condor air-to-surface missile continued throughout 1968.

At the Los Angeles Division, flights of both the 2,000-mile-an-hour XB-70 experimental air vehicle and the hypersonic X-15 rocket research aircraft continued under flight research programs administered by NASA.

Utilizing the facilities of its expanded Structural Machining Center, LAD carried out a wide range of subcontracts. Work included wings for Bell's HueyCobra helicopter, horizontal stabilizers for the McDonnell Douglas DC-9 commercial transport, and tooling for such aircraft as the Boeing 747 jumbo jet transport.

The durable F-100 Super Sabre fighter-bomber, rolled out by the Los Angeles Division in 1953, was performing vital service for the United States in Southeast Asia. The company produced a wide range of F-100 modification kits for the Air Force under a program for further extending the service life of this nation's first operational supersonic airplane.

Production of the Sabreliner business jet in the 10-passenger Series 60 model was stepped up during the year. Announcement was made that the aircraft would have nonstop transcontinental range with the installation in future aircraft of the new ATF 3 bypass engine being developed by The Garrett Corporation. The engine, in the 4,000-pound-thrust class, will be designed for retrofit to all Series 60 airplanes.

Early in the year Sabreliners passed the 1,000,000th flight hour as the more than 300 aircraft operated by the Air Force, Navy and civilian organizations continued in operation.

A new use for the versatile airplane was announced in October when a modified Sabreliner was delivered to the National Center for Atmospheric Research. NCAR will use the airplane for investigation into jet stream dynamics and turbulence, upper troposphere and lower stratosphere air movements, cloud physics and atmospheric electricity. Modification included installation of a long nose boom with special sampling probes, a sonde and chaff pod under the fuselage, a large nose radome and special fuselage doors and punting points for research equipment.

The Tulsa Division continued to build fuselage and wing leading edge sections for Boeing's 747 jetliner and parts for Boeing's CH-47A Chinook helicopter.

For the company's Aircraft Group, 1968 saw substantial progress in research and development work on one or more of the forthcoming major new aircraft weapon system competitions, including the versatile VFX-1 Navy carrier-based fighter; the Air Force advanced tactical air-superiority FX fighter; the Air Force Advanced Manned Strategic Aircraft (AMSA) to replace the B-52s; the Air Force vertical or short take-off and landing light intertheater transport (LIT); and the Air Force AX ground support aircraft.

North American Rockwell continued to manufacture a complete line of Aero Commander propjet and piston-engine business, private and agricultural aircraft in addition to 2 models of the Sabreliner.

The Aero Commander Division introduced a new merchandising concept for its line of planes in 1968. In concert with a "Tough Birds" advertising theme, the names of all planes were changed, each being identified by the name of a bird (Thrush Commander, Lark Commander, etc.).

Simultaneously, physical innovations were introduced into certain models, such as a new style radome nose and large picture windows, and all models were cosmetically changed to improve interior styling and sound control.

In February the Aero Commander Division joined forces with the University of Oklahoma to build a new research and development center at Norman, Oklahoma.

Acquisition of Remmert-Werner, Inc., one of the largest fixed-base operator organizations, was completed in April. At that time Remmert-Werner operated sales and service facilities in Trenton, Cleveland, Toledo, St. Louis and Perryville, Missouri, Dallas and Los Angeles. Later it established and prepared to operate an aircraft flight training, maintenance and service organization at a new 50,000-square-foot facility in Homestead, Florida. The facility will consist of a Federal Aviation Administration-approved repair station capable of performing major maintenance, overhauls and interior installation for all types of general aviation aircraft.

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 specialities—of the 115,000 people of North American Rockwell.

NORTHROP CORPORATION

Northrop Corporation completed its third consecutive record year, producing new high earnings, sales and backlog. Since 1965 the increase in net earnings averaged more than 20 percent per year, including a 25 percent gain in the past fiscal year. Total employment of the company and its subsidiaries rose to more than 25,000 and facilities expansion was completed for manufacture of major subassemblies for the Boeing 747.

Programs in communications, electronics, aircraft and other areas contributed to company gains during 1968 and increases were realized prior to the impact of the 747 program. While it will soon become the largest program, this project was still in its buildup phase in 1968 and 747 production accounted for less than 3 percent of sales.

Major increases were achieved in the national and international application of communications and electronics systems and both surface and aerial navigation.

First deliveries of the 153-foot center fuselage section for the Boeing 747 were made in 1968 with production scheduled to reach 31 shipsets in fiscal 1969 and 71 in 1970. Special equipment installed for high-volume commercial aircraft items, including stringers, wing fairings and titanium and aluminum flooring, is applicable for production of such components for other transport programs.

In military aviation, 3 new versions of the Northrop F-5 Freedom Fighter flew for the first time in 1968. They are the CF-5, produced under license in Canada; the SF-5, produced under license in Spain; and the RF-5, a photoreconnaissance version being built at Northrop for several U.S. allies. The NF-5, being built for the Netherlands, was scheduled for first flight in 1969. F-5 production was programmed into fiscal 1974.

Increased pilot training requirements extended the lifespan of the T-38 Talon supersonic trainer in use by the Air Force. The 1,000th T-38 was to be delivered to the Air Force in January 1968 and production was scheduled into 1972.

Northrop engineers were working with governments of several other nations on design requirements for a new generation tactical fighter for use by allied air forces in the 1975-85 period. It was expected this airplane would be introduced through a multinational program of joint development and production. In another program, Northrop was one of 4 companies developing designs and engineering data for a new close-support fighter, the AX.

Northrop started production for the Navy of the jet-powered MQM-74A high-speed, high-altitude target.

The company's high-speed, high-altitude target, the jet-powered MQM-74A, went into production for the U.S. Navy during the year.

A communications satellite earth station in Panama, the first in Central America, was completed by Northrop's subsidiary, Page Communications Engineers, Inc., and work was started on earth stations in Iran and Lebanon. Other Northrop-Page stations were installed in Maine, Washington, Hawaii, the Philippines, Thailand and Australia.

In another major field of long-range communications, Page completed the largest privately owned microwave troposcatter system in the world for joint use of Oasis Oil Company of Libya and Esso Standard Libya. Similar systems were being built for Occidental Petroleum Corporation of Libya and the Cabinda Gulf Oil Company of Luanda, Angola. Page was also maintaining and operating the 470,000-circuit mile radio communications network for the U.S. Army in Southeast Asia. This system was designed and installed by Northrop-Page.

This subsidiary was studying communications requirements for the University of California 9-campus system, updating a statewide information system for the Pennsylvania State Police, and conducting a study for the President's Task Force on Communications Policy to evaluate satellite communications techniques and their impact upon worldwide communications.

Another Northrop subsidiary, The Hallicrafters Company, received new orders for village radio systems now used to upgrade internal communications for 42 countries in Africa, Asia and South America.

U.S. Underseas Cable Corporation, a Northrop affiliate, was completing a 450-mile underwater cable between Siberia and Japan and was developing a 2,000-channel system for deep ocean communication.

The Northrop-designed inertial-Doppler navigation system for the USAF/Lockheed C-5 Galaxy transport, the world's largest airplane, moved into full production. The C-5, designed for worldwide deployment of troops and supplies, must be able to operate without resort to ground-based navigation aids. It utilizes Northrop airborne computers with its navigation and malfunction detection systems.

Northrop was chosen by the U.S. Navy to produce shipboard receivers for the Omega navigation system which will utilize low-frequency radio signals from 8 signals to provide a true worldwide position-fixing system. Northrop concluded an agreement with Marconi International Marine Company Limited of England to distribute Omega receivers for commercial use in the United Kingdom. Northrop also developed an airborne computerized Omega receiver for the Navy.

Other specialized electronics developments included application of the Polaris automatic checkout system to the Navy's new submarine-based Poseidon, evaluation of test evaluation and monitoring systems to be installed aboard all new Navy destroyer escorts, and a U.S. Army assignment to install Northrop voice warning malfunction detection systems aboard OV-1 aircraft and CH-47 and CH-54 helicopters.

During 1968 Northrop's Apollo earth landing system met NASA specifications following modification to accommodate an increase in the moon vehicle's weight from 11,000 to 13,000 pounds. This system will be used throughout the Apollo manned space flight program, inaugurated by the late 1968 flights of Apollos 7 and 8.

Under contract to NASA's Langley Research Center, Northrop tested several versions of the parawing astronaut landing system. This is a flexible fabric device combining characteristics of both aircraft wing and parachute. Program goal is to fabricate and demonstrate a large parawing suitable for landing a space vehicle weighing up to 9 tons.

In another space program, the Northrop-built HL-10 lifting body began rocket-powered flights during the year at Edwards Air Force Base, California.

Other Northrop space-related work ranged from the OV-2 research satellite to operational support of the Lunar Receiving Laboratory at NASA's Manned Spacecraft Center, Houston, Texas.

Weaponry production included Hawk missile loaders and components as well as a variety of ordnance.

Work progressed on a development program for the U.S. Navy of a torpedo-sized target which will simulate the characteristics of a full-scale submarine for the training of antisubmarine warfare forces.

In another ocean-related program, Northrop delivered communications and medical monitoring stations to be used in the Navy's Deep Submergence Systems Project.

Under a program sponsored by the U.S. Department of Labor, Northrop opened a training center in Venice, California, offering remedial education and technical training for people previously considered unemployable. The program is one of several Northrop approaches to assist the National Alliance of Businessmen's attack upon the hard-core unemployment problem.

PACIFIC AIRMOTIVE CORPORATION

On June 14, 1968, Pacific Airmotive's parent company, Purex Corporation, Ltd., acquired Airwork Corporation, headquartered at Millville, New Jersey. Purex began operating Airwork as a wholly owned subsidiary and as part of its Pacific Airmotive Group. Airwork's engine overhaul capabilities in the small airline, corporate operator and general aviation fields supplemented the engine overhaul and repair operation of Pacific Airmotive at Burbank, which is geared to the large airline customer. Added to the aviation products distribution network of Pacific Airmotive, Airwork's corresponding activities gave the group extensive coverage in important aviation markets throughout the United States and overseas.

Another addition to the Pacific Airmotive Group of Purex was made on October 24 through acquisition of the R. J. Enstrom Corporation of Menominee, Michigan. Enstrom is the developer and manufacturer of the 3-place, piston-engine F-28A helicopter. Development of a new turbine-powered version was initiated and slated for production in 1969.

The 3-place F-28A helicopter was being manufactured by R. J. Enstrom Corporation, which became a part of Purex Corporation's Pacific Airmotive Group.

Final details were completed in November for the acquisition of Aircraft Turbine Service, Inc., and Jet Turbine Service, Inc., New York. Handling overhaul of small gas turbines and components, the companies were also being operated within the Pacific Airmotive Group.

In 1968 an agreement was signed with General Aircraft Corporation under which Pacific Airmotive will manufacture the fuselage and empennage of the GAC-100, a 4-engine, 32-passenger commuter aircraft. Production go-ahead was scheduled for April 1969.

Cessna Aircraft Company selected PAC as the Southwest dealer for its new Fanjet 500, introduced at the National Business Aircraft Association convention in October. An 8-place business jet, the Fanjet 500 has a take-off weight of 9,500 pounds with a 402-mile-per-hour cruise speed. Customer deliveries of the aircraft were to begin in January 1972.

Effective October 15, Pacific Airmotive assumed complete ownership and responsibility for the conversion of the Convair 340/440 piston-engine aircraft to Allison turboprop power under an agreement reached with the Allison Division of General Motors Corporation. PAC launched a program for the sale of Convair 580 aircraft directed to domestic and foreign airlines and corporate and government customers.

During the year PAC completed the first executive interiors, including design and installation, on Boeing 737 and Douglas DC-9 aircraft. Sales and post-factory completion of the Fan Jet Falcon and Handley Page Jetstream continued to be important programs handled at the company's Long Beach facility.

Pacific Airmotive expanded its DC-6 conversion program with the purchase of 14 DC-6B aircraft to be modified as flying showrooms and/or classrooms, and for airline service.

Cal-State Air Lines, new third-level carrier initially serving 17 counties in California, signed a contract jointly with PAC providing for the complete maintenance and service by Pacific Airmotive of the airline's fleet of Handley Page HP-137s and Beech 99s. The work was being performed at PAC's Long Beach base.

Construction began on a new engine test cell complex which will accommodate the high-thrust jet engines powering the Boeing 747, Lockheed L-1011 and other advanced big jets, with completion scheduled for early 1969. Capable of testing engines of up to 100,000 pounds thrust, the test cell facility also will be utilized in conjunction with test and overhaul services required for Pratt & Whitney Aircraft JT9D and Rolls-Royce RB.211 engines during their respective preproduction ground and flight testing by Boeing and Lockheed.

Significant facility rearrangements and new plant construction were undertaken in preparation for implementing the big jet programs, including a 100,000-square-foot addition to the company's jet engine overhaul building with relative equipment and machine tool additions. At the close of the year, PAC's complement of heavy maintenance, accessory and test facilities had increased by 50 percent.

PAC's computer capabilities were enlarged in the area of inflight monitoring and parts failure statistics. By the employment of engine condition and mean time between failures data obtained from computer print-outs, Pacific Airmotive offered its customers evidence of engine and parts performance imperative to receipt of FAA approval for "on-condition" engine maintenance programs replacing the usual fixed time interval overhaul.

Another new program was the PT6 turboprop and JT12 pure jet engine maintenance program offering repair and overhaul, engine exchange and leasing, hot section inspection, basic and QEC engine accessory exchange, accessory repair and line and base maintenance kits including hot section inspection kits. PAC's small turbine activities were coordinated with those of Airwork's to provide consistent coast-to-coast engine service for operators in the United States.

Pacific Airmotive continued to support piston fleets throughout the world, servicing large Pratt &

Whitney Aircraft piston engines and Curtiss-Wright R3350s.

Service contract agreements were signed in 1968 with the McDonnell Douglas Corporation (for support of the JT8D engines on the USAF C-9A aircraft) and with Air California as well as with a number of other carriers.

In September ground was broken for the new 16,000-square-foot office and warehouse building later occupied by the Oakland Branch of the Aviation Products Division. The new building houses the $1,500,000 inventory of aircraft components, systems and supplies, as well as personnel and equipment, required to support PAC's airline provisioning and general aviation business in northern California and Nevada.

A new, improved Fuel Flow Test Bench model, designated the T420, was introduced by Pacific Airmotive in 1968. An important feature of the model is its unique capacity to test not only the Bendix PS and RS Fuel Injection systems but also the Continental Fuel Injection systems and engine-driven fuel pumps. Production of the T420 Bench marked the first time that both Bendix and Continental systems can be tested, measured and calibrated on a single stand.

Sales of Cessna aircraft rose sharply in 1968 over 1967 in Pacific Airmotive Corporation's Light Aircraft Division through its wholesale operations: Airflite, Inc. (Long Beach), Arinada Aircraft (Phoenix) and Business Aircraft Distributors (Oakland). Responsible in part for the increase was the introduction of the all-new Cardinal, a 4-place family aircraft, and Cessna's new pressurized entry in the executive market, the 6-place Model 421.

The record pace of student starts realized during the year contributed substantially to sales in the Learn-To-Fly category, Models 150 and 172 and the Cardinal.

Because of the extensive Air Age Education programs offered by Cessna Aircraft Company and implemented by PAC's distributor organization, interest in aviation instruction at the high school and junior college levels increased dramatically. A number of schools were offering not only classroom courses but flight experience as well. To stimulate schools in the area of flight instruction, Pacific Airmotive donated 2 new Cessna 150s to a high school and a junior college for use in their aviation programs for the 1968-69 school year.

PHILCO-FORD CORPORATION

AERONUTRONIC DIVISION

Philco-Ford Corporation's Aeronutronic Division ended calendar year 1968 with the highest backlog in its nearly 13-year history and simultaneously recorded the highest annual sales.

Aeronutronic, with headquarters in Newport Beach, California, is one of 11 divisions of Philco-Ford, a subsidiary of Ford Motor Company.

The Newport Beach aerospace/defense firm was engaged during 1968 in research, development, test and manufacture of tactical missile systems, air defense systems, automatic weapons, stabilized fire control systems, propulsion products, high-strength armor, radar, reconnaissance and intelligence systems, and missile and bomb fuzes.

Highlighting Aeronutronic's activities in 1968 was the awarding of the first increment of a 3-year $100,000,000 production contract for continued manufacture of the U.S. Army Shillelagh guided missile system, one of the division's major programs. Aeronutronic is prime contractor to the U.S. Army Missile Command for Shillelagh.

A separate $13,800,000 contract was awarded during the year to Aeronutronic for continuing production of guidance and control equipment for the Shillelagh missile system.

During 1968 the Shillelagh missile was deployed with additional U.S. Army troops within the U.S. and completed a testing program in Australia as part of a 4-nation military standardization loan program involving the United States, Great Britain, Canada and Australia.

Additionally, in mid-1968, Shillelagh desert tests and simulated arctic and tropic tests were conducted concurrently in 90 degree summertime temperatures in the New Mexico desert at White Sands Missile Range. Some of the test missiles received "arctic preconditioning" prior to firing, including storage tests at minus 65 degrees. Simultaneously, other Shillelagh missiles were prepared for "desert" firings after being preconditioned to 145 degree temperatures prior to launch, and missiles used for "tropic test" firings were preconditioned for humidity as well as high temperature prior to launch. Firings were made from 2 advanced U.S. Army vehicles: the General Sheridan armored reconnaissance airborne assault vehicle and the M60 A1E1 Main Battle Tank.

In an earlier test program over 100 Shillelagh missiles were fired in less than a week at Fort Riley, Kansas, in the first troop firings of the newly deployed missile system. The first troop firings resulted in a high record of successful hits by the 1st Battalion, 63rd Armor, at Fort Riley.

In addition to the General Sheridan and M60, Shillelagh was slated as the main armament for the new Main Battle Tank (MBT-70), being jointly developed by the U.S. and the Federal Republic of Germany for the 1970s.

Aeronutronic continued to produce the Chaparral air defense guided missile system, also under contract to the U.S. Army Missile Command. A $15,600,000 "second buy" Chaparral production contract was received by Aeronutronic in early 1968 for the manufacture of Chaparral launch and control assembly units. In addition to producing the launch and control assembly units, Aeronutronic is systems contractor on Chaparral, one of 2 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 the fall of 1968, Aeronutronic received several "third buy" contracts on the Chaparral air defense system for hardware, research and development, and engineering services, totaling approximately $33,000,000.

Initial production testing of Chaparral was carried out by the Army Test and Evaluation Command's Air Defense Board at Fort Bliss, Texas, during 1968, and plans were being made to transport men and equipment to Fort Greely, Alaska, and Fort Clayton, Panama Canal Zone, for evaluation of the effects of arctic and tropic environments on the system and all associated components before equipment is issued to troops in the field.

Aeronutronic continued production and development of advanced automatic weapons, including the XM129 grenade launcher and the XM140 automatic cannon, both designed for aerial applications.

In addition, during 1968, Aeronutronic completed production deliveries of the Vietnam battle-proved M-75 airborne grenade launcher. M-75 weapons delivered by Aeronutronic to the U.S. Army Weapons Command are mounted by the Army in the nose turret of the UH-1B Huey tactical helicopters as a part of the M-5 weapons systems.

The XM129 40-millimeter grenade launcher, in production by Aeronutronic, was also designed for several helicopter applications, including the UH-1C Huey, AH-1G HueyCobra, LOH, and AH-56A Cheyenne.

The XM129 is one of the world's 2 most advanced automatic weapons which were being built by Aeronutronic for the AH-56A Cheyenne high-speed combat helicopter. The other weapon is the XM140 30-millimeter automatic cannon, which will furnish the main firepower for the Cheyenne. The XM140 is mounted in a turret beneath the Cheyenne and the XM129 is mounted in the aircraft chin turret.

Three separate contracts totaling $6,000,000 were awarded to Aeronutronic in mid-1968 for development, advance production engineering, and production on the XM140 automatic cannon. Later in the year, it was announced that the XM140 had entered Engineering Tests/Service Tests (ET/ST), bringing the advanced new weapon another step closer to ultimate production.

In late September, Aeronutronic announced that it was leasing a new 879-acre site near San Juan Capistrano, California, for a remote test facility. The facility will be used to support various Aeronutronic research, development and manufacturing operations, with primary emphasis on testing of ordnance and electromechanical products under development and production for the Department of Defense. First increment of the new facility was scheduled to be completed in early 1969, with the second increment scheduled for mid-1969 completion. The overall program called for continuing development and expansion by Aeronutronic over the next 5 to 10 years.

Production continued at Aeronutronic on a lightweight, highly effective dual property steel armor which provides excellent multiple hit protection for helicopters and small boats. The Aeronutronic-developed armor plate is an adaptation of a patented Ford Motor Company process for producing ultra-high-strength steel. The steel is designated by the trademark AUSFORM. It is used on helicopters, fixed-wing aircraft, small boats and other vehicles where minimum weight and thickness are required for maximum ballistic protection against armor-piercing and ball-type projectiles. The armor has been installed on helicopters and river boats in Vietnam. Both .30-caliber armor and .50-caliber armor are produced by Aeronutronic.

Aeronutronic continued development and production of unique hot gas missile control valves for the Department of Defense. Aeronutronic is a major supplier of hot gas missile control systems and has in the past 5 years provided such systems for a number of missile and spacecraft programs. Various configurations of the valves were in production for guided missile programs of the U.S. Army, Air Force and Navy.

In 1968 Aeronutronic announced the development of an extremely low-cost, high-speed, rocket-powered military air target made of rolled paper tubing. Known as LOCAT (Low-Cost Air Target), the new military target vehicle is an expendable, 15-foot long, 155-pound air target which pops up from its ground launch site like a clay pigeon at a shooting range and attains speeds in excess of 500 miles per hour within 2 seconds. It was designed and developed by Aeronutronic for training of air defense gun crews against low-altitude enemy aircraft. LOCAT is a trademark of Philco-Ford Corporation.

In applications for which LOCAT targets are designed, the military can reduce air target "presentation" costs approximately 50 percent. A "presentation" is one pass of a target for the gunners. Generally designed for altitudes of 1,000 feet, but with a 10,000-foot range, the LOCAT target has a flight time of about 17 seconds. This can be adjusted through use of different launch angles to vary the range, altitude and flight time.

The LOCAT target consists of a minimum number of components: (1) a nose cone made of glass-reinforced plastic, (2) a sustainer motor, (3) a fuselage made of rolled paper tubing of the type used to store and ship household carpets, (4) glass-reinforced plastic fins and (5) the booster rocket motor which consists of 3 2.75-inch Folding Fin Aircraft Rockets (FFAR) of the type used as armament on some military aircraft. LOCAT targets were under evaluation by the Army and the Navy and were the result of cost-consciousness in both management and engineering philosophy at Aeronutronic.

PIPER AIRCRAFT CORPORATION

A top-level change in management, occupancy of new quarters and a record sales level approaching the $100,000,000 mark highlighted 1968 for Piper Aircraft Corporation.

In February, W. T. Piper, Jr., was elected president of the corporation. Mr. Piper had been with the company since 1934 and had been executive vice president, a position assumed in the 1968 switch by his brother, Howard Piper, previously vice president-research and development. W. T. Piper, Sr., who had been both president and chairman of the board since the founding of the company, retained the position of chairman of the board.

Piper's sales for the 1968 fiscal year (ended September 30) totaled $96,724,000, a 20 percent increase over the previous year and a record for the company. Net income increased 29 percent, from $2,991,000 in 1967 to $3,863,000 in 1968. Net income per share was $2.36, compared with $1.83 in 1967.

Piper officials attributed the record year to a steadily increasing demand for Piper's products, especially in the twin-engine line, where sales of Piper's new Navajo led the industry in its class for the year. To meet the demand, the company occupied 2 new plants at Quehenna and Renovo, Pennsylvania, where metal and fiberglass component parts for Lock Haven production were being manufactured.

Piper also occupied during the year a new corporate administration building at Lock Haven. The building serves as international headquarters for executive, administrative, marketing and sales staffs. Included in these organizations are finance and accounting, advertising, sales promotion, market research, public relations, customer service and spare parts, and corporate planning. The building contains approximately 33,000 square feet of floor space and its tiered effect of floor-to-ceiling tinted windows gives it an ultramodern appearance.

In November it was announced that Piper had selected Lakeland, Florida, as the site for a $2,000,000 manufacturing plant for a new 18-place commuter airliner. The plant will contain more than 100,000 square feet of floor space for assembly, paint and plastics operations and offices required for manufacture of the PA-35 Pocono. The facility will be constructed on 100 acres adjoining Lakeland Municipal Airport, with another 100 acres under option.

Piper's Lakeland operation will be confined initially to final assembly of the Pocono, which at year-end was in flight test status at the company's Vero Beach Research and Development Center. The Pocono, priced in the $200,000 category, has twin turbocharged engines of 500 horsepower each and a gross weight of 9,500 pounds. It made its first flight May 13, 1968.

In September, Piper signed contracts with all 3 major television networks for a concentrated "Learn to Fly" push. Time was purchased on the CBS "Evening News with Walter Cronkite," on NBC's "World Series of Golf" and on ABC's "Wide World of Sports."

In October, Piper announced a new flight training concept marked by the opening of Piper Flite Centers throughout the United States. The centers offer standardized training programs based on a Piper-developed flight training syllabus. Complete training in new Cherokee aircraft is backed up by thorough ground school courses. Piper Flite Centers also provide rental aircraft.

By year-end, Piper was employing more than 4,300 people and had produced more than 80,000 aircraft since the first E-2 Cub was flown in 1930.

PNEUMO DYNAMICS CORPORATION

In fiscal 1968 Pneumo Dynamics Corporation's 2 aerospace facilities—its Cleveland Pneumatic subsidiary and National Water Lift Division—established record highs in sales and year-end backlogs. Aircraft landing gears at Cleveland Pneumatic and flight control systems and components at National Water Lift accounted for the major share of Pneumo's aerospace business, with hardware for missile and space vehicle programs contributing a smaller but technologically significant portion of production. Another subsidiary, Claud S. Gordon Company, Richmond, Illinois, continued to supply thermoelectric heat-sensing elements, thermocouple instruments and temperature detection accessories to most segments of the aerospace industry.

CLEVELAND PNEUMATIC

Cleveland Pneumatic (CP), Pneumo's landing gear subsidiary, recorded in fiscal 1968 the largest dollar volume of landing gear sales in its 42 years in the landing gear business, and ended the year with its backlog at an all-time high.

In October 1968, CP completed a $20,000,000 expansion of its production, assembly and engineering test facilities which began in February 1967. The additional buildings and equipment constituted the largest single expansion of capacity by the landing gear industry since World War II and increased Cleveland Pneumatic's floor space by 50 percent.

The new complex, designed to accommodate the manufacture, test and assembly of large landing gears, comprises a 160,800-square-foot high-bay manufacturing plant; an Engineering Test Center equipped with 4 drop test towers ranging in height from 25 to 85 feet, a huge 107-ton static test frame equipped to simulate loads in landing gears and other aircraft components, with magnitudes varying up to 1,250,000 pounds per stroke; and a 16,000-square-foot high-bay addition to the adjoining assembly building. The new drop test tower, which will accommodate landing gears up to 32 feet extended length, has the capacity for gears twice as heavy as any on the drawing boards today. The entire new "big gear" complex is adjacent to and supplements the production of Cleveland Pneumatic's 500,000-square-foot main plant.

Cleveland Pneumatic, subsidiary of Pneumo Dynamics Corporation, completed a 640 by 220 foot "big gear" manufacturing plant, part of a $20,000,000 expansion project.

Production milestone of the year was the ahead-of-schedule delivery, in early August, of the first 5-gear shipset of landing gears for the Boeing 747 superjet. On-schedule delivery of subsequent sets continued throughout the year. The 747's 4 4-wheel main gears (2 wing and 2 body gears) and the 2-wheel nose gear represented the coordinated efforts of Cleveland Pneumatic and its 747 team of 58 second-tier suppliers.

Among several "firsts" on the 747 landing gears is the unique hydraulic equalizer system, controlled by a second "floating piston" built into each of the 4 main gears, which distributes the weight of the aircraft equally over all main gears on take-off, landing and ground maneuvering over the crowns and ramps of runways and taxi areas. Another exceptional feature is the welded outer cylinder for the wing gear, the largest shock-strut assembly ever built for any aircraft, reaching a length of approximately 15 feet when fully extended.

During 1968, production on the commercial side of Cleveland Pneumatic's aircraft business included landing gears and components for the McDonnell Douglas DC-8 and DC-9, maintaining CP's record of supplying landing gears for every model of the Douglas transport series beginning with 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. Delivery of commercial gears or spares continued for the Convair 880 and 990, Grumman's Gulfstream II, and Sud-Aviation Caravelles for United Air Lines.

In the area of military aircraft, Cleveland Pneumatic supplied landing gears or components for the Boeing KC-135 and B-52; Grumman A-6A, EA-6B and TC-4C; Fairchild Hiller C-123; Kaman HH-43B and HU-2K-1; Lockheed C-141; Ling-Temco-Vought F-8D and -8E; McDonnell Douglas C-124, C-133, F-4 and RB-66; North American XB-70, F-100, OV-10A and T-2B and J; and Vertol CH-46A.

During 1968, to meet the skilled labor requirements of Cleveland Pneumatic's increased production schedule, the company inaugurated an off-site Training Center, situated within 2 blocks of the new "big gear" plant, for the training of new employees and upgrading the skills of more experienced personnel.

NATIONAL WATER LIFT

Production of aerospace systems and components continued at a high level at National Water Lift's (NWL) 4 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 and McDonnell Douglas DC-9 continued, as did production of flight controls for the Lockheed C-130. Deliveries of the rudder power control actuator for the Boeing 747 began on schedule. In addition, NWL was designing the aileron and rudder servo systems for the Lockheed L-1011. During the year all McDonnell Douglas F-4 aircraft were being retrofitted with NWL's aileron flight control servo actuator.

In the area of aircraft engine controls, NWL supplied high-temperature engine components for various models of General Electric's J79, J85/15 and TF39 and for Pratt & Whitney Aircraft's TF30, as well as components for General Electric's SST engine.

Pneumo's aircraft weight and balance system, STOW (System for Take-Off Weight), was in steady production at NWL's Instrumentation and Control (I&C) operation in Grand Rapids, Michigan, with the system being installed on all TAC C-130 aircraft. The I&C Operation, working with NWL Kalamazoo and Pneumo's Cleveland Pneumatic landing gear subsidiary, was also developing another aircraft weight and balance system. This system, new in concept, involves the elimination of strut friction errors to enable accurate measurement of gross weight and balance by the use of pressure transducers.

NWL participated in the Apollo, Surveyor and Lunar Orbiter programs; the Apollo program alone utilized 36 separate NWL components.

RCA

DEFENSE ELECTRONIC PRODUCTS

RCA in 1968 retained its position as one of the largest and most broadly based enterprises devoted primarily to electronics. The company continued to pioneer in many areas of electronics, communications, and space sciences, from microminiaturized electronic components to large space surveillance systems. The Defense Electronic Products organization of RCA during 1968 was composed of 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.

RCA Defense Electronic Products initiated a Student Intern Program to provide college students with practical experience in engineering, manufacturing and other areas.

Defense Engineering

The position of Chief Defense Engineer was established to assure the government that, where required, the total engineering resources of RCA Defense Electronic Products would be brought to bear.

Four highly skilled operating activities reporting directly to the Chief Defense Engineer provided various DEP Divisions with additional resources as required. These 4 activities were Advanced Technology, Central Engineering, Defense Microelectronics, and Systems Engineering Evaluation and Research. The organizations, working closely with the RCA David Sarnoff Research Center, performed tasks for various DEP Divisions and, in highly selected areas, performed on techniques contracts for the government. These 3 areas of contact help assure an awareness of the latest results from basic research, realistic understanding of the government's needs and effective communications with Defense Electronic Products Divisions.

Advanced Technology

Advanced Technology is a techniques- and new product-oriented group which is a part of the central organization of Defense Electronic Products. Its function is applied research and advanced engineering in areas of future product interest to the DEP Divisions. AT's activities typically cover a large number of technical disciplines and require a mixture of physicists, electrical and mechanical engineers and computer specialists.

Advanced Technology's efforts are necessarily very creative and require continuous contact with military technical customers, the DEP products groups and the RCA Labs.

Programs active in 1968 included development of LSI/hybrid equipment technology, design automation for complex digital equipment, the use of lasers in tactical and high-density recording applications, pattern recognition using parallel organized computers for such applications as speech recognition and radar data classification, solid-state microwave techniques and sophisticated electromechanical systems for a variety of applications.

Central Engineering

Central Engineering is responsible for practically applying the capabilities of newly evolving technology to manufacturing processes necessary to produce 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

The Defense Microelectronics activity was established to pioneer microelectronics developments within RCA Defense Electronic Products.

Systems Engineering Evaluation and Research

SEER (Systems Engineering Evaluation and Research) is the Defense Electronic Products staff systems engineering organization that provides 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 with 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-DEP.

Aerospace Systems Division

The Aerospace Systems Division at Burlington, Massachusetts, provides a wide diversity of specialized electronic systems and subsystems for manned space flight, automated test equipment, command and control systems, and tactical products employing data processing, electrooptical and electronics technology.

During 1968, ASD was under contract to the U.S. Army for several automatic test equipment (ATE) programs. The Land Combat Support System (LCSS) program included all studies, investigations, design engineering fabrication, production and modifications of test equipment to provide complete field maintenance capability for the TOW, Lance and Shillelagh missile systems. Depot Installation Maintenance Automatic Test Equipment (DIMATE), developed for the Army Electronics Command, has proven the capability of automatic test systems to troubleshoot complete assemblies of Army electronic systems. It has reduced conventional testing time 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 situation, newly acquired air bases under combat conditions, temporary replacement or supplement to a fixed facility and training and mobility exercises. In addition, ASD was awarded a contract to build the AN/TSW-7 Air Traffic Control Towers, which are air transportable and completely equipped with all necessary communications for placement at tactical air fields. They have 3 controller's positions and can be unloaded from an Air Force transport at an unequipped air field, set up on integral jacks, and in full operation directing airport operations shortly after arrival.

ASD was also active in developing process control systems. One of these, Automatic Process Test Equipment, was delivered to the Electronic Components Division of RCA and was in operation testing color TV picture tubes. This type of equipment was being considered for use in manufacturing plants by large companies such as Lockheed and Martin.

The AN/APN-155 Low-Level Altimeter, developed by ASD under contract for McDonnell Douglas Corporation and qualified for use in the F-4 high-performance jet aircraft, has been a highly successful solid-state equipment. Placed into production in 1965, its excellent acceptance resulted in follow-on orders for additional units.

A second-generation altimeter, the AN/APN-201, was designed and tested at ASD. Featuring hybrid IC circuitry and a solid-state C-band transmitter, the receiver/transmitter weighs 4 pounds, or approximately 30 percent of the APN-155.

ASD was heavily involved in electrooptical systems and devices including their research, development and production. These included lasers, low-light-level TV, high-resolution TV, special applications of image devices to point source detection, and the combination of these systems. ASD delivered several models of laser rangefinding equipment for man-portable and Army vehicle applications. In addition, the division was designing and building laser illuminator and designator devices.

The Aerospace Systems Division was conducting research and development programs on laser devices and applications and was delivering products using operational laser systems. Classified studies on laser applications were being performed for the U.S. Navy and Air Force.

ASD was awarded several contracts by the U.S. Army for design, fabrication and testing of laser rangefinders for man-portable use and for tank and other vehicle applications. Also, a study was completed for the Army on the use of a laser in a helicopter as a unit for obstacle detection. For the Army, a flight test program was conducted using a laser as a weapons guidance technique. Under Air Force sponsorship, laser rangefinders and communicators were delivered and large integrated laser electrooptic systems studies performed.

During 1968 a program was under way for development of a laser track scanning system for high-speed railroad applications under sponsorship of the Department of Transportation.

ASD performed a Laser Design Concept Study for the U.S. Navy in which 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. Under contract to the Naval Air Development Center, ASD developed a Blue-Green Laser Transceiver Unit for use under water.

TV devices under investigation by ASD included low-light-level camera systems utilizing almost all classes of low-light-level image tubes. These include I-SEC, I^2V, isocon, and image orthicon. A unique pulse gating circuit permits operating these cameras in combination with pulsed illuminators. In addition, ASD was developing a high-resolution camera system which uses a return beam vidicon as the image pickup tube. ASD was conducting system analysis involving the utilization of these devices in many different military applications.

ASD was performing additional development work for the Air Force on the AN/FSR-2 Optical Surveillance Tracking System to further refine this satellite detection system, part of the SPADATS System.

The division completed development of a highly sophisticated, general-purpose aerospace computer, the VIC (Variable Instruction Computer). This computer was being incorporated into the Airborne Data Automation (ADA) system which will be used by the Strategic Air Command to demonstrate the feasibility of automating the present Airborne Command Post functions now performed manually in the EC-135C "looking glass" aircraft.

In addition, a study was completed for the Air Force Electronics System Division which defines the system configuration for an Advanced Airborne Command Post system that could be installed in the C-5 jumbo jet during the 1970s.

In the area of electronic warfare and advanced multifunction radar systems, ASD was engaged, under Air Force Avionics Laboratory contracts, in exploiting recent technological advances in integrated microcircuits by applying them to the design of an electronic warfare system and in the development of hardware. ASD was also under contract to develop a Target Homing and Warning System (THAWS) to provide for the integrated sensing, control and display of EW functions on board naval interceptor aircraft.

ASD was participating in the development of a number of classified Navy and Air Force electronic warfare systems and components for airborne applications. In general, these involve exploitation of very recent technological advances and defining future research in this area.

ASD developed and demonstrated a highly versatile airborne multisensor display capable of accepting the output of any of a number of airborne imaging systems and converting it to a standardized high-brightness TV-type display.

In 1968 the division provided assistance on overall systems and hardware engineering for the electronic subsystems to support Grumman's development of the Lunar Module portion of the Apollo program. ASD was under contract to supply Grumman the Rendezvous Radar, Transponder, and Landing Radar for the Lunar Module vehicle. Under contract to Grumman, ASD built 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 trim signals for the gimbaled descent engine. DECA controls the descent engine of the 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 is left behind with the remainder of the LM descent stage. In addition to the actual LM hardware, ASD has developed a large complex of ground test equipment to support development of the LM electronics and communications systems.

Astro-Electronics Division

The Astro-Electronics Division, also known as the RCA Space Center, has 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 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.

The division was supplying 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.

The division was also 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 covered a wide variety of spacecraft and spacecraft systems, including 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 also made contributions to the manned space flight program. A miniature, lightweight television camera built by AED provided the first live television pictures from space during the Apollo 7 space mission. 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, the division undertook studies for the manned space flight program in the areas of color television and 2 types of power supplies.

Seven 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 and October 2, 1966; January 26, April 20 and November 10, 1967; and August 16, 1968. The ESSA 1 and 2 operational weather satellites represent 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 and ESSA 6, transmitted, on a real-time basis, cloud cover pictures to APT ground stations around the world. ESSA 3 carried a pair of RCA Advanced Vidicon Cameras used on an operational mission for the first time. ESSA 5 carried the AVCS equipment which has been sending pictures to Command and Data Acquisition Stations in the United States.

RCA's Astro-Electronics Division was under contract to NASA's Goddard Space Flight Center to design and develop the next generation of weather satellites, known as the Improved Tiros Operational Satellite Systems (ITOS). The Navy contracted with AED to build the Navigation Satellite, developed by the Applied Physics Laboratory of Johns Hopkins University. The first launch of an RCA-produced navigational satellite took place March 1, 1968.

Collection and processing of scientific data from spacecraft also is an important activity at the Astro-Electronics Division. Specialized ground stations and ground station equipment were designed and built for meteorological and other satellite missions. New techniques in ground data handling were under investigation to meet the requirements for earth resources observation missions. Among these were the use of lasers for reproducing electronic images in the visible and near infrared portions of the spectrum on high-definition film. A laser beam image reproducer was built in support of the ground station requirements.

For the future, the Astro-Electronics Division was directing increased attention to developing those spacecraft and space systems which return practical benefits to the nation. Continued development and improvements in weather, natural resources, and communications satellites were planned, with new technology that will lead to greater scientific knowledge of the earth, planets and stars.

Defense Communications Systems Division

The principal facilities of the Defense Communications Systems Division (DCSD) are in Camden and West Windsor (near Princeton), New Jersey. These comprehensive facilities contain a complete engineering organization capable of effective project management as well as comprehensive systems and product engineering through all phases of design, development and manufacturing.

The headquarters of DCSD in Camden, employing over 6,000 engineers, scientists, technicians and manufacturing and administrative personnel, is a fully integrated design, development and fabrication facility devoted to handling a wide variety of defense and space electronics work. Specialized engineering laboratories and areas of technical competence are applied to light, heavy and digital communications equipment, recording devices, command and control, advanced communications technology and communications systems. A fully equipped Hybrid Microelectronics Laboratory is centrally located to support the engineering groups in advanced product design.

The division was working on programs for the design, development and production of communications for numerous government applications, including communications techniques investigation and conceptual studies. This large and diversified area encompasses the development and production of communications transmission and terminal equipment, plus systems for submarine, shipboard, manpack, vehicular, fixed plant, aircraft, missile, space-ground and space vehicle applications.

RCA has long been a leader in advanced tactical military communications, and DCSD was continuing this tradition with a number of very significant development and production programs. These included:

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. The 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 by year-end. The AN/PRC-77, a product-improved version with several added capabilities, was in mass production and was receiving an equally satisfying response from the user.

AN/ARC-144 (Ultrareliable 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 fivefold increase in reliability.

AN/ARC-142 and AN/ARC-143 (P3C HF and UHF Transceivers). Developed and in production for application to the Antisubmarine Warfare Aircraft (Lockheed P-3C), 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' minimum mean time between failures.

AN/TRC-97-97A. This operational equipment was being supplied to both the U.S. Marine Corps and 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 1 hour by 2 men. Over 400 AN/TRC-97s have been produced and delivered to date, and more than 100 were in use in Vietnam.

AN/UCC-5 Multiplex Carrier Equipment. The AN/UCC-5 is a solid-state 60-voice channel frequency division multiplex carrier equipment for use in microwave radio or line carrier systems. This equipment conforms to DCA Circular 175-2A for fixed station applications, to Military Standard 188B for tactical applications and to MIL-E-16400 for environmental service conditions and component requirements. The equipment was designed to operate on a continuous basis with a minimum of maintenance or adjustment. This has been achieved through the use of transistors and integrated circuits in a conservative design. Ninety-six percent of all components are mounted on plug-in printed circuit boards for ease of maintenance and system expansion.

Digital communications and switching systems and equipment are an important part of the DCSD product; 3 programs of interest are:

Ship's Interior Communications System (ICS). A centralized circuit switching system for the control of interior shipboard communications, this system, the first of its kind, will use a computer to perform circuit switching functions previously performed by discrete hardware. Complete rearrangement of a ship's internal communications will be accomplished by simply changing computer programs. Two switching centers will serve up to 2,500 subscribers. ICS will be a stored program system with sufficient redundancy for high reliability and survivability under battle conditions.

Minuteman Sensitive Command Network (SCN). DCSD, under subcontract to The Boeing Company, designed, developed and produced the SCN that interconnects 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 DCSD, handles secure launch or inhibit launch command messages, and processes digital messages for automatic system and network check-out. The operational equipment has far surpassed the ultra-high-reliability goals. DCSD continued to provide engineering services and equipment modification on the Minuteman Force Modernization Program.

Automatic Digital Network (Autodin). A vital link in the DoD worldwide logistics-data communications network, this is the world's largest and most advanced operational data communications system. Under contract to Western Union, DCSD designed, developed, produced, programmed and installed these equipments. The initial network included 5 large automatic switching centers capable of terminating 550 lines. The Autodin Expansion Program increased the network to 9 centers capable of terminating 2,700 lines. As part of a program to modernize the Autodin Network, DCSD was awarded a contract by Western Union to provide new integrated circuit Communications Data Processors for the 9 Autodin Switching Centers in the United States.

DCSD was also responsible for major space communications programs:

SHF TACCOMSAT Terminals. The SHF Tactical Communications Satellite Terminals will provide extremely reliable tactical communications together with high mobility for battlefield and airborne use. Five configurations are being supplied: airborne, 1¼-ton truck shelter, jeep-mounted, teampack and manpack terminals. Delivery was started during 1968. The tactical stations will be tested with an experimental satellite by all 3 branches of the military.

Apollo Command Module Communications. DCSD 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 provide a voice and data communications link between the LM, the CM and the astronaut on the lunar surface.

Apollo Lunar Module Communications Subsystem. DCSD, 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 is devoted to interface definition and control, and to detailed testing and performance evaluation of the communications equipments when operated as an integrated subsystem.

Extravehicular Communications System (EVCS). DCSD was developing for NASA a spacesuit communications system that will permit a team of astronauts (2 or more) to explore the lunar surface while in communication with each other and, through the Lunar Module, with mission controllers on earth. EVCS will have full duplex transmit-receive capability, will weigh about 6 pounds and will be about the size of a cigar box. It will be carried as part of the astronaut's portable life-support system. In addition to voice communications, EVCS will transmit biomedical telemetry data on the astronaut's condition, and will sound an alarm to indicate any drop in the spacesuit pressure.

DCSD was conducting research on recorder technology, and had available a number of advanced recorder/reproducer equipments:

PT-501 Wideband Recorders. Designed to meet the requirements of aircraft, ships, ground vehicles or other portable configurations, the PT-501 series of video recorders is the ultimate in portable wideband recorder systems. Typical of the many uses for the PT-501 are monopulse radar, quadrature bipolar radar pulses, PPI displays, FDM signals, standard and slow-scan TV applications, and spectrum analysis. The configurations are housed in 3 separate packages which are suitable for hand carrying in suitcases.

Continuous Video Recorders (CVRs). A number of CVRs were developed and available. For example, the TR5-LO-10-CVR is a transverse-scan recorder/reproducer incorporating a speed reduction of 10 to 1 compared to normal wideband machines. The TR42-LO-10-CVR is a low-speed playback unit which runs at 1/10 the speed of a normal TR42-CVR for bandwidth compression of wideband information recorded on the latter.

DCSD has considerable experience in major communications systems, involving study, synthesis, design, development, production and operational support. Two 1968 system programs of interest were:

Integrated Communications Control System (ICCS). This is an advanced communications control system that will simplify the operation of airborne radios, reduce costs and weight, and conserve important aircraft space. ICCS employs the Multiple Interior Communications System (MINCOMS) concept, which uses multiplexing techniques to simultaneously send separate signals over a single cable about the size of a pencil. Initially designed for naval aircraft, ICCS connects and controls multiple intercom stations, radio receiver/transmitters and other avionics components, with connection and control effected from a single panel.

Mallard System Studies. Mallard is an international program (United States, United Kingdom, Canada and Australia) for creating advanced communications for field military units of the mid- and late 1970s. The Mallard concept embraces an integrated communications system utilizing elements ranging from mobile radios to complex electronic switching systems to communications satellites. RCA's 18-month study program was nearing completion, at which time the program was to move into another phase involving some equipment development and simulations. Two parallel systems studies were being performed, one by U.S. industry and one in the United Kingdom.

Missile and Surface Radar Division

The Missile and Surface Radar Division (M&SR) is located at Moorestown, New Jersey.

From installation of the first precision monopulse tracking radar, the XN-1, at Patrick Air Force Base in 1957, M&SR has designed and produced a family of 71 such radars of ever-increasing sophistication and capability; they are installed at locations around the globe, both on land and on ships at sea. The standard RCA 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. Both are ideally suited for assuring range safety and for tracking rockets, missiles, nose cones, boosters, tankage assemblies, instrument packages, debris, earth-orbiting satellites, and space vehicles.

The 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&SR has perhaps contributed more to scientific antiballistic missile research than any other single installation. It is here where the highly advanced radar net, BMEWS, was designed, developed and manufactured for installation at 3 widely separated sites in the western hemisphere. From 1958, the Missile and Surface Radar Division observed test launchings of all U.S. missiles and analyzed data obtained from thousands of observations of bodies reentering the atmosphere. This installation has also been a leader in space object identification since it made its first such measurements on Sputnik II, using an FPS-16 at Patrick Air Force Base, Florida.

M&SR developed a high-performance tactical radar, the 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 phase of amphibious operations.

Another advanced tactical system under development at M&SR in 1968 was the TPQ-27 program which will direct tactical aircraft to bombing targets with high precision by use of ground-based precision tracking radar, command control systems, and data links.

Under the Apollo Reentry Ships Program, M&SR developed CAPRI, the first precision tracking radar to use integrated circuits for all essential electronic functions. This instrument has the general capability of the AN/FPS-16 radar, except that the user has a number of options in the pedestal and antenna subsystems. The resultant savings in space, weight and power make it easily adaptable for installation on board ship, in a trailer or in small one-story buildings.

The division was designing and developing advanced over-the-horizon radars for the armed forces. M&SR's recognized capability in transmitters, antennas and signal processing has put it in the forefront of the fast-growing over-the-horizon radar art.

The first major real-time ground-support system for space missions to use integrated circuits was installed on the Air Force Eastern Test Range by M&SR. It consists of 4 ground stations at Antigua Island, Ascension Island, Grand Bahama Island and Pretoria, South Africa, and a control station at Cape Kennedy.

Shipborne stations are also deployed. The system enables flight scientists to select and call up various telemetry data from space vehicles while they are in flight down the Eastern Test Range.

M&SR 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 and can detect man-sized targets at ranges up to 1,500 meters, defining range within a few meters and angle within a few degrees. A communication mode is also provided, enabling 2 units to set up a secure voice link. The RCA Hand-Held Tactical Radar is an all-solid-state system, using the latest in integrated circuits and miniature electronics.

Following a far-reaching evaluation of existing equipment for Navy air defense, M&SR was chosen by the Navy to develop a concept for the Advanced Surface Missile System. As head of a team which includes Bendix, Raytheon, and Gibbs and Cox, the division will develop an advanced integrated command control and missile launching system for fleet air defense in the 1970s.

To enable astronauts on the moon to communicate with earth, a 10-foot parabolic antenna was needed. It would 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.

One of the Missile and Surface Radar Division's newest capabilities is high-volume production of precision multilayer printed circuits. A completely mechanized printed circuit manufacturing facility with 25,000 square feet and employing 125 production personnel began operations in early 1968.

Electromagnetic and Aviation Systems Division

The Electromagnetic and Aviation Systems Division (previously known as the West Coast Division) has 3 facilities: Huntsville, Alabama; West Los Angeles, California; and Van Nuys, California, headquarters for the division.

The Huntsville facility is concerned with field service and depot support, primarily for the Saturn Ground Computer Check-out System. It has 128 employees and an area of 15,000 square feet.

The Aviation Equipment Department, located in West Los Angeles, designs and builds weather radar systems, distance measuring equipments, transponders, navigation-communication equipments and Aircraft Integrated Data Systems. These equipments and systems are for both airline and general aviation aircraft. About 65 percent of all weather radars in use by airlines and 75 percent of the general aviation radars were built by the Aviation Equipment Department. In 1968 the department was developing an Aircraft Integrated Data System capable of monitoring more than 1,000 parameters. The facility had 396 employees and 91,250 square feet of plant space at year-end.

The Van Nuys operation designs and builds Electronic Warfare Systems, Ordnance Systems, Military Display/Memory Systems, and Military Aviation Products and Systems, a counterpart of the commercial work in the Aviation Equipment Department. The Van Nuys facility has been a leader in the development and manufacture of special-purpose computers, random access memory systems, display systems, electronic warfare equipment, and secure communication systems since 1960. The facility had more than 1,425 personnel and 240,000 square feet at year-end.

The division has made an outstanding contribution to the nation's defense effort in electronic warfare. This includes techniques and equipments for deceiving, jamming, evading and effectively destroying electromagnetic threats. Thus, a shield is provided which permits ships, planes and ground vehicles to aggressively penetrate the enemy's defense and limit his effectiveness in offensive action. The Electronic Warfare group has been a major developer and supplier of jamming equipments to the Department of Defense, and in 1968 was engaged in engineering and manufacturing programs for electronic warfare components and complete systems. In support of these and future electronic warfare programs, the Electromagnetic and Aviation Systems Division had independent research and development programs.

EASD participates in the design, development and manufacture of ordnance products, especially fuzing assemblies for mortars, rockets and bombs. An extensive independent research and development program was conducted during 1968 on radio proximity and optical fuzing techniques.

The division was producing Mark 25 Monitor Assemblies and Mark 26 Safing Devices under contract to the U.S. Navy. In addition, the division was under contract to Harry Diamond Laboratories to design and develop the XM588 Near Surface Burst Fuze.

Independent research and development projects included development of reliable low-cost electronic fuzing systems, and optical sensors for fuzing.

The division's major developments in military information systems were card and drum random access mass memories, video data display systems and the Saturn Ground Computer System.

The division developed 2 generations of Card Memories, the Model 3488 and the Spectra 70/568. The Spectra model has an access time under .5 second and stores 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 time and greater capacity at lower cost per bit.

The Random Access Drum Memory Systems broke the bit-per-volume barrier in drum memories. The RCA drum stores 25,000,000 bits, more than 3,000 pages of typewritten material, in an area of approximately 1.5 cubic feet with an access time of 8.5 milliseconds. This drum memory, a development of the division's independent research and development program, was being produced for use in the Tactical Fire Direction System (TACFIRE) program. Another drum memory system was under development for commercial applications.

The division was developing and manufacturing several different types of commercial and military display systems. These systems included:

- The Spectra 70/752, a compact, self-contained, stand-alone display with third-generation logic and memory. The screen capacity is 1,080 characters.
- Modular video data system, which provides anywhere from 8 to 48 70/751 video data terminals from one controller. Three screen arrays are available.
- Check-out and launch control displays.
- Tactical Information Processing and Interpretation (TIPI) displays.
- Airborne displays.

EASD has been a major producer of specialized information systems since its founding. One of the major products has been the Saturn Ground Computer System for the National Aeronautics and Space Administration's Marshall Space Flight Center. The Saturn Ground Computer Automatic Check-out System is part of the key to the success that Saturn launches enjoy. Located immediately below the launcher in the first Saturn V launch, the Computer Check-out System had to be constructed so as to absorb the vibration of the blast effect. This system provides real-time control, check-out, and monitoring of digital and analog data from the Saturn missile systems. The major equipments in the data-processing system are the Saturn Computer and the Saturn input/output data channel display, which provides a visual presentation of alphanumeric and symbolic data in tabular and graphic formats.

The division for several years has been a major supplier of aviation equipment products to commercial airlines and to general aviation. The division successfully converted this experience as a supplier of commercial aviation products to a specialized military market when it received a major contract for distance measuring equipment from Lockheed Aircraft Corporation for the AH-56A program. Among the equipments that the division will be marketing are distance measuring equipments, weather radars, IFF transponders, navigation equipment, traffic direction and control equipment, airborne display/memory systems and airborne integrated data systems.

ROHR CORPORATION

The year 1968 represented a period of unprecedented growth for Rohr Corporation, with significant advances in several areas. A major factor in improving efficiencies was the continuing successful effort to widen computer applications to manufacturing operations.

One of the first companies to become involved in numerical, or computer, control of machine tools, Rohr developed advanced use of computers in materials handling, parts flow control, scheduling and other applications bearing directly on manufacturing efficiency.

The company in 1968 was evaluating potential markets for an automated, computer-controlled warehousing system in operation at the main plant in Chula Vista, California. Possible applications for the system were seen in air freight handling and in operations requiring complete control of the flow and processing of large quantities of parts and products.

Rohr continued to strengthen its engineering and research and development efforts to keep pace with rapid technological advancements in the industry and to develop new product lines. In the area of sound suppression, research effort was producing materials which show some promise of diminishing engine sound. All of these efforts were part of a comprehensive program that permitted the company to become an associate contractor in a number of new projects.

One of the most significant new programs was a contract to produce propulsion pods for McDonnell Douglas Corporation's DC-10 trijet airliner. Rohr, long a specialist in the power plant field, will design, test, fabricate and assemble the pods, including the nose cowl, forward fan wrap cowl, fan nozzle and core engine cowl.

The company also moved into production of engine pods and pylons for The Boeing Company's 747 superjet airliner, the first of which was rolled out on September 30.

The Lockheed C-5 logistics transport, which made a successful maiden flight in June, received its Rohr power plants and pylons in February and the manufacture of production articles was proceeding on schedule.

The company continued to gain industry recognition for its capabilities in the thrust reverser field. Two new systems, both proprietary to Rohr, were completed during the year. In March the first shipset of thrust reversers was delivered to North American Rockwell for the Sabreliner business jet. The company also completed design of a thrust reverser for the Boeing 737 twin-jet airliner and production of these units was in progress. In addition, Rohr designed and was building the pods, pylons and thrust reversers for the Grumman Gulfstream II business jet.

Deliveries of power plant assemblies continued for many of the company's long-running aircraft programs, such as the Boeing 707 and 727 airliners, the Lockheed P-3 antisubmarine patrol plane and the McDonnell Douglas twin-jet DC-9 and Super 62 and 63 DC-8 aircraft. The company had 14 major aircraft programs in various stages of production; approximately one power plant assembly for every working hour was delivered to customers through the year, or more than 200 per month.

The free world's expanding global communications continued to create a demand for ground station satellite communications antennas and Rohr's Antenna Division produced and installed 3 97-foot-diameter antennas in Thailand, the Philippines and Chile during the year. The division also continued its diversification in the marine products field and was producing welded aluminum hulls for Navy work boats, 2 65-foot air-sea rescue vessels and hulls for 2 85-foot Navy tugs.

One of the most significant programs to develop in the company's Space Products Division during the year was a contract to produce the motor cases, motor case insulation and ablative nozzles for the 120-inch, solid-propellant rockets which are used as booster stages for the Titan III-C, -D and -M space launch vehicles. Rohr was producing these components under a contract with United Technology Center, a division of United Aircraft Corporation.

The division, receiving increasing recognition for its capabilities in composites and fiberglass laminates, was selected by Lockheed Missiles & Space Company to build the fiberglass outer hull for the Navy's DSRV-2 deep submergence rescue vehicle. The 49-foot DSRV-2 is designed to rescue crews from disabled submarines.

With the company entering new programs and diversifying, there was an accelerated trend in the installation of machinery and equipment designed to reduce labor costs in the manufacture of tools, fabrication of parts and movement of materials. Eleven major pieces of equipment were placed into operation to boost Rohr's manufacturing capabilities. In addition, 2 hot-sizing presses, designed and developed by the company, were installed to form various titanium alloys into difficult and complex configurations.

Construction of new facilities in fiscal 1968 aggregated more than 104,000 square feet of manufacturing floor space.

RYAN AERONAUTICAL COMPANY

A new, supersonic generation of jet targets joined the Ryan Firebee family during 1968, a year which also saw operations of the veteran subsonic drones greatly expanded. During the same period, Ryan's moon landing radar system moved closer to its supreme test and the XV-5B Vertifan V/STOL entered a new research phase.

The slender, stiletto-nosed, sweptwing Firebee II (BQM-34E), first of 14 prototype flight test versions being built for the Naval Air Systems Command, was rolled out in March at the Naval Missile Center, Point Mugu, California, where it entered an intensive flight test program prior to scheduled operational use by the fleet in 1970.

First faster-than-sound flight was achieved in June, and it reached its design speed of Mach 1.5 (1,000 miles per hour) in September. Soon afterward, the BQM-34E attained another major milestone with its first ground launching. Combining subsonic flight capabilities of the widely used BQM-34A Firebee with supersonic speed ranges, the Firebee II was hailed as the most advanced aerial target of its kind, providing a realistic target for training air defense pilots and ground gunners and missilemen.

Meanwhile, deployment of subsonic Firebees and Ryan field support crews extended to Panama, Okinawa, Taiwan, Korea, South Vietnam and the Philippines for Army, Navy and Air Force exercises. Further enhancing the realism which has prompted combat-seasoned pilots to compare the Firebee with MiG fighters in performance was installation of Increased Maneuverability Kits, enabling the drones to execute steep banks and turns characteristic of evasive maneuvers of enemy aircraft. At year's end a new dimension was added to the Firebee capabilities by the first remote-controlled waterborne launch in the 20-year history of the target, from a 104-foot Navy Aviation Rescue Boat (AVR) off Point Mugu.

Recognition of the essential role performed by the Firebee target system was award of a $20,619,000 Air Force contract to meet fiscal 1968 Firebee requirements of the Air Force, Army, Navy and Marine Corps, the largest single order in 2 decades of production during which more than 3,800 jet targets have been delivered.

Ryan's moon landing radar system took its first "look" at space aboard an unmanned Apollo Lunar Module in January, in the flight of LM-1, and deliveries of other systems for succeeding LM missions continued through the year. The system, which will actually guide the first 2 American astronauts to soft landings on the moon, was scheduled for delivery in late 1968. The Ryan-built Radar Altimeter and Doppler Velocity Sensor had, by early 1968, established a reputation for reliability in the 5 successful moon landings of unmanned Surveyor exploration space vehicles. As it will with Apollo, the Ryan radar triggered retrorockets to sharply decelerate Surveyor to gentle landings.

Data from continuous measurement of the Lunar Module's speed, altitude and rate of descent will be used automatically by the LM's control computers to fire or throttle the vernier descent engines which control spacecraft attitude. Acting on radar information, the astronauts will slow to a near hover, like a helicopter, before a soft touchdown on the moon.

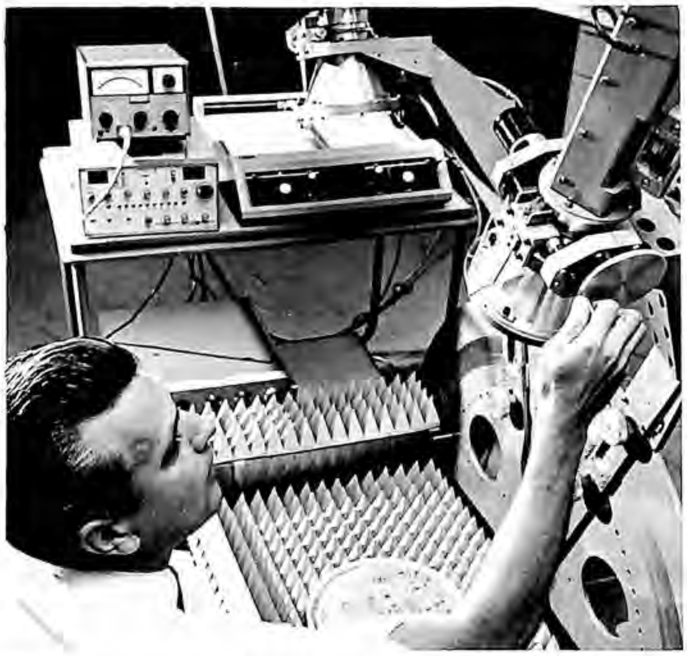
Besides the LM radars, Ryan's 1968 production featured navigation sensors for antisubmarine helicopters and for high-altitude aircraft. The first international sale of the AN/APN-182 Doppler radar navigation sets was recorded when the Italian Navy ordered a quantity for its new SH-3 Sea King ASW helicopters. The radars control the automatic descent and hover maneuver required in ASW operations while the helicopter makes soundings with its acoustical sonar device.

A Ryan radar device designed to measure aircraft landing impact, initially developed under Navy contract as an aid in carrier landings, was employed for the first time commercially, in a Boeing 737 transport, during flight certification of the new aircraft. Advanced from experimental to flight operational status during the year by the Naval Air Systems Command, the AN/APQ-135 sink rate radar assists flight test or maintenance personnel in determining possible structural damage or stress from the effects of hard landings. The sensor units have been purchased by manufacturers for testing various military aircraft, including McDonnell Douglas for the F-4 Phantom, Boeing-Vertol for the CH-46 helicopter and Lockheed-Georgia Company for the C-130 Hercules transport.

The only plane of its kind in the nation, the Ryan XV-5B fan-in-wing Vertifan, was delivered in mid-1968 to NASA-Ames Research Center on completion of a $1,000,000 renovation and modification program that improved the aircraft's reliability and maintenance.

As the XV-5A, the Vertifan successfully demonstrated, in 338 flights from May 1964 through late 1966, its ability to take off vertically, dart away at subsonic speeds and return to land in an area no larger than a tennis court. In 1968, NASA was utilizing the XV-5B as a flying laboratory in continued testing of the vertical-lift principle utilizing a set of counterrotating fans submerged in the wings and driven by jet exhaust.

Ryan expanded its capabilities in remote sensor electronics with further development of other devices, including scatterometers, microwave radiometers, reflectometers and wave height profilers. The scatterometer is a continuous-wave Doppler radar that measures reflectivity of land and sea surfaces day or night, in all weather, to indicate surface roughness on land and height of ocean waves. It was in use by NASA for earth resources applications. The radiometer is a highly sensitive, passive microwave receiver that picks up the natural thermal radiation of the earth in studies of surface temperature, soil moisture content and atmospheric properties. The reflectometer is a precision instrument used in the laboratory or the field to determine the dielectric constant of natural materials to confirm measurements made by aircraft or satellite sensors. The wave height profiler is a radar and infrared device that makes accurate measurement of ocean waves and is used on hydrofoil craft to aid navigation and on offshore towers for ocean research.



Ryan Aeronautical Company's Remote Sensor Group designed and fabricated a unique microwave reflector, which measures the natural electrical properties of soils, rocks or liquids by reflecting microwave energy from the sample in the dish.

An outgrowth of Ryan's development of remote sensors was the award of a contract by the U.S. Department of Commerce Environmental Science Services Administration to determine ways that various hydrological measurements—such as rainfall distribution, water retention in the soil, evaporation, flow of water underground, water runoff from glaciers and snow packs, snow line surveying, and water content of the atmosphere—can be correlated to give scientists the most meaningful information.

Ryan's continued interest in solar panel structures, which have harnessed the sun's energy for such space vehicles as the Mariner Venus and Mars probes and the Navy Navigation Satellites, was highlighted in 1968 with the completion for the Jet Propulsion Laboratory of a 250-square-foot prototype roll-up solar cell array, one of the largest ever built. The structure, 43 feet long and 7 feet wide, provides 30 watts of solar electrical power for each pound of weight.

The pioneer aerospace firm also commenced development of a system for remote-control operation of minesweeping jeeps under a contract to the U.S. Army's Mobility Equipment Research and Development Center. Meanwhile, a Ryan remote-controlled Firefish target boat was ordered by the Marine Physical Laboratory of the Scripps Institution of Oceanography, La Jolla, California, for use as a "slave" unit in obtaining ocean soundings between San Diego and Japan during 1969.

T. Claude Ryan, board chairman, one of America's few major industrialists who still actively head companies founded 40 or more years ago, celebrated his 70th birthday and 45 years in the aerospace industry.

Another personnel note was the affiliation with Ryan of Admiral U. S. Grant Sharp, who retired as commander-in-chief of all military forces in the Pacific-Southeast Asia areas. Admiral Sharp joined Ryan as consultant and a member of its Advisory Board.

SINGER-GENERAL PRECISION, INC.

(Formerly General Precision Systems Inc.)

In 1968 General Precision became a part of The Singer Company, and General Precision Systems Inc. was changed to Singer-General Precision, Inc. As a member of the $1.6 billion Singer family, the company continued as a major producer of electronic, electromechanical, optical and other precision-made products for the military, government and industry.

The company has won worldwide recognition for achievements in Doppler, stellar and inertial navigation and guidance; analog and digital computation; simulation and training; weapons control; and analog and digital communications. Its product line in 1968 ranged from large ground-based, computerized systems and simulators and airborne digital computers to tiny gyroscopes and instruments used in interplanetary space vehicles. Virtually every major aircraft, missile, space vehicle and antisubmarine warfare vessel in operation or under development uses a General Precision product.

The wide range of products offered by the company to the overseas markets required 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. Its products and services 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 its products. This flexible operation allows the company to support the U.S. government's overseas sales program.

During 1968, 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

Several major equipment contracts for navigation, guidance and airborne data processing that were received in 1966 and 1967 reached major milestones during the latter part of 1968 when, having completed their development cycle, they entered the initial phases of production. Among these contracts were those received by Kearfott Systems Division and GPL Division for Doppler inertial systems to be used on the Navy's P-3C aircraft and on the Navy/Air Force A-7D/E.

Other applications for Kearfott's inertial equipment under contract were for the SRAM missile, the F-105 T-Stick II program and inertial measurement units for Collins Radio, to be used in commercial and business aviation.

At GPL, Doppler systems were being produced for the FB-111 strategic bomber and for the C-5A Galaxy transport. In addition, a special hybrid inertial heading and vertical references, combined with GPL's Doppler system, were being produced for the Army's AH-56A armed helicopter.

Concurrent with these activities in the navigation system field, Kearfott Products Division instituted a program of advanced digital computer developments with the objective of establishing a family of digital machines having the inherent modular accommodation and growth capability for the airborne navigation, fire control and weapon delivery requirements of the 1970s.

In 1968 Kearfott Products Division shipped production versions of its advanced microelectronic analog-digital converters and its control and display panels for the advanced avionics system being integrated by NAR-Autonetics Division for the FB-111 strategic bomber. By midyear the first system was integrated into the FB-111, flight tested and delivered to SAC for Category 2 flight tests by the Air Force. Other versions of the control and display panels and of the analog-digital converters were delivered to the Autonetics Division for incorporation into the advanced avionics system for the tactical fighter bomber, the F-111D.

Other conversion equipment produced by Kearfott Products was shipped to IBM Federal Systems Division to be integrated with its 4 Pi computer into the avionics system for the A-7D/E.

The flights of the Apollo spacecraft in 1968 also featured a diverse variety of Kearfott-produced equipment such as an Orbital Rate Drive Electronics Assembly that is used to convert the Apollo's inertial attitude references into real earth and real moon coordinates for the astronauts' attitude indicators. This device is unique in that the front panel uses lunar white electroluminescence for illuminating the characters of the controls on the display control panel. Two other electroluminescent displays were aboard, one to indicate helium temperature and pressure and the other for an indication of propellant quantity aboard.

Significant advances were being made in the field of advanced electronic detection and ECM equipment. Although the details cannot be made public, advances were made in the state of the art of this equipment.

Other work in the research area was highlighted by the award to the Kearfott Group of citations for the development of 2 among the 100 most significant technical products of 1968. The first citation was for a quartz crystal vibrating beam accelerometer, and the second was for a practical Doppler Sonar Navigation system. Another major research accomplishment was the development of a room-temperature liquid laser. This development will lead to future high-power, highly efficient lasers.

LIBRASCOPE GROUP

Librascope Group is composed of the Products Division, Systems Division, and Optics Technology Center.

Products Division was designing and manufacturing 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 continued as the leading manufacturer of computing and data-processing systems for shipborne antisubmarine warfare weapon-control systems. The division was producing one of the largest mass memory systems for data processing used in industrial, scientific 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.

A pilot's view of Los Angeles as seen through the L-193 Head-Up Display developed by Librascope Group of Singer-General Precision, Inc.

Optics Technology Center was producing sophisticated optical systems and instrumentation for aircraft, space vehicle, laboratory, land and sea applications. The center designed and fabricated the sextant and telescope navigation-simulation assemblies for the Apollo mission simulator.

Other products manufactured in 1968 were pilot sights for jet aircraft, photonavigational viewfinders 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.

An active engineering program was 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 1968 engineering had research projects on woven thin-memory plates; infrared and visible-light detection devices; and acoustic-processing systems and associative processing systems as well as new disc-memory systems.

LINK GROUP

At the Link Group the 1968 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 VAMP system was purchased by several commercial airlines and will be used with a weapon-systems trainer that Link was 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 took their first "flight" to the moon long before their actual blast-off from Cape Kennedy. The Apollo and Lunar Module Mission Simulators permit them to take the trip safely, and with remarkable realism, many times without ever leaving the ground.

The Advanced Products Division developed a growing business in information storage and retrieval devices and was supplying high-accuracy, precision measurement equipment used in mapping operations and determining missile flight characteristics. Other Advanced Products Division 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 and explosive systems and in the production of sophisticated electroordnance 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 nonmetallic 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 was also producing other educational products such as the computer-oriented electronic learning systems. Link's Transportation Products Division was producing a complete line of traffic control devices.

The main offices of the Link Group are in Binghamton, New York, where a new engineering and administration building provides nearly 670,000 square feet of floor space. Construction of an 864,000-cubic-foot manufacturing wing was started in 1968. In addition to the extensive engineering and manufacturing facilities in Binghamton, Link maintains a modern, fully equipped facility in Sunnyvale, California, where the Advanced Products Division is located; the Operational Training and Information Sciences Divisions in Silver Spring, Maryland; and Sales and Service offices in Washington, D.C., Dayton, Los Angeles, Salt Lake City, Orlando, Houston, Dallas, Minneapolis and Sacramento.

The new air-conditioned Kirkwood Facility is in the Broome Industrial Park, approximately 4 miles east of downtown Binghamton. Its 290,000-square-foot structure houses the majority of Link engineering and administrative personnel, and general offices in the Binghamton area.

Link's main manufacturing plant, Plant I, is in the residential Hillcrest section of Binghamton and contains approximately 236,000 square feet of floor space. It contains 146,000 square feet of manufacturing floor space. Here the latest and most modern of techniques available are applied in every aspect related to the design, development and fabrication of flight simulators and other simulation equipment. Plant I is also the headquarters of Link Group's School Trainer Division. Plant I is serviced by a railroad siding and has adequate dock space for shipping and receiving by truck lines. Special facilities for trailerized simulators are also provided.

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, and 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 worldwide 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. Services offered by this division include planning and erection of plant facilities as well as design, manufacture, installation, personnel training and in-the-field maintenance and service.

Tele-Signal was founded in 1957 to produce fully transistorized solid-state voice frequency telecommunication and data systems and modular equipment for use by common carriers, the military, private communications systems, and public utilities for transmission over wire lines, radio and satellite relay media. Products that Tele-Signal produced in 1968 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.

At year-end Tele-Signal had more than 900 engineering, production and administrative personnel. It was occupying more than 100,000 square feet in several plants located in the heart of Long Island, close to the source of ample production personnel and materials and to rapid transportation facilities.

SOLAR DIVISION OF INTERNATIONAL HARVESTER COMPANY

Continued production of advanced components for space vehicles and aircraft and gas turbine auxiliary power units for helicopters and business jets and an ever-broadening usage of its industrial turbines in applications around the world marked 1968 for Solar Division of International Harvester Company.

Major production programs included compressor vane-and-shroud assemblies and precision high-temperature parts for Pratt & Whitney Aircraft jet engines. These engines include the TF30, J52, JT11, JT8 and JT3.

Saturn/Apollo contributions from Solar included, for the launch vehicle's 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 Command Module, main communication antenna structures.

For the Biosatellite, Solar produced a liquid recovery system and the environmental-control radiator.

The IH Division continued to fabricate the stabilator slotted leading edge and the boundary-layer-control ducting for the McDonnell Douglas F-4 jet fighter.

Solar, for years a leader in the manufacture of industrial bellows and expansion joints, introduced a new air-supply blast-closure valve for protection of military and industrial installations from nuclear explosions and contamination.

Solar aircraft auxiliary power units, driven by the 80-150-horsepower Titan gas turbine, were being used in every major U.S. military cargo helicopter program as well as on board smaller airliners and business jets. A major new Air Force program will utilize the Titan turbine in Solar-built 30- and 60-kilowatt ground generator sets for forward combat operations. Marine versions of this engine were installed to supply electricity on the Boeing hydrofoil *Tucumcari* and the new Sikorsky assault support patrol boat.

Other Solar gas turbines, rated at 350, 1,100, and 3,000 horsepower, were finding increasing industrial applications in 1968. These tasks include driving standby and continuous-duty generators, natural gas compressors, liquid pumps and a variety of heavy industrial equipment, as well as propelling high-speed boats and off-highway hauling equipment. The growing offshore petroleum industry proved an especially bountiful field for this revolutionary power plant originally conceived for aircraft propulsion.

Solar's family of industrial turbines has been designed, developed and manufactured exclusively for industrial-type tasks.

In Solar Research Laboratories, new 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 nonmetallic. Solar metallurgists continued efforts to upgrade materials used throughout turbine engines.

A second 48-inch-diameter cold-wall vacuum furnace was readied for operation alongside an earlier model at Solar Division of International Harvester Company.

Solar in 1968 installed its second 48-inch-diameter cold-wall vacuum furnace for brazing operations on aerospace components, giving the division one of the largest vacuum-furnace capacities in the United States. Facilities and machine tools for advanced aerospace fabrication continued to be expanded at Solar's San Diego plant.

SPERRY RAND CORPORATION

SPERRY FLIGHT SYSTEMS DIVISION

Research, development and production of automatic flight control and flight instrument systems continued as the major activity at Sperry Flight Systems Division in 1968.

Appearance of the first Boeing 747 jetliner marked the beginning of service for Sperry's latest commercial flight control system. This combined autopilot and stability augmentation system produced by Sperry for the 747 has integrated computer channels serving both the autopilot and the flight director. It is a fail-passive system, with provision for growth to fail-operational capability.

Also in service on the 747 is a Sperry magnetic heading reference system. This couples a magnetic sensor with the aircraft's inertial navigation system to provide accurate and stable magnetic heading outputs for the autopilot and for instrument indicators.

Automatic landings by airliners were the subject of increasing research and development by Sperry in conjunction with several airlines and airframe manufacturers. One international carrier using Sperry equipment logged several thousand automatic landings, and several other carriers were outfitting aircraft, evaluating equipment, and training crews for automatic landings.

Research in flight control and instrument display techniques for use in advanced aircraft designs, both civil and military, was continuing at Sperry. As a part of this effort, during 1968 Sperry began work under a contract to study advanced flight control electronic systems for the U.S. supersonic transport.

An intensive engineering program aimed at filling the requirements of corporate-owned aircraft for both autopilots and flight instruments continued. Matching the advanced flight performance of such aircraft with all-weather navigation capability has been sought by an increasing number of business aircraft operators.

Quantity production of gyromagnetic compass systems and of vertical gyros for attitude reference continued for a large variety of civil and military aircraft.

Central air data computers for all types of large aircraft also were among Sperry's important products related to autopilots and flight instruments. These computers process data from sensors of pitot and static air pressure and of outside temperature, and provide data on airspeed, altitude and altitude rate of change.

Stability and flight control systems for use in helicopters and other V/STOL aircraft also were being produced or were in research and development stages.

For space applications, research and development work continued on stability augmentation systems for reentry space vehicles, such as the X-24, and on control moment gyros and reaction wheels for spacecraft attitude stability and control functions.

SPERRY GYROSCOPE DIVISION

Sperry Gyroscope Division highlights for 1968 included delivery of the first modernized Terrier missile fire control systems to the U.S. Navy; continued development of the Attitude Reference Unit (ARU) for the Sentinel program's Spartan anti-ICBM missile; delivery of Ship's Inertial Navigation Systems for Navy attack submarines; successful field evaluation of the first transportable Loran-D radio navigation transmitter complex; further work on an advanced surface ship sonar system; and continued work on the Advanced Surface Missile System (ASMS).

The Navy was modernizing DLG-class ships with improved MK 76 fire control systems. Sperry, serving as systems manager for the project, delivered the first 4 systems in record time and was working on 6 additional guided missile 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 being readied for fleet use.

For future shipboard radar needs, Sperry engineering teams were at work in advanced technologies including sophisticated transmitter wave forms, digital signal processing techniques and antenna systems.

In another program, development work on the Attitude Reference Unit (ARU) of the Spartan missile continued and prototype designs entered the missile flight test program.

In midyear, additional funding was received from the Navy for continued work on an advanced surface ship sonar system aimed at improving the Navy's ability to detect, classify, track and engage an undersea target. The new microcircuited sonar system was expected to significantly enhance the Navy's capabilities in ASW. Company-sponsored research continued in such related areas as underwater communication, fire control systems and countermeasures.

The division was also producing precision Ship's Inertial Navigation Systems (SINS) for Navy attack submarines and aircraft carriers. Aboard the carriers, Sperry's SINS equipment is used to precisely align the inertial systems of attack aircraft prior to missions.

For future precision navigation tasks, Sperry engineers were exploring the potential of a new inertial component, a multiple rotation gyroscope, under company and Air Force funding. The new device was expected to lead to higher accuracy inertial systems than are presently available.

Work continued on fixed-site and mobile electronically scanned radar systems which employ a computer to control the radar beam from a fixed antenna. Earlier work on this new breed of radar was embodied in Sperry Gyroscope's HAPDAR (Hard Point Demonstration Array Radar) in operation at White Sands Missile Range, New Mexico. During the year additional funding was received to study an experimental phased array radar which was expected to aid in the development of new phased array tracking radars.

Sperry's transportable Loran-D radio navigation transmitter underwent successful field testing at Eglin AFB, Florida, during the year and under an Air Force contract the division developed and successfully flight tested a new Loran/Inertial Navigation System (LINS). These skills were being applied toward a Loran/Inertial Weapons Delivery System for jet fighter aircraft to aid in all-weather attack missions.

In the field of electrooptics, Sperry engineers continued work on special infrared beacons for use in weapon guidance and tracking systems, and on development of both infrared and ultraviolet devices to detect the flash of artillery, missile launches and even small arms fire. In laser development, a family of tiny gallium arsenide diode arrays were developed and placed in production. With the advantage of high peak power, these very small devices can solve sensor problems in navigation, intrusion detection, communications and armament fuzing. Sperry work also continued on development of the laser gyroscope it pioneered. Called a "ring laser," it offers potential as a future navigation device for space and aviation applications.

SPERRY MICROWAVE ELECTRONICS DIVISION

Major aerospace production at the Sperry Microwave Electronics Division in 1968 included semi-automatic check-out equipment for flight-line and depot maintenance programs of A-7A, F-111A, B-52 and B-58 aircraft 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 check-out 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 check-out equipment is being devoted to this activity.

Several standard radar test sets, including the AN/UPM-29 and AN/UPM-32, were also being produced by Sperry Microwave.

The division achieved several major milestones in the microwave component area. First sales were recorded for the ATTO solid-state microwave signal source, the PACT (Progress in Advanced Component Technology) Program resulted in improved circulators, isolators, filters and basic ferrite technology, and major publications recognized the Sperry lead in microwave integrated circuits. Entire circuit subassemblies were demonstrated using a combination of microstrip, ferrite and thick film technology. As a result, the division was awarded research and development contracts from the government to further pursue these studies. Sperry began deliveries of components for specialized miniature radar systems and showed first hardware results in a phased-array radar program. The division engineering organization was altered to reflect the growing importance of work in the microwave integrated circuit field and in the general semiconductor development field.

SPACE SUPPORT DIVISION

The Space Support Division in 1968 continued support services at the National Aeronautics and Space Administration's Marshall Space Flight Center, Huntsville, Alabama, and at the Goddard Space Flight Center, Greenbelt, Maryland.

A one-year contract at Marshall was renewed for $11,900,000 in April. The extension continued the engineering support at the Marshall Astrionics Laboratory. The new pact was the third one-year renewal option to a contract first awarded in March 1965. Under its contract Space Support Division was responsible for development and integration of missile system guidance and control equipment, instrumentation, communication and tracking equipment associated with the Saturn/Apollo program.

At Goddard Space Flight Center, the Space Support Division received a $3,400,000 one-year contract for continued engineering support of the Goddard Systems Reliability.

SPERRY SYSTEMS MANAGEMENT DIVISION

The mission of the Sperry Systems Management Division, as its name implies, is the design, development and integration of complex systems from design conception, through manufacture, delivery and long-term support. The division's 1968 activities encompassed submarine systems, deep ocean systems, avionics, surface ship systems and civil and industrial systems.

SSMD marked a major milestone in integrated avionics technology with the delivery of the prototype of ILAAS, an advanced weapon delivery and navigation system for attack aircraft, to the Naval Air Systems Command. The system, which was tested in an A-6 in November, can deliver all types of air-to-ground ordnance with pinpoint accuracy while providing the pilot complete flexibility in maneuvering and evasive tactics.

As navigation subsystem manager, the division continued to supply technical support to the U.S. Navy's Polaris and Poseidon fleet ballistic missile programs. The technical concepts for achieving the greatly increased accuracy of the Poseidon navigation subsystem were verified at sea. In addition, the first pilot production equipments of this navigation subsystem, including the UNIVAC-manufactured CP-890/UYK computer and CB-2342/UYK converter, were delivered ahead of target schedule.

Activity in ocean systems and marine sciences was broadened. Although primarily interested in integrated instrument systems for deep submergence vehicles, the division was conducting systems work in the fields of vehicle propulsion, deep diving work systems, vehicle systems and the marine sciences. The vehicle systems activities included bathyscaphs, nuclear research, undersea search and rescue, submersible transport and industrial submersible work systems.

Efforts in the marine sciences were directed at ocean instrumentation systems such as the National Data Buoy System, integrated ship control, collision avoidance and navigation systems for commercial shipping and diver support systems.

SSMD was expected to be one of the prime contenders in the competition to construct an advanced range instrumentation ship for missile and space vehicle tracking. Sperry was the prime contractor on the earlier ARIS missile tracking ships.

The division expanded its activities into the civil and industrial area with the award of a contract from the Bureau of Public Roads for the development of an automated traffic control system. Other commercial and industrial problem areas of the complexity and proportion to require a systems management approach were being investigated. These included industrial processing systems, medical and hospital systems, transportation systems and waste management systems.

The division's expanded business interests in 1968 were reflected in the growth of its work force and facilities. SSMD manpower showed a 25 percent increase during the year and at year-end stood at about 1,500 people. An additional 35,000 square feet of space were added to the division's Great Neck, New York, facilities which totaled about 100,000 square feet. Another 100,000 square feet of plant space, which houses SSMD's Polaris and Poseidon groups, was located in Syosset, New York.

UNIVAC DIVISION

Activities of Sperry Rand's UNIVAC Division in 1968 paralleled the dynamic growth of electronic data processing during the year. Worldwide employment rose to about 33,000, 7,000 over 1967.

A substantial portion of UNIVAC's 1968 activity was in aerospace. In the aviation field United Air Lines inaugurated the largest real-time computer system in the world using 3 UNIVAC 1108 II Computers at Elk Grove, Illinois. The 1108s handle 17 major applications including reservations and ticketing and answer requests from any of 3,000 agent locations in less than 1 second. The United system uses cathode ray tube terminals to connect the agents with the computers and automatic devices for printing the tickets.

During 1968, 2 other major international carriers, Iberia Airlines and Air Canada, ordered computer reservation systems, joining such users of the UNIVAC system as Northwest Orient Airlines, Air France, British European Airways, Scandinavian Airlines, and Eastern Airlines.

Sperry Rand Corporation's UNIVAC Division was supplying some 3,000 individual agent display sets for expediting passenger reservations for United Air Lines.

In the U.S. space program, UNIVAC was a major contributor to the Apollo moon project. Over 100 of its computers were being used in NASA's worldwide tracking and communications network. These include UNIVAC 1230 and UNIVAC 1218 computers which process telemetry, command, or radar data at each tracking station; UNIVAC 494 Real-Time Systems which route data at the Goddard Space Flight Center and the Manned Spacecraft Center; and UNIVAC 1108s which perform scientific and engineering calculations in support of missions.

The division was also actively working on future computer-based air traffic control systems for terminal areas. UNIVAC 1219 Computers process radar tracking data in the New York Common Instrument Flight Rules Room, which was dedicated in July 1968 at John F. Kennedy International Airport.

A leader in the technical advance of electronic data processing systems, the division introduced 2 new major systems. A medium-scale computer, the UNIVAC 9400, as part of the UNIVAC 9000 Series for a wide range of applications, was announced. Also introduced was the UNIVAC 418 III, the third generation in the 418 series, which are particularly useful for communications-oriented applications such as message switching and data collection. Other new products included the UNIVAC 1557/1558 Graphic Display Subsystem. Designed for direct interconnection with a large-scale computer, this system shows data on a cathode ray tube using digital deflection techniques. These new products all have applications in the aerospace industry.

UNIVAC disclosed plans to open a new assembly plant in Jackson, Minnesota. To be operating early in 1969, the 15,000-square-foot plant will produce electronic subassemblies for computer systems. The division also announced that it would open a new 11,000-square-foot facility in Strasburg, Pennsylvania, for production of precision computer components.

During 1968, UNIVAC formed a new Information Services Division, which was providing computing services through an integrated nationwide network of data-processing facilities.

New orders mounted from government and industry for the 9000 series of small- and medium-scale computers handling accounting, inventory and many other functions.

Among large-scale systems, 20 UNIVAC 1108s, worth about $50,000,000, were ordered by Computer Sciences Corporation for the firm's nationwide system of regional time-sharing computer centers. The Swiss Postal, Telephone and Telegraph Service began installing an advanced automatic telegraph exchange system using UNIVAC 418s in Zurich. UNIVAC announced a $6,300,000 contract for the system in 1967.

In October the UNIVAC Federal Systems Division received a $2,700,000 follow-on contract for programming, engineering and operations of the UNIVAC 494 Real-Time Computers at the Manned Spacecraft Center in Houston. This work is part of the extensive programming support for the 494s, which are vital to the Apollo lunar mission.

A UNIVAC computer, the CP-901, is the heart of Lockheed's P-3C Orion antisubmarine aircraft unveiled in the fall. The computer, from the UNIVAC Federal Systems Division, performs about 85 percent of the work normally done by the crew, including much of the steering and selection of weapons.

The Federal Systems Division was also under contract for aerospace computers for the Air Force's Titan III system. Deliveries started in 1968.

VICKERS DIVISION

Sperry Rand's Vickers Division continued its preeminent position in hydraulics with large-scale activity in military and commercial aerospace programs. These programs included hydraulics for military aircraft and missiles and for commercial aircraft. A wide diversity of equipment produced included the McDonnell Douglas F-4 Phantom fighter aircraft series, and helicopters such as the Huey, HueyCobra and CH-47 Chinook. Vickers-produced hydraulics were installed aboard Lockheed's new C-5 Galaxy aircraft and in power packages for the Minuteman II missile and Poseidon missile.

During the year, production contracts were received for hydraulic systems for the Army's AH-56A Cheyenne, the world's most advanced armed helicopter, for the Chaparral surface-to-air missile's launcher drive system and for the Navy A-7A attack aircraft.

In support of the growth of commercial aviation, major production at Vickers in 1968 included hydraulics for the Boeing 707, 727 and 737 jet transports and McDonnell Douglas DC-8 and DC-9 commercial jetliners.

In what is one of the most important new areas of commercial aviation, the large-capacity giant jets, Vickers received a contract to produce main engine hydraulic pumps for the Lockheed L-1011. This award followed an existing order for the main engine pumps and motors for the Boeing 747, which was rolled out in September.

SUNDSTRAND AVIATION DIVISION OF SUNDSTRAND CORPORATION

Sundstrand Aviation, celebrating the first anniversary of its 680,000-square-foot engineering, manufacturing and test facilities, continued to grow as a leading supplier of aircraft equipment and components.

Located in Rockford, Illinois, Sundstrand Aviation's prime product continued to be the constant-speed drive (CSD) for military and commercial aircraft. Since the first units were installed in the B-36 in 1946, Sundstrand had produced by year-end more than 55,000 CSDs with an accumulated flight time of more than 100,000,000 hours.

The constant-speed drive converts variable engine input power to constant-frequency output power to operate aircraft secondary power systems. The most recent product advancement in constant-speed drives is the Sundstrand Integrated Drive Generator (IDG) system. The IDG combines the reliability-proven axial gear differential (AGD) constant-speed drive with a constant-frequency A.C. generator in a single package. This combination package provides a reduction of 20 to 30 percent in both size and weight and an increase in reliability over the separately housed drive-generator combination.

Significant contracts for the year included IDG systems for the Lockheed L-1011 and AGD drives for the McDonnell Douglas DC-10. These 2 advanced technology commercial transports join the Boeing 747, British-French Concorde and most other aircraft which are equipped with Sundstrand Constant-Speed Drives.

Sundstrand Aviation was also active in many other fields. Several production and prototype torpedo propulsion units were produced and delivered to Westinghouse Electric Corporation's Underseas Division for testing in the U.S. Navy's Mark 48 torpedo program. Fuel component and systems testing was conducted in Sundstrand Aviation's new Turbine Systems Research Laboratory, a 20,000-square-foot complex equipped for the research, development and production testing of advanced, hot-gas turbomachinery systems. Sundstrand managed the development of the fuel tankage and recovery system of the torpedo and is delivering all handling and workshop test equipment to be used in fleet turnaround for the power plant and tankage.

Sundstrand also was awarded a contract valued at more than $2,000,000 from Lockheed Missiles & Space Company for production of hydraulic power units for the Poseidon fleet ballistic missile. Sundstrand was to supply 120 of the turbine-driven hydraulic units between July 1969 and April 1970. Each missile will carry 2 of the units in the motor nozzle movement system to provide thrust vector (direction) control.

In addition, continuing programs of research and development were being conducted on such products as the dual-mode transmission, a fully automatic transmission for trucks and heavy vehicles; an onsite power system fueled by natural gas; and hydraulic pumps and motors for tomorrow's aircraft requirements.

Two Sundstrand subsidiaries, Howard Foundry in Chicago and United Control in Redmond, Washington, are allied with the Aviation Division and Defense Products Group. Howard Foundry has complete casting and machining capabilities, using materials ranging from gray iron through the exotic metals. United Control designs and manufactures electronic components, systems and instrumentation for the aerospace industry.

Bruce F. Olson was named chairman of the board and chief executive officer of Sundstrand Corporation in 1968. Mr. Olson had served as president of the corporation for nearly 20 years. Louis H. Schuette, formerly senior executive vice president, was named to the newly created post of vice chairman of the board. He had been with the company for 30 years, starting as a project engineer. James W. Ethington, financial vice president and secretary since 1964, was named president. He joined Sundstrand in 1939 as an accountant. Evans W. Erikson, who had held several managerial positions in the Aviation Division, was named vice president, Aviation and Defense Products Group, Sundstrand Corporation. In this capacity he directs the operations of the Aviation Division and 3 Sundstrand subsidiaries, United Control, Howard Foundry and Sundstrand Aircraft Service Corporation.

THIOKOL CHEMICAL CORPORATION

Thiokol Chemical Corporation made significant contributions to the nation's space program and to rocket propulsion technology in 1968. Vernier rocket engines produced by the Reaction Motors Division helped soft-land Surveyor 7 on the moon. Eight Thiokol solid-propellant rocket engines performed auxiliary missions on the successful Apollo flights.

After the first-stage engines shut down, 2½ minutes following launch, 4 Thiokol retrorockets fired in a reverse direction to brake and separate the first stage permitting the second stage to propel the spacecraft on its way. Seconds later, another Thiokol motor was fired to separate and jettison the escape tower located above the Command Module. The tower's function is to pull the capsule free in case of a near-ground emergency. At about the same moment the 4 retros separated the first stage, 3 small Thiokol ullage motors fired to force liquid propellants into pumping position in the second stage. Their kick is necessary to allow liquid fuels to be pumped without the help of gravity.

In a remarkable dual success, the Air Force's Minuteman III and the Navy's Poseidon made their debuts on the same day. The Wasatch Division was producing the first stage for the Minuteman and was involved in a joint venture with Hercules Incorporated for the development of the 2-stage Poseidon propulsion system. The Elkton Division was also active in the Poseidon program.

The Air Force selected the Wasatch Division as a backup contractor for current third-stage Minuteman motor production. The contract involves manufacturing and testing of qualification motors. The Minuteman third stage was under development by Aerojet-General Corporation.

With a successful static test of a 156-inch-diameter motor, the Wasatch Division closed the Air Force Large Solid Rocket Motor Program, making available for future use a fully developed large solid booster.

The Reaction Motors Division delivered oxidizer tank metal bladder subassemblies, incorporating their high-efficiency Rolldex concept for a potential surface-to-surface missile system application. This concept, initially studied at the Naval Weapons Center, uses rolling metal bladders to provide positive expulsion of propellants. As a result of Reaction Motors' tests in various configurations and sizes, using various propellants and pressurizing fluids and under severe temperature and acceleration conditions, Rolldex may be successfully applied for a variety of applications. Anticipating future requirements involving very fast starts, higher temperatures and maximized mass fractions, Reaction Motors was exploring new Rolldex materials, processes and component approaches.

The Longhorn Division received an Army award to begin preproduction studies and tool design for Spartan, one of the 2 antiballistic missiles in the new Sentinel system. Under the contract, Longhorn was to develop the production planning and engineering criteria for facilities and tooling needed to load solid-propellant Spartan motors.

During 1968 Longhorn produced its 6,000,000th mortar round, including all calibers and all loads, and the 10,000,000th artillery and mortar round.

Under an Army development program, the Huntsville Division successfully static tested a full-scale prototype solid rocket motor confirming breakthroughs in high burning rate, solid propellant technology. Pioneering studies demonstrated a major advance for low-cost composite solid propellants required for high-acceleration missile interceptor systems like the Sentinel system.

In sounding rockets, the Astro-Met Division designed, manufactured and assembled the payload for the first launches of barium payloads ever made from Puerto Rico. A Nike-Tomahawk was used by NASA to propel payloads for studying the D-region of the atmosphere. In addition to systems management, Astro-Met designed and fabricated the mechanical and electrical components of the payload and the sounding rocket vehicle. Astro-Met sold its 400th Nike-Tomahawk vehicle in 1968.

The Elkton Division played an important role in the Radio Astronomy Explorer launching. A Thiokol spherical motor powered the third stage and a Thiokol kick motor helped position the RAE in a perfect earth orbit.

Elkton successfully test fired a Cajun solid-propellant motor which had been stored at Wallops Island for 12 years and was once submerged in sea-water during a flood.

The Georgia Division increased production rate of specialty chemicals fourfold over its 1967 production rate, highest in its history.

The year completed Thiokol's 27th year of progress in rocket and associated technologies.

TRW INC.

The aerospace activities of diversified Cleveland-headquartered TRW Inc., continued to grow during the year, which was highlighted by significant contributions to national and international space activities; further use of advanced technology in nonspace, nondefense programs; and new penetration into the superjet aircraft business.

In space, TRW-built Pioneer VIII and a Test and Training Satellite were launched piggyback style. Pioneer VIII was providing data on solar wind, magnetic fields and cosmic rays. The 44-pound NASA Test and Training Satellite was inserted into earth orbit. Its S-band communication system transmitted for 4½ months and helped check out the worldwide Apollo communications network and train ground station operators. Pioneer IX joined the 3 earlier Pioneers in solar orbit in December.

On March 4, 1968, a 1,347-pound Orbiting Geophysical Observatory carried a record 25 experiments to conduct a series of comprehensive measurements over a wide range of energy characteristics in the earth's trapped radiation belts, through the magnetosphere and in interplanetary space (the fifth in NASA's 6-satellite program).

The initial launch of Intelsat III (September 18, 1968), a 332-pound communications satellite, failed when its booster malfunctioned and had to be destroyed. A December launch was successful, however, and additional launches were planned for 1969.

Part of a USAF 4-satellite payload, the 18-pound OV5-2 carried a radiation mapping experiment and the 31-pound OV5-4 included a heat transfer experiment. Both satellites, launched September 24, 1968, were part of the Environmental Research Satellite series initiated in 1961.

Eight 100-pound communciations satellites were orbited June 13, 1968, to complete the USAF's global Initial Defense Satellite Communications System. TRW provided 6 major subsystems for each spacecraft.

Among TRW milestones of 1968 were these: The Lunar Module descent engine was test fired in space for the first time on NASA's Apollo 5 mission. The initial Minuteman III launch marked the continuation of TRW's systems engineering and technical direction of USAF ballistic missiles dating back to Atlas in 1954. A flight test evaluation program for a new penetration aid developed by TRW for ballistic missiles, originally calling for 10 flights, was successfully completed after 5 flights, with all mission objectives of the $4,200,000 program met. Sparta, a joint U.S.-U.K.-Australia project to study ballistic missile reentry phenomena, successfully completed a series of test launches from the Woomera Test Range in Australia (TRW served as ARPA's prime contractor for the project). TRW provided launch operations support as Australia orbited its first satellite, the Wresat 1 scientific spacecraft. TRW also supported ESRO (European Space Research Organization) with the successful launch of its first spacecraft, ESRO 2. Under a technical exchange agreement with England's Hawker Siddeley Dynamics, TRW assisted in the design of the scientific satellite and provided prelaunch test facilities and launch support.

The Mariner '69 propulsion system was delivered to Jet Propulsion Laboratory. The 50-pound-thrust engine was to be employed to adjust the trajectories of a pair of NASA spacecraft to be launched toward Mars in 1969. The first radioisotope propellant gauge in space, one of several TRW projects related to the use of radioisotopes to solve measurement problems that cannot be handled by conventional techniques, was orbited on board a Navy Solrad scientific satellite. A multikilowatt solar array in a new, compact, accordion-fold configuration was demonstrated in semioperational, full-size, mock-up form; the array could provide electric power for lunar surface exploration. Prototype hardware was completed for a new-type azimuth-seeking gyrocompass that slashes to minutes the time required to obtain an extremely precise true north fix; the gyrocompass has many applications, including tactical and strategic weapons and an advanced SST, for which a precise north reference is required. A portable pulsed argon ion laser utilizing a high-current cold cathode was produced for the first time; a special underwater model of the laser was being tested to survey the ocean floor and additional military, scientific and commercial applications were being studied. Deliveries of a large number of gunfire control display systems for installation on tactical aircraft were initiated.

During the year TRW was awarded a USAF contract for integration, assembly and check-out of the 407L Tactical Air Control System, a continuing program to improve the existing system through upgrading components and procuring newly developed equipment. The company also received an Air Force contract for work on the Hard Rock advanced missile silo development program, plus an award for the design and manufacture of a prototype digital data system for tactical aircraft applications.

In addition, follow-on systems engineering contracts were received for work on the Minuteman, ASW and Apollo programs.

USAF contracts were received during the year for avionics hardware having immediate and future tactical applications. Work in 1968 was concentrated in 2 areas: aircraft electronic systems and navigation satellite user equipment.

The company also received a USAF contract to develop computer software which will allow base commanders to predict advanced facility requirements more accurately and will provide computerized maintenance for high-performance aircraft and ground vehicles.

There was a wide variety of study contracts, with subjects ranging from low-cost launch vehicles (for NASA), navigation satellites (USAF and NASA), TV broadcast satellite (NASA), application of Gemini electronics to helicopters and V/STOL aircraft (NASA) and the worldwide fleet broadcast communications system (USN).

During 1968 TRW continued its technical support of the Army's Cheyenne helicopter project, and the Lunar Module Abort Guidance System (LMAGS) was readied for its first orbital test during NASA's Apollo 9 flight.

The company made deeper penetration into the emerging civil systems market in 1968. TRW established a new firm, Canadian Systems/TRW Limited, in Toronto, Canada, to apply systems engineering, aerospace technology and computer software to the civil sector of the Canadian economy.

Assistance was being provided the U.S. Bureau of Public Roads in developing a traffic control system using electronic sensors and computers to monitor and regulate traffic. The project will result in a pilot system at Washington, D.C., affecting 100 major intersections.

TRW was conducting 5 studies for the Department of Health, Education and Welfare to assist the federal government in the development of an expanded national air-pollution control program.

TRW was also conducting a 2-year project for Fresno, California, to provide a modern and systematic method of planning and implementing city renewal and economic development programs. The project includes the design of an automated management system which directs, reviews and updates the programs.

Under an Army Corps of Engineers' contract, TRW was using systems techniques to perform a research study for the improvement of flood plan management and development as part of a major program to find ways of curbing the toll of lives and the cost of damage due to floods. Part of the study called for finding the best ways of solving flood control problems.

New ways of chemically disposing of huge amounts of waste plastics without polluting the air were being studied by TRW under contract to the Department of Health, Education and Welfare. The study was also to investigate useful byproducts that could be obtained from the high-temperature chemical burning of plastics.

Advanced concepts for hospital communications, special care units, materials handling, automatic data processing, and educational systems were developed by TRW for the Army Surgeon General in a study to provide data needed for the construction of a new Army Walter Reed General Hospital. From the systems studies, plus a survey of the traffic flow of doctors, nurses, patients and students using the hospital, a space allocation plan showing the interrelationships of the hospital's different operations was prepared to support systems that will efficiently and effectively implement the medical care, research and educational functions of the hospital.

Under a contract awarded by the Kennedy Airport Access Project, TRW studied high-speed methods of transporting passengers and baggage from downtown Manhattan to the central terminal area of Kennedy International Airport. The study was being conducted to assist New York City transportation officials in solving the mounting motor vehicle congestion surrounding one of the nation's busiest airports. The Kennedy Airport Access Project is an ad hoc group representing the Metropolitan Transportation Authority, the Port Authority and the major airlines serving Kennedy Airport.

For the Department of Transportation, TRW was performing 4 studies to develop criteria for the automated inspection of motor vehicles, used car safety standards, motor vehicle inspection stations and performance standards of vehicle braking systems. Work on the Department of Transportation's High-Speed Ground Transportation Program for the Northeast Corridor continued during the year.

To keep up with trends in the aerospace business, TRW completed in 1968 an 8-year construction program in Redondo Beach, California, with the opening of the 13th building on a 110-acre site. Meanwhile, the first building on an adjacent site in Manhattan Beach was expected to be completed at the end of the year. The company announced plans to build a facility in McLean, Virginia, to house the 900-man Washington Operations, and opened a fourth building at its Houston Operations. In addition, TRW placed a $2,400,000 space simulation chamber, one of the world's largest and most versatile, in operation at the Redondo Beach facility.

TRW Systems Group placed in operation at its Redondo Beach, California, facility this $2,400,000 space simulation chamber.

For the year, employment at TRW's Systems Group, the company's main aerospace arm, was relatively unchanged from year-end 1967—17,000 persons.

This group announced plans to employ, train and retain 130 hard-core unemployed persons under the National Alliance of Businessmen's JOBS (Job Opportunity in the Business Sector) program.

TRW maintained steady production schedules of parts for current aircraft and related industries. At the same time, development work was under way on components for engines of the 1970s. An initial shipment of precision-forged fan blades was made for the Pratt & Whitney Aircraft JT9D engine, which will propel the Boeing 747 jumbo jetliner. While the 747 will provide substantial orders over the next few years, advances in forge capability resulting from this program should be applicable to other superjets. In addition, the company received its first follow-on order to supply 3 stages of turbine blades and vanes for the Rolls-Royce RB-211 engine being built for the Lockheed L-1011 air bus. Demand for this type aircraft was expected to total 1,000. TRW also won contracts to produce components for General Electric's TF34 turbofan engine which will power the VFX antisubmarine aircraft and for GE's CF6 which will drive the McDonnell Douglas DC-10 air bus.

At least 2 new giant aircraft, the C-5A Galaxy and the 747, will carry TRW pumps. After shipping 16 preproduction main engine fuel pump units for the JT9D, TRW received a sizable production order. The first 747s in the air will carry these pumps. The company hoped for an eventual production rate of 35 per month. The C-5A, which began flight testing in 1968, carries 12 TRW dual-element booster pumps in its wings and fuselage.

In nuclear components, TRW was awarded a sizable order for units of a control rod drive mechanism for the Navy's nuclear submarine program. The order extended the company's backlog for this sophisticated device into 1972.

The company received its fourth fiscal year contract award for production of propulsion systems for the Navy's advanced Mark 46 torpedo. Delivery of these units was scheduled for 1969. These systems performed well during in-water tests and proposals for future Mark 46 work were being made for delivery in 1970.

In metallurgical research, attempts to achieve directional grain growth in castings continued. The improved thermal and structural characteristics of such castings were expected to permit upgrading of jet engine performance. A big step was taken toward establishing a new process for surface coating turbine blades and vanes for high-temperature operation. TRW researchers continued work under an Air Force contract to develop "supersize" superalloy investment castings containing both heavy and ultra-thin walls to replace weldments in next-generation jet engines. The goal is to produce castings up to 4 feet in diameter with walls as thin as .04 inch for stationary engine parts. Parts could include compressor housings, diffuser cases and turbine hubs. Such castings would weigh up to 350 pounds after gates and risers are removed. Tolerances will be close enough that machining will be required only where surfaces mate.

Also under intensive study was the application of high integrity investment castings in industrial gas turbines. Experimental vane segments for the Westinghouse W-251 turbine engine were being produced. Other possibilities include castings for heavy duty (more than 1,000 horsepower) turbine applications, aircraft engine conversions to stationary power plants, and turbines for truck and off-the-road equipment.

TWIN INDUSTRIES CORPORATION A DIVISION OF THE WHEELABRATOR CORPORATION

New business in 1968 put Twin Industries to work in new and expanded areas of capability, a response in part to an extensive modernization and expansion program inaugurated the year before. The acquisition of new equipment, with emphasis on increased capacity and cost savings, was a feature of the 1968 phase of the program. Added facilities and equipment included a titanium processing line, a bonding press, an enlarged chemical milling facility, and tape-controlled machine shop equipment.

These factors, added to Twin's historic competence in airframe component manufacture, contributed to the achievement of a new backlog record and increased employment.

Production continued on vertical fin, rudder and spoiler assemblies for Boeing's 707/720, and ground and flight spoilers for the Boeing 727.

Manufacture of the complete empennage for the Gulfstream II continued as deliveries of Grumman's business jet accelerated. A new subcontract, also from Grumman, called for Twin to supply bonded panels for the F-111.

A definitive contract valued in excess of $24,000,000, covering window panel assemblies and fuselage frames for the Boeing 747, was awarded Twin by Norair Division of Northrop Corporation. Deliveries of these components were being made in 1968 as were honeycomb bonded doors for Northrop's F-5 Freedom Fighter.

Floor panels for the 747, a bonded sandwich panel construction of PVC foam core with aluminum and titanium skins, were being supplied to The Boeing Company under a contract received late in 1967.

Another of the year's highlights included receipt of a major contract for the manufacture of fixed-wing leading edges for Lockheed-Georgia's C-5A military transport, world's largest cargo jet, and deliveries commenced in the spring.

Other contracts under which deliveries were being made included one requiring the production of splitter assemblies for engine thrust reversers for General Electric and another for Raytheon for the supply of electronic equipment consoles for the Hawk missile system.

Completed in 1968 were the cabin, cockpit structure, nose section, flaps and vanes to be installed on a Convair 240 as an inflight simulator of supersonic transport flight and landing characteristics. Contractor was Cornell Aeronautical Laboratory.

Twin's management capability was increased by the strengthening of the Program Management Group, a continuation of Twin's policy of the management of each program by the program management philosophy.

New orders and follow-on orders received during 1968 increased the backlog by over $12,000,000, with year-end backlog estimated in excess of $58,000,000.

UNITED AIRCRAFT CORPORATION

United Aircraft Corporation maintained its position of leadership in 1968 as a designer and manufacturer of aerospace equipment.

The company's products included jet and rocket engines, helicopters, space and life-support systems, fuel and environmental control equipment for aircraft and spacecraft, propellers, advanced radar systems and other tools of flight.

The year brought changes in the corporation's top management, continued streamlining of its operations, and increased acceptance of its products for aerospace and other uses.

In the management changes, William P. Gwinn, who was president and chief executive officer, succeeded H. M. Horner as chairman. Mr. Horner, who retired, was designated chairman emeritus and remained a member of the board of directors and of its executive committee.

Arthur E. Smith, former executive vice president, succeeded Mr. Gwinn as president. Mr. Smith also is chief administrative officer of the corporation. Before becoming executive vice president on January 1, 1968, Mr. Smith was division president of Pratt & Whitney Aircraft.

Bernard A. Schmickrath succeeded Mr. Smith as division president of Pratt & Whitney Aircraft. At the Sikorsky Aircraft division, Wesley A. Kuhrt became division president, succeeding Lee S. Johnson, who retired after having served as division president for 11 years.

United Aircraft's work force leveled off in 1968 at about 78,000 employees at manufacturing sites in 4 states: Connecticut, Florida, California and Pennsylvania.

During the year Pratt & Whitney Aircraft delivered the first of its JT9D turbofan engines for such new-generation jetliners as the Boeing 747. Versions of the JT9D produce up to 45,500 pounds of thrust.

By autumn of 1968, more than 120 of the world's airlines were operating or had ordered jet transports powered by Pratt & Whitney Aircraft gas turbine engines and equipped with Hamilton Standard fuel controls.

Pratt & Whitney Aircraft gas turbines modified for industrial and marine use gained even wider acceptance in such non-aviation applications as electrical power generation, natural gas pumping, and ship propulsion.

United's solid-propellant boosters and liquid-propellant rocket engines operated successfully in such programs as Titan III-C and Centaur/Surveyor, while development continued on other rocket programs, including work on hybrids.

United continued its contribution to the Apollo program. Pratt & Whitney Aircraft fuel cells, for example, flew successfully in the first manned Apollo missions in October and December.

United Aircraft continued to broaden its diversification in 1968. A new 60,000-square-foot plant was opened in Riverside, California, for large-scale production of Techite® pipe by the United Technology Center division.

Techite is a light, high-strength fluid conveyance pipe of reinforced plastic mortar developed by UTC from knowledge gained in the research and production of glass fiber rocket motor cases.

Among other 1968 highlights, TurboTrains designed and built by Sikorsky Aircraft were delivered to the U.S. Department of Transportation and to Canadian National Railways. The DOT trains were for service between Boston and New York, and the CNR trains for the Montreal-to-Toronto route.

United Aircraft established and began operating a training center in Hartford, Connecticut, to help unemployed and so-called unemployable persons prepare for jobs in Greater Hartford business and industry.

Through its 6 operating divisions and Research Laboratories, the corporation continued to advance the state of the art in the broad areas of power conversion, metallurgy, lasers, advanced vertical and short take-off and landing aircraft, electronics and communications.

Because each division has its own product lines and technical interests, detailed activities of the company are reported separately in the following columns under the names of each.

They are: Pratt & Whitney Aircraft, gas turbine engines for aviation, industrial and marine applications, rocket engines, fuel cell power plants; Hamilton Standard, jet engine fuel controls, space and life-support systems, space ground support equipment, biomedical equipment, propellers and other accessories for spacecraft and aircraft, electronics; Sikorsky Aircraft, helicopters, advanced vertical-lift aircraft, surface transportation systems; Norden, radar, telemetry and other electronic systems; Electronic Components, microelectronics, high-power transistors, semiconductor devices; United Technology Center, solid-propellant boosters, hybrid rockets, advanced space propulsion systems, Techite pipe.

PRATT & WHITNEY AIRCRAFT
DIVISION OF UNITED AIRCRAFT CORPORATION

Deliveries of the first versions of the 43,500-pound-thrust, advanced technology JT9D turbofan engine, power plant for the Boeing 747 superjet and the McDonnell Douglas DC-10 Series 20 trijet, and the expansion of facilities for development and production of the engine highlighted 1968 at Pratt & Whitney Aircraft. The JT9D was scheduled to grow to 45,500 pounds by September 1971, with higher-thrust models planned beyond that.

By the end of September 1968, 3 ground test and 10 flight engines had been delivered to Boeing. All told, 872 engines had been ordered for the 747 as of September 30, the day the huge plane was rolled out.

In East Hartford 11 engines were to be utilized in the P&WA JT9D development program. Ten of these were in operation by mid-October and had accumulated more than 2,000 hours of test time. This program included a JT9D installed on a modified B-52, test flights of which began in mid-June and had totaled more than 70 hours during the 4 months through mid-October. These flights demonstrated that the JT9D virtually eliminates smoke. Also, extensive noise measurements of the engine showed that despite the fact that it is more than twice as powerful as the largest engines in commercial service, it is quieter. An improvement in fuel consumption of more than 20 percent over current commercial aircraft engines is another outstanding feature of the JT9D.

As part of the JT9D engine development program, P&WA completed in 1968 a major expansion of its Willgoos Turbine Laboratory in East Hartford. A 15-foot-diameter altitude chamber was built to accommodate the new generation of high bypass ratio engines with their large-diameter fans.

Production of the JT9D was to be centered in a 500,000-square-foot manufacturing and assembly building completed in the spring of 1968 as an addition to the P&WA Middletown, Connecticut, plant.

The 4,000th JT8D engine came off the Pratt & Whitney Aircraft East Hartford assembly line on August 25, 5½ years after the first JT8D delivery. By the end of September, this popular 14,000-15,000-pound-thrust turbofan, versions of which power the Boeing 727 and 737, Douglas DC-9 and Sud Aviation Super Caravelle, had accumulated 13,500,000 flight hours. An afterburning version, built under license by Svenska Flygmotor, is used in the Swedish Air Force Mach 2.5 Viggen fighter aircraft.

Pratt & Whitney Aircraft announced in June 1968 the development of a modified combustion chamber for the JT8D which significantly reduces smoke. Six airlines in the U.S. and Europe are conducting service evaluations of 50 sets of these chambers in Boeing 727 and 737 and Douglas DC-9 series aircraft.

Another principal P&WA commercial engine, the JT3D turbofan with up to 19,000 pounds thrust, powers most Boeing 707 and Douglas DC-8 series aircraft. The JT3D had accumulated more than 42,000,000 flight hours by the end of October, exactly a decade after the inaugural commercial jet flight by a P&WA-powered Pan American Boeing 707 from New York to Paris on October 26, 1958.

The JT12 turbojet, with up to 3,300 pounds thrust, continued to perform satisfactorily in the twin-engine North American Sabreliner and the 4-engine Lockheed JetStar. A free turbine version of this engine, the JFTD12, is power plant for the Sikorsky S-64 Skycrane, the free world's largest helicopter. The engine had more than 2,000,000 flight hours by October 1, 1968.

At the end of September, P&WA commercial gas turbine engines of all types had accumulated over 76,400,000 flight hours and were in use or on order by 117 airlines throughout the world.

Major military aircraft P&WA gas turbine engines include the TF33 turbofan, with up to 21,000 pounds of thrust, for the Lockheed C-141A StarLifter, versions of the Boeing C-135 and the B-52H; the J52 turbojet (up to 9,300 pounds of thrust) for the Douglas A-4 Skyhawk and the Grumman A-6 Intruder; the J57 turbojet (up to 18,500 pounds of thrust) for versions of the Boeing B-52 Stratofortress, Douglas A-3 Skywarrior, LTV Aerospace Corporation F-8 Crusader, North American Rockwell F-100 Super Sabre, McDonnell F-101 Voodoo and General Dynamics/Convair F-102 Delta Dagger; the J75 turbojet (up to 26,500 pounds of thrust) for the Republic Aviation F-105 Thunderchief, General Dynamics/Convair F-106 Delta Dart and Lockheed U-2.

The Pratt & Whitney Aircraft TF30 turbofan powers the Navy's highly successful LTV Aerospace Corporation A-7 Corsair II, a subsonic, multipurpose attack plane which entered service in late 1967. By October 1, more than 90,000 flight hours had been accumulated on the engine. The afterburning version of the TF30, the world's first afterburning turbofan, is the power plant for the Air Force General Dynamics twin-engine supersonic F-111. This engine is in the 20,000-pound-thrust class. Another version of it, the TF306, was developed by SNECMA of France for use in versions of the single-engine French Dassault Mirage.

All told, nearly 72,000,000 hours had been accumulated on P&WA military aircraft engines by October 1968.

Major growth occurred during 1968 in non-aviation applications for P&WA gas turbine engines. More than 400 units had been delivered or were on order, as of October 1, for use in electrical generating, petrochemical, gas transmission, and marine areas since the company entered the field 6 years earlier with the formation of its Turbo Power and Marine Department.

More than 150 P&WA gas turbine units, capable of producing more than 4,000,000 kilowatts, were in service for electric utilities. They ranged from single gas turbine driven generator power packages to an installation of 2 160,000-kilowatt generating stations for a large eastern utility. These 2 stations will be powered by 16 Pratt & Whitney Aircraft FT4 units coupled directly to generators and will be ready for service in mid-1970.

During the second half of the year P&WA delivered 3 gas turbine powered 15,000-kilowatt mobile electric generating stations, each installed in a pair of large truck trailers. The first of their kind in the U.S., these tractor-trailer generating stations were designed and developed by P&WA. The units can move over paved highways at speeds up to 60 miles per hour to serve in emergencies and otherwise function as a highly mobile and flexible source of power.

More than a dozen leading natural gas transmission companies were operating Pratt & Whitney Aircraft gas turbine engines as prime movers for gas pipelines. These engines range in size from 2,500 to 16,500 horsepower and had accumulated by mid-October 1968 more than 700,000 in-service hours.

In the marine field, P&WA gas turbine engines rated at 20,000 horsepower supply boost power for a fleet of 9 2,800-ton Coast Guard Hamilton Class high-endurance cutters. Seven of these vessels were in commission by October. The 694-foot roll-on, roll-off merchant ship *Admiral William F. Callaghan* is powered by 2 P&WA FT4 gas turbine engines, each developing 25,000 horsepower. In service with the Navy's Military Sea Transportation Service (MSTS), the *Callaghan* set a speed record for merchant ships early in 1968 when it made a 3,371-mile transatlantic crossing at an average speed of nearly 26 knots. By the end of September 1968, the *Callaghan* had made 14 round trips between the U.S. and Europe since its maiden voyage in December 1967.

Other marine applications of P&WA engines included boost power for 2 Royal Danish Navy frigates, and a new series of destroyers and a hydrofoil vessel for the Royal Canadian Navy.

At Pratt & Whitney Aircraft's Florida Research and Development Center, in West Palm Beach, development of a new high-performance turbofan engine for advanced military aircraft began. This engine, the JTF22, will be built and tested under an 18-month program funded by the Air Force and Navy. If selected for further development at the end of the initial development program, which is competitive, the JTF22 will power a new Air Force air superiority fighter and a carrier-based Navy fighter. Performance details of the JTF22 are classified.

The Florida Research and Development Center also received a contract from the Air Force Rocket Propulsion Laboratory to build and test a powerful new liquid-hydrogen/liquid-oxygen rocket engine. The XLR129 will produce up to 250,000 pounds of thrust through use of high pressure and will have a 2-position nozzle that permits a single engine to obtain high performance for both sea-level and outer space missions. Tests of a full-scale thrust chamber have already proved the XLR129's staged combustion design in which hydrogen fuel is ignited in a preburner chamber before it passes into the main combustion chamber. Thrust of the XLR129 can be varied over a wide range.

Work continued on a small, advanced technology power plant for V/STOL aircraft, including helicopters, with component testing for the 1,500-horsepower ST9 turboshaft engine. The ST9, featuring improved performance and easy maintainability in the field, was being developed under a 2-year program sponsored by the Army.

Engineering evaluation of a lightweight waterjet propulsion system for high-speed boats moved from the static test stand at the Florida plant into a 32-foot experimental boat. This new marine propulsion system consists of a Pratt & Whitney Aircraft SJ6 waterjet pump powered by a 450-horsepower ST6 gas turbine engine produced by United Aircraft of Canada, Limited. The experimental boat test program for the SJ6 waterjet will provide operational experience under actual seagoing conditions to verify performance, durability, handling and maneuvering characteristics, and will explore the feasibility of much larger units—up to 40,000 horsepower—for large Navy and merchant ships.

Product improvement continued at the Florida center on the J58 turbojet, 2 of which power the Air Force's Lockheed Mach 3 YF-12A interceptor and SR-71 reconnaissance aircraft. The YF-12A is the holder of 9 speed records. The J58 is in the 30,000-pound-thrust class. Work was also continuing on the 15,000-pound-thrust RL10 rocket engine that powers the second stage of NASA's Atlas-Centaur space vehicle.

Pratt & Whitney Aircraft continued to be a major industry factor in fuel cell research, development and production. Three P&WA Powercels® 3A provide on-board electricity for the Apollo spacecraft command and service modules. Performance of these Powercels was successful in the flights of Apollo 4 in November 1967, Apollo 6 in April 1968, Apollo 7 in October 1968 and the Apollo 8 lunar mission in December 1968. Pure water is a byproduct of the fuel cell operation and was used by the 3 astronauts for drinking and food preparation.

The design life requirement for the Powercel 3A is 400 hours. In a NASA-supervised test, one of these fuel cells completed a test run of 1,526 hours, well over 3 times the original design requirement.

In the largest research effort ever undertaken by the gas industry, Project TARGET, P&WA and 28 gas utilities throughout the U.S. were sponsoring a 3-year, $20,000,000 study of the feasibility of natural gas fuel cells for consumer use. The second year of the effort, 1968, continued with intensive technical research, and a large amount of detailed economic data was obtained and analyzed. In a one-week experiment in July, a Powercel 10 successfully provided the electricity for a typical suburban family of 5 in Ohio, demonstrating technical feasibility of fuel cell electricity for homes.

HAMILTON STANDARD
DIVISION OF UNITED AIRCRAFT CORPORATION

Hamilton Standard in 1968 emerged as a major supplier of environmental control equipment for the next generation of subsonic luxury jetliners.

Lockheed-California selected Hamilton Standard to develop and build the L-1011 trijet's integrated pneumatic system. The system is comprised of the environmental control system, auxiliary power unit and engine starters.

Production of Boeing 747's environmental control system began as prototype equipment, including air-conditioning units and cabin temperature and pressurization controls, was shipped to Boeing at Everett, Washington. Hamilton Standard also is supplying the 360-passenger jetliner's engine fuel controls and starters.

Cabin pressurization systems were delivered for the Boeing 737, the first airliner equipped with a fully automatic system. Production of air-conditioning equipment continued for the Northrop F-5, Douglas A-4E, Ling-Temco-Vought A-7 military jets and Lockheed JetStar executive plane.

The Apollo Lunar Module's environmental control system built by Hamilton Standard successfully passed its first space test during the unmanned LM earth orbit in January. Porous plate sublimators supplied by the division cooled guidance and telemetry equipment on the Saturn IB and Saturn V launch vehicles during the year's manned and unmanned Apollo missions.

The first Apollo life-support backpack which will be used on a manned space flight was delivered to the National Aeronautics and Space Administration. The portable life-support system is designed to create and maintain a livable atmosphere inside an astronaut's space suit. Hamilton Standard is fabricating for the U.S. Air Force an experimental space suit with integrated maneuvering thrusters built into a hard shell torso. Design work progressed on an advanced integrated life-support system (AILSS) for manned interplanetary missions.

Hydrazine-fueled rocket engines built by Hamilton Standard were fired in space for the first time in February aboard the Applications Technology Satellite III (ATS-3). Hughes Aircraft selected the division to build monopropellant rockets for the new Intelsat 4 series of advanced communications satellites.

Fuel controls were supplied in quantity for General Electric, Lycoming and Pratt & Whitney Aircraft gas turbine engines that power approximately 25 commercial and military airplanes and helicopters. Flight testing of the new fuel control for the Boeing 747's P&WA JT9D engines was completed, and all prototype models were delivered.

Lightweight pusher propellers with fiberglass blades and integral gearboxes were delivered for the Lockheed AH-56A armed helicopter. Propellers were manufactured for the Handley Page Jetstream business plane, North American OV-10A counterinsurgency aircraft, Lockheed P-3 antisubmarine patrol plane, Lockheed C-130, Grumman OV-1 reconnaissance craft and de Havilland CV-7 Buffalo cargo carrier. Vereinigte Flugtechnische Werke GmBH (VFW) of West Germany selected the division to develop 23-foot propellers for its prototype VC-400 vertical take-off and landing (VTOL) transport.

Hamilton Standard was developing an advanced space suit for future missions that offers considerably greater mobility than existing pressure suits.

In electronics, production continued on fuel controls for industrial gas turbine engines, flight controls for the Sikorsky SH-3 submarine hunter and Fairchild Hiller FH-1100 helicopter, and static inverters for the Northrop F-5. Temperature controls were manufactured for the Grumman OV-1, Grumman A-6A attack aircraft and Lockheed P-3 submarine hunter.

Electron beam welding continued to make inroads into mass production of auto parts as machines were delivered for high-speed welding of steering column sections and ball joints. Ford Motor Company added machines to its production line for welding engine flywheels. A cold cathode welder that fires high-speed electrons to weld, bond or braze different metals was delivered to the Air Force for testing as a multipurpose metalworking tool for astronauts. Under contract to the American Gas Association, Hamilton Standard was building a machine that will automate the welding of gas transmission pipelines.

Hamilton Standard's computer-controlled heart-assist pump, which was under clinical evaluation, was used in Montreal and Des Moines hospitals to save the lives of 3 heart attack patients during the year. A new multipatient cardiac monitor using telemetry techniques was introduced by Hamilton Standard for hospital intensive care and coronary care units. Contracts were received for continued research into advanced heart-assist devices and artificial kidney equipment for the National Institutes of Health.

Hamilton Standard's composite materials group received an order for 3,000 pounds of boron filament from the Air Force. Boron filament was purchased by many aerospace firms for the fabrication of a variety of airframe sections and engine components. The division began production of boron filament and Borsic®, boron filament coated with silicon carbide for use in metal composites, in a newly equipped facility.

Ground support equipment developed by Hamilton Standard included computerized test equipment that automates and speeds up the testing of armored tank engines and transmissions for the U.S. Army and a portable test unit designed for diagnostic analysis of gas turbine engines in the field. The Federal Aviation Administration approved airport approach lights developed by the division for installation at both commercial and private airfields.

Hamilton Standard combined its overhaul and repair and ground support equipment departments into a single aerospace services department to build equipment and provide overhaul and modification services that support products made by the division and other customers. In midyear, a new 56,800-square-foot plant was opened in Long Beach, California, to service West Coast customers. United Aircraft transferred the components department of its Norden division to Hamilton Standard in August. The department builds tachometers and pressure ratio indicating systems for aircraft jet engines.

SIKORSKY AIRCRAFT
DIVISION OF UNITED AIRCRAFT CORPORATION

Sikorsky Aircraft in 1968 continued as a leader in the production and development of large helicopters.

A U.S. Marine Corps CH-53A helicopter built by Sikorsky flew at a gross weight of 51,900 pounds in February, a record for free world production helicopters.

Sikorsky's S-64 Skycrane helicopter, flown by the U.S. Army as the CH-54A, underwent changes to increase its lifting capacity. A growth version of the Skycrane was prepared for tests.

The HH-53C, a more powerful version of the HH-53B used by the Aerospace Rescue and Recovery Service, was delivered to the U.S. Air Force to enhance the service's rescue capability. Sikorsky's medium-size S-61 series also was improved to provide greater speed and power.

Development of surface vehicles, an addition to Sikorsky's overall program in 1967, continued in 1968. The division's surface transportation systems section guided the TurboTrain, a high-speed carrier capable of speeds above 170 miles an hour, into its final test period. Two 3-car TurboTrains were formally delivered to the U.S. Department of Transportation for operation between Boston and New York. Five 7-car TurboTrains were placed in service by Canadian National Railways between Montreal and Toronto. Designs and mock-up were completed for a fast, turbine-powered gunboat for the U.S. Navy.

Helicopters and VTOL (vertical take-off and landing) aircraft, however, were the mainstays of Sikorsky assembly and research. Variety was the key to helicopter production figures. Five basic aircraft, the S-58, S-61, S-62, S-64 and S-65, were built in a dozen different configurations to meet military and commercial commitments. The S-61 series included, for instance, the U.S. Navy's SH-3D, the U.S. Air Force's HH-3E and CH-3E, the U.S. Coast Guard's HH-3F and the commercial S-61L and S-61N. Helicopters were delivered to all U.S. military services, foreign military services (many produced by Sikorsky licensees), and commercial operators both in the U.S. and abroad.

The S-65, newest and largest of the Sikorsky helicopters, continued to gain favor as a fast, tough, dependable aircraft. CH-53A and HH-53B versions of this twin-turbine workhorse won respect in Vietnam. Marine CH-53As arrived in the Asian war zone late in 1966 to form HMH-463 at Marble Mountain Air Facility near Danang. They were used as troop and supply carriers and as heavy lifters. HMH-463 flew as many as 1,252 sorties in a week, and recovered 450 downed aircraft in a year. One CH-53A carried 75 combat troops on a single mission; another carried 169,000 pounds of cargo in a single day. CH-53As were vital to the resupply of troops in the besieged cities of Hue and Khesan. Air Force HH-53Bs helped the 3rd Aerospace Rescue and Recovery Group record its 1,000th combat save. Two HH-53Bs rescued 8 downed airmen in a single day. More than 100 rescues were reported in less than a year. The HH-53B, like the medium helicopter, the HH-3E, relied on a probe for aerial refueling to allow close coverage of fighter and bomber attacks.

Sikorsky delivered its 100th CH-53A to the Marines in early 1968. Growth engines, responsible for increased power in the HH-53C, were being installed in both Marine and German CH-53As. The CH-53A was selected for procurement by the German government in July. An initial order for 2 CH-53As was received by Sikorsky through the U.S. Naval Air Systems Command. Funding by the German government was expected to assure production of 133 additional aircraft.

Sikorsky S-64 Skycrane helicopters made inroads into both the military and the commercial markets. Army CH-54As, used by the U.S. Army in Vietnam in increasing numbers, transported fuel, bulldozers, road graders, howitzers, other aircraft and a variety of supplies needed by combat troops. These second-generation cranes followed an initial Army order in 1964; they carry improvements suggested by field reports, such as engine air particle separators to protect the twin-turbine power plants from sand and other debris (similar separators are used in the CH-53A). The Army also ordered portable vans from Sikorsky to carry troops and weapons and to serve as combat hospitals, command posts, maintenance quarters and communications centers. The first van approved by the Federal Aviation Administration to carry troops was delivered in 1968.

S-64Es, designed by Sikorsky for commercial lifting projects, were earmarked for a number of purposes. Two were sold to a Texas drilling company. Others were used by Sikorsky to demonstrate the crane's ability to serve the construction, drilling, utility, and cargo transportation industries.

Both the HH-53C and CH-54A were placed high in the list of aircraft supporting the Apollo space program. Both were tested and found suitable for lifting an Apollo module. Other Apollo-oriented helicopters included the SH-3D, the Navy's principal vehicle for fast pickup at the end of splashdown, and the HH-3E, scheduled for launching site guard duty along with the HH-53B.

Even larger versions of the S-64 and S-65, the present giants of the Sikorsky line, were envisioned for the near future. The CH-54B, an improved CH-54A, will be able to lift more than 12 tons instead of the CH-54A's 10. The S-64B, with 3 engines instead of 2, was expected to lift nearly 18 tons. Hardware for the S-64B was already delivered to Sikorsky. Crane helicopters able to lift 30, 40 and even 50 tons are clearly possible if the need should arise, according to Sikorsky engineers. A commercial, compound version of the S-65 was designed for a gross weight of 63,600 pounds, a passenger capacity of 86, and lower operating cost than present airline helicopters.

S-61-type helicopters went to a number of services and a number of countries in 1968. The SH-3D, uprated version of the U.S. Navy submarine hunter, the SH-3A, went into service here and abroad. More and more, the Navy relied on SH-3As and SH-3Ds in Vietnamese waters to fly long overwater and over-jungle missions to rescue downed fliers. Refueling was accomplished from surface vessels. HH-3Es, the Jolly Green Giants of the Air Force's Aerospace Rescue and Recovery Service, added to their rescue totals in Vietnam. The number now stands at more than 600. Captain Gerald O. Young, HH-3E pilot, received the Congressional Medal of Honor in 1968 for one of his exploits west of Danang. The addition of refueling probes to the HH-3Es, as well as to the HH-53Bs, reduced the time between emergency call and pickup. CH-3Es, cargo versions of the Air Force S-61, continued their Pony Express roles in Vietnam, lifting men and supplies between recovery flights. The Coast Guard HH-3F, with a sophisticated collection of navigational and communications equipment, neared the end of its test period at Sikorsky's Stratford plant. First delivery was scheduled for the end of 1968. HH-3Fs were expected to supplement the search and rescue activities of the single-turbine HH-52As, mainstays of the Coast Guard air arm since 1963.

The S-58 helicopter, an aircraft with seemingly endless life, rolled off Sikorsky's assembly line again in 1968 in limited quantities. The S-58 first flew in 1954. All those built in 1968 were marked for delivery overseas under the U.S. government's military assistance program.

Foreign military orders and deliveries were significant. In addition to the CH-53As marked for Germany, SH-3Ds were in production in England for the British Navy and in Italy for the Italian Navy. The Brazilian Navy ordered SH-3Ds directly from Sikorsky.

Sikorsky licensees will produce many of the helicopters ordered by foreign nations. These licensees include Westland Aircraft Ltd., of England, Gruppo Fratelli Agusta of Italy, Mitsubishi Heavy Industries Ltd., of Japan, and Sud Aviation of France. Technical assistance agreements continued with Vereinigte Flugtechnische Werke GmBH of Germany and Royal Netherlands Aircraft Factories Fokker of Holland.

Commercial sales of S-61 models remained steady in 1968. Helicopter airlines in 5 different countries were using Sikorsky helicopters as passenger and cargo carriers. These included the United States, Greenland, England, Italy and Australia. In addition, S-61s were being used as offshore oil and gas rig supply ships.

Sikorsky continued its study of the commercial market in 1968. Beyond the present S-61L and S-61N, it was indicated, are the compound S-65, available in 3 to 5 years, and the stowed rotor, available in 10. An S-61F experimental compound continued to gather data for future designs.

Research at Sikorsky centered on growth versions of existing aircraft and new designs that may revolutionize VTOL travel. The latter include an ABC (for "advancing blade concept") helicopter, with 2 counterrotating main lifting rotors on a single axis and an optional pusher-propeller in the rear; a TRAC (for "telescoping rotor aircraft"), with retractable rotor blades that can be telescoped in flight; and the heavy-lifters that are direct outgrowths of the S-64 and S-65 systems.

NORDEN
DIVISION OF UNITED AIRCRAFT CORPORATION

During 1968 Norden division of United Aircraft Corporation intensified its development and production of advanced airborne radar and cockpit display systems and extended its militarily oriented product line into the commercial aircraft field.

The Norwalk, Connecticut, firm, famed during World War II as the producer of the Norden bombsight, observed its 40th anniversary in 1968 as a leading designer of equipment that gives all-weather, low-level flight capability to high-performance aircraft.

A highlight of the year was the first automatic terrain-following flight by a United States helicopter employing an integrated avionics system. In April a Marine Corps/Sikorsky CH-53A Sea Stallion flew at 5 selected altitudes from the shores of the Pacific Ocean to 4,600-foot altitudes in the Saddleback Mountains near Santa Ana, California. The Norden radar scanned the terrain out to 5 miles ahead, and, by computer processing, calculated a flight path based on the helicopter's speed, altitude, and altitude required, enabling the helicopter to move over obstacles and at safe rates of climb.

Flight information was projected on Norden cockpit displays. Radar information was shown in "shades of gray," each shade representing the maximum elevation of terrain at various distances ahead of the aircraft. Other display modes employed a variety of symbols to show airspeed, altitude, heading, pitch and roll attitude, and test flights verified the integrated avionics approach for all-weather helicopter flight.

The Norden equipment is part of the Integrated Helicopter Avionics System (IHAS) developed by the Teledyne Systems Company for the Naval Air Systems Command. Norden also was under contract during 1968 to develop cockpit display systems for the Air Force F-111D, the Army's AH-56A Cheyenne armed helicopter and the Navy's Integrated Light Attack Avionics System (ILAAS).

Norden delivered the first integrated display sets for the F-111D to Autonetics Division of North American Rockwell Corporation, developer of the integrated avionics system for the advanced fighter-bomber. Multisensor, vertical situation, and head-up displays present attitude, flight director, weapon delivery, attack, terrain-following radar and aided-visual sensor information that enable the pilot to fly under all weather conditions. A Norden cockpit display was installed in a Navy A-6A Intruder late in the year as part of the flight test program for ILAAS by the Sperry Systems Management Division of the Sperry Rand Corporation, ILAAS developer. Deliveries of radar and display equipment continued to the Lockheed-California Company, which was to flight test an advanced integrated avionics system aboard the Cheyenne during 1969.

Exploiting its technological gains from military equipment, Norden announced the availability of a new all-electronic cockpit display system specifically designed for use in commercial aircraft. The system, known as an electronic attitude director indicator (EADI), is designed to reduce pilot work load, especially during adverse flight conditions, to increase operating safety at reduced minimums, and to realize the full potential of a specific model of aircraft. It was successfully flight tested aboard a Boeing 707 during the year.

Production continued on search and track radar systems for the Grumman A-6A Intruder, the spearhead for Navy and Marine all-weather attacks in Vietnam. Using Norden radar, the Intruder's 2-man crew can detect on cockpit screens targets and geographical features that could be obscured by darkness or weather. Production models of terrain-following radar systems also were delivered to Lockheed-Georgia Company for the Air Force C-5A transport. The C-5A radar was successfully flight tested aboard C-141s during 1968 and was to be installed in C-5As in 1969.

In the communications field, Norden broadened into the systems field by producing a stored program display system for the National Aeronautics and Space Administration for use in processing data on space projects, and a telemetry and hardwire communications system for the Air Force Weapons Evaluation Test System. Production continued on the Vector product line of digital, FM and RF telemetry equipment, at the Norden facility in Trevose, Pennsylvania.

UNITED TECHNOLOGY CENTER
DIVISION OF UNITED AIRCRAFT CORPORATION

Production of dependable propulsion systems for both civilian and military aerospace programs and advances in the development and manufacture of new materials and products for earthbound use took place at United Technology Center in 1968.

Twice during the year the Air Force Titan III-C space launch vehicle was boosted aloft by its UTC-produced stage zero, or launch stage. The largest of its kind to be assigned to operational use in the nation's space program, the massive booster system includes a pair of 120-inch-diameter, segmented solid-propellant rockets producing a combined thrust of approximately 2,500,000 pounds. In June a Titan III-C placed into orbit 8 satellites for the Defense Department's Initial Defense Satellite Communications System which joined a network of 18 communication satellites previously orbited by

Titan III-C vehicles in 1966 and 1967. In October another launch placed 4 research satellites, 3 Orbiting Vehicle satellites and a Lincoln Experimental Satellite into precise orbit.

UTC's reliable FW-4 solid-propellant upper-stage rocket continued to prove its versatility with flights on the National Aeronautics and Space Administration's Delta and Scout boosters and on the Air Force Atlas F rocket. These payloads included GEOS 2, Orbiting Vehicles 13 and 14 and Explorers 37, 39 and 40 for the U.S., and ESRO I and II-B for the European Space Research Organization. For the first time, a pair of FW-4 motors, each with its own satellite, were launched aboard a single booster, an Atlas F, during which time they placed a combined total of 17 experiments into orbit.

During the year, UTC supplied subscale solid-propellant booster rockets to NASA for use in the Saturn Improvement Studies program. The space agency was evaluating proposed modifications to its Saturn IB and Saturn V launch vehicles, including the possible use of full-scale, 120-inch-diameter rocket motors as a booster stage, or for boost augmentation. The 1/58th scaled-down versions of 120- and 156-inch-diameter solid boosters were used in test firings with a model of the Saturn launch facility to examine the effect of increased exhaust flow on launch pad hardware and flame dispersal trenches.

A continuing program to determine the shelf life, or storage longevity, of large, solid-propellant booster rockets reached its seventh year in 1968, as close surveillance and environmental testing of a 100-inch-diameter, solid-propellant rocket motor segment, loaded in 1961 with 14 tons of propellant, indicated no noticeable changes in the propellant's properties. Originally estimated to have a 5-year storage life, the results hold out the possibility that the massive motors will have a useful life of better than 10 and possibly as long as 20 years.

The second and third flights of the hybrid rocket-powered Air Force Sandpiper target missile were successfully conducted in January and February, making it 3 for 3 for the multithrust, low-cost engine.

UTC continued its advances in hybrid technology by designing a family of high-energy, upper-stage hybrid rocket engines capable of meeting a wide variety of propulsion requirements for unmanned space missions in the 1970s and beyond. The work is part of a broad program under way by NASA to establish design criteria and capabilities of several rocket propulsion systems in order to compare their cost-effectiveness for space applications planned for the next 15 to 20 years.

Utilizing knowledge gained from hybrid rocket technology, UTC demonstrated a long-burning, high-intensity, infrared generator which could be used as a flare to create infrared, or heat rays, on towed airborne targets used by the Air Force to evaluate heat-seeking weapon systems and to provide combat training for its pilots. The generator, which outperforms conventional pyrotechnic flares in use today by producing greater infrared yield for a longer burn time, is throttleable and can change its infrared characteristics to simulate a variety of targets.

A systems design study for hybrid rocket-powered magnetohydrodynamics (MHD) generators was awarded to UTC by the Air Force Aero Propulsion Laboratory. The program, which will involve the study and design of 5 different generators, each with a different power output and operating duration, is classified.

United Technology Center started manufacture of Techite, a reinforced plastic mortar pipe for use in fluid conveyance systems.

In November it was revealed that rocket nozzle inserts of wire-wound, plasma-spray-bonded tungsten were performing exceptionally well in high-pressure rocket motor tests being conducted at the Edwards AFB Rocket Propulsion Laboratories. Called Project HIPPO (High Internal Pressure Producing Orifice), the tungsten inserts have been subjected to pressures as high as 2,800 pounds and to a duration of up to 22 seconds with no, or only negligible, erosion of the nozzle throat.

From UTC's research laboratories came a discovery of how to use fire to reproduce sound. Discovered while searching for ways to produce underwater sound generation, this phenomenon could prove important in the development of very-high-speed information transmission systems and superfidelity loudspeakers. While many applications, ranging from the mundane to the highly sophisticated were envisioned, UTC was already studying the use of the electrothermal flame in evaluating the combustion efficiency of experimental liquid rocket engines by taking sound recordings from inside the combustion chamber while the rocket is firing.

The U.S. Forest Service may benefit from work done by UTC which will help reduce fire hazard and facilitate reforestation in logging areas. Drawing on its experience in aerospace research and production of rocket motors, UTC created a system for igniting forest waste remotely rather than with torches or preplanted incendiary charges. Successfully tested by the Forest Service early in 1968, the system consists of a rifle-like launcher and a self-propelled incendiary projectile that bursts and ignites on impact.

UTC took a major step in diversification in 1968 with construction of a multimillion-dollar manufacturing facility for large-scale production of its Techite pipe. The plant, by year-end operating at full capacity in Riverside, California, was the second production center for the company's reinforced plastic mortar pipe for fluid conveyance. Techite, one of the most recent examples of applying knowledge gained in carrying out programs in support of the nation's space effort, is a byproduct of UTC's work in the research and development of glass fiber rocket motor cases.

ELECTRONIC COMPONENTS DIVISION OF UNITED AIRCRAFT CORPORATION

The Electronic Components division completed its first year of operation as United Aircraft's microelectronics center. The division's line of discrete semiconductor devices, hybrid microcircuits and integrated circuits increased its concentration on the communications field.

Discrete semiconductor achievements were highlighted by the introduction of the first single-chip RF power transistor capable of 10 watts of power at 1 GHz. The transistor was designed for high power output UHF Class C amplifier service. The division continued as a prime supplier of transistor chips to the computer industry and packaged devices to the community antenna television field. The standard discrete device line was expanded to meet new applications in high-frequency/high-power aerospace communications, guidance and control, and telemetry systems.

Hybrid microcircuit components for similar applications included microminiature voltage controlled oscillators, low-level differential amplifiers, video amplifiers, digital interface circuits, and functional blocks. Medium scale integration (MSI) was achieved during the year with the perfection of the multilayer technique. MSIs in production include as many as 25 multifunction integrated circuits on a 1-inch-square substrate. These components were in use in digital computer engine indicator and fuel control systems. The division continued to increase its versatility with the production of single layer, multilayer and stacked hybrid microcircuit components.

The division's integrated circuit product line was expanded with the introduction of several new devices. A family of transistor/transistor/logic (TTL) integrated circuits was placed into production during the year. These devices perform the complex gate and memory functions in high-speed commercial and military computers. A high-power voltage logic integrated circuit was introduced for use in commercial aircraft control systems. The 28-volt device is designed to perform electronic reasoning to insure safe operation of the aircraft. Typical functions include control sequencing, control monitoring, situation monitoring, warning control, indication control and system control. A third new integrated circuit was a monolithic quad voltage translator with more than double the output voltage swing of previously available circuits. The device is used to interface between standard current sinking logic and MOS multiplexers. The increased voltage swing also permits its use as a neon display driver.

UNITED AIRCRAFT RESEARCH LABORATORIES

Advances in research in such diverse fields as propulsion, lasers, metallurgy and electronics were recorded by United Aircraft Research Laboratories during 1968.

Changes in top management of the laboratories occurred during the year as Charles M. Kearns, Jr., became United's vice president for research and Dr. Russell G. Meyerand, Jr., became director of research.

The laboratories also increased by 76,000 square feet their office and laboratory space in East Hartford, Connecticut.

Work at the Research Laboratories during 1968 continued to advance United Aircraft's traditional interest in flight propulsion and power conversion systems.

Scientists and engineers continued programs concerning advanced air-breathing missile propulsion systems, with emphasis on low-volume integrated booster ramjets burning hydrocarbon fuel. Particular concentration was on inlet components where angle-of-attack effects could severely compromise the effectiveness of the propulsion system.

There was progress in research on supersonic combustion ramjet propulsion systems for both cruise vehicles and missile applications. Emphasis was on ignition, combustion and fuel mixing characteristics, and structural cooling using fuel regeneration.

Other propulsion programs included research in chemical and nuclear rocketry and in advanced gas turbine engine technology.

United Aircraft Research Laboratories scientists reported several significant events in laser research during the year. These included the development of a laser device potentially useful in the simulation, design and calibration of radars and in electronic countermeasures. Called LATREC, for laser-acoustic time reversal, expansion, and compression, it can record, store, play back and reverse electromagnetic signals just as a tape recorder does with sound.

Scientists also discovered that an ultrashort burst of laser light "chirps," or changes in frequency from one end of the pulse to the other. In subsequent experiments, the scientists devised a technique to compress the laser pulse while eliminating the frequency chirp.

Using the new technique, the scientists were able to generate a laser pulse 4 ten-trillions of a second in duration. This was the shortest laser pulse ever generated.

Ultrashort laser pulses are applicable to such fields as radar and ranging, controlled thermonuclear studies, optical information processing and high-speed photography and are extremely useful in laboratory work where precise measurement is demanded.

The laboratories also built and delivered to the Air Force the first available commercial version of a high-powered, single, ultrashort laser pulse generating system.

In the field of metallurgy, work continued in composite materials studies, and researchers fabricated the first full-scale parts from a eutectic alloy which had been unidirectionally solidified in a patented United Aircraft process. Through such solidification, one member of the alloy becomes a reinforcement in a matrix of the other member, and provides much higher strength than conventionally cast alloys.

Materials scientists continued experiments with Borsic, a silicon-carbide coated boron filament developed by the laboratories. Composites containing Borsic as a reinforcement were studied for a variety of applications which demand high strength, high modulus of elasticity, and high temperature resistance.

As the central research organization for United Aircraft Corporation, the laboratories provided such support to the divisions as a central computer laboratory and test facilities including several wind tunnels.

In a move reflecting the corporation's growing interest in ocean science and engineering, the laboratories undertook a 10-month study of mineral deposits under water in Long Island Sound under a grant from the State of Connecticut.

In other programs, research scientists continued work in fluid mechanics, physical chemistry, low-temperature physics, solid-state electronics, plasma physics, and systems analysis.

UNIVERSAL OIL PRODUCTS COMPANY

The year 1968 for Universal Oil Products Company saw the corporation more closely identified with the airline and aerospace industries. Both new and follow-on contracts contributed to an increase in all areas of involvement covered by its Aerotherm, Instruments and REF Dynamics divisions.

Of significant importance in the overall growth picture of UOP was the merging of Calumet & Hecla Corporation into the UOP organization. This merger presented the opportunity for UOP to expand its capabilities in the highly important field of nuclear energy and to enter the exciting areas of desalination and thermal water pollution control. Calumet & Hecla corporate headquarters are in Evanston, Illinois, with plants in Decatur, Alabama; Detroit, Michigan; Dearborn Heights, Michigan; Bartlett, Illinois; and Ontario, Canada. The company is also engaged in copper mining and refining in upper Michigan and operates forest and timber holdings in Wisconsin and northern Michigan for the production of hardwood veneers. The Flexonics Division provides flexible couplings and conduits for the aerospace and aircraft industries.

In mid-1968, Lester B. Knight & Associates, management and engineering consultants, were engaged by UOP to assist in the planning of new corporate headquarters, to be located on the northwest corner of Mt. Prospect and Algonquin Roads in Des Plaines. The company's rapid growth and diversification increased the need for these facilities. As recently as 1959, when UOP became publicly owned, it had a total of 1,500 employees. Through mergers, acquisitions and normal growth, UOP at year-end 1968 had more than 12,000 employees. New building construction was started in the fall and occupancy was expected in late 1969.

In August, UOP announced the acquisition of the business and assets of Mace Industries, Inc., in Jacksonville and Miami, Florida. Mace Industries serves the airline and airframe industry by providing equipment for food and passenger service to airline passengers. The primary line of products consists of ovens, tray carriers, liquor kits and refrigerators. Redesignated the Mace Unit and reporting to the company's REF Dynamics Division which is a major supplier of inflight feeding and ground support equipment, the Florida operation offers good growth potential in providing additional capabilities and geographical representation to REF.

Recognizing the importance of in-depth studies of materials ceramics, polymers, rubber, reinforced plastics and other composites and their effect upon production and entire industries, UOP announced the appointment of Dr. Robert D. Carnahan as director of a new Material Science Laboratory which was expected to establish UOP as a leading center for materials research. A few anticipated areas of scientific inquiry were fracture analysis, stress, corrosion, crystal growth studies, applied mechanics, solid-state physics and optimum reinforcement with fabrics, silica, fiberglass and other materials. A new building to house the Material Science Laboratory was to be completed and operational in 1969.

A new research and development department was established within the Transportation Equipment Group with responsibilities to explore and expedite the technical organizational process by which new products are moving from the idea stage to the market place. Coordination of divisional R&D programs in the group was also of primary concern. The Transportation Equipment Group includes the UOP Aerotherm Division, Bantam, Connecticut, manufacturers of commercial and military aircraft passenger seats, crew seats, lounges, aero-stretchers and cargo pallets and containers; the UOP Bostrom Division, Milwaukee and Cudahy, Wisconsin, manufacturers of truck, tractor, automotive and heavy-duty ground transportation equipment seating; the Bostrom-Amalga Corporation, Menominee Falls, Wisconsin, creators and fabricators of filament-wound fiberglass tubular products; the REF Dynamics Division, Mineola, New York, manufacturers of inflight food service equipment, including galleys, auxiliary units, bars, carts, ovens, brewers, refrigerators and freezers, plus ground support test equipment and airframe assemblies.

Of interest was the 1968 opening of a Westminster, California, sales and engineering office for the greater Los Angeles area. A complete prototype shop was staffed and research and development programs involving materials and concepts for advanced state-of-the-art seating products are already under way.

UOP showed significant growth and major technical achievements in many areas of operation outside the aerospace industry. UOP continued to be one of the world's leaders in providing research, development and engineering services for the petroleum refining and petrochemical industries. Other operating divisions of the company were engaged in air and water management, fragrances, metals and alloys, plastics, chemicals, plant construction and transportation equipment. UOP was providing components for such growth industries as desalination, nuclear power, environmental control, instrumentation and aircraft. Corporate headquarters are in Des Plaines, Illinois.

UOP AEROTHERM DIVISION

Following a 1967 year of above-industry average growth, the UOP Aerotherm Division, designers of sophisticated commercial aircraft seating, military troop seating, crew seats, inertia reels and related products, experienced an even higher rate of growth in 1968. The growth in part reflected introduction of 2 entirely new commercial aircraft seating concepts, the Olympian and Glide-Away Recline. Both new designs were created especially for the new generation of larger jets which includes the Boeing 747, the McDonnell Douglas DC-10 and the Lockheed L-1011. Contract announcements were made naming Aerotherm to provide Pan American World Airways with 23 shipsets of tourist seats for its 747 fleet. Also announced was Northwest Airlines' selection of Aerotherm to equip its fleet of Boeing 747s with first-class and tourist passenger accommodations.

Follow-on orders and new contracts with Pan American, Northwest, Braniff, National, United, Aloha, Mohawk, Grumman, Ozark, World Airways, Philippine Airlines, British Aircraft Corporation and Pakistan International Airlines comprised the primary commercial production growth for 1968.

Of importance in the growth was the selection of Aerotherm to provide troop seats for the giant military Lockheed C-5A transport airplane. This represented the largest passenger seat contract in the history of military aviation. Deliveries began in August. During the year Aerotherm developed a new concept in pallets for aircraft applications. The entirely new design is constructed of extruded aluminum planks and offers the advantages of longer life (because delamination has been eliminated), lighter weight and longer service life. First production pallets were undergoing inflight testing and certification in late 1968, while static and dynamic tests proved the design to be far superior to other existing products. Developments for baggage and cargo containers were started during 1968 with expectations of production designs in 1969.

To meet the demands placed upon it by the accelerated growth, the Aerotherm facilities in Bantam, Connecticut, continued a scheduled expansion program by completing a 44,000-foot addition and starting construction of another 44,000-foot addition scheduled for occupancy in March 1969.

Expanded capabilities during 1969 included the opening of engineering and sales liaison offices with its sister REF Dynamics Division in Westminster, California, and Bellevue, Washington. The new field service offices provide a closer liaison and technical capability with the airframe manufacturers. Major programs under way at Aerotherm at the close of 1968 were directed to completing designs for the large jumbo jets and to establishing levels of interchangeability as plus factors to the airlines that have purchased 2 different aircraft designs.

REF DYNAMICS DIVISION

The REF Dynamics Division experienced extended growth in 1968, both in total sales and in facilities expansion. The establishment of a sales and engineering office in Bellevue, Washington, was highlighted by the decision to assemble aircraft galley units in the Bellevue 12,000-foot facility. By mid-1968 parts were being shipped from the main plant in Mineola, New York, and assembled into complete units at Bellevue. This facility also provided a depot where repair work and modifications could be executed without having to return galley units to the East Coast.

Sales and engineering representatives were serving the Lockheed and McDonnell Douglas companies and airlines in the Southwest through the new Westminster office. The addition of Mace Industries also provided REF with a Southeast capability in serving the Lockheed-Georgia Company and airlines of the Southeast. The Mace product line enhanced REF's capabilities because of the specialized nature of its manufacture of inserts, and it provided a repair capability for its geographical area. The Mace facility is located in Jacksonville, Florida, and the group maintains a sales-engineering office in Miami. The total REF complex, therefore, provides sales and engineering services to the airframe manufacturers and airlines in the geographic areas where the primary aircraft market has been established.

REF in 1968 established an internal product support department and initiated a scheduled customer service program. Along with these steps, it established a new service policy that met with great acceptance.

New products introduced in 1968 included a 40-cup coffee brewer designated as the "Q-Brew" system, designed to fit into existing galley cavities in which 12-cup brewers had previously operated. Another major innovation in food service facilities was the development of a freezer/oven which offers greater utilization of space by eliminating the need of transferring frozen entrees from a freezer/refrigerator into a warming oven for reconstituting.

REF continued to provide aircraft galley equipment to Western Airlines and in midyear introduced the liquid-nitrogen refrigeration system on Western's 737 galleys. Crew galleys for the Lockheed military C-5A transport were delivered in early 1968. New and follow-on orders from American, Pan American, Eastern, Piedmont and United airlines and from the military contributed greatly to REF's growth and production of galleys and auxiliary units.

In the latter part of 1968, greater emphasis was placed on REF's capabilities in providing ground support test equipment for electrical, hydraulic and pneumatic systems. REF continued to grow in the manufacture of airframe assemblies primarily as a subcontractor for Grumman Aircraft Engineering Corporation in providing pylons, extensible work platforms and electrical pallet assemblies for military aircraft. Trailing edges, tab assemblies, dive brakes, main wheel doors, cargo hatches, etc., continued in high-volume production.

High-priority design efforts were directed to the development of new concepts for inflight passenger feeding as associated with the Boeing 747, McDonnell Douglas DC-10 and Lockheed L-1011 airplanes. Creative efforts were directed not only to the airlines interested in the conventional galley structures and systems but also to those interested in the lower lobe galleys.

To meet the demands of accelerated growth, arrangements were made in late 1968 to move the Mineola Plant II to larger quarters for expansion of its molded reinforced fiberglass and fabricating departments. REF also established agreements for representation in countries outside the continental United States. Although REF has experienced a rapid growth since joining UOP in August 1967, prospects for additional growth were high and contracts in hand in late 1968 reflected increasing acceptance of REF products.

UOP INSTRUMENTS DIVISION

The UOP Instruments Division experienced overall growth during 1968. The largest growth area was in the nuclear instrumentation department where large contracts for instruments to be used on the nuclear-powered aircraft carrier were received from the Westinghouse Plant Apparatus Department. Large contracts were also involved in providing instrumentation for 2 nuclear-powered destroyers.

The Instruments Division's aerospace department showed a substantial growth over the previous year which was due primarily to the division's entrance into the field of emergency oxygen supply equipment and of individual passenger oxygen supplies with contracts from McDonnell Douglas Corporation. It was in this area also that new products were introduced, including 10 separate versions of oxygen manifolds for use in the overhead pods, emergency oxygen control valves and small manifolds for use on the C-9A aero-med litter stations.

New and repeat orders, primarily from the National Water Lift Company, The Boeing Company, Bell Helicopter and Ling-Temco-Vought, contributed to a solid rate of growth for the division.

The Instruments Division also experienced several new areas of operation in conjunction with other UOP divisions. A considerable amount of production was involved in the manufacture of radiation level detectors, UOP Monirex octane analyzers, valve position detectors used in the Molex process and boiling point monitors, all for the UOP Process Division. Additional product capabilities were demonstrated in the assembly of ovens and coffee brewers used in aircraft galleys for the REF Dynamics Division.

Increasing research and development activities were responsible for the introduction of new oxygen equipment, and greater emphasis was slated for research activities.

WESTINGHOUSE ELECTRIC CORPORATION

WESTINGHOUSE DEFENSE AND SPACE CENTER

Aerospace Division

One of the important programs at the Aerospace Division of the Westinghouse Defense and Space Center in 1968 was the manufacture of a new reconnaissance radar with higher resolution than others of its kind. The advanced radar, designated AN/APD-8, is one of the reconnaissance systems carried by the Air Force's RF-111A reconnaissance aircraft.

The AN/APD-8 radar was being supplied under contract to the Fort Worth Division of General Dynamics, builders of the RF-111A. The radar was designed to produce pictures of land areas that will have photographic quality and will provide tactical reconnaissance information in day or night in all kinds of weather. The RF-111A uses the side-looking radar to "see" wide areas of terrain on either side of the aircraft flight path without directly flying over a target area.

Inherently high resolution in the AN/APD-8 system gives it the ability to obtain clear pictures. The receiving and recording techniques used in the radar allow for the display of extremely strong targets directly adjacent to weak targets.

In the reconnaissance version of the aircraft, the radar is mounted in a pallet that occupies the space normally allocated to the bomb bay. Built-in test functions and automatic fault isolation were expected to make the system easy to maintain. The AN/APD-8 self-test mechanism can be operated in flight or on the ground. The test and fault isolation equipment is linked with a central computer aboard the aircraft for integrated fault isolation.

Another radar program at the Aerospace Division was the AN/APQ-97 side-looking radar, a k_a frequency band, real aperture system used in Project RAMP (Radar Mapping in Panama), a program of the U.S. Army Engineer Topographic Laboratories. AN/APQ-97 was developed for the U.S. Army Electronics Command.

During 1968 Westinghouse Defense and Space Center established 2 new plants designed to employ the hard-core unemployed. The first was in the Brushton section of Pittsburgh, an area of high unemployment, where Westinghouse planned to manufacture electric personnel carriers for industrial plant use. The second was a small manufacturing facility in the Greenmount area of Baltimore for assembling electronic components to be used on radar equipment.

Surface Division

In 1968 the Surface Division of Westinghouse Defense and Space Center built, near Baltimore, Maryland, a new radar test range complex described as "one of the best instrumented and most automated in the country." In addition to its use by the company for its own programs, Westinghouse planned to lease services of the range to other users.

The facility includes 2 major 3-axis antenna mounts at receiving sites, and a number of smaller mounts. One 40-foot and 3 80-foot towers at various ranges provide transmit sites; each is equipped with remotely controlled generator and antenna. Using the sites in various combinations provides 6,000-foot, 5,082-foot, 780-foot, 724-foot, and 700-foot ranges. The latest addition is a 1,650-foot ground range.

The facility is unusual in its capability for testing very large antennas in the frequency range from 50 MHz to 10 GHz. The 5,280-foot range, for example, allows testing of S-band antennas up to 45 feet in diameter, X-band antennas 15 feet in diameter and C-band antennas 20 feet in diameter. The 724-foot range allows testing of large, lower-frequency antennas. It has a 40-foot dual-band, phased-array signal source antenna that allows range operation either in the UHF region or in L-band while maintaining constant illumination of the test aperture across both bands. All ranges have remote control of signal source operations such as antenna pointing, frequency, adjustment, polarization, and on-off switching. Instrumentation includes automatic radiation distribution printers, tape recording and reading equipment, rectangular pattern recorders, and digital readout of angles to .01 degree.

Surface Division also produced a new converter in 1968. The new unit converts to 9-bit digital words at a rate of 1,000,000 words per second. It was designed for such high-speed applications as radar moving target indicators, data collecting and logging, computing systems and other equipment. The converter combines a pair of densely packed printed circuit cards and a compact cabinet, suitable for 19-inch-wide rack mounting, to form a complete high-speed unit. The cards, which are accessible from the front panel, contain the A/D converter as well as the sample, hold and timing circuitry. Other features include small size (19 inches by 8½ inches by 3½ inches), light weight and a temperature range of −33 degrees Centigrade to +62 degrees Centigrade for the circuit cards.

In a joint announcement, the Surface Division and North American Rockwell's Columbus Division said they would team to pursue the Navy's ASMS (Advanced Surface Missile System) program. Westinghouse was the prime contractor contender. The announcement followed a North American Rockwell notification to the Navy's SMS Project Office that it was withdrawing from the competition as a prime contractor contender. The complete Westinghouse team in addition to the North American Rockwell Columbus Division includes IBM Corporation, North American Rockwell's Autonetics Division and Tracor, Inc.

ASTRONUCLEAR/UNDERSEAS DIVISIONS

In August, Westinghouse announced an organizational change whereby the Astronuclear Laboratory and the Underseas Division were combined under a single management. Dr. W. E. Johnson, vice president and formerly general manager of the Astronuclear Laboratory, was assigned responsibility for the merged divisions.

The Underseas Division thereafter consisted of 3 main components:

• The Ocean Research and Engineering Center, near Annapolis, Maryland, which was to continue activities in ocean research, life support systems, design and operation of underseas research submersibles, sonar and advanced studies in the recovery of ocean resources.

• Sanford Marine Services, Inc., a wholly owned subsidiary, Morgan City, Louisiana, which continued to provide diving, salvage and other services to the marine, petroleum and construction industries and a variety of other customers.

• The missile launching and handling department, responsible for developing and providing launching capability for the Navy's fleet ballistic missiles, Polaris and Poseidon. In merging this department, which is located at Sunnyvale, California, with the Underseas Division, the division acquired an extremely broad capability in the design and manufacture of equipment for underseas applications. The hull of the highly successful submersible Deepstar-4000, which has made nearly 500 dives for deep ocean research, was fabricated at the Sunnyvale facility.

The Deepstar-2000 underseas research vehicle neared completion at the Ocean Research and Engineering Center. The new submersible, similar in design to the Deepstar-4000, was to be ready for operations in early 1969. At that time, the Deepstar-2000 was to be assigned to the Westinghouse Research Laboratories' Ocean Research Laboratory at San Diego, California. It was to be used in research efforts and as a test-bed for prototype instrumentation. The submersible is 20 feet long and 7 feet wide and is capable of carrying 2 scientists and a pilot to depths of at least 2,000 feet. It will operate for as long as 8 hours at a maximum cruising speed of 3 knots.

Westinghouse also announced that the Underseas Division had started construction of a 20,000-foot-depth submersible, the deepest-diving privately owned submersible. The vehicle, capable of reaching 98 percent of the world's ocean floor, will be the third member of the Westinghouse Deepstar family.

"We expect to complete the Deepstar-20,000 by 1970," S. A. Jordan, Underseas Division general manager, said. "There is an obvious need to explore and work at great depths in the ocean. We've been planning a 20,000-foot submersible for a long time. For several reasons, we feel that we can now go ahead with the project. Our development programs in hull materials, flotation materials and buoyant structural materials are quite far along. These and other technological advancements have brought the predicted cost of the vehicle to a still very high but reachable level. Also, the market for deep diving submersible services seems to be developing." The submersible will be able to transport 3 men and instruments or equipment to a depth of 20,000 feet for 16 hours of work.

Westinghouse Underseas Division initiated work on a super-deep submersible (artist's concept shown) designated Deepstar-20,000 and designed to take 3 men to 20,000-foot depths for 16 hours of work.

The Westinghouse Ocean Research and Engineering Center formed an ocean sciences group that concentrates the center's oceanographic capabilities. The new group was to further develop the center's relationships with industrial oceanographic laboratories, educational institutions and government agencies, and it will undertake research and studies for and with these organizations.

Formed as part of the center's engineering department, the new group was involved with work in ocean physics, electrochemistry, physical chemistry, underwater acoustic and sound propagation and measurement, fluid dynamics, underwater energy transmission, mathematical analysis and analytical simulation of ocean properties and parameters.

A new Westinghouse sonar system was being tested in a special testing pool at the Ocean Engineering and Research Center. The 15-foot-deep pool in the new laboratory is used in research on a wide variety of underseas equipment. The sonar was the Westinghouse ocean-bottom scanning sonar used to produce photo-like images of the ocean bottom at any depth. It is towed by a surface ship so that it travels at a preset depth above the ocean floor. In this way, it is able to survey large areas of the bottom relatively fast. Westinghouse sonar systems similar to this unit have been used to locate the wreckage of an airliner in Lake Michigan, to survey the wreckage of an offshore oil platform downed by a hurricane, to locate the fault scarp of an earthquake off the coast of Alaska, and in other underwater search and survey projects.

A new barge was serving the offshore oil industry in the Gulf of Mexico in 1968. Called *Ranger*, it is a pipeline and derrick barge for use in laying and repair of pipe, salvage, construction and all kinds of diving service. It was built and was being operated by Sanford Marine Services, Inc.

Because of the size and capability of the *Ranger*, it can be used for smaller jobs at less cost than most available barges. It has a 50-ton diesel crane.

The barge is equipped with 2 spuds for fast anchoring in water depths to 35 feet and with anchors for greater depths. The spuds are metal posts, 40 inches by 40 inches and 60 feet long, that fit through wells in the hull of the barge. Lowered vertically by a winch, the spuds sink into the mud on the bottom and hold the barge in place. This saves a large part of the time involved in spreading each of the barge's 4 anchors by a tugboat every time the barge is moved.

The barge is 175 feet in length and 60 feet wide. When fully loaded with fuel and water, the 10-foot-high hull has a draft of about 4½ feet. Fuel capacity is 40,000 gallons; water capacity is 60,000 gallons.

Two generators, one rated at 100 kilowatts and the other at 60 kilowatts, provide the electrical power needed on the barge. Welding capability is provided by 2 300-ampere machines. *Ranger* has a diving station with an air compressor to provide filtered breathing air for underwater work. When put into operation in the summer of 1968, *Ranger* joined Sanford's fleet of 3 barges, 2 tugboats and 2 crew boats.

An extremely precise telescope for the University of Texas' McDonald Observatory was built and was being tested at the Westinghouse Sunnyvale, California, facility.

The 105-inch astronomical telescope was so large that it could not be fully assembled at the plant. Parts and subassemblies had to be fitted and tested there and then shipped to the telescope site on Mt. Locke, Texas, for installation.

The 40-ton polar axis shaft is supported on bearings on 2 pedestals, with the telescope tube offset for minimum distance between the tube and the polar axis. The third largest optical telescope in the world, it will be used for a broad range of astronomical work, including a study of Mars during its next nearest approach to earth.

The huge scientific instrument was being built under a subcontract from the University of Texas. The university is the prime contractor for the National Aeronautics and Space Administration as part of a cooperative venture to build a telescope for lunar and planetary observations.

The U.S. Navy awarded the Westinghouse missile launching and handling department a contract to produce launching and handling equipment for the Poseidon submarine-launched intercontinental missile.

The $11,800,000 award was the first of several similar Poseidon production contracts the Westinghouse Sunnyvale plant expected to receive. A $52,000,000 contract awarded in 1966 for the design, development and pilot manufacture of launchers was to proceed concurrently with the production contract. The Navy wanted to expedite equipping nuclear submarines with Poseidon, which has twice the payload and accuracy of the Polaris missile it will eventually replace on many of the Navy's missile launching submarines.

Westinghouse successfully completed an underwater launch of a Poseidon test vehicle in August—ahead of schedule—at the Navy's San Clemente underwater test site, off the southern California coast. Tests with dummy missiles were continuing there and at San Francisco Bay Naval Shipyard. Production was also under way at the plant, under a $2,400,000 Navy contract, on Poseidon launching and handling equipment for crew training at the Navy's guided missile school in Dam Neck, Virginia.

The Navy's incentive-type contracts with Westinghouse will reward the company for bettering targets on delivery, performance and cost.

A system designed for loading missiles from a tender to a submarine was successfully tested at the San Francisco Bay Naval Shipyard by the Sunnyvale group.

The automatic landing and positioning system (ALPS) was designed to damp out motion and guide the loading fixture into the launcher tube extension which is a fixture attached to the submarine. A tender crane picks up the missile, in a tube or liner, and lifts it from the tender into loading position above the launch tube. A launcher tube extension fastened temporarily to the deck of the submarine acts as a funnel, and the ALPS directs the missile loading fixture into this funnel.

It was necessary for Westinghouse to design the ALPS because the Poseidon missile is too large and too heavy to be guided by men on deck.

As the missile loading fixture nears its destination, 4 lines on the launch tube extension are hooked to an adapter on the bottom of the loading fixture. Through an intricate system of sheave and air cylinder, the lines tighten to guide the fixture into the funnel. The adapter seats on the launcher tube extension to prevent tipping if the ship rolls. Once the link is made, the missile can be lowered from its liner into the launch tube.

To test the accuracy of the ALPS system, a series of tests was being conducted using a 450-ton gantry crane with a balance beam carrying the missile loading fixture and 42 tons of counterweight. A 2½-foot vertical motion to simulate the heaving of a ship was provided at the same time that wire cables attached to a mobile crane provided horizontal motion. The motion equaled the maximum swing and heave the landing and positioning system would be subjected to in operation.

The development of a new type of thermoelectric power generation systems component brought remote power system technology much closer to the practical application stage. Combining its power systems experience, such as the nuclear rocket reactor and SNAP-23 work, with its newly perfected thermoelectric generator, the Westinghouse Astronuclear Laboratory developed concepts and designs for a wide variety of remote power sources to meet nearly any need. (SNAP stands for Space Nuclear Auxiliary Power.)

Remote power systems are part of a class of advanced technology "products" that must be designed specifically for each application. Although these systems may have many features in common, virtually all are tailored for particular applications. The "breakthrough" in development of such systems occurs when key subsystems or components evolve as standardized hardware available for a wide variety of applications. The tubular thermoelectric generator is one such subsystem development. It enabled the Westinghouse Astronuclear Laboratory to bring more commonality to remote power system technology.

Some of the remote power system applications the Westinghouse laboratory examined included signal source, battery charger, backpack, buoy power, spacecraft power, terrestrial station, undersea remote power, space systems power and marine applications. Combinations of types of heat sources and power requirements were considered. The types of heat sources investigated were nuclear reactors, radioisotopes, and fossil fuel burners. The power requirements ranged from 1 to 50,000 watts.

"By grouping our tubular thermoelectric generators and by applying the power systems know-how we've obtained from work on the nuclear rocket reactor and other power system programs, we can develop a practical remote power system for nearly any application," said Joseph Kenney, manager of the Westinghouse laboratory's tubular module development program.

The heat source for lightweight terrestrial or marine applications, such as backpack and buoy power supplies, is the fossil-fueled burner. For deep sea or space applications, the heat source is a nuclear reactor or a radioisotope.

Using the new tubular thermoelectric module, systems for use in space, at remote land locations, on the surface of oceans or lakes or even under water will be more readily attainable. The module is the first thermoelectric device developed that can be manufactured as a standard system component or as a subsystem. Because of its highly compact and rugged tubular design and construction, it has high reliability and a lifetime long enough to outlast remote mechanical or electronic equipment it would power, such as a pump or a transmitter. Units had been in test status at the Westinghouse laboratory for well over 2 years by the end of 1968.

The tubular thermoelectric generator module can operate in air or inert gas, or even submerged in liquids. Tests in Westinghouse and government laboratories have shown that the monolithic modules can resist impacts as great as 10,000 g's and are not sensitive to thermal cycling or nominal overheating.

The tubular module was the result of 8 years of development and testing work at the Westinghouse laboratory. Total testing time on developmental modules exceeded 180,000 hours at year-end. Some individual units had been on test for over 20,000 hours.

An inert gas autoclave for heating long specimens to high temperatures became available for contract work. Installed by the Astronuclear Laboratory, the autoclave can be pressurized with helium to 30,000 pounds per square inch. It will accommodate specimens up to 6 inches in diameter and 36 inches long. Its resistance furnace heats uniformly up to 1,000 degrees Centigrade throughout the entire length of a 36-inch zone. Nearly any combination of time, temperature and pressure can be made with the autoclave's exceptional control system. Some typical applications of the autoclave are material compaction, pressure bonding, diffusion bonding, and device fabrication.

A series of cold-flow tests of an experimental nuclear rocket engine was successfully completed at the Nuclear Rocket Development Station in Jackass Flats, Nevada. The test series was a continuation of the technology effort of the Joint Atomic Energy Commission/National Aeronautics and Space Administration nuclear rocket project.

The cold-flow test series began April 2, 1968. This was the first of a series of engine tests to be conducted at the engine test stand (ETS-1). The experimental engine cold-flow tests were conducted by the NERVA (Nuclear Engine for Rocket Vehicle Application) test organization of Aerojet-General Corporation and Westinghouse Astronuclear Laboratory, designers and developers of the engine.

In a cold-flow test, experiments are conducted using an experimental engine assembly identical to the design used in hot tests except that the engine's nuclear reactor does not contain any fissionable material nor produce a nuclear reaction. Therefore no fission power was generated in the reactor core of the experimental engine during the test.

Functionally the design of the experimental engine was similar to the breadboard engine system tested in 1966. The primary difference between the 2 was in the physical arrangements of components. This experimental engine more closely approached that of flight configuration than previous engine systems tested in the nuclear rocket program.

This test series was conducted to verify that the test stand was ready for hot engine testing and to investigate engine start-up in the test stand under simulated altitude conditions. Other objectives included the checking of operating procedures that had not been demonstrated in previous tests and the investigation of engine malfunctions under simulated conditions.

The engine system and test facility operated as planned and the test results provided the basis for proceeding with the hot testing of the experimental nuclear-powered engine.

AEROSPACE ELECTRICAL DIVISION

At the Aerospace Electrical Division in 1968, a new way of moving molten metal led to a pump that is more reliable and needs a minimum of maintenance. The concept was a result of aerospace research and development work by the division, particularly in the area of materials behavior.

Key elements of the new pump are ceramic components for all parts that come in contact with molten metal, a new metal-to-ceramic coupling, and a rotor that moves the molten metal by means of an "induced vortex."

The induced vortex is similar to the effect of axially spinning a bucket with some water in it. The spinning action causes the water to climb the sides of the bucket and spill over the top.

As part of the development, the Westinghouse division designed a multiple-range pump that will move from 10,000 to 400,000 pounds of molten aluminum per hour at a discharge head of 6 feet of water. The flow rate is controlled by the rotor speed and by the size of the inlet orifice. Orifice sizes are preselected for particular flow rate ranges and the rotor speed is controlled within these ranges to obtain necessary flow rates. The pump is designed to alleviate unscheduled shutdown and maintenance problems due to thermal shock and corrosion.

In addition to more effective prevention of condensation and ice on the pilot windows of airplanes, new temperature controls produced by the Aerospace Electrical Division will increase safety and reduce the frequency of window replacement.

Reducing replacement of the windows will result in large savings since the cost of a window replacement for a single aircraft may be as much as $15,000.

Minute bubbles and cracks in the glass and separation of the layers of the windows are the main reasons for replacement. Altitude and climate temperature extremes create thermal stresses in the windows that over a period of time cause defects.

By precise control of window temperature, the new equipment largely eliminates the temperature variations that are the chief cause of window defects. It increases or decreases the heat applied to the window in small steps so that window temperature changes are gradual. The window temperature is maintained within a few degrees of the optimum.

The gradual increase of heat to the windows also has the advantage of an increase in safety. Cold glass is much more brittle than warm glass and is more easily broken by impact. By keeping the temperature of the windows at that of maximum impact strength, window temperature controls provide an added measure of safety. This temperature is usually in the range of 85 degrees Fahrenheit to 130 degrees Fahrenheit depending on the type of window.

The window temperature controls provide a voltage to a transparent conductive layer in the window which acts as a resistance heater. The amount of voltage is determined by a temperature sensor in the window.

The new controls do not cause the usual problems associated with stepless variable control. By changing the power to the window in small increments, they approximate stepless control but without generating an undesirable amount of electromagnetic interference and without causing harmonic distortion on the a-c input.

The controls operate on the principle of static tap changing. The tap-changer circuits used in the temperature controls could be used to control voltage in any single-phase or 3-phase a-c system with an output of up to 480 volts r/min. Maximum rating of the tap changer is normally 12,000 voltamperes although higher ratings can be arranged. Westinghouse patents on the tap changer are pending.

New aircraft generator and constant-speed drive test stands with thyristor power supplies and transistor speed regulators were being produced by the Aerospace Electrical Division. The transistorized regulator offers the latest improvements in drive speed control. No motor-generator sets are required.

The new stands feature increased reliability, high efficiency, rapid response, wide speed range of 0 to 12,000 revolutions per minute, no starting transients, and reduced maintenance costs.

Test stand assemblies include drive assembly, power supply and speed control assembly housed in a 44x22½x78-inch cabinet, 40-120 kVA load bank, custom-designed metering console and an oil supply assembly for constant-speed drives and oil-cooled generators. The Westinghouse system is available with ratings from 55 horsepower to 200 horsepower for testing aircraft generator constant-speed drive packages with outputs to 120 kVA.

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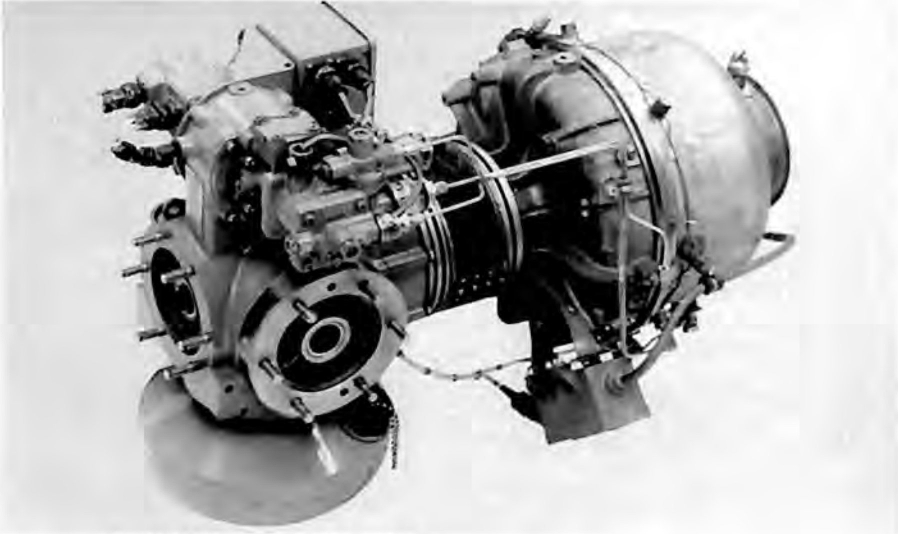
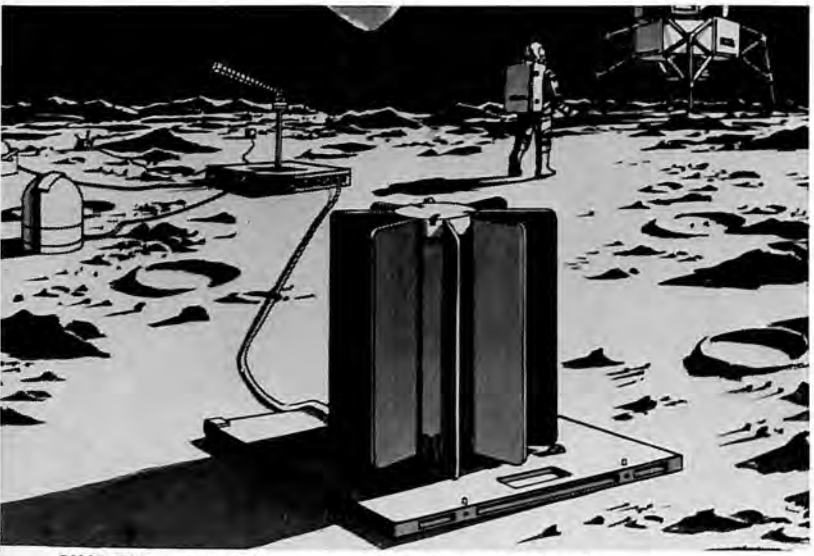


Solar's Titan gas turbine engine



SNAP 27 thermoelectric power system for lunar experiments

Beryllium structure built by Solar for lunar power system

Vietnam to Outer Space

Solar "know-how" solves the tough ones!

A recognized leader in the design, manufacture and production of gas turbine engines for industry and the military, Solar has turned out more than 3000 *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.

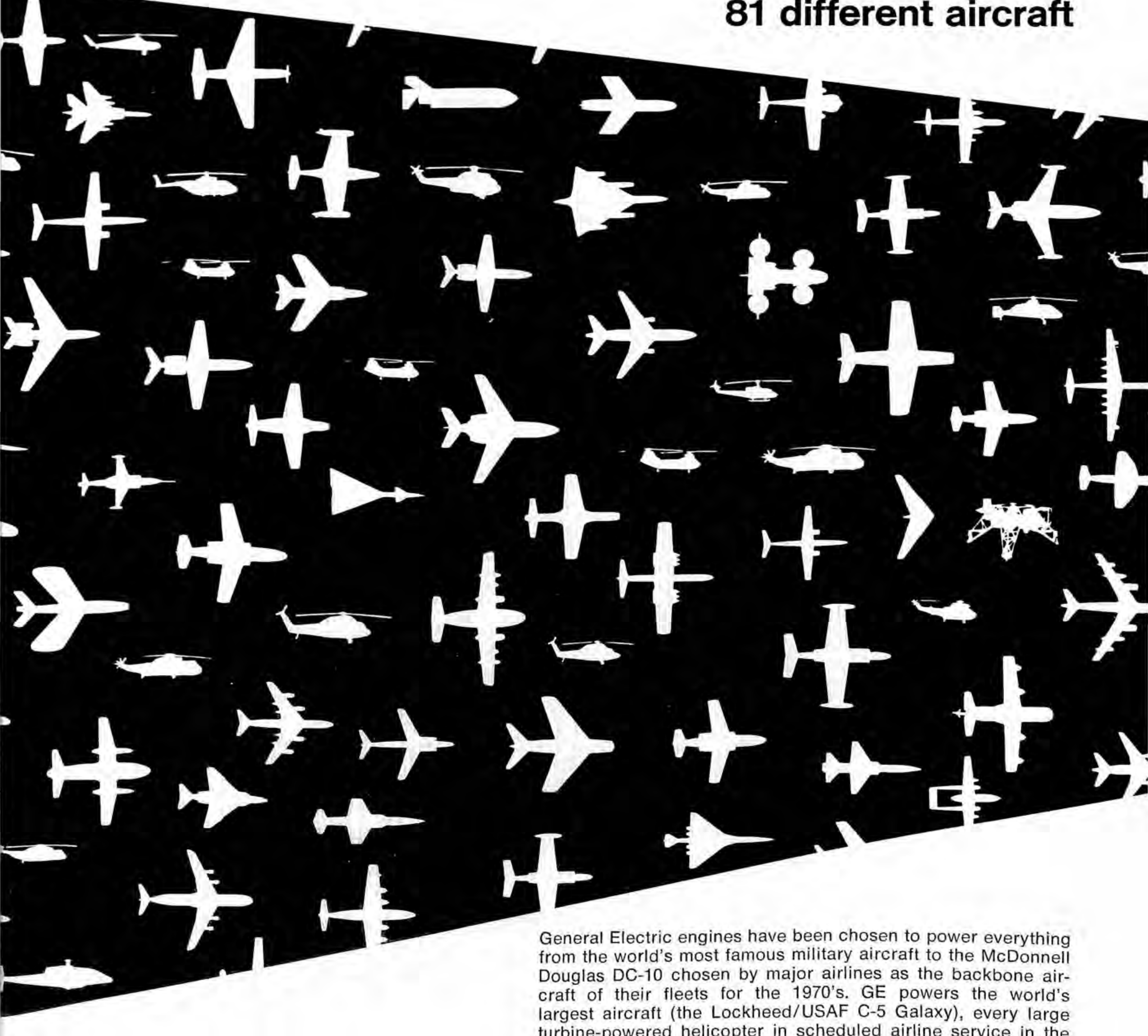
In addition, Solar scientists and engineers have demonstrated outstanding capabilities in the area of hard-to-work metals and materials. The firm today is highly experienced in the forming, joining, welding, brazing, machining and processing of stainless steels, super alloys, as well as titanium, aluminum, and beryllium. One example is the advanced beryllium structures for the SNAP 27 thermoelectric power system that was designed to be left behind on the moon's surface by Apollo astronauts to enable experimental instruments to transport data back to earth. Solar has built 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. R-403, San Diego, California 92112.

IH SOLAR

DIVISION OF INTERNATIONAL HARVESTER COMPANY

Since 1942, 63,000 General Electric jet engines have been built to power 81 different aircraft



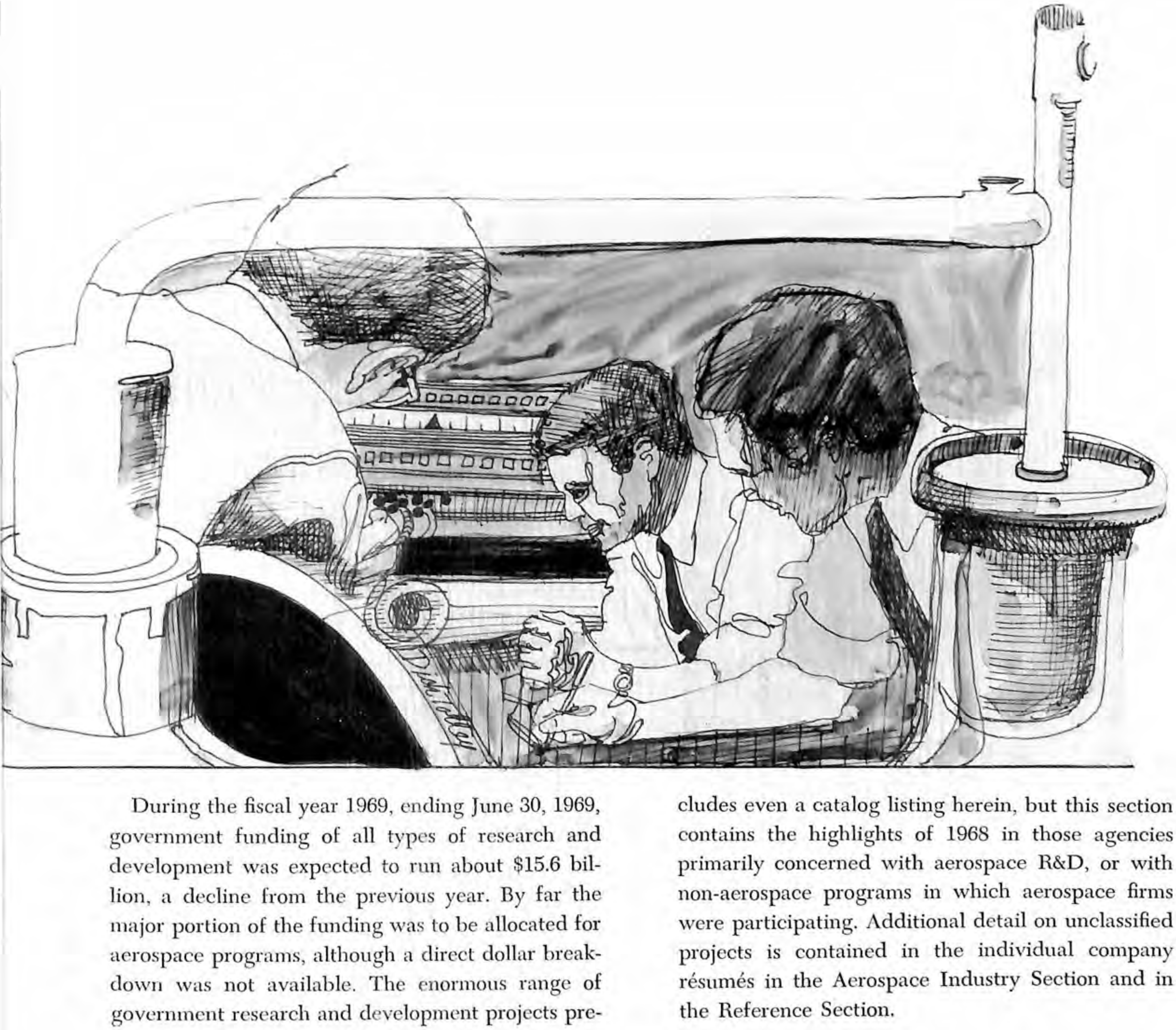
General Electric engines have been chosen to power everything from the world's most famous military aircraft to the McDonnell Douglas DC-10 chosen by major airlines as the backbone aircraft of their fleets for the 1970's. GE powers the world's largest aircraft (the Lockheed/USAF C-5 Galaxy), every large turbine-powered helicopter in scheduled airline service in the free world, and is the world's leading manufacturer of engines for business jets. And GE engines will power the Boeing-built U.S. SST scheduled to enter airline service in the 1970's. The result? The experience needed to meet any aircraft propulsion requirement. **AIRCRAFT ENGINE GROUP**

GENERAL ELECTRIC

205-73

Government Research and Development

AIA



During the fiscal year 1969, ending June 30, 1969, government funding of all types of research and development was expected to run about $15.6 billion, a decline from the previous year. By far the major portion of the funding was to be allocated for aerospace programs, although a direct dollar breakdown was not available. The enormous range of government research and development projects precludes even a catalog listing herein, but this section contains the highlights of 1968 in those agencies primarily concerned with aerospace R&D, or with non-aerospace programs in which aerospace firms were participating. Additional detail on unclassified projects is contained in the individual company résumés in the Aerospace Industry Section and in the Reference Section.

ATOMIC ENERGY COMMISSION

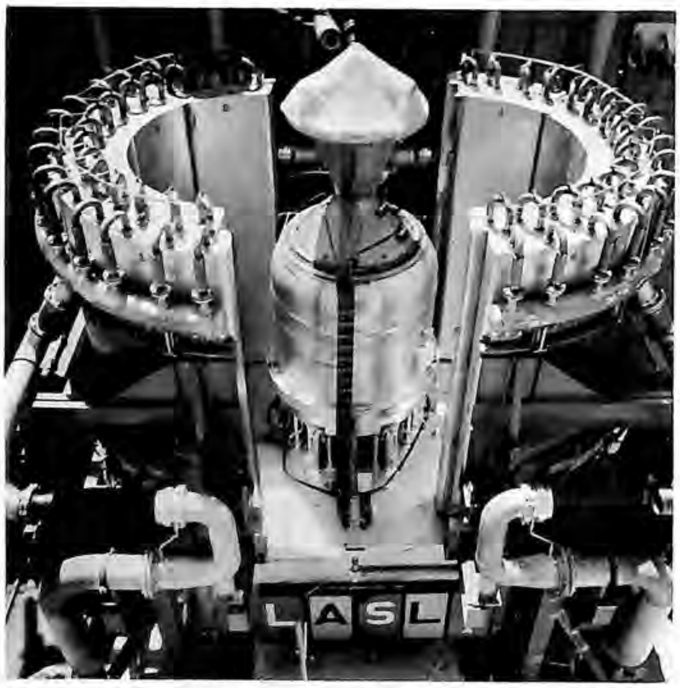
A highlight of the year in aerospace application was the ground test of the largest rocket reactor yet developed in the joint Atomic Energy Commission-National Aeronautics and Space Administration nuclear rocket program.

In other areas of atomic energy progress of interest to the aerospace industry, utility orders for nuclear electric plants continued to attract wide attention during 1968 as electric utilities made known plans for 18 nuclear power plants and placed orders for 15 with a total capacity of about 12,800,000 kilowatts.

Nuclear reactors for other applications also received considerable attention, particularly dual-purpose plants which would desalt water as well as produce electric power and process steam.

Overall uses of nuclear energy, such as the extensive applications of radioisotopes and radiation and the many promising uses of peaceful nuclear explosives in the Plowshare Program, made further advances in 1968.

Three nuclear cratering experiments were conducted as part of the AEC's program to develop technology using nuclear explosions in large-scale excavation projects: Project Cabriolet, Project Buggy and Project Schooner.



Pre-test view of Phoebus-2A, 12th in a series of nuclear rocket reactors developed for Project Rover by the Los Alamos Scientific Laboratory. The system was first tested in June, reaching a level above 4,000,000 thermal kilowatts.

In June the joint AEC-NASA nuclear rocket program successfully ground tested for the first time the largest nuclear rocket reactor yet developed at the Nuclear Rocket Development Station in Nevada. The Phoebus-2A experimental reactor, designed and developed by the Los Alamos (New Mexico) Scientific Laboratory, was operated for about 32 minutes at power, of which about 12 minutes were at a level above 4,000,000 thermal kilowatts. The power level was greater than that achieved by any previous rocket reactor or any power reactor. Additional power runs were made later in the year.

In April an experimental nuclear rocket engine was tested without nuclear fuel. The series of "cold flow" tests was conducted to verify that the engine test stand was ready for "hot" engine testing and to investigate engine start-up in the test stand under simulated altitude conditions.

AEC was planning to develop a radioisotope thermoelectric generator (atomic battery) as the power source for a Navy navigational satellite. It began negotiations with TRW Systems Group, Redondo Beach, California, at year's end for design and development of a 20-watt, plutonium-238-fueled nuclear generator. Development objectives included a 5-year operating life and a weight of less than 20 pounds. The generator will provide a continuous, reliable source of electrical power to satellite sensory equipment from which naval and commercial vessels can precisely determine their position at any point on the earth at any time.

Two radioisotope thermoelectric generators were on NASA's Nimbus-B experimental weather satellite which was launched from Vandenberg Air Force Base, California, on May 18. Shortly after a launch malfunction, the satellite fell into the sea about 4 miles north of San Miguel Island off the coast of southern California. The generators were to supplement power from solar cells. The valuable nuclear fuel from the generators was recovered in October. Two similar generators were to be used on the Nimbus-B2 weather satellite which NASA planned to launch during 1969.

Work continued on the development by the Navy and the AEC of a nuclear-powered deep submergence research and ocean engineering vehicle. The manned vehicle will have long endurance because of nuclear power. Its operating time will be limited only by the amount of food and supplies it will carry. It will have a crew of 5 and 2 scientists. The vessel will have viewing ports and will be able to perform detailed studies and mapping of the ocean bottom for military, commercial and scientific uses.

As of November 1, Congress had authorized 108 nuclear-powered submarines, including the deep submergence research vehicle, and 7 nuclear-powered surface ships. Of these, 77 submarines and 4 surface ships had been placed in operation by year-end. They had steamed over 11,900,000 miles without ever having to abort a mission because of reactor plant failure.

The Army's floating nuclear power plant, installed in the barge *Sturgis,* was towed to the Panama Canal and was providing power as an interim solution to the Canal Zone's power shortage problem. The increase in water usage for operating the canal locks required curtailment of some water supply for hydroelectric generation of power. The floating nuclear power plant is capable of generating full power of 10,000 electrical kilowatts for one year without refueling.

A radioisotope-fueled heater developed by the Atomic Energy Commission for wetsuits worn by divers was being ocean tested by the Navy. The device, for which the AEC was granted a patent, uses plutonium-238 to heat water which is circulated through tiny plastic tubes woven into the diver's undergarment. Two fuel capsules provide about 105 watts of heat each. The battery, pump and fuel capsule assemblies are attached to the outside of the suit. The heater, being tried out at depths up to 600 feet, allows the diver to perform working assignments for longer periods than otherwise possible in deep and chilly ocean waters.

Research and development of a strong and versatile concrete and plastic material was under way at AEC's Brookhaven National Laboratory on Long Island, New York, and at the Bureau of Reclamation's Engineering and Research Center in Denver. The Office of Saline Waters was also cooperating in the project. The new concrete polymer is produced by irradiating concrete impregnated with liquid plastic. Characteristics of the new material include resistance to extreme temperatures and also to corrosion, abrasion and water absorption. Applications under study include flash distillation units in water desalination plants and other construction projects.

Three nuclear cratering experiments were conducted as part of AEC's program to develop the technology of using nuclear explosions in large-scale excavation projects.

Project Cabriolet took place January 26 at the Nevada Test Site. The nuclear explosive used in Cabriolet had a yield of about 2.5 kilotons and was emplaced at a depth of 170 feet underground. Designed to provide data on cratering effects in hard, dry rock, the explosion produced a crater about 360 feet in diameter and 120 feet deep.

The first nuclear row-charge experiment in the Commission's Plowshare Program was conducted at the Nevada Test Site on March 12. It consisted of the simultaneous detonation at 135 feet deep in hard rock of 5 nuclear explosives, each having a yield of about 1 kiloton. The ditch-like crater has a smooth bottom and sides and is 254 feet wide, 70 feet deep and 865 feet long. The success of Project Buggy is particularly significant because of the critical relationship between a simple, effective ditching technique and the feasibility of using nuclear explosions for construction projects.

Project Schooner took place at the Nevada Test Site on December 12. It consisted of the underground detonation of a 35-kiloton nuclear explosive emplaced at a depth of 350 feet below the surface of the ground. Designed to provide data on cratering effects in hard rock using higher-yield explosives, Schooner produced a crater about 800 feet in diameter and about 290 feet deep.

Collection and analysis of data from Project Gasbuggy—the first joint government-industry experiment to study the use of nuclear explosions to stimulate the production and economic recovery of natural gas—continued during the year. The nuclear explosion for the project took place December 10, 1967, near Farmington, New Mexico. Analysis of limited initial data obtained by the participants—the AEC, the Department of the Interior, and El Paso Natural Gas Company—indicated that radioactive contamination of the gas was below the predicted levels.

The Atomic Energy Commission and the Department of the Interior announced on May 31 that they had agreed to join with the State of Arizona in a detailed study of the possible use of peaceful nuclear explosions to help meet Arizona's increasing need for water. General indications from previous studies were that the chimney of broken rock formed by an underground nuclear explosion might be used to channel water underground to depleted aquifers (naturally formed underground reservoirs). Also of interest was the possibility of using peaceful nuclear explosions to construct dams to retard the runoff of surface water; this water then could be diverted to other uses.

AEC made available on January 6 a report from a 10-member panel on a proposed Omnitron accelerator. Total cost of the machine, proposed to be located at the Lawrence Radiation Laboratory, Berkeley, California, was estimated at $26,500,000. It would be designed to accelerate ions of any element in continuously variable energies up to 300-500,000,000 electron volts per nucleon. It would make possible new research in nuclear chemistry, biology, medicine and physics by providing quantities of energetic ions of elements over the entire mass range.

A progress report released in October revealed that the huge Stanford Linear Accelerator had achieved a beam of 21 billion electron volts during a test run and had operated routinely at its peak design energy of 20 bev during regular experimental operations. Higher energy means each accelerated electron has greater probing power when it meets its target, the nucleus of the atom; thus it can provide finer measurements of nuclear structure and can reveal more about the atom's core.

Chairman Glenn T. Seaborg announced on October 22 that the AEC was making available for sale for the first time a limited amount of californium-252, one of the world's rarest materials. He pointed out that the radioisotope will see its greatest use in minute quantities. It was being sold for $100 for one-tenth of a microgram (one ten-millionth of a gram), which is equivalent to $450 billion per pound, if a pound were available. Dr. Seaborg emphasized that the applications of californium-252 could have a far-reaching effect in improving personal health, the quality of products from the industrial complex and increasing energy resources.

In the area of civilian nuclear power, a 10-volume comprehensive plan for development of fast breeder reactors was issued by the AEC after a 2-year conceptual study. (A breeder reactor produces more nuclear fuel than it uses while generating power.) The plan outlined a development program for a safe, reliable, and economical liquid metal-cooled fast breeder reactor.

AEC was also conducting a technology development program for a thermal breeder reactor designated the molten salt reactor. (A thermal breeder reactor usually converts or "breeds" atoms of non-fissionable thorium-232 into fissionable atoms of uranium-233. A fast reactor converts atoms of non-fissionable uranium-238 into fissionable atoms of plutonium-239.)

The number of nuclear plants announced and ordered in 1968 dropped in comparison with the previous year. As of December 31, 1968, electric utilities made known plans for 16 nuclear power plants and placed orders for 17, with a total capacity of about 15,550,000 kilowatts. In 1967, 32 plants were announced and 31 were ordered, with a total capacity of 25,570,000 kilowatts.

As of December 31, there were 13 operable nuclear power plants, 44 being built and 34 planned for which reactors had been ordered, and 11 planned for which reactors had not been ordered, representing a total of about 72,842,100 kilowatts.

While AEC was working on liquid metal-cooled fast breeder reactor and thermal breeder reactor concepts, it was cooperating with industry in the development of a high-temperature, gas-cooled reactor for use in a nuclear power plant being built near Platteville, Colorado. The 300,000-kilowatt plant will be owned and operated by Public Service Company of Denver and will be designed and built by Gulf General Atomic. The AEC was funding certain developmental features of the plant. Many of the major components of the type to be used in the plant will provide technology that could be useful for the development of gas-cooled fast breeder reactors.

A report on nuclear energy centers for industrial and agro-industrial complexes was issued by the AEC's Oak Ridge National Laboratory. The report concludes that such centers have potential for bolstering the economies of arid regions of the world. A typical industrial complex might include interrelated industrial processes for the production of fertilizers, aluminum, phosphorus and ammonia. The complex would be located on the seacoast and include large-scale desalting of seawater for highly intensified irrigated agriculture. Nuclear reactors producing low-cost power would serve as the energy source for the electrical and other energy requirements.

In the field of defense operations, AEC had announced, as of December 31, 1968, 27 underground nuclear weapons-related tests and one nuclear test detection research experiment at the Nevada Test Site in 1968. In addition, a calibration test was conducted in the Hot Creek Valley of central Nevada to help determine suitability of the area for later testing at yields higher than are feasible at the Nevada Test Site.

Investigation and development of probable test locations in central Nevada continued during the year, as similar preparations were being made on Amchitka Island, Alaska. The 2 areas were expected to be ready for use by mid-1969, but no tests had received final authorization.

DEPARTMENT OF DEFENSE

Total fiscal 1969 funding for research, development, test and evaluation in the Department of Defense budget was pegged at $7.1 billion in new obligational authority (this was the figure for the basic budget and was exclusive of any supplemental R&D appropriation for the particular requirements of the Vietnam war). The figure compared with $7.045 billion in the previous year.

As in previous years, the Air Force got the largest share of the RDT&E funds. The USAF's FY 1969 allocation was $3.28 billion, up from $3.13 billion in the previous year. The Navy figure was $1.86 billion, a slight decrease from 1968's $1.87 billion. The Army budget called for $1.53 billion, down from $1.55 billion.

Also included in the DoD budget was $464,000,000 for programs of the Advanced Research Projects Agency. Primary aerospace project in this category was Defender, a broad program of research and exploratory development in the field of ballistic missile defense, penetration aids and defense against satellites.

Highlights of the major DoD research and development programs are contained in the résumés of the individual services which follow.

AIR FORCE

Military requirements continued to pace the nation's scientific and technology programs during 1968 and the Air Force Systems Command (AFSC) played a major role in meeting those requirements.

"Research and development," explained General James Ferguson, commander of the Air Force Systems Command, "is charged today with the responsibility of being in 2 places at once—at the frontier of future opportunities and on the doorstep of present problems."

In 1968, AFSC research activities were directed in 5 major areas: limited war support for operations in Southeast Asia (SEA), management of Air Force scientific and technical resources, the national space effort, new aeronautical developments and technological advancements.

Nearly every new system, weapon or item of aerospace equipment entering the Air Force's operational inventory during 1968 was a product of Systems Command's research and development, modification or acquisition efforts. These front lines of technological ability extended to Southeast Asian combat areas, where a Systems Command liaison team was identifying problems which technology can help solve.

Night-time battlefield illumination may be more reliable and practical when the Air Force Aero Propulsion Laboratory's (AFAPL), Wright-Patterson AFB, Ohio, "Project Brilliant" is completed. In the test program a lightweight device was fitted onto an F-4 aircraft and successfully beamed a light 500 times brighter than moonlight over a half-square-mile area from an altitude of 1,000 feet.

In June came the announcement of a "fast-fix" cement which in tests hardened sufficiently in only 30 minutes to support the weight of a jet fighter. The mixture was tested in South Vietnam. Developed by AFAPL, it was designed to repair mortar-and rocket-damaged runways and may also find application where quickly built hardstands are needed as helicopter landing sites.

At the Air Force Flight Dynamics Laboratory (AFFDL), Wright-Patterson AFB, Ohio, tests began on a new one-man rotor-glider. When attached to the parachute, the device would permit an ejected pilot to maneuver himself away from hostile ground elements into a more favorable rescue pickup location.

A flare firing intervalometer, developed by Rome Air Development Center (RADC), Griffiss AFB, New York, in August, will give Southeast Asia air crews a self-contained unit for dropping flares which is expected to increase safety in handling and provide firing on command.

Aircraft in Southeast Asia can now be weighed out-of-doors using a new mobile electronic weighing system (MEWS) developed for the Aeronautical Systems Division (ASD), Wright-Patterson AFB, Ohio. It determines the gross weight and the center of gravity on 4 types of loads, replacing the former system of jacking the aircraft inside a hangar.

Missile reentry tests in the Pacific area came under a centralized scheduling and coordinating facility in May. Known as the Joint Pacific Area Scheduling Office, it was organized under the direction of the commander of the Air Force Western Test Range (AFWTR), Vandenberg AFB, California, and consisted of personnel from the Army, Navy, Air Force and other agencies.

Ground-breaking exercises at AEDC on May 17 marked the start of construction on airfield facilities which will provide support for that Systems Command unit.

The Air Force Human Resources Laboratory (AFHRL) began operations at Brooks AFB, Texas, on July 1. One of the organizations under AFSC's director of laboratories, AFHRL will be the focal point for Air Force efforts to satisfy technology needs in human resources, education, training and management.

A new element of the Air Force Systems Command, the Armament Development and Test Center (ADTC), began operations at Eglin AFB, Florida, on August 1. At the same time the Air Proving Ground Center (APGC) at Eglin was discontinued. ADTC was assigned responsibility for non-nuclear munitions programs, including acquisition, development, test and evaluation.

Fuchu, Japan, is the site of a new Systems Command liaison office aimed at promoting quick response to the technical problems of U.S. forces in Northeast Asia. It will provide a link between operational elements of the 5th Air Force and the research and technical facilities of AFSC.

At RADC, a new laboratory was dedicated. It will provide the center's engineering division with modern facilities to carry out exploratory development in reliability and maintainability of various surveillance and intrusion detection devices.

In November, USAF Headquarters awarded the Space and Missile Systems Organization (SAMSO), Los Angeles, California, the Outstanding Management Improvement Program Award for an "outstanding cost reduction program." The unit had a validated savings of over $68,000,000.

At the Air Force Eastern Test Range (AFETR), Patrick AFB, Florida, an Atlas-Centaur vehicle boosted a NASA Surveyor spacecraft to a soft landing on the moon for the fifth time. The Surveyor G mission completed all of the program objectives in support of the Apollo program.

At AFETR an Atlas-Agena booster launched the fifth and final Orbiting Geophysical Observatory in the series which carried a record number of experiments for a United States satellite. The experiments studied the earth's space environment and its relationship to the sun.

At Vandenberg AFB, a major milestone was passed April 27 with the launching of the 200th Atlas ICBM by the 6595th Aerospace Test Wing of SAMSO.

A SAMSO-developed Titan III-C standard launch vehicle successfully orbited 8 communications satellites from Cape Kennedy on June 13 to augment the Initial Defense Satellite Communications System.

In a launch of the Space Experiments Support program, managed for Department of Defense (DoD) by SAMSO, a Titan III-C placed 4 satellites into precision orbit during September. They included an experimental tactical communications satellite, one to monitor radiation around the earth, one to study heat transfer, and a 475-pound physics research laboratory.

Both the Eastern and Western Test Ranges supported the Apollo 7 mission in October when 3 astronauts spent 11 days in earth orbit. The Saturn IB rocket was launched from facilities at the Eastern Test Range, while the Western Test Range provided communications, weather information, and its entire complement of instrumentation ships on station in the Pacific Ocean. Similar support was provided for the Apollo 8 lunar mission in December.

A joint NASA-AEC-AF study resulted in the development of a distillation, vapor-filtered water recovery system which may prove important in future deep space penetration efforts. In 2 30-day tests, the device produced bacteria-free, potable water.

Roll-out of the world's largest aircraft, the Lockheed-built C-5, in early March brought together national and military leaders, including President Johnson, to commemorate the event. Three months later the giant cargo aircraft made its first flight from the Lockheed plant site in Georgia.

At the Air Force Flight Test Center (AFFTC), Edwards AFB, California, a modified HL-10 lifting body made its first flight, piloted by Major Jerauld R. Gentry. It marked another milestone in the joint NASA-Air Force lifting body effort.

The first 2 of 127 A-37B attack aircraft were rolled out of the Cessna Aircraft Company plant at Wichita, Kansas, in late May. Developed by ASD for the Tactical Air Command, the plane was designed to meet specific close air support requirements of counterinsurgency operations.

The XV-4B Hummingbird II aircraft was rolled out of the Lockheed-Georgia Company plant at Marietta, Georgia, on June 4. Developed under the supervision of ASD, the 2-place jet with 4 lift engines and 2 lift-cruise engines will be used by AFFDL to study vertical and short take-off and landing integrated flight control systems. The craft made its first flight on September 28.

Another important roll-out in June was that of the first of 8 new C-9A Nightingale aircraft at the McDonnell Douglas Corporation plant at Long Beach, California. Essentially a DC-9 commercial aircraft, its interior was redesigned for aeromedical evacuation flights; it can carry 30 to 40 litter patients or more than 40 ambulatory patients.

Contracts were announced in September for initial development phases for a high-performance afterburning turbofan engine suitable for the new Air Force aircraft F-15.

In September the Australian Minister for Defence accepted the first F-111C aircraft for the Royal Australian Air Force during turnover ceremonies at General Dynamics, Fort Worth, Texas.

Transfer of the data reduction process on reentry trajectories from Kirtland AFB, New Mexico, to Holloman AFB, New Mexico, was completed in January. Known as the Airborne Astrographic Camera System, it consists of 2 KC-135 aircraft, each instrumented with 17 special cameras to record trajectory information to help determine weapons system effectiveness.

The world's largest X-ray machines, part of the Air Force TREES facility that measures the Transient Radiation Effects on Electronic Systems, became operational at the Air Force Special Weapons Center (AFSWC), Kirtland AFB, New Mexico, in November. The 2 machines weigh more than 600 tons. The facility simulates the radiation from a nuclear detonation and studies its effects on electronic systems.

Use of a new transonic wind tunnel at AEDC began in January, culminating construction begun in 1966. It is used to test articles designed to serve SEA needs. In 6 months of use, 10 air munitions tests were conducted in the new 4x4-foot tunnel.

An unofficial world record for a single parachute delivery was claimed by the 6511th Test Group at El Centro, California. The pallet, dropped from a C-130 Hercules aircraft at an altitude of 1,200 feet, weighed over 50,000 pounds.

Testing of Walleye, a television-guided, stand-off glide bomb, was completed in February. Walleye is programmed for use with the F-4C and F-4D fighter aircraft.

At Electronic Systems Division a contract was awarded during February for a tactical electronic switching center in connection with the Air Force's 407L Tactical Air Control System. It will provide up to 475 programmable 4-wire line and trunk terminals and is compatible with other types of telephone systems now in operation.

At AEDC a pulsed laser was used for the first time as a light source for photographing models in flight at velocities of 20,000 feet per second. It provided heretofore unavailable examination of model integrity, surface erosion and degree of nose recession.

Contracts totaling nearly $500,000 were awarded to 2 firms for sensor analysis studies concerned with the control and surveillance of friendly forces on the ground and in the air. Monitored by ESD at L. G. Hanscom Field, Massachusetts, the study is aimed at improved command and control communications.

Work began in April at AFMDC on a new rain erosion facility. It will permit study of the effects of rain upon various types of artillery shells and various aircraft or space systems. It consists of a 2,000-foot-long, double line of shower heads separated by a 24-foot-wide asphalt strip.

RCA employee displays model of an experimental system which may permit astronauts to move in space simply by speaking directional commands. RCA is developing the system for the USAF's Avionics Laboratory.

RADC took receipt in April of a new, lightweight tactical modular display console utilizing microelectronics. It is planned for use in ground-based, shipboard or airborne environments.

The Fourth International Symposium on Bioastronautics and the Exploration of Space, sponsored by the Air Force Aerospace Medical Division (AFAMD), Brooks AFB, Texas, was held in San Antonio, Texas, in late June.

Project SEEK DAWN, developed under the supervision of ESD, was installed in SEA. It is a new system to monitor and direct tactical air operations in combat using high-speed computers to process flight plans and check aircraft routes by radar tracking.

RADC announced in June that a new backpack radio unit, designed by engineers there, was expected to facilitate close air support, logistics and rescue operations during combat. Known as the AN/PRC-72, the 35-pound, battery-operated unit will enable forward air control units to communicate with air and surface forces.

At Holloman AFB, New Mexico, testing of television cameras to guide a missile to its target began when 2 TV cameras were mounted in the nose of a C-130 aircraft. The object of the test program is to determine whether the contrast tracker system can effectively select a target by discriminating between the contrast of the target and its surroundings.

At the AFETR, the first test launch of the Air Force Minuteman III missile was conducted on August 16.

Systems Command's ESD accepted a new 13-story-high space track radar built at Eglin AFB, Florida, during October.

Testing of ultra-high-frequency communication satellites was begun by ESD using limited terminals with the Lincoln Experimental Satellite-6 (LES-6) in a parked orbit over the equator.

Future astronauts may be able to talk their way from one spacecraft to another if experiments conducted by a team of scientists at the Air Force Avionics Laboratory (AFAL), Wright-Patterson AFB, Ohio, are successful. They were working on a voice-actuated control system for astronaut maneuvering units. The machine is expected to respond to 14 voice commands—words such as stop, back, right, open, down, etc.—freeing the astronaut's hands for other work.

Requests for proposals for the contract definition phase of a high-speed Airborne Warning and Control System (AWACS), equipped with radar, computers, displays and communications to direct aircraft against both ground and air targets, were issued in December by AFSC's Electronics Systems Division. The program called for modification of either a McDonnell Douglas DC-8 or a Boeing 707 with a large radar "rotodome" mounted above the airframe.

ARMY

A large part of the Army's 1968 research and development effort was concentrated on the versatile helicopter.

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 for the Army 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 AH-56A has the capability of employing a variety of weapons including a 7.62-millimeter machine gun, 40-millimeter grenade launcher, 30-millimeter automatic gun, 2.75-inch rockets, and the TOW missile. Fabrication of the 10 prototype aircraft was completed. The ground and flight test program made significant progress. Air firing tests of weapons began in August 1968 with favorable results. The aircraft flew at speeds up to 205 knots and demonstrated its maneuverability and agility. Army tests were expected to begin early in 1969.

In another major program, the Army established an improvement program for the AH-1G/HueyCobra attack helicopter and production contracts were awarded.

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 placed priority on the development of helicopter weapons systems and methods to increase the battlefield survivability of both aircraft and crews. Improvement in standoff and weapons systems lethality received major emphasis through the development of airburst and delay 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.

Air firing tests of weapons arming the AH-56A Cheyenne began in August; fabrication of 10 prototype aircraft was completed during the year.

In the area of missilery, a major development was the start of flight testing of the Spartan missile; the first developmental system was fired from Kwajalein Missile Range in March. Spartan is the longer-ranging member of the Sentinel anti-ICBM defense system; the system also includes the high-acceleration Sprint missile, which has been in flight test status at White Sands Range since 1965, the Perimeter Acquisition Radar (PAR) and the Missile Site Radar (MSR).

Kwajalein was being readied for full-scale intercept tests by both Spartan and Sprint, in which ICBMs launched from Vandenberg Air Force Base, California, toward Kwajalein will be used as targets.

Selection of sites for deployment of the Sentinel system moved along on schedule during 1968. Some 15 general areas containing potential sites to be surveyed were announced. In October construction started on the first site, in the Boston area.

In another missile development, the SAM-D surface-to-air system moved into advanced development status. SAM-D is oriented primarily toward air defense of the field forces, although it also has application to continental air defense. The 1968 effort was confined largely to development of components, or "building blocks"; no deployment decision was made.

In active development were the Chaparral, Lance and TOW missiles.

Tests continued at White Sands Missile Range on Chaparral, basically a Navy-developed Sidewinder IC modified for ground-to-air rather than air-to-air launch. The missile successfully intercepted Firebee targets on some of the flights. The Army awarded a contract to Sanders Associates, Inc., of Bedford, Massachusetts, for design, development and fabrication of a portable radar for the Chaparral/Vulcan systems; the radar, to provide early detection of attacking enemy aircraft, is called the Forward Area Alerting Radar.

The 20-millimeter Vulcan self-propelled and towed air defense weapon was being developed as a companion system to Chaparral; it will be deployed in composite battalions with Chaparral.

The Lance missile system continued in advanced development with test firings of Tactical Prototype (TP) weapons at White Sands Missile Range; the Army termed test results satisfactory. Already in production was support equipment for the Lance, including a self-propelled launcher, the transporter/loader, the lightweight launcher and miscellaneous other equipment.

While testing continued on the basic TOW system, designed to replace the Entac missile and the 106-millimeter recoilless rifle, the Army initiated development of a new version, the XM-26, for use on helicopters.

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 1 part in 200,000. The Army suffered 2 setbacks in 1968 in efforts to expand the SECOR satellite network. On May 18, SECOR 10, a secondary payload on the Nimbus launch, was lost because of booster malfunction. A second attempt to increase the network, this time with 2 SECORs aboard an Atlas-Burner 2 multiple spacecraft launch on August 16, also failed with a malfunction of the Burner 2.

In the communications field, the Army continued to develop and test ground terminals for comsat networks. In addition to tests of the Initial Defense Satellite Communications System, which was expanded to 25 satellites during the year, the Army was participating with the USAF in development of a tactical communications system. The Army conducted tests of terminals used with the LES-6 solid-state experimental military comsat launched September 26.

NAVY

The Naval Air Systems Command, as the largest of 6 Material Systems Commands, has the responsibility for managing the development, production and technical support of all air weapon systems for the Navy and the Marine Corps. The command supports the activities of more than 130,000 personnel engaged in air systems work throughout the world. Additionally, it has responsibility for 7 Naval Air Rework Facilities where major aircraft overhaul and repair work is accomplished.

In fulfilling the command's mission to provide the Navy and Marine Corps with the best air weapon systems available from current technology, significant achievements were made during 1968.

The year saw the Naval Air Systems Command involved in extensive studies on contractor proposals for the Navy's newest carrier-based supersonic fighter aircraft. An evaluation group of approximately 350 officers and civilians looked into specific technical areas, including airframe characteristics, propulsion, avionics and costs.

At year-end, competition for the VFX-1 had been narrowed to 2 major contractors. The new aircraft, designated the F-14A, will be a 2-place fighter with tandem seating, equipped with Pratt & Whitney Aircraft TF30-P-12 afterburning turbofan engines. It is designed with an optimized combination of speed, acceleration, maneuverability and radius of action, including a fire control system with multiple weapon options. Plans called for the first flight of the F-14A in early 1971 and introduction to operational service with the fleet in 1973.

First operational deployment of the Navy A-4F Skyhawk took place in January. Improvements over earlier models include a zero-zero escape system, nose-wheel steering, improved avionics, wing lift spoilers to provide better crosswind performance and shorter landing roll, and a more powerful engine. The A-4F is produced for the Navy by McDonnell Douglas Corporation.

Early in 1968, the Naval Air Systems Command awarded a contract to Grumman Aircraft Engineering Corporation to modify its E-2A Hawkeye aircraft with an improved general-purpose computer. Known as the Mod AX, the program will provide the Navy with a new microelectronic programmable computer having greater tactical flexibility, increased memory capacity, and improved reliability and maintainability. First fleet delivery of the modified aircraft was scheduled for January 1970. The modified aircraft is designated the E-2B.

An extension of the operational E-2A airborne early warning and command/control concept is the incorporation of the APS-111 radar which greatly enlarges the operational capability of the aircraft by permitting it to operate successfully in an overland environment. The requirement for a radar with an overland capability stems from the inherent limitations of previous radars which had only a "blue water" capability. The Naval Air Systems Command began developing the overland radar in 1962 and successfully demonstrated the APS-111 in the summer of 1967. In addition to the improved radar capability of the APS-111, the use of microelectronics and state-of-the-art improvements will greatly improve the reliability and maintainability of the weapons system.

Schedules called for the first production of the E-2A/APS-111 in fiscal year 1971 with fleet deliveries and first deployment of the aircraft to follow in calendar year 1973.

The first Grumman TC-4C Gulfstream aircraft was delivered to Naval Air Station Oceana, Virginia Beach, Virginia, in January, approximately one month ahead of schedule. An initial outfitting of spares and special support equipment was also delivered to the squadron in advance of scheduled delivery date. This aircraft provides a "flying classroom" for use in training A-6A replacement Navy and Marine aircrews, primarily the bombardier/navigator, in operation of the highly sophisticated A-6A avionic system under realistic flying conditions.

The TC-4C is a twin-turboprop aircraft, configured with a complete A-6A avionic system. The cabin area contains an A-6A training cockpit which accommodates a student pilot and student bombardier/navigator, an adjacent instructor's seat, and 4 student bombardier/navigator repeater stations. It can climb to an altitude of 30,000 feet and has a cruising range of 2,081 nautical miles. The aircraft were to be distributed equally to NAS Oceana; Marine Corps Air Station, Cherry Point, North Carolina; and Naval Air Station, Whidbey Island, Oak Harbor, Washington.

Final delivery of A-5A to RA-5C conversion aircraft was made to the fleet in the spring of 1968. In 1964 a contract was awarded to commence conversion of the A-5A aircraft to the RA-5C. Forty-three of the 44 A-5A aircraft produced were converted to the RA-5C configuration. The remaining one is a test aircraft being used at Naval Air Test Center, Patuxent River, Maryland.

The RA-5C is a carrier-based, long-range, supersonic, all-weather, multisensor reconnaissance aircraft. All major airborne systems of the A-5A were used in the newly converted aircraft. This reconnaissance configuration has a wing with improved lift characteristics, additional fuel capacity, and a streamlined pod along the bottom of the fuselage to house the various reconnaissance equipment. Outwardly, the appearance of the aircraft remains the same as the A-5.

The conversion of the 43 aircraft was completed in 3 years, the first converted aircraft joining the fleet in April 1965 and the last one delivered in April 1968.

Newest addition to the Grumman A-6A Intruder family, built under the direction of the Naval Air Systems Command, is the 4-place EA-6B aircraft, which successfully completed its first flight in May 1968. The flight lasted for 1 hour 45 minutes and was declared a complete success. The EA-6B is a twin-turbojet, electronic warfare aircraft designed for carrier and advanced base operations. It combines an improved version of the proven A-6A airframe with highly advanced electronic systems.

Carrier suitability tests for North American Rockwell Corporation's OV-10A Bronco light, armed reconnaissance aircraft were conducted in the fall of 1968.

The trials were conducted by the Flight Test Division of the Naval Air Test Center at Patuxent River, an activity of the Naval Air Systems Command. The aircraft completed 6 touch-and-go landings, 2 full stop landings and 2 free deck launches. The OV-10A performed its full stop landings with approximately 25 knots of wind over the deck, coming to a stop in less than 200 feet. The OV-10A is not equipped with a tail hook or catapult fittings and was completely dependent upon its own reversible-pitch propellers and brakes to bring it to a halt. To afford the Bronco maximum braking action, the cross-deck pendants of the ship's arresting gear were removed for the tests.

Developed and built for joint service use under Naval Air Systems Command management, the OV-10A was operational in 1968 with the Air Force as well as the Marine Corps in Southeast Asia.

The Navy's newest land-based antisubmarine weapon system, which will provide the fleet with a search and detection capability never before available in airborne ASW, had its first public showing in October.

The new aircraft, the Lockheed YP-3C Orion, is the product of a multimillion-dollar research and development program which had its beginnings in 1960. The YP-3C ushers in a new era in antisubmarine warfare techniques and equipment which will provide the Navy with an advanced weapon system to more effectively detect, classify, localize and attack undersea targets through the use of automatic data-processing equipment.

The research and development on the new avionics equipment for the YP-3C was done under Project A-NEW. This project was designed to provide the Navy with an integrated airborne ASW system capable of handling the enemy submarine threat. The objective of A-NEW was to optimize the use of contemporary ASW techniques and equipment through the use of a general-purpose digital computer and an integrated tactical display installed on board the aircraft.

The performance of the YP-3C will be substantially enhanced by improved ASW sensor capabilities, improved human factors through systems integration and data-processing engineering, increased reliability, and improved maintainability.

Avionics equipments are designed in modular form to facilitate rapid replacement aloft or on the ground. The maintainability goal is to be able to fix 95 percent of all YP-3C mission equipment failures within 30 minutes. Computer-initiated systems and diagnostic tests, plus the installation of built-in testing devices, will afford complete fault isolation at the replaceable module level.

The YP-3C differs little in outward appearance from its predecessors, the P-3A and the P-3B. The interior of the YP-3C, however, bears little resemblance to the earlier models in that it houses more than 300 pieces of avionics equipment, some 200 of which were not incorporated in the A and B models. The interior has been designed to provide access to most equipment from 3 sides of the console mount.

In February a contract was awarded to Bell Helicopter Company for procurement of 40 light helicopter day/night trainers. These aircraft will be an equipment-modified version of the Bell 206A Jet-Ranger and will be used for training Navy helicopter pilots. The new trainer was designated TH-57A. Production of all 40 helicopters was completed in calendar year 1968.

The TH-57A is a 5-place, single-engine, turbine-powered helicopter with fixed landing skids. The main and tail rotor blades are each 2-bladed, the main rotor blade incorporating tip weights for high rotor inertia in order to insure good autorotational characteristics. It carries a crew of 3 and is powered by an Allison 250-C18 engine. It will climb to 20,000 feet, have a mission range of 250 nautical miles at a speed of 100 knots and a useful load of 1,387 pounds.

These new primary helicopter trainers were to be assigned to the Naval Air Training Command at Pensacola, Florida, where they replace Bell TH-13Ms which have served in this role for the past 12 years.

Under a Naval Air Systems Command contract, the Sikorsky NH-3A (S-61F) compound helicopter completed an integrated controls flight test program in September 1968. The 19,000-pound helicopter was fully integrated with fixed-wing controls. The goals of the program were to determine the merits of complementing rotor flight controls with fixed-wing flight controls at speeds up to 200 knots. Thirty-six flights totaling more than 30.3 flight hours were completed during the evaluation. The fixed-wing controls were decoupled from the rotor controls for 8.4 hours of flight to determine the base line for comparison. It was found that the integrated controls provided 50 percent more response than the baseline aircraft at high speeds and that the compound responded like a fixed-wing aircraft. During maneuvering flight the fixed-wing controls provided enough of the total control power and response to reduce the stress levels in the rotary flight controls system. Additional testing of the NH-

3A by Naval Air Test Center and NASA was planned for 1969.

In the fall, a U. S. Marine Corps/Sikorsky CH-53A Sea Stallion helicopter, largest and fastest helicopter in production in the free world, performed a series of loops and rolls, unprecedented maneuvers for a helicopter of its size.

The maneuvers were part of a joint Naval Air Systems Command-Sikorsky flight test program to investigate the CH-53A's rotor system dynamics and maneuverability characteristics in order to extend its mission capabilities.

Engineering analysis indicated that rolls and loops could be safely performed within the approved altitude and speed limitations of the CH-53A. The Navy granted authorization for a one-time exploratory flight in a fully instrumented production aircraft to gather desired engineering data.

The Marine Corps CH-53A helicopter performed a series of loops and rolls, unprecedented maneuvers for an aircraft of its size, in a joint Naval Air Systems Command/Sikorsky flight test program to investigate rotor system dynamics and maneuverability.

The Bell X-22A, a tandem tilting duct research V/STOL aircraft, completed a significant portion of its flight demonstration program, culminating in a Military Preliminary Evaluation (MPE) in the spring of 1968. Equipped with a Variable Stability System, the X-22A is a unique tool for conducting flight research on flying qualities and flight control problems associated with a wide variety of V/STOL aircraft.

The MPE team (consisting of test pilots from the Navy, Army and Air Force) reported favorably on the flight characteristics of the vehicle and indicated that it should be able to accomplish its basic flight research mission. The pilots also reported no difficulty in making the transition to this novel aircraft despite a substantial lack of experience with V/STOL aircraft.

The first powered flight of the Naval Air Systems Command's new supersonic jet drone was successfully completed in June 1968 at Navy's Pacific Missile Range, Point Mugu, California. Designated BQM-34E Firebee II, the drone is a remote-controlled, versatile successor to the subsonic BQM-34A.

The growth-version target is capable of supersonic flight (Mach 1.5) at altitudes ranging from 50 feet to 60,000 feet. Designed and developed for the Naval Air Systems Command by Ryan Aeronautical Company, San Diego, California, as an air-launched target from DP-2E aircraft with an alternate ground launch capability, it provides a target for air-to-air and surface-to-air missiles. It is highly maneuverable and recoverable by parachute for repeated utilization over military aerial target ranges. To allow for future growth, the supersonic Firebee is structurally designed for a 100-pound increase in maximum gross weight and a flight speed of Mach 2.5 at 60,000 feet altitude.

The target is powered by a Continental turbojet J69-T-6 engine providing 1,840 pounds static sea-level thrust. For certain missions, depending upon the missile system being exercised, the BQM-34E is equipped with passive radar reflectors such as the Luneberg lens or active traveling wave tube augmentation devices. It is also designed to carry and operate electronic countermeasures equipment to simulate the radar-jamming capabilities of enemy missile systems and threat aircraft.

Production targets are planned for delivery to the Navy and Air Force in 1970. The BQM-34E, with its variable payload capability, will then provide a variety of missions for missile development, evaluation and training exercises.

The long-standing problem of the high-speed jet engine's inefficiency when operating at reduced speeds and low altitudes was substantially reduced by the Navy's first major jet engine development program in 7 years.

Powering its first jet-powered antisubmarine warfare aircraft, the VSX, the Naval Air Systems Command disclosed in 1968 that the plane will use General Electric TF34 high bypass turbofan engines. These engines are designed to consume fuel at a decreased rate and give the VSX aircraft an increased length of time on station plus a higher maximum speed capability when compared with earlier ASW aircraft.

Previously, conventional turbofan engines, which sacrificed efficiency and economy at lower speeds and altitudes, were considered impractical for ASW operations, where these characteristics are essential for proper mission performance. The new high bypass turbofans will enable the engines to utilize their fuel supply much more efficiently.

Once operational, the VSX is expected to outperform the existing carrier-based propeller-driven ASW aircraft by a significant measure in terms of range, endurance and maximum speed capability.

The Crew Systems Division of the Naval Air Systems Command, a division concerned with aircrew safety, was engaged in several significant projects during 1968.

Considerable progress was made to improve aircraft inflight escape systems. (1) A tractor rocket aircrew extraction escape system was demonstrated to be feasible for A-3B and EKA-3B aircraft, which do not have an ejection system at present. (2) A modification to improve the performance of the ejection seat in A-4 aircraft was qualified. This system provides zero-altitude/zero-speed escape capability and improved performance under aircraft high-sink-rate/adverse-attitude conditions. (3) Design and test of escape system improvements for A-7 series aircraft were initiated. A ballistically spread parachute will open faster and afford recovery of the pilot under adverse circumstances. (4) A rocket-assisted propulsion unit was developed to improve the inflight escape system of TF/AF-9J aircraft. (5) A program was initiated to develop an automated aircrew escape system for T-28 aircraft presently having only bail-out capability. Service experience of the cockpit capsular escape system in emergency situations demonstrated its reliability. In 5 successive escapes, a total of 10 capsule occupants were saved without injury. (6) Planning continued for advanced development of the helicopter capsular escape and survival system. (7) A comprehensive search and rescue system development program was initiated for improved methods of saving pilots forced to eject from aircraft in hostile areas. Effort under way ranged from high-speed rescue hoists to self-rescue ejection seats embodying lift and propulsion that enable an ejected aircrewman to fly to safety. (8) Evaluation of parafoils, parawings and sailwings was initiated to develop maneuverable/gliding personnel delivery systems for specialized use. (9) A new automatic parachute actuator was developed to increase the reliability of operation of this lifesaving device. The new actuator is designed to prevent maintenance personnel from assembling it incorrectly.

A dual ejection on take-off from a crippled F-4 Phantom in the spring turned out to be an unplanned but successful test of a new rocket-propelled escape system.

In the mishap, one aircrewman ejected less than 3 seconds after take-off at an estimated altitude of 70 feet. The pilot ejected seconds later at an altitude of 200 feet with the nose of the aircraft pointing nearly straight up. The 2 men landed safely as the aircraft fell to the runway and burst into flames.

The new system, developed under Naval Air Systems direction, replaces the old Martin-Baker MK H-5 escape system which lacked a low-speed, low-altitude escape system. Optimum capability was set at zero speed and zero altitude. The MK H-5 escape system required a speed of 130 knots to provide a successful ground-level ejection.

The new system, designated the MK H-7, has an escape capability ranging from zero speed at zero altitude to 600 knots at ground level. It will provide safe escape with the aircraft in a 20-degree nose-down attitude and at a speed of 90 knots. This condition is representative of an unsuccessful catapult off the bow of an aircraft carrier. The MK H-7 escape system is a fully sequenced system which, upon activation by the pilot, will complete the escape sequence of rear-canopy jettison, rear-seat ejection, front-canopy jettison and front-seat ejection in approximately 1.39 seconds.

Installation of the Martin-Baker MK H-7 escape system started in production F-4 aircraft in December 1967. In 1968 the system was being incorporated on a retrofit basis in all Navy and Air Force aircraft.

The Naval Air Systems Command adopted a new jungle rescue system that will protect a downed aviator from injury while he is being hoisted aboard a hovering helicopter.

The new jungle penetrator is a compact, bullet-shaped device which has a "pop-out" umbrella and 2 seats for dual rescue. The umbrella acts as a shield to ward off heavy jungle foliage on the way up to the rescue helicopter. The 2 seats will enable a helicopter crewman to descend and pick up an immobilized airman.

A study of rescue operations in Southeast Asian combat zones clearly established the need for a device with a protective canopy. Downed airmen faced the hazard of collision or entanglement with branches and vines of the jungle canopy during lift-off operations. Reports of personnel fatality attributable in part to the lack of a protective shield prompted the Naval Air Systems Command to establish the requirement for a protective device as a component of any jungle penetrator developed for search and rescue operations. Further requirements called for a positive jungle penetration capability, easy handling and operation by the survivor, compactness for ease of stowage in the rescue helicopter, and a capability for a dual pickup in the case of an injured airman.

Responding to these requirements, the Billy Pugh Company of Corpus Christi, Texas, developed and demonstrated a jungle penetrator/pickup device. The Navy conducted evaluations of this unit in simulated jungle environments at Lakehurst, New Jersey, and Warner Springs, California. Following stateside tests, combat-experienced helicopter crews conducted tests at the Naval Air Station, Cubi Point, Philippines. This site was selected because of its similarity to the jungle environment of Southeast Asia.

When the jungle penetrator is lowered to a downed airman, the compact capsule measures 2½ feet in length and 8½ inches in diameter. After actuating the "pop-out" mechanism, the dual-seated capsule expands to a length of about 5 feet with the protective canopy extending to 3 feet in diameter. The capsule weighs 48 pounds.

Downed naval aviators in Vietnam will stand a better survival chance because of a new safety feature which will change the colors of their inflatable lifesaving equipment. Instead of the standard bright yellow or international orange, the color of the aviator's life preserver and raft will change to blue.

The old colors proved to be a handicap to the downed pilot in Vietnam who sought concealment from the enemy while awaiting rescue. To alleviate the problem, the Naval Air Systems Command used a tested and approved blue marking ink. The ink and appropriate instructions for use have been sent to the combat area to permit rapid dyeing of inflatables now in use. The new blue inflatables will not reduce the pilot's odds of being rescued. The downed aviator still has other locator devices such as transceivers, radio beacons, strobe lights, flares, mirrors and dye markers.

The Naval Air Systems Command purchased a limited quantity of a new type anti-exposure suit which is expected to improve survivability chances of Navy aircrewmen forced to abandon their aircraft in cold water.

Based on the skin diver's "wet suit" principle, the air ventilated wet suit (VWS) introduces a new concept in constant wear, cold water anti-exposure protection for Navy aircrewmen. The VWS has been designed specifically for pilot-cockpit compatibility and uses an integrated air ventilation system as part of the suit. The VWS is made from 3/16-inch unicellular neoprene foam and is lined with a knitted nylon stretch fabric to increase the life expectancy of the garment and to facilitate easier donning and doffing. The suits were evaluated by both the Atlantic and Pacific fleets.

Naval Air Systems Command activities, not restricted to hardware only, moved ahead in several other major areas. These areas included avionics, fire fighting, ordnance, radar, photography, crash locators, and astronautics.

In a long-range effort to halt the proliferation of special-purpose avionic test equipment, the Naval Air Systems Command embarked upon a program for introducing the general purpose VAST (Versatile Avionic Shop Test) system to the fleet. Its primary objectives were reduction of avionic shop space requirements aboard aircraft carriers, reduction of the requirement for highly skilled avionics technicians, and reduction of costs of sophisticated avionic test equipment.

The first carrier aircraft to be supported by the VAST system will be the A-7E, with such support to commence in 1970. Plans called for the support of other aircraft and equipments as they are introduced. It is expected that by the late 1970s VAST system test stations will be able to support over 75 percent of the avionic equipments installed in carrier aircraft. By that time, avionic shops are expected to occupy approximately one-half the space required in 1968.

The Naval Air Systems Command developed a new fire extinguishing agent to combat aircraft fires at shore stations and aboard ships. Called "Light Water," the new technique uses a noncorrosive, nontoxic liquid foaming concentrate which mixes with water, can be aerated into foam, and will smother aviation fuel fires in seconds. It then forms a liquid which spreads a vapor seal cover on the fuel surface to prevent further flash fires.

An illuminating flare candle producing a luminous intensity of about 25,000,000 candles was tested in 1968 at the Naval Ammunition Depot, Crane, Indiana, under joint Navy-Air Force sponsorship. The Navy portion of this program is managed by the Naval Air Systems Command. The flare candle provides a means of achieving wide area illumination with a single flare candle instead of area saturation with a large number of smaller candles. The amount of light generated by the candle is equivalent to about 20 MK 24 Mod 4 Aircraft Parachute Flares.

In 1968 an X-band phased array antenna, designed and fabricated for the Naval Air Systems Command by Hughes Aircraft Company, underwent contractor evaluation. The assembled antenna array, which is comprised of 2,400 waveguide elements, was evaluated both as an antenna unit and as an integral part of an operational radar system. Lightweight power supplies were being designed and it was anticipated that a flyable model of the phased array system would be available early in 1969.

A significant feature of this phased array antenna is its ability to meet the tactical requirements of an airborne intercept mission. The phased array provides for multiple target track capability with high data rates utilizing beam steering by nonmechanical means.

The scanning pattern and the data rate in Navy aircraft are restricted by the mechanical scanning antenna system. The need for higher data rates is greatly increased for the multiple mission radar system. The phased array antenna system provides the capability of providing the desired beam shape plus required data rate.

In 1968 the Naval Air Systems Command developed a mobile, aerial reconnaissance color film laboratory which will provide the Navy and Marine Corps with a field processing capability for aerial reconnaissance color film when it becomes operational in the summer of 1969.

Designated ES-81A, the new air-mobile photo labs are fitted in 2 20-foot vans, measuring 8 feet wide and 7 feet high, equipped with removable running gear to provide stability once the units are set in place. With a combined weight of nearly 6 tons, the 2-unit complex can be airlifted by helicopter or transport to remote locations from which

Navy and Marine Corps photographic reconnaissance squadron detachments are operating.

With service introduction of the ES-81A slated for 1969, it was anticipated that the 5-man service crew would be able to process 200 feet of aerial color film within 50 minutes, thus enabling photographic interpreters and intelligence officers to view the film more quickly than was heretofore possible. The ES-81As are fully equipped and contain their own internal water supply, air-conditioning units and portable generators.

In 1968 the command began flight test and service evaluation of a crash-survivable, ejectable, airfoil package containing a flight data recorder and a location beacon to facilitate crash location. The system was installed on a P-3 Orion for testing at the Naval Air Test Center, Patuxent River.

Referred to as CPI/FDR, for Crash Position Indicator/Flight Data Recorder, the system is designed to provide a reliable means of recording aircraft flight data, to safely deploy this data automatically from the airplane in a crash situation, and to transmit automatically a distress signal from the accident location.

Specific aircraft and aircraft systems performance data, together with voice data from both the pilot and copilot crew stations and the cockpit area, can be monitored and recorded. The location beacon will transmit on 243 MHz, the standard international distress frequency which automatically initiates search and rescue operation. Upon location of the accident, the recorded data may be easily removed from the airfoil and played back to determine the cause. The system, which is small in size and light in weight, is designed for flush-mounting in the port side of the aircraft's vertical stabilizer.

The Navy continued to support efforts to apply space technology to the areas of navigation, geodesy, communications, meteorology, oceanography and science. During 1968 particularly significant achievements were made in the scientific field.

The major Navy effort in the science area was the Solar Radiation (SOLRAD) Monitoring Satellite project. Since 1960 7 SOLRAD monitoring satellites developed by the Naval Research Laboratory have been placed into orbit as part of an exploratory development program sponsored by the Naval Air Systems Command. The objective of the SOLRAD project is to perform continuous monitoring of solar X-ray and ultraviolet emissions of the solar fireball to provide indices of solar activity upon which a system of ionospheric disturbance forecasting can be based. The latest SOLRAD satellite (SR-IX), launched March 5, 1968, provides data which are reduced and encoded in a standard format and distributed within 15 minutes of reception. Acquisition and analysis of these data on the solar environment are basic to understanding sun-induced natural phenomena in the near-earth region which affect military operations, particularly HF communications. Prime Navy operational interest is to utilize the data to forecast the onset of HF communication disturbances. The satellite data are also distributed to the Air Force SOFNET (Solar Observing and Forecasting Network), to ESSA (Environmental Science Services Administration), to NASA and to the scientific community.

The second experiment in 1968 through which knowledge of the space environment was increased was the Department of Defense Gravity Experiment (DODGE). The DODGE satellite was developed to investigate the military potential of 3-axis gravity-gradient stabilization at near synchronous altitude. The gravity-gradient scheme is a system of booms and masses that utilizes the gravity force differential between 2 or more masses coupled by the booms to achieve the desired stabilization in space. At synchronous altitude (19,323 nautical miles), the satellite remains in the same position relative to a point on earth. DODGE is at an altitude of 18,161 nautical miles, which provides a 22-hour orbit; therefore, it crosses the same point on the equator every 12 days.

Major accomplishments achieved by the satellite were the first 3-axis gravity-gradient stabilized satellite at any altitude; first color pictures of the full earth disc to be transmitted from an unmanned spacecraft; first satellite to be launched with multiple and variable damping systems (a total of 4); direct measurement capability (TV camera) of the thermal bending of booms; capability of combining an active angular momentum flywheel with the passive gravity-gradient booms to obtain 3-axis stabilization.

The project was sponsored by the Department of Defense, Office of the Deputy Director of Strategic and Space Systems. Development of the DODGE satellite was accomplished by the Applied Physics Laboratory, Johns Hopkins University, under assignment from Astronautics Division of the Naval Air Systems Command.

FEDERAL AVIATION ADMINISTRATION

Research and development programs assist the Federal Aviation Administration in carrying out its primary responsibilities of improving air safety and advancing civil aviation. These programs are managed by the agency's Systems Research and Development Service, Aircraft Development Service, Office of Noise Abatement, and Office of Aviation Medicine.

Since industry conducts a large part of the FAA-sponsored research and development on a contract basis, the agency holds annual "Report to Industry" meetings to inform representatives of the aviation community of progress, goals, results and trends of current projects.

Topics discussed at the meeting held in June 1968 included recent air traffic control developments in both terminal and en route facilities, communications and data acquisition, future landing aids, aircraft wake turbulence, propulsion, general aviation safety, subsonic aircraft developments, airframe safety and equipment and aeromedical research.

As a result of long-range planning, FAA's Systems Research and Development Service completed specifications and received bids in 1968 for a terminal air traffic control system designed to meet the specific requirements of more than 60 of the busiest air terminals in the United States. The equipment, called the Automated Radar Terminal System (ARTS III), was scheduled for installation in the first of the high-density terminals within a year of the contract award, which was expected early in 1969. All major and medium activity terminals, which account for about 75 percent of the instrument aircraft operations and about 80 percent of passenger enplanements, should be equipped with the new ARTS III system by 1973.

A proposed horizontal console display designed for use by air traffic controllers in a Terminal Radar Approach Control (TRACON) facility to be equipped with an Automated Radar Terminal System (ARTS III).

The new semiautomated system to be installed in terminal facilities will provide radar controllers with information on the identity, altitude and ground speed of all properly equipped aircraft. This information will appear on the radar in the form of alphanumeric data tags attached to the appropriate target, or "blip."

At facilities without this ARTS equipment, controllers must memorize the identity of each aircraft target on the radar screen or write the information on small, clear plastic markers (shrimp boats) which then must be moved manually across the radar screen.

ARTS III computers also will permit automated entry and retrieval of flight plan information, calculation of estimated times of arrival and automated coordination between terminal and en route air traffic control facilities.

In addition, the built-in modular expansion capability of ARTS III will permit subsequent upgrading of terminal automation to include radar tracking, mosaic radar display, sequencing, final approach spacing, metering and multiple runway feeding, all calculated to handle greater numbers of aircraft faster.

Another 1968 achievement, the Bright Radar Indicator Tower Equipment (BRITE-1), soon to be functioning in more than 80 airport control tower cabs, demonstrated that airport surveillance radar (ASR) data can be displayed effectively in tower cabs under all light conditions, including bright sunlight. By interconnecting BRITE-1 with the ARTS III computer, the controller who controls aircraft on final approach to an airport will have a better means of coordinating information with controllers in the Terminal Radar Approach Control (TRACON) facility.

Installation of ARTS III terminal equipment was scheduled to mesh with the installation of the National Airspace System (NAS) Stage A en route air traffic control center automation, now well under way. The first full-scale Stage A air route traffic control center to reach initial operating capability for flight data handling and alphanumeric data display was to be the Jacksonville, Florida, center sometime during 1969. The remainder of the 20 centers serving the mainland United States should have the new equipment by 1973.

Communication is another area of prime importance in achieving maximum utility from ATC automation. Two basic modern techniques under study in 1968 were digital data transmission and electronic voice switching. Digital data remoting from long-range radars was being implemented as part of the air traffic control automation program. Recent projects showed that electronic voice switching requires less space than present fixed-wire electronic-mechanical switching systems and is more reliable and extremely versatile.

In the area of navigation and landing aids, emphasis continued toward reducing approach and landing minimums. Continued refinements in both ground-based and airborne Instrument Landing System (ILS) components and monitors are basic to this continuing program.

During 1968 FAA pilots logged more than 500 successful landings in a C-141 StarLifter jet using a prototype automatic all-weather landing system (AWLS) capable of putting an airplane on the runway under simulated zero-zero visibility conditions. With the AWLS, the pilot's role is one of a monitor. All decisions in operating the controls, which keep the aircraft on course at the proper rate of descent and speed, are performed by small but complex sensitive computers, each about the size of a shoe box. The pilot, however, remains in command at all times and may override the automatic system at his discretion and either elect to land manually or execute a missed approach.

The flight tests at the FAA's National Aviation Facilities Experimental Center (NAFEC) marked the first attempt by agency pilots to evaluate a completely integrated AWLS under field conditions. FAA will use the data accumulated during the C-141 flights, along with that from other programs, to write criteria for Category III landings, that is, landings when the ceiling is zero and runway visibility ranges from 700 feet down to zero.

FAA was investigating improved methods and devices for measuring weather criteria, such as runway and taxiway visual range and slant range visibility as well as cloud height and ceiling determination. A need also exists for an airport surface traffic system that will permit operations on the ground under all visibility conditions.

FAA continued its investigation of wake turbulence, the twin tornado-like, horizontal vortices which an aircraft in flight leaves in its wake. Energy contained in these trailing vortices can cause structural damage, loss of control and passenger discomfort when encountered by another aircraft. By using actual aircraft, FAA researchers were at work determining the characteristics of vortex flow, its effect on encountering aircraft and practical applications of facts learned.

Two turbine engine fire test programs were conducted to provide additional information on the inflight fire protection requirements for pod-mounted turbofan and rear fuselage side-mounted turbojet power plant installations. The tests provided engineering and design data which were being used in the design of new high compression ratio turbine engines.

FAA's program for investigating the use of thickened fuels for reduction of survivable crash fire hazards continued. The agency supported research to obtain a more stable and compatible thickened fuel and to compare fire reduction qualities of various fuels already developed. Following the selection of the optimum thickened fuel, the agency planned to support tests to determine the extent of modification an aircraft engine will need to utilize the new fuel.

The FAA was sponsoring a program to establish flight characteristics for improved stability and control of modern, high-performance, light general aviation airplanes when operated under instrument conditions by an average pilot. Tests showed that the stability and control characteristics of light aircraft were adequate throughout their certificated range but could be improved during the landing approach when the pilot load is heaviest.

With the expanded use of short take-off and landing (STOL) aircraft, the FAA was focusing attention on operational safety aspects of this type of aircraft. Flight test programs to determine safe landing distances and how steep a glide slope can be used and to establish obstacle clearance standards for instrument approach procedures were under way at the agency's National Aviation Facilities Experimental Center. The agency was also considering requirements for STOLport design and location.

Other programs under way concerned use of grooved runways to provide better traction for aircraft using wet runways and use of improved aircraft interior materials to reduce emission of heat, smoke and toxic gases during survivable crashes.

FAA initiated a program to establish a methodology whereby a computer can be used to determine analytically means for improving the crashworthiness of an aircraft fuselage. Results obtained by year-end showed that the computer analytical program does permit a good assessment of the crashworthiness of fuselage structures and does provide a tool which can be used to evaluate the effectiveness of crashworthy design.

FAA aeromedical research teams were engaged in evaluating aircraft evacuation techniques and cabin designs to make sure passengers receive maximum protection in event of an emergency. Medical experts and engineers cooperated in testing seat structures, safety belts and various aircraft interiors to provide passengers the maximum protection. They also studied the effects of drugs, alcohol and toxic materials, such as pesticides applied by agricultural aircraft, on flight safety. Studies also were being run to devise improved evacuation procedures for the high-capacity jets which will be entering airline service in the early 1970s.

FAA was participating in a number of aircraft noise studies. In one, total aircraft noise exposure was being measured at 29 representative airports in a 3-phase study which will lead to a computerized method of determining present and future noise levels at all airports. Another phase of the study will be an analysis of various alternatives for reducing noise and the effect of these procedures.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

The highlight of the year for the National Aeronautics and Space Administration, also the highlight of the Space Age and possibly man's greatest adventure of all time, was the December 21-27 mission of Apollo 8 which took 3 astronauts into lunar orbit.

The mission clearly established the U.S. as the world leader in space flight and paved the way for a 1969 manned lunar landing. Crewed by Frank

Borman (spacecraft commander), James Lovell (Command Module pilot and navigator) and William Anders (systems engineer). Apollo covered 570,000 miles in 147 hours and included 10 orbits of the moon. In addition to man's first visit to the vicinity of the moon, the flight marked man's first operations in a gravity field other than earth's and the fastest velocity ever attained by a manned vehicle (24,600 miles per hour during earth reentry).

The flight was also the first manned mission launched by the Saturn V superbooster, which performed perfectly. The Apollo 8 mission was a "textbook" flight, right on the planned mission profile from start to splashdown. The 28th manned flight in history and the 18th by a U.S. crew, it gave the U.S. 3,215 man-hours of space experience, compared with 629 for the Soviet Union.

Apollo 8 was the fourth Apollo mission of the year, following one manned and 2 unmanned flights.

The precise reentry and splashdown on October 22 of the 11-day Apollo 7 flight ended what was called a 101 percent successful mission. Manned by astronauts Walter Schirra, Donn Eisele and Walter Cunningham, the Apollo 7 performed flawlessly for more than 260 hours in space, including firings of the spacecraft's primary propulsion system and the first live TV from a U.S. manned vehicle.

Shortly after launch, with the Saturn IB rocket second stage still attached to the spacecraft, the astronauts exercised manual control of the combined vehicle from the spacecraft. Following space vehicle separation, the astronauts flew the spacecraft around the second stage and simulated a docking, using the Lunar Module Adapter as the target. Later, with the second stage in a different orbit, the spacecraft "found" the vehicle and rendezvoused with it, demonstrating the ability of the Command Module to maneuver to the Lunar Module if the latter should become disabled on a manned lunar landing mission.

Most of the critical tests necessary to "wring out" the spacecraft equipment took place early in the flight. Crew performance, prime and backup systems, and mission support facilities were checked.

The astronauts used hand-held movie and still cameras to photograph both earth and stars. The astronauts had colds during the flight.

The flight not only accomplished all mission objectives but also completed some tests not included in the original flight plan. Apollo 7 flew some 4,500,000 miles on the first manned Apollo flight.

The April 4 flight of Apollo 6 was the second unmanned Saturn V mission to demonstrate launch vehicle and spacecraft systems performance. Two problems were experienced with the rocket systems —vertical oscillations, or "pogo" effect, in the first stage and rupture of small propellant lines in the upper stages.

Through a determined post-mission analysis and an aggressive ground testing and evaluation program, these Saturn V problems were corrected.

During the January 22-23 Apollo 5 mission, Lunar Module systems and structural performance met all objectives, including 2 firings of both the ascent and descent propulsion systems.

The unmanned Lunar Module was boosted into earth orbit by a Saturn IB. Post-flight analysis determined the Lunar Module ready for manned earth orbital missions.

During 1968 scientist-astronauts John A. Llewellyn and Brian T. O'Leary withdrew from the training program, Air Force Lieutenant Colonel Michael Collins underwent surgery for removal of an arthritic bone growth, and Navy Lieutenant John S. Bull withdrew due to pulmonary disease.

Where the mighty engines of Saturn V, the free world's largest and most powerful booster, demonstrated their ability to orbit heavy payloads, NASA also successfully operated a very different type of power plant in 1968. Two ion, or electrical, engines were tested on a spacecraft, producing a thrust equivalent to the weight of one-half of an office staple.

Instead of 2½ minutes of operation, the ion engines fired for a total of 23 hours in 5 separate tests. And where Saturn V's great F-1 engines gulp 15 tons of chemical propellants per second during their brief firing, only one-tenth of a pound of cesium was required to fuel each of the ion power plants. This supply is enough to keep a satellite in stationary orbit above the earth for more than 3 years.

Because satellites placed in synchronous or stationary orbit tend to drift slowly, ion power plants are ideal for countering the gravitational forces acting on the spacecraft. Only very-low-thrust, lightweight engines are required to nudge the satellite from time to time to keep it at a precise point above the earth.

The 2 NASA ion engines were tested aboard Applications Technology Satellite 4, launched August 10. Two more were scheduled for testing on the ATS-E to be launched in August 1969. Each unit weighs but 10.2 pounds and measures 12x10x4 inches.

A decade of operations was only beginning to reveal the great variety and value of potential space vehicle operations, both manned and unmanned. The space program's intensive scientific and technological effort brought great advancements in knowledge about the moon, the solar system and earth-sun relationships in 1968.

Among the objectives desired in developing space science and applications for 1968 were:

- To obtain a detailed understanding of the physical interactions and dynamic processes which control the earth's space environment.
- To explore new regions of space in order to

increase understanding of the nature and evolution of the solar system and the universe.

• To define the space environment and assess the hazards to men and machines.

• To exploit space as a laboratory for investigations and experiments not feasible on earth.

The space agency used a number of different vehicles designed to obtain data in achieving these objectives. The Explorer series, the first of which discovered the Van Allen Radiation Belts in February 1958, continued in 1968.

Explorer 38, called Radio Astronomy Explorer I, opened a new window to the universe in July. To accomplish its mission, the spacecraft deployed 4 antennas, each 750 feet long (1,500 feet tip to tip), and a damper boom extending 315 feet (630 feet tip to tip). Explorer 38 was monitoring low-frequency natural radio signals from space which the atmosphere cuts off from ground stations.

Explorer 36, together with the earlier Explorer 29, was measuring the small variations of the earth's gravity field, fixing more precisely locations of points on earth.

Generally, Explorers are relatively small satellites placed into differing orbits serving a particular purpose. Some provide data on the composition, density, pressure and other properties of the upper atmosphere. Others provide information on the physics of interplanetary space and the moon. Their findings are added to the accumulating fund of knowledge about the earth's space environment and will be useful in developing better communications systems as well as in gaining a better understanding of factors involved in weather forecasting.

Related to activities of the Explorers are NASA's Orbiting Geophysical Observatories. These are designed to provide more knowledge about the earth and space, and how the sun influences and affects both. OGOs are generally several hundred pounds heavier than the Explorers and carry many more experiments. For example, OGO V, launched in March 1968, carried 24 different experiments; Explorers usually carry about 8.

Principal advantage of the OGOs is that they make it possible to observe numerous phenomena simultaneously for long periods of time. This permits study in depth of the relationships between phenomena. For example, some OGO experiments report on the erratic behavior of the sun. Others may describe concurrent fluctuations in earth and interplanetary magnetic fields, space radiation, and properties of the earth's atmosphere.

NASA opened a new series of Pioneer spacecraft experiments with the launch of Pioneer VI on December 16, 1965. The ninth of the series, sent aloft November 6, 1968, was to acquire additional data on solar plasma and energetic particles, and magnetic fields propagated by the sun toward the earth. These data, combined with information from previous Pioneer spacecraft still operating, were being used in the continuing study to understand solar processes, the interplanetary medium, and effects of solar activity on the earth's environment. The data were also providing an additional basis for forecasting solar weather, important in protecting Apollo astronauts on the way to the moon. The Pioneers can give up to 15 days' warning of storms on the sun.

Solar weather also affects radio communications and power transmission. Some scientists suggest that solar weather (particle bombardment) has long-term effects on earth weather and climate.

Pioneer IX, joining 3 other Pioneers spotted around the sun, was traveling in solar orbit, scheduled to pass behind the sun 770 days after launch. At this point, Pioneer IX's focused radio beam must travel 180,000,000 miles across the solar system back to the deep space network on earth. More than 6 billion data bits had been returned to earth from Pioneers VI, VII and VIII, which had received some 20,000 commands from the ground. The spacecraft measure only 35 inches high and 37 inches in diameter and weigh but 140 pounds.

NASA's Applications Technology Satellites program is designed to test promising new techniques and equipment in space which may be used in future meteorological, navigation, and communications satellite systems.

During the first half of 1968, ATS III was used in the task of gathering new clues about the formation of tornadoes. It may have helped pinpoint a possible new origin for the tornadoes that periodically devastate the American Midwest. ATS III was in stationary orbit about 22,240 miles high and had taken color photographs of the earth covering more than half the globe. An attempt to put ATS IV in a similar orbit failed in August.

The last of the Surveyor series, VII, was landed on the moon in January 1968, close to the Crater Tycho. It had 3 major experiments to perform: TV photographs (2,274 on the first day), lunar surface material analysis (43 hours' analytical time), and surface sampling.

It was found that the chemical composition of the highland surface material differs from that of the lunar "seas," which was examined similarly by previous Surveyor craft in other locations. There seems to be a smaller amount of iron elements in the highland samples, which could be the reason for the brighter appearance of the moon's uplands compared with the maria.

A new indication of the weight of moon material was obtained when the Surveyor's claw picked up and "weighed" a lunar rock.

Altogether, Surveyor VII and 3 preceding soft-landers returned some 70,000 pictures of 4 different locations on the moon. These have given scientists extremely detailed and close-up views of the lunar surface impossible to obtain with the finest telescope.

One of the most important scientific satellites launched in 1968 was the Orbiting Astronomical Observatory, OAO II, sent aloft December 7. Ten feet tall and 21 feet wide with its solar arrays unfolded, OAO II contains 328,000 separate parts, nearly 3 times the number making up the Surveyor spacecraft. It is also NASA's heaviest—4,400 pounds —and most automated unmanned vehicle. It was launched into a nearly circular orbit at 480 miles.

The star-studying observatory carries 11 telescopes designed to investigate the past of the universe so that astronomers can better determine its future. Two experiments were provided by the University of Wisconsin and the Smithsonian Astrophysical Observatory. These were examining the extremely hot young stars in the ultraviolet part of the spectrum invisible to earth-based observatories. Over a 6-month period, astronomers hoped to study more than 50,000 stars. Some of the hot stars are believed to be only tens of thousands of years old. Compared to this, our sun is believed to be in middle age, about 5 billion years old.

OSO IV, along with its cousin, OSO III, continued to observe the sun and its radiations from earth orbit during the year. OSO IV was launched in the last quarter of 1967.

GEOS II, launched January 11, joined GEOS I in continuing measurements of the earth's gravity field and in establishing more precisely the shape and size of the planet.

GEOS II carried a laser detector device which permitted it to receive and analyze laser signals beamed at the satellite from earth stations in a series of continuing experiments. In May, for the first time, the spacecraft identified a laser beam directed to it while it was illuminated in sunlight.

Riding piggyback into orbit with Pioneer IX was the 40-pound TETR-2 satellite. In its 200x500-mile earth orbit, it was being used as an orbiting target for checking out equipment and training personnel of NASA's Manned Space Flight Network in preparation for future Apollo missions.

Although no Mariner planetary flights were initiated during the year, scientists calculated that on January 4 Mariner V's orbit carried it within about 54,000,000 miles of the sun. This was closer than any other man-made object had approached to the center of our solar system. The spacecraft made its closest approach to Venus in October 1967.

Preparations continued during 1968 for Mariner flights to Mars in 1969, 1971 and 1973. NASA announced that the 1973 mission would be named Project Viking and would use the Titan III-D/ Centaur as its launch vehicle.

Viking Mars 1973 science equipment will be finally determined after the 1969 mission to the planet. Two 6,000-pound orbiting spacecraft will each send soft-lander vehicles to the Martian surface. Mission objectives place special emphasis on returning information about life on the planet.

The orbiting of Air Density and Injun satellites (Explorers XXXIX and XL) August 8 with a single Scout launch vehicle extended studies of complex radiation-air density relations to areas in space above the earth's polar regions.

Besides launches serving its own experiment programs, NASA successfully launched 7 spacecraft for other agencies or governments during the year. They included the NRL Solar Explorer for the U.S. Navy; 2 weather satellites, ESSA VII and VIII, for the Environmental Science Services Administration; and Atlantic I of the Intelsat III series for Comsat Corporation.

For the European Space Research Organization, ESRO-I and -II and HEOS-I were launched in NASA's International Cooperation Program.

ESRO-I undergoes pre-launch testing. NASA launched the satellite for the European Space Research Organization as part of the international space cooperation program.

Also during 1968, 35 investigators from 8 foreign countries were selected to carry out experiments with the first lunar surface samples to be retrieved by NASA. Four foreign-contributed experiments were flown on NASA spacecraft, 122 sounding rockets were launched in scientific programs with 8 countries, geodetic satellite observations were carried out with 34 countries, and significant aeronautical research was conducted in cooperation with Canada, France, Germany and the United Kingdom.

Among the continuing research and development projects in aeronautics were noise abatement, flight safety, and the materials, propulsion and flight dynamics of supersonic and hypersonic aircraft, lifting bodies and vertical/short take-off and landing (V/STOL) craft. NASA also was giving more attention to general aviation and the problems of the private pilot, especially in areas of safety and ease of operation.

In structures research, a new supercritical airfoil was developed which permits thicker wing sections without increasing cruise drag, compared with former designs. This means a higher lift-drag ratio and increased payload and range.

In addition to applying new techniques in older disciplines, NASA was expanding its program in the newer sciences important in advancing aeronautics: avionics, human factors, flight dynamics and operational environment.

A quiet engine program was started with the goal of producing a turbofan engine which would operate at a noise level of at least 15-20 decibels below power plants used by commercial aircraft such as the 707 and DC-8.

More and more, NASA was moving into activities for improving general aviation and commercial aircraft formerly fulfilled by military research and development. Because there is an increasing divergence between military and civil aircraft requirements, there is a growing gap between research and prototype flight equipment or aircraft, and NASA was moving to fill that gap.

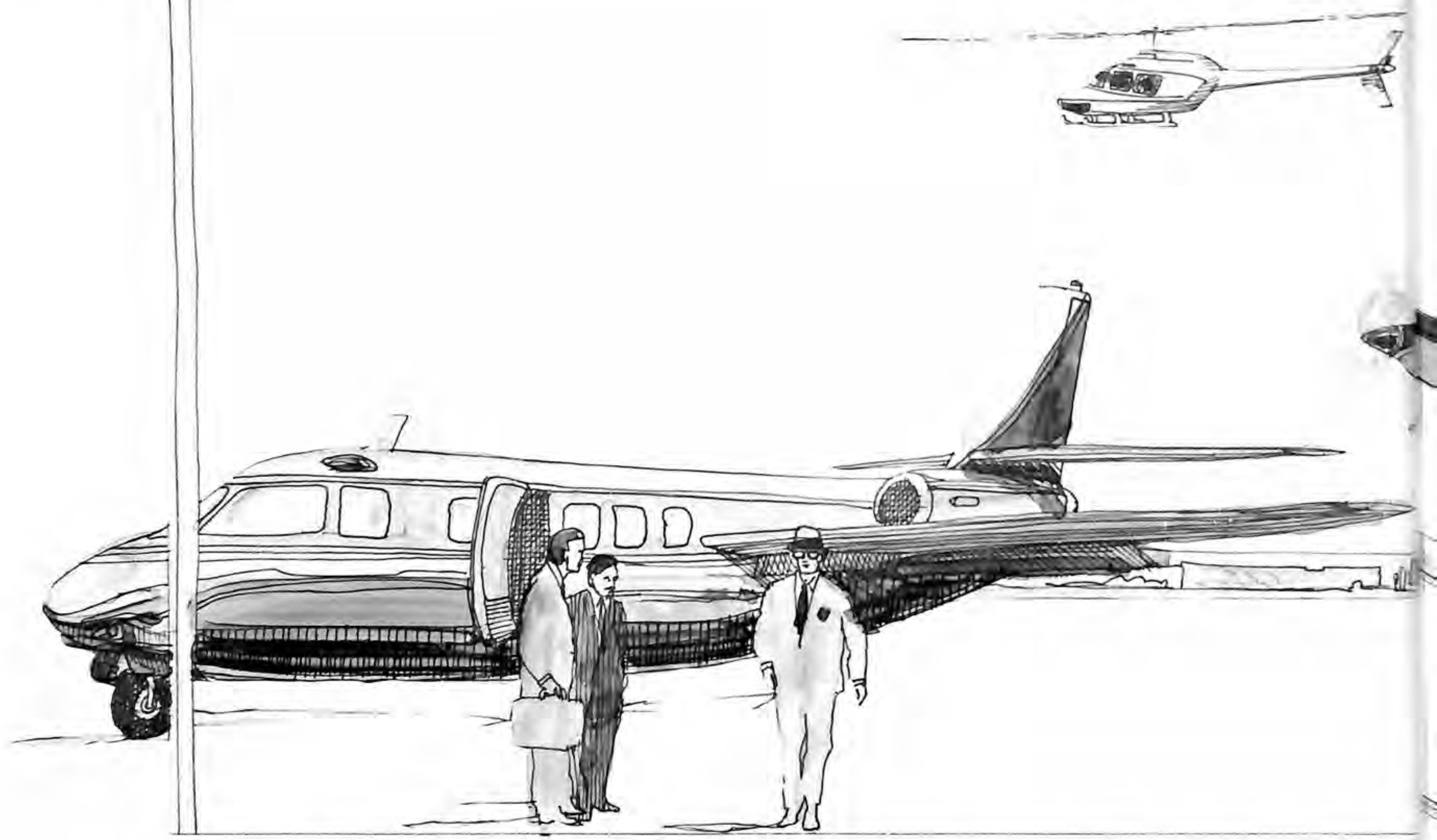
NASA scientists and engineers, working with university and industry groups, pushed ahead in the fields of space power, electric, nuclear and chemical propulsion to enhance the capability of already-proven launch vehicles.

NASA continued to transfer to industry, small business and the scientific community the new technology coming out of space-related research and development activity. Most of this technology comes from NASA field centers where specialists continuously review research and development projects for promising new ideas. In addition, NASA contractors are required to report inventions, discoveries, innovations and improved techniques they develop in work for NASA.

Three basic tracking networks were keeping tabs on NASA's orbiting satellites: Manned Space Flight Network (MSFN), Deep Space Network (DSN) and the Space Tracking and Data Acquisition Network (STADAN).

At year-end, there were 26 sites in the 3 networks, some single, some of multiple purpose, located in 15 countries around the world. Each network is designed to support specific types of missions, depending on whether it is near earth, manned or probing deep space.

These networks are constantly being strengthened to handle the demands of the newer and increasingly sophisticated satellites. In 1969 NASA plans to add a 210-foot-diameter antenna in Spain and in Australia to beef up the DSN for future missions into deep space. The 210s provide 6½ times increased performance over existing 85-foot antennas, making it possible to return useful scientific data from 3.5 billion miles from earth.



Civil Aviation

AIA

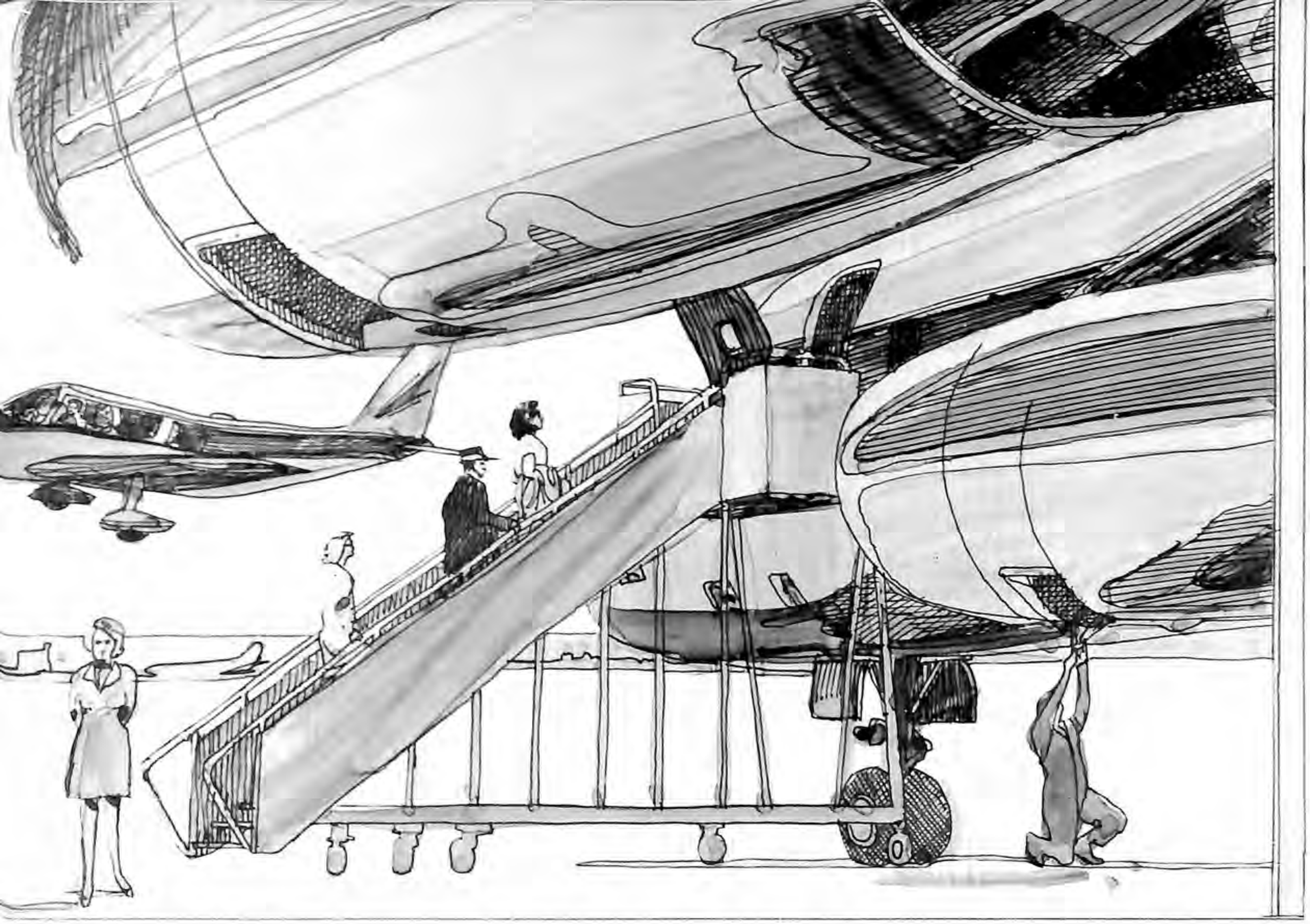
THE AIRLINES

The U.S. air transport revolution which began with the introduction of the first U.S. scheduled jet service marked its 10th anniversary on October 26, 1968. During those 10 years of the jet age, the airlines invested $7 billion in new planes and ground equipment. Air passenger traffic tripled and cargo traffic increased fivefold.

For the year 1968, it was estimated that the airlines would carry more than 150,000,000 passengers, compared with 132,000,000 in 1967 and 110,000,000 the year before that. This means that while the United States is growing by about 7,000 citizens a day, the airlines are adding more than 40,000 passengers a day to their flights, which is equivalent to the population of a city the size of Anchorage, Alaska. As to passenger miles, the airlines expected to fly some 115 billion in 1968, an increase of about 16 percent over 1967.

The airlines at year-end had in their fleets 274 jet aircraft capable of all-cargo operations worth $2.1 billion. Six years earlier, there were no all-cargo aircraft in airline fleets. The result is that cargo ton-miles carried by the U.S. airlines have been doubling every 4 years. It was estimated that the U.S. scheduled airlines would carry 4.2 billion ton-miles of cargo (mail, express and freight) in 1968, representing an advance of 21 percent over 1967.

The year 1968 marked the 50th anniversary of the air transport of mail. It cost the Post Office Depart-



ment 22 percent less in 1968 to buy space for a sack of mail aboard an airliner than it did 10 years earlier. All first-class mail—at the first-class rate of 6 cents—was moving by air when space was available.

During 1958-68 the airlines became the No. 1 form of public transportation between cities. In 1958 the airlines accounted for only 35 percent of all public intercity traffic. In 1968 that figure was about 70 percent and on the rise.

To keep pace with this public demand for their services, the airlines expected to take delivery of more than 450 planes during 1968, at an average cost of $6,500,000 per plane, or approximately $3 billion. This exceeded the 1967 figure for new aircraft by about $1 billion. More than 400 of the planes received in 1968 were to be pure jet, the remainder turboprops; no piston planes were on order.

The airlines expected to add some 32,000 jobs to their work force during 1968, bringing total employment to approximately 280,000, about double the 1958 figure. The airline payroll was to amount to almost $3 billion, triple the 1958 payroll, and represented an average salary for airline employees of more than $9,000, up more than 60 percent over a decade earlier.

Of the total number of airline employees, some 27,000 were pilots and copilots, about double the 1958 level. The airlines estimated that they will need about 3,200 more annually through 1970.

The number of mechanics employed by the airlines stood at about 60,000, representing a 60 percent increase over 1958. Annual additional requirements through 1970 were estimated at 8,500. Employment in the stewardess category almost tripled since 1958, to about 26,000 in 1968.

Communications, aircraft and traffic servicing and office employees make up the rest of the people of the airlines and are generally referred to as Ground Support Personnel. They numbered some 175,000 at year-end, almost double the 1958 figure. Employment in this category was expected to increase to keep pace with the anticipated growth of the industry.

To help remove the possibility of a serious constraint to the continued growth of air transportation, the airlines proposed in 1968 that an Airport Development Trust Fund be set up within the Department of Transportation. It would be similar to the Highway Trust Fund and would be financed by a 2 percent tax on airline passengers within the United States and by a $2 fee on those departing to a foreign point.

Financial assistance would take the form of paying up to 70 percent of the debt service of airport bond issues and it would provide short-term loans for planning, land acquisition and the start of urgently needed projects pending arrangements of long-term financing. Eligible projects would include the construction, alteration and improvement of airfield facilities and terminal facilities which represent more than half of the necessary expansion projects.

It was estimated that $109,000,000 would be generated by the new taxes during the first year. If all of this were used for debt service, the Trust Fund would be able to support about $1.9 billion in airport projects during the first year alone.

Such a fund would make a meaningful contribution to the expansion of the nation's airport system. Both large and small airports would be eligible for assistance and there would also be funds for reliever airports for private aviation traffic. Funds would also be available for large airports to build short runways for smaller aircraft which do not need the long, jet runways. This plan would enable cities to develop a much better pattern of air service, with equitable facilities for public air transportation as well as for private flying.

For some time the airlines have had under study a program which, for the first time, would expand the use of computer technology in the passenger reservations field to high-volume users of air transportation. Their search took a significant step forward in April 1968 when the Air Traffic Conference of America accepted the recommendation of a steering task force of the conference to proceed with the implementation of a common automated reservation system which would provide travel agents and commercial accounts with immediate access to the reservations systems of all participating airlines. Basic to the system would be a data bank, composed of 2 IBM computers. Initially the data bank would store information on airline schedules and seat availability in a quick reference format. Looking down the road, the system's capability could be programmed to compute fares, issue tickets and provide direct access to domestic and foreign hotels, motels, car rental firms, available tours and other travel-oriented information. Thus it would enable a travel agent, for example, to construct a complex itinerary with ease. During busy periods there would be no delay in obtaining information on seat availability as the system would be programmed for a maximum response time of 3 seconds.

Contracts to install the system were being negotiated with the domestic airlines and with travel agents. Once contracts have been signed domestically, negotiations will begin immediately with international carriers. Depending on the success of negotiations, the system could become operational within a year.

The airlines' extensive fog-dispersal test program initiated at the end of 1967 continued actively during 1968. Fog is the major source of flight cancellations attributed to airport weather conditions. Cancellations due to fog cost the domestic airlines an estimated $75,000,000 annually. Although cold fog (fog below freezing temperature) has been successfully dispersed operationally for more than 5 years, it accounts for only 5 percent of all fog in the contiguous 48 states. The remaining 95 percent is warm fog (water droplets above 32 degrees Fahrenheit) and it was to try out new methods of dispersing warm fog that the airlines launched their test program at Sacramento, California, in November 1967.

Purpose of the airline tests was to see how well an airport closed by warm fog could be opened to airline operations by seeding chemicals into the fogged area. World Weather, Inc., a Houston-based weather modification firm, was contracted by the Air Transport Association (ATA) to perform the tests.

Tests at Sacramento were conducted through March 1968 and were followed up by tests in the Cape Cod area from June through August. The conclusion drawn by the airlines was that the tests proved that the aircraft seeding techniques could disperse warm fog and thus open an airport to airline operations. A full-scale operational fog-dispersal program was proposed for Portland International Airport for some time in 1969.

Advancement was made during 1968 in the airlines' program toward developing an airborne collision system (CAS), a device that can detect potential collision threats and tell the pilot when to maneuver and what evasive action to take.

Four manufacturers were building prototype equipment to meet the airline requirements. Martin Marietta of Baltimore, Maryland, was selected by the airlines during the year to perform flight tests of the collision avoidance equipment and to make the first test in 1969. To make it possible for general aviation aircraft to use CAS, the airline industry CAS system has as part of its design what is known as "limited equipment." Significant complexity was added to the air-carrier CAS version to permit this limited-equipment version to be provided at the lowest possible cost to general aviation.

Notable progress was made during the year in the airlines' runway-grooving program, a program begun in 1966 to test-prove that thin, shallow grooves cutting the surface of a runway substantially improve an airplane's stopping distance on wet runways without causing excessive wear or damage to landing gears.

Based on the tests, the airlines were convinced that runway grooving is a valid air traffic control technique and were engaged in bringing this new safety aid into widespread operational use by working with airport authorities and FAA to have more runways grooved. At year-end, or by early 1969, 3 more grooved runways were to be added to the 3 originally grooved in 1967 for evaluation purposes. They were located at the following airports: Washington National, Kansas City (Missouri) Municipal, New York's John F. Kennedy, Chicago's Midway, Charleston (West Virginia) Kanawha and Atlanta (Georgia) Municipal Airport.

AIR CANADA

Canada's Centennial celebrations and Expo '67 combined to create a travel boom that made 1967 the most successful year in Air Canada's 31-year history. As a result, traffic figures for 1968 showed a degree of adjustment toward a more normal level.

During the first 9 months of 1968, the airline carried 4,862,878 passengers, up slightly from the 4,847,280 carried in the same period in 1967. This volume was achieved despite several adverse factors that plagued air travel in the early months of the year, including a general wave of belt-tightening through Canadian industry, political troubles in Europe, pressure against overseas travel by U.S. citizens and a lower rate of immigration to Canada.

Air cargo continued its impressive rate of growth. During the first 9 months of 1968, the airline carried 107,261,656 pounds of air freight, up 24 percent over 86,488,054 pounds in the same period of 1967. Air Canada recorded a profit of $3,500,000 in 1967 and forecasted another profitable 12 months in 1968.

The Canadian airline took delivery of 3 McDonnell Douglas DC-8-53 jetliners, 3 long-body DC-8-61s and 18 DC-9 twin-jets during the year. The 94-passenger DC-9-32s were being used on the company's short-to-medium routes in Canada and the U.S. At the end of the year, the airline's fleet totaled 119 aircraft for its 68,645 miles of unduplicated routes.

Air Canada had on order 8 more DC-9s and 13 long-range DC-8-63s, all for delivery by May 1970. In addition, it ordered for delivery in the 1970s 3 Boeing 747 jumbo jets, 4 Anglo-French Concorde supersonic transports and 6 Boeing U.S. SSTs.

During the year, the airline expanded service on many of its routes, increasing flight frequency and adding jet service to a number of cities.

Early in the year a new daily DC-8 jet service was added between Montreal and Vancouver, bringing to 15 the number of daily transcontinental flights within Canada. A daytime Sunday flight was started between Toronto-Montreal and London, and during the summer transatlantic frequency was increased to 37 flights a week to the U.K. and 19 a week to continental Europe.

In April a daily nonstop service was introduced between Toronto and Frankfurt, and Western Arrow service from western Canada to the U.K. and Europe was increased to 11 a week from 7.

The airline continued to expand service to Florida and Caribbean points, a second daily nonstop DC-8 flight was added between Toronto and Los Angeles, and expanded service was provided to other U.S. cities such as New York and Chicago.

Cargo service capacity was increased late in the year with a total of 6 all-cargo flights to Europe and 8 from Montreal to Vancouver each week. Improvements were made in cargo-handling facilities at many Air Canada destinations.

The airline moved operations to Vancouver's new $32,000,000 airport during the late summer, and for 1969 looked forward to opening new terminal facilities it will share with BOAC at Kennedy Airport in New York.

AIR WEST

Editor's Note: On December 31 the Air West board voted to sell the assets of the company to Hughes Tool Company. The sale required CAB approval.

In April 1968 a merger of 3 western U.S. airlines created Air West, a multilevel air transportation system uniting more than 100 communities with destinations as diverse as Sun Valley and Los Angeles, as distant as Calgary and Puerto Vallarta. The merger created a system embracing 3 countries, 8 states, 79 airports and 10,000 route miles.

Air West was born of a merger between Bonanza Air Lines, serving the Southwest from its base at Phoenix; Pacific Air Lines, headquartered at San Francisco; and West Coast Airlines, based at Seattle.

A new insignia appeared in the western skies: Air West, created by a merger of West Coast, Bonanza and Pacific.

Heading Air West were Nick Bez, of Seattle, former president of West Coast Airlines, who was serving as chief executive officer and chairman of the board of directors; Edmund Converse, of Phoenix, former president of Bonanza Air Lines, vice chairman of the board; and G. Robert Henry, of San Francisco, former president of Pacific Air Lines, president of Air West and chief operating officer.

In coming together as Air West, West Coast, Bonanza and Pacific concluded a rapprochement begun in 1945, when West Coast Airlines initially petitioned the Civil Aeronautics Board for routes in

California that were awarded to Southwest Airways instead. The decision to create 3 operating areas, those served initially by West Coast, Southwest and Empire, set a pattern for determining the geographical scope of certificates awarded, ultimately, to 13 local service carriers. Mergers had decreased this number to 9 by mid-1968, the others being Frontier, Trans-Texas, Ozark, North Central, Mohawk, Allegheny, Piedmont and Southern.

The combined Air West fleet at time of merger, April 17, 1968, comprised 33 Fairchild F-27 propjets, seating 40 passengers; 3 Boeing 727 standard trijets; 8 75-passenger McDonnell Douglas DC-9 Series 10 twin-jets; and 4 6-place MiniLiners. The latter aircraft flies regular schedules to about a dozen small airports on the Air West system which cannot be served efficiently by the larger planes—Sun Valley, for example.

In addition, Air West placed a $70,000,000 order for 16 of the larger super DC-9 twin-jets seating 97 passengers. The first of these went into service in June 1968; by summer of 1969 all 16 were to be in operation. Air West ordered 2 Boeing 727-200 trijets for 1970 delivery.

Air West began service to La Paz, Mazatlan, and Puerto Vallarta on the west coast of Mexico April 30, 1968. In June it was awarded additional nonstop authority within its basic system which included Salt Lake City/Los Angeles, Salt Lake City/Las Vegas, and San Diego/Las Vegas. A Civil Aeronautics Board examiner also recommended the granting of nonstop rights from Denver to Seattle, Portland, Boise and Salt Lake City, which will constitute a major extension of the Air West route structure into the heart of the Rocky Mountains. Air West had applications for other important service extensions, including routes from San Francisco to points in Mexico, and from Los Angeles, San Francisco and Las Vegas to Albuquerque in New Mexico, a state outside the Air West system.

The comprehensive nature of Air West's operational reach is emphasized by the fact that it serves 3 of every 4 airports—74 out of 99—certificated by the federal government for commercial scheduled airline service in the 8 western states.

Headquarters of Air West is at San Francisco. Its maintenance department and training center are based in Phoenix, with all other administrative functions at the San Francisco offices.

ALASKA AIRLINES

Alaska Airlines, as a result of 2 mergers completed in 1968, was serving at year-end 94 percent of the population of Alaska. On February 1 the merger with Cordova Airlines became effective, adding such commercially important cities as Juneau, Cordova, Yakutat and Valdez to the Alaska Airlines' route map. The Alaska/Coastal merger, completed on April 1, opened all the southeastern region of Alaska to the Golden Nugget Service of Alaska Airlines.

As the mergers reached the final stages, Alaska Airlines accepted delivery of its third Boeing 727C fanjet complete with Gold Rush-Gay Nineties decor. The carrier was put into immediate service.

More passengers than ever before were taking advantage of the access Alaska Airlines offers to the 30,000 miles of Alaskan coast, to innumerable streams and rivers, to the lush valleys of southern Alaska and to the tundra of the Arctic. The tremendous increase in passenger boardings influenced Alaska Airlines to offer other services to the tourist in support of its transportation function.

Under a management contract, Alaska Airlines was assisting in the promotion and development of the Alyeska Ski Resort. Alyeska, a year-round ski operation, was fast gaining a reputation among ski buffs for offering long, challenging trails of up to 12 miles. The double chairlift at Mt. Alyeska is 1¼ miles long, with not only unparalleled skiing at the conclusion of the ride but also a spectacular view of vast glacial bowls, steep cliffs soaring to 4,000 feet and snow-laden valleys during the trip. The versatility of the resort was enhanced by the construction of a 32-room hotel which was scheduled to open late in 1968.

The hotel will be a rustic chalet-type building with a dining room, cocktail lounge and convention facilities. Within a year the resort will be enlarged by the construction of a 40-unit condominium. Plans for the condominium included a heated outdoor swimming pool and an ice-skating rink adjacent to the hotel.

Alaska Airlines, having taken over management of Bell Island Hot Springs Fishing Resort, was offering quick and efficient flight service to this location which boasts "more King Salmon caught per person than anywhere else in Alaska." Bell Island, located outside Ketchikan, offers not only great fishing but a comfortable rustic lodge and the largest outdoor swimming pool in Alaska, maintained at a constant 84 degrees.

The "real" Alaska, as seen by few non-Alaskans, was introduced to thousands of visitors by Alaska Airlines in 1968. Through the Arctic Tour, the beauty of the Far North and the cities of Nome and Kotzebue steeped in winter were revealed. Highlights of the tour included watching the famous King Island Eskimo dancers perform their centuries-old ceremonial dances, observing skilled ivory carvers and skin sewers at work, taking a dogsled ride, learning to ice fish, bartering for Eskimo artifacts, watching the Eskimos hunt walrus, seal and polar bears and enjoying the spectacle of their famous blanket toss.

Commencing with Alaska Airlines' strong promotion in 1968 of southeast Alaska, the area was becoming a much-in-demand, year-round vacation land. The vacationer, sportsman and adventurer can see with greater convenience this area of majestic forests, soaring mountains, vast glaciers and sparkling fjords. The Southeast abounds with fish, game and wildlife, towering totem poles, colorful Indians, quaint villages and modern cities. Sitka, Skagway, Petersburg, Wrangell and Ketchikan have become regular tourist attractions as a result of Alaska Airlines' consistent promotions on a worldwide basis.

Looking ahead to 1969, Alaska Airlines planned to seek new avenues of growth. At year-end, the airline had 2 petitions pending before the Civil Aeronautics Board, one asking for the right to fly the Seattle/Portland-Hawaii-Anchorage route and the other seeking the Seattle-Twin Cities-Milwaukee route.

ALLEGHENY AIRLINES

Merger with the former Lake Central Airlines on July 1, 1968, marked a significant milestone in the continued expansion of Allegheny Airlines. The resulting service area includes 17 New England, middle Atlantic and midwestern states, Ontario, Canada, and the District of Columbia. The merger made possible a number of new services between major points, such as Philadelphia and Dayton, Boston and Indianapolis, and Boston and Cincinnati.

A number of major route-strengthening awards were granted to Allegheny by the Civil Aeronautics Board during 1968. They included nonstop rights in several important markets: Pittsburgh, Memphis, Nashville, Louisville, Columbus, Dayton, New York City, Buffalo, Baltimore, Albany, Philadelphia and Washington, D.C.

Allegheny had pending before the Civil Aeronautics Board applications to provide nonstop service in a number of major markets. These included Pittsburgh-Chicago; Indianapolis/Dayton-New York City; Norfolk-Chicago; Minneapolis/St. Paul and Milwaukee to and from a number of midwestern and eastern points; Philadelphia and Baltimore-Bermuda; Philadelphia to Columbus, Cleveland, Dayton and Indianapolis; Memphis-New Orleans; Chicago-Memphis; Chicago-Nashville; St. Louis-Dayton/Columbus/Pittsburgh.

To keep pace with its rapid growth and to develop new markets, Allegheny planned to expand its 1968 fleet of 12 100-passenger DC-9 fanjets to 20 by mid-1969. Allegheny's turboprop fleet included 43 Convair 580s, 9 F-27Js and 12 Nord 262s.

Much activity during the months immediately following the merger was directed to integration of the marketing areas of the 2 airlines. Major schedule changes were effected on August 1, October 27 and November 15, and were to be continued throughout 1969.

For the third quarter of 1968, Allegheny reported an operating profit of $720,000, compared to an operating loss of $126,000 for the same quarter of 1967. Through October 1968, operating profits totaled $2,102,000 compared with an operating loss of $1,263,000 for the first 9 months of 1967.

Allegheny showed a net loss of $2,479,000 during the first 9 months of 1968, down from a $3,647,000 loss posted during the comparable 1967 period. Comparative results for the period prior to the merger reflect the combined results of Allegheny and Lake Central on a pooling of interest basis.

To accommodate increased passenger and cargo traffic, Allegheny undertook an extensive program to expand and remodel its ground facilities, including terminal improvements at Philadelphia, Pittsburgh and Boston.

Allegheny's fleet of 12 McDonnell Douglas DC-9s was to be expanded to 20 by mid-1969.

Inaugurated late in 1967, Allegheny's highly successful program to improve air service at intermediate cities, the Allegheny Commuter, was expanded during 1968 to provide new services between Danville, Illinois, and Chicago's O'Hare International Airport; Salisbury, Maryland, and Baltimore's Friendship International Airport; and Hazleton, Pennsylvania, and Newark's Municipal Airport. Both passenger and community acceptance of the Allegheny Commuter program was enthusiastic. In response to community requests, the Allegheny Commuter was to be expanded to other cities in 1969.

During the first 10 months of 1968, Allegheny boarded more than 3,773,000 passengers and flew approximately 864,000,000 revenue passenger miles, both of which represented substantial increases over the totals flown during the entire year of 1967.

ALOHA AIRLINES, INC.

Highlights of the year for Aloha Airlines included announcements of new jet routes, inter-island facilities and service innovations, a switch to Boeing 737s and another increase in traffic volume.

Aloha Airlines turned to the recording industry in a new and ambitious marketing venture early in 1968. An original album, "The Wonderful World of Aloha," incorporated musical selections especially designed to assist mainland travel agents in selling the aura of the islands to their clients. An entire advertising campaign evolved around the music. The title song became the basis for a 1-minute color TV commercial which incorporated breathtaking island scenics with air-to-air shots of the company's Alohajets.

In March, Aloha introduced a semiautomated, greatly accelerated reservations system into its basic electronic data-processing equipment. An interim step toward an instantaneous automated setup, this is one of the most sophisticated applications ever attempted on an IBM 360 Model 20 card system.

A surge in the carrier's inter-island traffic dictated an upgrading of facilities and the opening of a new sales office in downtown Hilo on March 22. The design scheme and modern decor employ all the basic elements in the company's Alohajet fleet. Silver-colored paneling on the main walls is symbolic of the streamlined jet exteriors. Blue-green carpeting and gold-and-coral striped upholstery come direct from the plane's interior. A motif fronting the reception desk duplicates the "Bird of Paradise" on the tail.

Step 2 in Aloha's Big Island expansion program was a new look, in line with the entire Hilo Terminal renovation program. The new terminal construction more than tripled Aloha's office space, more than doubled its outside counter area and greatly expanded the baggage claim facilities. In addition, the old baggage weigh-in system was completely eliminated in favor of a new, improved piece concept.

Flightime, a top-quality, 4-color magazine, was introduced to Aloha's inter-island travelers beginning the first week in May. The bimonthly publication reaches a total yearly audience of 11,200,000, 1,000,000 via the seat backs of the airline's fleet and a 10,200,000 mainland exposure over the routes of Pacific Southwest, National, Continental and Los Angeles Airways.

Aloha's popular promotional troupe traveled over 100,000 miles in 1968 in an effort to bring travel agents up to date on new Hawaii travel and hotel developments.

On June 14, Aloha initiated pure-jet service into Kona, Hawaii, and introduced the most extensive flight schedule in its 21-year history. Passengers were offered an unprecedented 38,338 seats inter-island per week, an increase of 61 percent over the spring schedule and 3.6 percent over the greatly expanded operation of the 1967 summer.

The airline took to the "silver screen" as co-sponsor of a new movie filmed for Hawaii's Japanese Centennial Celebration, June 15-23. The 2-hour production, in commemoration of the 100th anniversary of Japanese immigration to the islands, featured Aloha's BAC One-Eleven, Honolulu terminal counter and stewardess Karen Awa. Thirty top-ranking Japanese movie stars, singers and technicians collaborated in the production under the auspices of the Shochiku Company of Tokyo.

With the introduction of its "standard on-line" ticket plan, Aloha became the first carrier in the islands to revolutionize its time-consuming ticket-writing chores. Each of its terminal and sales offices is issued plates, resembling plastic credit cards. Each embossed plate is set up for a specific island routing, complete with fare, tax, validation stamp, carrier's code and refund values. Travelers holding Aloha Airlines' credit cards find the process even quicker, since the credit card can be run through the machine simultaneously with the route plate. In addition to the big time-saving factor, "standard on-line" ticketing eliminates the possibility of computation error, and refiguring the residual value of the ticket.

As a new note in its customer service program, by early summer Aloha's 5 major island terminals added assistant managers-customer sales and service stationed in front of each check-in counter. Their primary duties were to aid all tour conductors and other group movements, both in and out of their respective stations.

Thanks to a new arrangement between CP Air and Aloha Airlines, island-bound vacationers from Canada can travel inter-island under the $5 Common Fare. The Canadian program is similar to the existing privileges via the 3 U.S. carriers with the exception that Honolulu is the only point of entry and departure on CP Air routings. The new proposal, however, gives Canadians the additional advantage of round-trip passage between Honolulu and Hilo—4 islands for $15.

With the opening of its new Seattle office and the appointment of Ralph A. Johansen as sales manager, northwest area, Aloha increased its international facilities to 5 mainland outlets and one Tokyo outlet.

On October 31, Aloha Airlines announced it would replace its existing fleet with 6 Boeing 737s and go all-jet, effective with the summer 1969 schedule. The inter-island carrier planned to place 2 of the twin-engine, short-haul jets in service beginning March 1 and to have a total of 5 on the line by late May or early June. The sixth Boeing, scheduled for delivery in February 1970, will bring Aloha's ultimate investment in excess of $25,000,000 for parts and equipment. The switch to 737s enables Aloha to become the first major airline in Hawaii to guarantee jet loads of passengers and baggage into and out of Kona and Molokai. Additionally, with the introduction of its 118-passenger configuration, Aloha will offer the biggest and roomiest aircraft ever available for inter-island travel.

AMERICAN AIRLINES

In January 1968, George A. Spater assumed the responsibilities of American Airlines' chief executive and president. Marion Sadler had retired from the presidency for reasons of health; C. R. Smith severed all relations with American in February to accept the post of U.S. Secretary of Commerce.

Mr. Spater continued the leadership started by his predecessors and guided American into a year of major developments in domestic and international marketing, corporate planning for the 1970s, community affairs, operations, maintenance and engineering, flight and passenger and freight services.

Early in the year American became the first airline to order a major new type of aircraft, the DC-10, destined to become the most versatile commercial airliner of the 1970s. The 252-passenger trijet will have short-, medium- and long-range capability and will be able to operate out of smaller airports, such as LaGuardia, that cannot accommodate aircraft of the Boeing 707 size.

American planned a 252-passenger interior for its McDonnell Douglas DC-10 trijets ordered in 1968.

American expanded its overseas marketing effort in 1968. New offices in Paris and Seoul were opened, and teams made up of domestic and international marketing executives traveled to 4 other continents. The marketing teams held sales presentations in 16 major cities for travel agents and interline salesmen. Top U.S. vacation spots and destination cities usually favored by travelers were described, detailed explanations of U.S. discount fares were given and open discussions were held after each session. Among other activities aimed at encouraging travel in and to the U.S., American distributed a brochure entitled "Discover America/Fly the American Way" to countries all over the world. The brochure was printed in 5 languages.

Promoting travel through the U.S. by Americans, the airline among other activities initiated a radio/television tour across the nation encouraging travel from the western half of the country to the East Coast and from the East to the West. American Airlines stewardess Miss Judi Nardecchia, and Miss Patty Poulsen, American's 1967 Queen of the World's Airline Stewardesses, were appointed official Discover America envoys for the tour.

The Astrosphere, a repeater from 1967, ended its 2-year tour of major U.S. shopping centers in the summer. The huge, 45-foot-high inflatable structure, which housed booths providing information on travel and a theater containing 128 first-class 707 Astrojet seats laid out to create the impression of an airline cabin, brought the story of travel in America to more than 2,000,000 people. A "Certificate of Appreciation" for Astrosphere's contribution to travel and the Discover America program was presented to American by N.A.T.O.

American's revenue passenger miles for the first 3 quarters of 1968 were up 16 percent to 11,723,747,000. Net earnings for the first 10 months ended October 31, 1968, were $36,874,000, which included the effect of the loss on sale of property and equipment to Internord. Revenues totaled $801,331,000 for the first 10 months of 1968, an increase of 14.6 percent over the same period in 1967. Commercial freight volume for the first 10 months of 1968 amounted to 349,147,000 ton-miles, an increase of 17.5 percent over the first 10 months of 1967.

In March, American's advertising theme, "The Airline Built for Professional Travelers," evolved into "Fly the American Way, the Airline Made Up of Professionals." The new campaign took another step forward later in the year with corporate advertising based on the employees of American Airlines. A search was started throughout the airline's system for the employee "stars" of the new campaign. Through advertisements, employees explain their feelings about American, its professionalism and their jobs.

In a new freight campaign launched in the fall, the nation's business leaders were challenged to "Go Ahead, Ignore It" if they could. The campaign was started with American's first double-page newspaper spread for air freight. The ad showed the nose of a jet freighter trying to push its way into a board of directors meeting. Purpose of the campaign was to convince decision makers to take a close look at their total cost of distribution, transportation being only one portion. Air freight can cut substantially into the costs of other parts.

American Airlines did away with the concept of uniforms for its stewardesses in late 1967. In 1968, 4,000 passenger and freight service employees donned their colorful new wardrobe. Bright new red and blue dresses blossomed by year's end behind ticket counters and at air terminals served by the airline in the U.S., Mexico and Canada. In this new wardrobe change, part of the company's "American Way" campaign, the men of American were presenting a more dapper appearance, too. Passenger and freight agents were wearing dark blue suits, a choice of white or blue shirts and red or blue ties and pocket squares. Passenger service managers, who provide personal assistance to travelers with personal problems or needs, are easy to identify in their dark red-and-blue striped blazers, white or blue shirts, blue ties and dark blue slacks. The new styles were the result of more than a year's planning and research.

Fun was again in store for top U.S. business leaders when they teamed up with stars of professional baseball and football in the unique second annual golf tournament sponsored by American Airlines February 14-16. The American Astrojet Golf Classic, a $30,000, 54-hole event, was held at the LaCosta Country Club near San Diego, California. Proceeds of the 3-day tournament went to the American Cancer Society.

Recognizing the need for the exchange of information on modern airline managerial techniques provided by electronic data processing with its international interline partners, American Airlines in 1968 initiated a series of seminars for foreign airline executives. Two technical and 2 nontechnical seminars were held during the year near American's main SABRE installation in Briarcliff Manor, New York, with airlines from all parts of the world participating. No secrets were withheld; the seminars were work sessions designed to instruct the participating executives in the nontechnical seminars on the basics of EDP and how such systems may be applied to airline management and in the technical seminars on the latest EDP techniques applicable.

During the school year that ended in 1968, American Airlines sponsored 133 "American Youth Performs" concerts in 50 major areas throughout the United States. The American Airlines-sponsored AYP organization is dedicated to the recognition of young singers and musicians who compete throughout the nation. The most outstanding of these young performers participated in national concerts in Washington's Constitution Hall and New York's famed Carnegie Hall in May. The program began its fourth year in September.

Again working with American youth, the airline sent a specially trained team of stewardesses during 1968 to disadvantaged neighborhoods in major U.S. cities to teach good grooming and makeup techniques to girls between the ages of 14 and 18, and joined with Cessna Aircraft Company in producing Air Age Education Kits to be used in teaching young people about both commercial and general aviation in classrooms throughout the country.

Among other long-range facilities planning for the 1970s, American announced plans to construct revolutionary "super bay" maintenance hangars at New York's Kennedy Airport, Boston, Chicago, Newark, Los Angeles and San Francisco and at a new supersonic airport between Dallas and Fort Worth. With a floor area covering about the same space as 7 football fields, the 5-story-high "super bay" hangar was designed by American for 3 different operations (light maintenance, heavy maintenance and overhaul) for at least 6 different airplanes, including the 2 subsonic jumbo jets, the DC-10 and the 747, and the U.S. and British-French supersonic transports.

A new freight terminal, longer than 3 football fields, was one of the highlights announced regarding new freight facilities for the 1970s. The cost of this terminal, to be built at Kennedy Airport by mid-1970, was estimated at $11,700,000. American expected to spend more than $50,000,000 on its nationwide program of new and expanded freight facilities by 1975.

To serve more effectively the heavily traveled commuter-type segments on American's system, the airline started the Jet Express concept in 1967 with hourly departures from New York to Boston, Washington and Chicago. The program met with such success that in 1968 the company started half-hourly service from the New York metropolitan area to Chicago and maintained the hourly service to Boston and Washington. The half-hourly schedule provided Newark Airport with flights every hour on the half hour to Chicago, and LaGuardia with flights every hour on the hour. All flights on the New York-Chicago Jet Express were moved from heavily congested Kennedy Airport.

Before American started the Jet Express service between New York and Boston, its participation in the market was minimal. By year-end, with a strong pattern between the 2 cities, it was again providing a marketing threat to its competitors as it overcame the competitive inroads of the last few years. This was also true in the New York-Washington market.

In the New York-Chicago market, American was carrying approximately one-half of the industry passengers, providing 37,670 jet seats weekly.

American's pattern of service continued to grow. Examples of nonstop, round-trip service added during the year were Hartford-Los Angeles and Oklahoma City-San Francisco. The nonstop service on heavily traveled segments was also increased.

In the highly competitive New York-Los Angeles market, American retained its dominant position and its passenger market share ran well above its seat-mile share. In the New York-San Francisco market, its market share continued to improve and was equal to the seat-mile share.

In the spring American announced that it had become the world's first commercial carrier to achieve operational approval to use an automatic inertial navigation system. The Litton Industries' system, known as the LTN-51, replaces complex navigational procedures requiring fixes and calculations, which take navigators approximately 20 minutes to complete. Pinpoint navigation is accomplished automatically in 1/20 second by the LTN-51.

In the summer American announced completion of the first major phase of a $1,200,000 program that promises to lift much of the burden off the nation's busy air traffic controllers and at the same time improve air safety and help to relieve airport congestion. American completed fitting its entire fleet of Boeing 727 Astrojets with "automatic altitude reporters," or the aircraft portion of what is sometimes referred to as the "alphanumeric" radar system. When coupled with ground equipment being prepared by the Federal Aviation Administration, data will automatically flash on radar controllers' screens at ground stations, instantly giving aircraft altitude and identity; thus much of the routine conversation that now accounts for up to 40 percent of the controllers' work load will be eliminated.

An elegant addition to Mexico's impressive array of tourist facilities was announced in the fall in the form of a towering new hotel for Acapulco. The $13,000,000, 21-story hotel, to be operated by American Airlines, will overlook the shimmering sands of Condesa Beach, a setting of extraordinary natural beauty. Construction started on the hotel, the Condesa del Mar, and completion was expected in November 1970. The building was being constructed and will be owned by a group of prominent Mexican businessmen. It will open with 500 guest rooms and a complete range of convention, recreation and shopping facilities. American will operate the hotel through its hotel, restaurant and airline catering subsidiary, Sky Chefs, Inc. Sky Chefs in 1968 was operating 3 hotels in the U.S., at Rochester, New York, Fort Worth, Texas, and Cincinnati, Ohio. A second hotel was under construction at Rochester and one was planned for Boston. American was participating in the construction of a 500-room luxury hotel in downtown Seoul, Korea, which Sky Chefs was also to operate.

American entered even more aggressively into the region of sports in 1968 as a means of reaching the consuming public and, again, of supporting the nation's youth. This included advertising in conjunction with the New York Yankees, San Francisco Giants, New York Mets and St. Louis Cardinals televised baseball games, the National Hockey League games and the National Football League games, including the Super Bowl. In addition, American became the only airline to show the NFL Game of the Week every week on its unique inflight movie system, Astro-Color. Baseball clinics in the New York metropolitan area were held for Little Leaguers, with players from the Yankees and Mets as instructors. American again served as a travel consultant to the United States Youth Games, an annual competition for youths, ages 10 to 15, from cities across the nation.

"Music 'Til Dawn," an all-night semiclassical, popular and classical music program sponsored by American Airlines in 10 cities throughout the country, including 5 CBS-owned stations, celebrated its 15th anniversary in 1968 with everything from special music programs, salutes from officials and cultural leaders, and exchanges of greetings between the 10 program hosts, to on-the-air birthday parties (including birthday cakes). Coinciding with the anniversary, The National Federation of Music Clubs awarded Special Three Star Awards of Merit to American Airlines and CBS Radio for "Music 'Til Dawn." The awards, the highest form of recognition given by the national federation, recognized both the program's continuing promotion of American music and a special "Music 'Til Dawn" program of music by American composers which was broadcast February 22, 1968.

AMERICAN FLYERS AIRLINE

The year 1968 was the most significant in the history of American Flyers Airline as the supplemental carrier achieved important progress in all areas of its operations and simultaneously laid the foundation for future expansion and growth.

During 1968 American Flyers accepted delivery of 2 Boeing 727-100C fanjet aircraft, increasing the airline's charter capacity by 80 percent. During the latter part of 1968 American Flyers announced the addition of 2 McDonnell Douglas DC-8 Super 63 jet airliners to its charter fleet, increasing the airline's charter capacity by another 70 percent. The 250-seat DC-8s enabled American Flyers to offer nonstop service on such routes as New York to Rome or Chicago to Hawaii and the airline began booking charter flights on the DC-8 equipment to Europe and Hawaii beginning in June 1969.

With the addition of the new DC-8s, AFA was operating a fleet of 125-passenger Boeing 727s and 89-passenger Lockheed Electra IIs, offering the widest choice of charter aircraft in the industry. This equipment was capable of handling virtually any size charter group and of operating from practically any size airport.

American Flyers was actively participating in the greatly expanding inclusive tour charter market sanctioned by Congress in 1968. Earlier, AFA had been known in the industry as the predominant domestic and Caribbean group charter airline. With the addition of the new long-range jets, the airline was moving aggressively into the international charter markets.

American Flyers holds all requisite permits from the CAB, FAA and Military Airlift Command, and its operating authority includes flights to Europe, Africa, Hawaii, Canada, Mexico, the Caribbean and the continental United States. Executive offices are located in Fort Worth, Texas, and the maintenance and operations headquarters are in Ardmore, Oklahoma. Regional sales offices are maintained at Fort Worth, Los Angeles, Chicago, Washington, D. C., New York City, Atlanta, Detroit and London, England.

The company was founded in 1939 as a charter service for businessmen at Fort Worth's Meacham Field. In 1951 AFA became the first supplemental airline to fly Civil Air Movement (CAM) flights for the U.S. government. AFA was also instrumental in the development of the civilian charter market, pioneering in flights of college and university athletic teams. From a total of 182,299 passengers in 1965, American Flyers' passenger count increased to 215,483 in 1967 and exceeded 265,000 in 1968. AFA crews during 1968 flew to all 50 states and some 30 foreign countries. Average flight time for the airline's captains and first officers is in excess of 11,000 hours, with some ranging up to 22,000 hours.

Since August 1967 the airline has been controlled by Pittsburgh Coke & Chemical Company of Pittsburgh, Pennsylvania. Lucian J. Hunt has headed AFA as president and chief executive since June 1966. Mr. Hunt was formerly a vice president of American Airlines responsible for maintenance and engineering during American's transition from pistons to jets.

In early 1968 American Flyers introduced programmed group charters to the industry. These are special group charter flights from high-density population centers on a regular basis. Groups chartering these flights do not pay the usual ferry charges or costs for "aircraft positioning miles." This is possible because AFA's Central Bid Control assures the maximum utilization of the airline's aircraft geared to integration of schedules from these population centers. This new, low-cost group charter concept, developed after extensive research and planning by AFA, proved profitable because of the airline's meticulous aircraft scheduling system and aggressive marketing program.

Programmed group charters and ITCs were to be strong marketing areas for American Flyers during 1969 and part of the airline's continuing program of developing new mass-travel concepts in low-cost air transportation.

BRANIFF INTERNATIONAL

Braniff International, the airline with a flair for innovations and color, continued to set trends for the airline industry in 1968.

New services, new fashions, stepped-up activity in tourism development of South America, new facilities and the industry leadership in on-time performance were the keys to growth in 1968 for the airline.

Record highs were consistently set, then bettered, in virtually all categories of traffic carried during the year. Operating revenues for the first 9 months were increased by 17 percent and net income for the first 3 quarters showed an increase of 129 percent.

Nonstop services were inaugurated by Braniff in the Denver-Memphis and San Antonio-Denver markets during 1968, and at year-end Braniff was waiting final Civil Aeronautics Board approval of authority to operate nonstop between Dallas/Fort Worth and Minneapolis/St. Paul, overflying previously mandatory stops.

Nonstop services were increased on many other major routes served by Braniff, including Houston-Chicago, Chicago-Kansas City, Houston-Dallas/Fort Worth, New York/Newark-Washington and Seattle-Portland.

In April, Braniff inaugurated the first jet freighter service between Texas and the Pacific Northwest with Boeing 727QC jet cargo flights between Dallas/Fort Worth and both Seattle/Tacoma and Portland. This new service increased Braniff's domestic jet freighter network to link 15 major U.S. cities with 5-night-a-week service.

As 1968 drew to a close, Braniff was awaiting final Civil Aeronautics Board approval of recommended new routes between South America and additional U.S. gateway cities including Los Angeles, San Francisco, New Orleans, Washington and New York.

The airline was also awaiting new route authority for which it had been recommended in other route cases pending before the CAB, including the Reopened Pacific Northwest-Southwest Service Investigation and the Gulf States-Midwest Service Investigation.

Additional important cases in which Braniff had applications pending were the Southern Tier Competitive Nonstop Service Investigation, the Miami-London case and, perhaps most important of all, the vast Transpacific Service Investigation in which Braniff sought authority between Hawaii and 8 major U.S. inland points: Miami, Atlanta, Dallas/Fort Worth, Houston, New Orleans, Denver, Kansas City and St. Louis.

Emilio Pucci once again created colorful haute couture wardrobes for Braniff hostesses and the new fashions, unveiled in July 1968, were greeted with enthusiastic approval by hostesses and passengers alike. In 1968 Pucci discarded all that went before. The print leotards and shifts were replaced by "pretty, ladylike, elegant dresses," to quote Pucci. Pucci-print scarves were substituted for hats, and a soft, silvery vinyl apron becomes the serving smock for inflight meal services.

Braniff believes that international airlines have a responsibility to each country they serve that goes beyond providing the finest service in the air and on the ground. In view of this, Braniff was participating in 3 separate tourism-building projects in South America. The airline was a direct participant in 2 of these and acted as the catalyst in the third to bring interested parties together.

The latter is Tourism Investments, S. A. (TISA), formed by a group of leading travel agents, tour wholesalers and finance, business and airline executives to undertake such construction projects as small hotels, inns, resorts, restaurants, shops, entertainment centers and hunting, fishing and other outdoor sports facilities throughout South America.

Another project announced in 1968, and the largest of the 3 projects, was Hotel Associates, S. A. (HASA), a unique, multinational corporation formed to undertake a tourism development program in South America calling for a total investment approaching $150,000,000 over the next 10 years. Braniff became a full partner with 3 other hotel and international investment firms in HASA, which will concentrate on new hotel construction in order to provide the first system of major affiliated hotels throughout South America and a 60 percent increase in the total of first-class and luxury accommodations available or planned for tourists.

The third project, announced earlier, was Braniff's participation in a Peruvian corporation formed to create 3 major tourism attractions: a marketplace and restaurant, a spectacular country club and a beach club hotel in Peru.

Major facilities opened by the airline during 1968 included a new and sparkling $2,000,000 Braniff International Hostess College near Love Field in Dallas, dedicated in January.

The college, which houses up to 142 hostess trainees simultaneously and contains a beauty salon, mirrored exercise room, sauna, recreation room, cafeteria, makeup room and auditorium in addition to living quarters and classrooms, is a self-contained "small city" in what the architects term "a feminine building." The facility was designed to help Braniff continuously improve its inflight presentation.

A $10,000,000, 13-gate Braniff Air Terminal at Dallas/Fort Worth's Love Field also was dedicated and opened in December 1968. The colorful facility, adjacent to the existing Love Field terminal building, enabled Braniff to operate its more than 100 daily flights much more efficiently at that hub of its system.

In the new terminal, Braniff has all-second-level aircraft loading; a completely separate baggage claim area; special facilities for standby travelers, aged or ill passengers and young children; and the world's largest single electronic flight-information board. Early in 1969 Braniff was to begin operation of the world's first Fastpark Jet Rail, a monorail system to connect the boarding area of the terminal with a new 1,500-car parking area nearby. The $2,000,000 Jet Rail will speed the passenger's way from car to plane and cut walking distance to a maximum of about 400 feet.

Braniff opened a new 13-gate, $10,000,000 terminal building at Dallas/Fort Worth Love Field.

Braniff's all-jet fleet stabilized at 68 aircraft with no additional jetliners delivered during 1968, as contrasted with 1966 and 1967 when 51 new jets were delivered. This stabilization permitted improved operating reliability and enabled Braniff to take the industry lead in on-time operations for the year.

Braniff was looking toward the future, however, and in January 1968 announced a $48,000,000 purchase of 2 Boeing 747 jumbo jets for delivery in early 1971.

Braniff also had 3 British-French Concordes and 2 Boeing supersonic transports on order for delivery in the mid-1970s. The airline was looking forward to additional aircraft purchases, possibly aircraft of the air bus type, in the not-too-distant future.

CP AIR

A modern new look and a new name marked the 1968 transition at Canadian Pacific Airlines.

As part of an overall polishing up of the corporate image of its parent Canadian Pacific organization, the airline was designated CP Air, a new emblem (dubbed the multimark) was adopted and the jet fleet was to appear in striking orange, red and silver livery.

When the changeover is complete, everything from place mats on airborne meal trays to letterheads and advertising will bear the CP Air name with the multimark. Transitional period was expected to last well into 1969.

First real impact of the new look came at Vancouver International Airport at the beginning of November when a sleek new Boeing 737 twin-jet flew in from the Boeing plant at Seattle, resplendent in the bright new colors.

It was the first of 7 of the $5,000,000 short/medium-range airliners CP Air had on order. Five were to be delivered by the end of the year to operate on routes covering British Columbia, Alberta and the Yukon. The DC-6B propeller-driven fleet was to be phased out.

The sixth and seventh 737s, slightly heavier versions, were scheduled for delivery in March 1969 for use on the Vancouver-San Francisco route and in transcontinental service. Those deliveries would make CP Air an all-jet airline, with the exception of 2 small feeder routes in central British Columbia to be operated with DC-3s.

Sharing the remarkable global growth of air traffic, the company was expanding its routes and increasing frequencies on established routes, with commensurate additions to the jet fleet.

But all was not as bright as the new orange color indicated; CP Air continued to face the challenge of economic crisis. Said CP Air President J. C. Gilmer: "We have come to the end of the time when steadily rising costs of almost all goods and services are offset by the progressively greater efficiency and productivity of successive aircraft and engine types. With revenue yields declining and expenses still climbing, the airlines are in trouble."

Though CP Air's transportation revenue for the first half of 1968 was up 9 percent over the first half of 1967, net income was substantially down. The same situation was expected for the second half of 1968.

First-half transportation revenues totaled $48,-200,000 compared with $44,100,000 in the first half of 1967. The first-half net income was not announced. CP Air carried almost 15 percent more passengers in the first half of 1968 than in the same period the previous year and passenger mile total was up over 10½ percent.

"In general terms, we are prepared for the fact that 1968 revenues will be substantially below forecast and the year's profit will not be a healthy one," said Mr. Gilmer. "However, the airlines have successfully weathered more difficult periods and we see the long-term outlook as reassuring."

Underlining this statement, he detailed recent and upcoming developments:

• Delivery of 4 DC-8-63 Spacemaster jets during the first half of 1968 enabled the airline to proceed with its planned expansion of routes and frequencies. Unavoidable delays in delivery of these aircraft had forced CP Air to mark time for a year or so.

• A second daily cross-Canada flight linking Montreal and Vancouver, with stops at Toronto and Winnipeg and adding Edmonton and Calgary to the route, was introduced in February. This was the first step in further servicing of this route under the Canadian government's aviation policy which provides for CP Air to increase its transcontinental flights so that by 1970 it will be operating 25 percent of the total capacity, and to maintain that percentage thereafter.

• An important new destination was added to Canadian air routes September 9 with the inaugural flight to Athens, extending the long-established eastern Canada-Rome route.

• Beyond Athens, CP Air was actively interested in extending its services into the Middle East and Africa. A number of Middle East destinations were lively prospects, but extension of the route pattern there depended on the results of economic studies and diplomatic overtures in progress at year-end 1968.

• As a result of the signing of a bilateral air agreement between Canada and Panama, CP Air was planning to land at Panama on one or possibly 2 flights per week en route from Mexico City to Peru, Chile and Argentina, subject to the approvals of the governments concerned.

• In the South Pacific the airline doubled its frequency to Sydney from fortnightly to weekly, with a separate flight continuing the fortnightly service to Auckland.

• Taking shape at Vancouver International Airport was a large new maintenance, overhaul and training base to be known as the CP Air Operations Centre. This $24,000,000 facility was to include the largest hangar in Canada and was to be capable of handling all aircraft flying or on the drawing boards. It was expected to meet the airline's requirements for the next 20 years.

• In the summer of 1969 CP Air was to reenter the international charter program which had been sharply curtailed in 1967 and 1968 because of delays in delivery of new equipment and priority demands of scheduled services. From May 1 to October 31 a DC-8-63 Spacemaster jet will provide charter service between Canada and Europe in a 240-seat configuration. The high capacity of this charter jet will enable the airline to offer split charters (2 affinity groups on the same aircraft) at new low prices.

In the longer perspective, Mr. Gilmer noted, CP Air was "alert to the significance of the air bus, jumbo and the supersonic era of the next decade."

He said that though CP Air holds delivery positions for 3 Boeing supersonic transports, the company was concerned over the delays the program had encountered which could affect CP Air's competitive position in the 1970s. Progress of the Anglo-French Concorde supersonic transport was being monitored.

On jumbo jets, CP Air was keeping abreast of developments but could not foresee sufficient traffic density on the company's routes to justify ordering these large aircraft.

CAPITOL INTERNATIONAL AIRWAYS

Capitol International Airways continued its record of leadership in the supplemental airlines industry during 1968 with advances in several departments:

- Capitol became the first supplemental airline to put stretched DC-8-63 aircraft into operation when it accepted delivery of 2 of the 250-passenger craft in August.
- The airline paid more than $1,000,000 in commission to travel agents who booked charter flights.
- Capitol flights carried more than 90,000 commercial passengers overseas.
- The company's gross revenue increased by 35 percent to $44,000,000 in 1968.
- Capitol moved into the inclusive tour charter field with several tour operators taking advantage of the authority granted by the Congress and signed into law by the President.
- Capitol generated 68 percent of its gross revenue from commercial charters with an increase in revenue from those charters of 90 percent.
- The company operated a DC-8 on a jet lease arrangement to Air Congo throughout the year on flights from the Congo to Brussels, Paris and Rome.
- Capitol flights carried many educational groups, including students of the world's greatest international school organization, again in 1968 as it had done for the previous 4 years.
- A significant number of the airline's flights (40 percent) originated in foreign countries, thus helping a favorable balance of payments situation for the U.S. government.

Capitol looked forward to another record-setting year in 1969 with an all-jet fleet of 7 DC-8 aircraft to be increased by 2 more of the Super 63s during the summer. Aircraft bookings for 1969 were at an all-time high.

CARIBAIR

For Caribair, 1968 was a year of transition into the jet era and of route development. Caribair's Convair fleet of both turboprop 640s and 340 equipment was increased with the arrival of 3 DC-9 Series 30 115-passenger jets.

The airline concentrated on improving the on-time performance factor and by midyear it ranked among the top 3 of all trunk carriers operating on the mainland.

The short San Juan-St. Thomas market began receiving jet service and by October 15 most daily flights on that segment were performed with Caribair's new DC-9 equipment.

Caribair established its popular island-hopping flight 621/620 which departs San Juan at 8:00 a.m. and arrives at Port of Spain, Trinidad, at 5:20 p.m. after stopping at 12 American, English, Dutch, French and independent islands along the way.

In addition to these flights, Caribair added daily DC-9 jet service to Trinidad via the Virgin Islands, Saint Maarten, Antigua, Martinique and Barbados. The combination of multistop turboprop service with the skip-stop DC-9 eastern Caribbean service is proving to be a very attractive incentive for visitors to discover the different and lesser-known islands of the region.

Caribair expected to receive major route awards from the final decision in the Caribbean/South America Route Case Investigation. This case had been in process for 7 years.

Caribair was recommended late in 1967 by a CAB examiner for permanent certification on the routes the airline was operating. In addition, Caribair was recommended for routes into Haiti, Kingston and Montego Bay, Jamaica, and Miami, Florida. Southbound, Caribair was recommended into Caracas, Venezuela. This recommendation would provide Caribair with the most complete route system in the entire Caribbean with strong anchors at Miami, San Juan and Venezuela.

While it was costly to the company to equip, train, pioneer and develop operations geared to the existing route system, Caribair expected and looked forward to an extremely bright 1969 with the new routes and a full year of jet experience accomplished.

CONTINENTAL AIRLINES

During 1968 the "Proud Birds" of Continental Airlines displayed their golden tails along a domestic route mileage which, at the end of the year, totaled 9,008 miles. Revenue passenger miles increased sharply in 1968; during the month of August, for example, passenger traffic was up 39 percent over the same month in 1967.

Flying an all-fanjet fleet, Continental inaugurated new service in Texas, Colorado and Washington. Nonstop Chicago-Colorado Springs flights began in May; service was reestablished to Austin, Texas, in April after an interruption of several years; and new nonstop daily flights between Houston and Seattle were started in July.

All present-generation aircraft outstanding on Continental's order book were delivered in 1968. Continental's 3 Boeing 747 superjets were to arrive in 1970, and its 3 Concorde SSTs were scheduled for delivery in 1972. The company also held delivery positions on 3 Boeing SSTs, with probable delivery in 1978. Together with spare parts, the aircraft received during 1968 were valued at over $87,000,000.

Continental's short-range DC-9C passenger/cargo convertible fleet was rounded out at a total of 19, and the long-range fleet was increased by 5 more

Boeing intercontinental 320Cs to a total of 13. During the late summer a complete fleet of 13 long-bodied 727s was delivered from Boeing and immediately began operations on the majority of the network, including the new nonstop Houston-Seattle service, Continental's longest domestic flight.

In 1968 Continental became the first and only airline to do away with 6-abreast seating on all of its aircraft operated within the U.S., a unique passenger service feature. The passenger is offered a choice of 3 classes of service (economy being about 15 percent less expensive than coach class). Spacious 5-abreast seating is provided for both economy- and coach-class passengers in a single cabin on the Boeing jets operating on Continental's longer route segments. This allows the line a flexibility of seat allocation between coach and economy class on each flight segment.

Eight Boeing 720Bs were reengineered during 1968 to match the interiors of the new aircraft. The design of the interiors is complementary with the "New Look" and redesigned corporate image introduced in October 1967. The new corporate colors—red, orange and gold—touched almost everything used by the line, and the new corporate symbol replaced the old Continental thunderbird.

A milestone along the road of airline efficiency was established when Continental went "on-line" in June with SONIC 360, the world's first third-generation, real-time passenger-name-record reservations system. Based on IBM's PARS system, the Continental complex includes a unique seat reservation capability that enables the agent to display the aircraft seating plan on SONIC's TV-like screens for seat selection. Reservations offices in Los Angeles, Denver, Houston and Chicago have instant access to the vast storage of the 2 IBM System 360 computers that are the heart of the SONIC complex, which is located in the line's general office building in Los Angeles. Immediate confirmation of reservations is possible because of the system's instantaneous reaction to all demands.

Continental's president, Robert F. Six, opened the world's largest air cargo building at Chicago's O'Hare International Airport in June. Containing 320,000 square feet on 3 levels, the building houses 11 tenant airlines in addition to Continental's cargo operation, regional offices and regional SONIC 360 reservations facility.

During 1968 Continental continued as a contractor with the government for Military Airlift Command (MAC) flights. An average of 8 Boeing 320Cs were allocated to this service, mostly orginating flights in California for Southeast Asian destinations. Continental marked its fourth anniversary of transpacific operations in September 1968.

On May 16, 1968, a Boeing 727-100C took off westbound from Hawaii to inaugurate the scheduled operations of Continental's new airline in the Central Pacific, Air Micronesia. Under a contract from the government of the Trust Territory of the Pacific Islands, Continental was flying a route network of 6,377 miles to, from and within Micronesia, as the Trust Territory is more frequently called. The twice-weekly Air Micronesia services from Saipan through Guam, Truk, Ponape, Kwajalein and Majuro to Honolulu and down to Palau forged a completely new link between the Trust Territory Islands and the outside world. Once weekly, the Continental 727 also linked Guam and Saipan (the Trust Territory capital) with Okinawa. Air Micronesia is one of the world's most unusual airlines, providing jet service to tiny primitive islands from short, palm-fringed coral runways.

During the first 9 months of 1968, net earnings after taxes were $4,819,000, or 48 cents per share. For the same period of the previous year, earnings amounted to $13,716,000, or $1.37 per share. Total revenues rose to a record high of $155,400,000 for the first 9 months of the year, up from $141,705,000 in the same period of 1967. Passenger revenues increased by 30 percent, while revenue miles flown were up 46.5 percent.

DELTA AIR LINES

Delta Air Lines during fiscal 1968 set new records in operating revenues and traffic statistics, substantially increased its available seat miles by continued expansion of its DC-8 and DC-9 fleets, pursued a vigorous program of building expansion and announced the largest aircraft purchase agreement in its history for additional jet aircraft in the future.

Highlights from the 1968 fiscal year financial report were: earnings after taxes (including surtax) of $1.89 per share, or $36,134,000; record operating revenues of $431,600,000; operating expenses of $363,000,000; revenue passenger miles up 11 percent to a new high of 7.1 billion; and a total capacity of 12 billion available seat miles operated, an increase of 24 percent.

By comparison, 1967 fiscal year earnings were $2.57 per share on present shares outstanding. But the profits for 1967 were enhanced by 3 external influences: the July-August 1966 strike against 5 major competitors, major delays in new aircraft deliveries beginning in December 1966, and the special item profit on the disposition of flight equipment. Each of these influences inflated short-term profits and camouflaged the continuing growth trend in traffic, revenues, and even earnings.

Delta carried 10,368,831 revenue passengers on its domestic and international routes. This total, too, was a record and a gain of 10 percent over the 9,422,422 revenue passengers carried in fiscal 1967.

Revenue cargo ton-miles increased 14½ percent, from 118,832,000 in fiscal 1967 to 136,018,000 in fiscal 1968.

A jet leader, Delta 10 years earlier was one of 3 domestic trunk carriers to pass up turboprop jet aircraft and wait for the pure jets. In fact, Delta was the only airline in the world to introduce 3 different commercial jetliners. The airline inaugurated DC-8 service on September 18, 1959; led again with the Convair 880 on May 15, 1960; and presented the world premiere of McDonnell Douglas DC-9 service on November 29, 1965.

During fiscal 1968 the company took deliveries of 3 DC-8-61 Super Models, one Standard DC-8 and 19 DC-9-32 Super Models, bringing its total DC-8 fleet as of June 30 to 26 aircraft and its total DC-9 fleet to 37 aircraft. With 16 Convair 880s also in service, Delta operated a jet fleet of 79 aircraft at fiscal year's end.

Orders and options for additional McDonnell Douglas jets will increase Delta's DC-8 fleet to 34 aircraft (including 13 Super Models) and its DC-9 fleet to 72 (including 58 Super Models).

In April 1968 Delta's board of directors approved the largest aircraft purchase agreement in the company's history with the award of a contract to Lockheed Aircraft Corporation of Burbank for 24 250-passenger Lockheed L-1011 trijet airplanes.

The $360,000,000 agreement called for the first 12 aircraft to be delivered beginning in autumn of 1971, with the second group of 12 set for delivery beginning in 1973.

They will join 5 Boeing jumbo jets, which are being added to Delta's fleet at a cost of $100,000,000, with deliveries scheduled to begin in 1970.

With these new orders, the value of Delta's jet fleet will surpass the billion-dollar mark.

By the summer of 1969 the airline's passenger fleet was to be completely jet. Under a piston aircraft phase-out program, the DC-7s were retired in February 1968 and the DC-6s in September 1968, and the twin-engine Convair 440s were gradually being replaced by the twin-engine DC-9 jetliners, which were adding many new jet cities to the nation's air traveling map.

During fiscal 1968 DC-9 service was expanded to 7 additional cities, with 4 others gaining DC-9 service before January 1, 1969. For 2 of these, Lexington, Kentucky, and Monroe, Louisiana, Delta's DC-9 meant the first jet service of any kind.

In the field of air cargo, Delta was the first airline (in 1966) to place the commercial version of the famed Hercules L-100 all-cargo propjet transport in scheduled service and was first in 1968 to offer service with the stretched version. The L-100-20 gave a 20 percent increased cargo lift capability and offered next-day delivery coast to coast and border to border. It can be loaded and unloaded in 20 to 30 minutes, utilizing a new high-speed loading system.

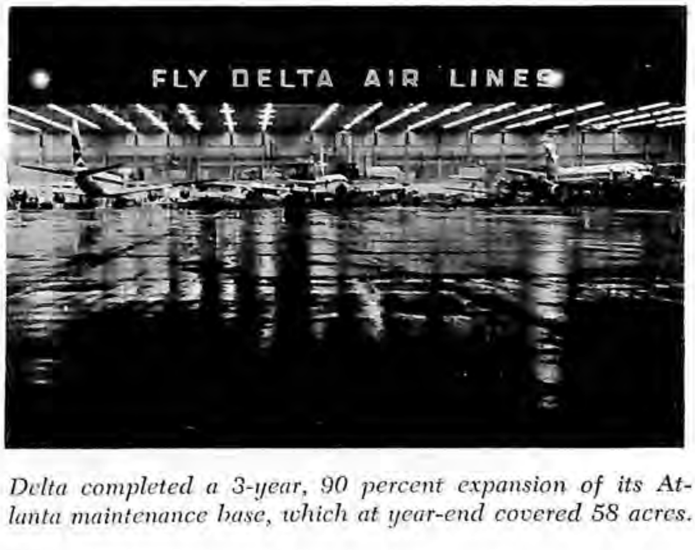
Delta celebrated the fourth anniversary of its interchange service with Pan American to Europe. A daily flight serves New Orleans, Atlanta, Washington, London and Frankfurt. In an application filed November 7, 1968, with the Civil Aeronautics Board, the airlines proposed to operate additional service between New Orleans, Washington, Boston and Paris. If approved, Delta proposed to purchase 5 DC-8s from Pan American for use on interchange flights.

Delta was also seeking authorization to serve a number of new international and domestic routes.

In the Transpacific Route Investigation, Delta's application asked for authorization to provide service between San Francisco/Oakland, Los Angeles/Long Beach and San Diego, and the terminal points of Honolulu, Hawaii, and Manila, Philippine Islands, via specific intermediate points in Hawaii and the Far East.

In other cases, Delta was engaged in seeking authority to provide one-plane service from Dallas to Phoenix and Albuquerque; to serve the Rocky Mountain cities of Denver and Salt Lake City from the South; to provide new service for San Antonio, Cleveland, Memphis, Huntsville and Nashville; to operate through the Miami gateway to the Caribbean; and 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.

Keeping pace with the jet aircraft acquisition program and route expansion was Delta's continuing modernization program for ground facilities.



Delta completed a 3-year, 90 percent expansion of its Atlanta maintenance base, which at year-end covered 58 acres.

In May a "rededication" of the airline's sprawling maintenance base heralded the completion of a multimillion-dollar, 90 percent, 3-year expansion program started in 1965. The jet base facility covers a total of 58 acres, 16 of which are under roof, and can readily handle up to 4 huge jetliners at one time.

Two futuristic rotundas were opened in Atlanta, each providing 6 gate positions for a total of 24 ultraconvenient high-volume passenger boarding areas at the Atlanta Airport. The rotundas, part of Delta's $7,000,000 Atlanta Airport expansion program, feature restaurant and beverage facilities, Delta's patented standard sequential seating in all passenger interval areas, huge tinted-glass panoramic window walls, 200 tons of high-velocity fresh air cooling equipment, and cabin-level passenger boarding.

A new Computer Center was constructed on property near the Greenbriar Shopping Center in Atlanta. Containing 51,000 square feet, the center provided for consolidation of all system-wide data-processing activities, including Deltamatic Reservations System, Material Inventory Control, Revenue Accounting, and Cost Distribution.

By 1969 Delta was to be operating a new Ground Training Center containing more than 50,000 square feet for classrooms, faculty offices, conference rooms and stewardess trainees' housing. The facilities will be used for many functions of Delta's training program, including orientation of new employees, tariff classes, Deltamatic instruction and training for personnel in Maintenance, Inspection, Stores and other departments, as well as flight crews.

In October 1968, Delta stockholders approved a proposal made by the company's board of directors to amend Delta's Certificate of Incorporation and increase the number of directors from 14 to 16. The newly elected directors were company officers.

Also in October, Delta's executive base was broadened with the appointment of 12 new officers as assistant vice presidents. All Delta veterans, the new officers represented a total of 274 years' experience with the company.

EASTERN AIRLINES

For Eastern Airlines, 1968 was the "Year of Commitment"—total commitment to honor the passenger ticket and the freight airbill not only as legal contracts to perform certain specified services but also as unwritten moral contracts to live up to the full expectations of every customer. Extensive training was undertaken throughout the system to implant this precept.

It was a year also of some slowing down in rate of growth, of unprecedented problems in air traffic, and of increasing revenues offset by constantly rising costs of operation. But it was also a year of continuing modernization of equipment on the ground as well as in the air and of great expectations for the future.

At year-end, the Civil Aeronautics Board issued decisions of importance to Eastern. In the Transpacific Service Investigation, the board bypassed the examiner's recommendations that Eastern be awarded new nonstop routes to Hawaii. In the Bermuda Service Investigation, however, the board granted Eastern the routes for which it had applied, linking Chicago and Detroit with Bermuda.

Important new nonstop routes authorized earlier in the year were inaugurated on June 13 between both Philadelphia and Baltimore and the Bahamas.

On November 27 the CAB announced the award to Eastern, with concurrence of President Johnson, of new nonstop routes linking both New York and Washington/Baltimore with Kingston and Montego Bay, Jamaica; and Miami with the Virgin Islands.

New route applications filed by Eastern in 1968 included one for New Orleans-Miami-London service and a proposed new pattern of flights across the southern transcontinental U.S., linking Miami, Atlanta, Dallas/Fort Worth and Houston with Los Angeles and San Francisco.

Eastern continued to hold its place as the free world's second largest carrier of air passengers, with 18,798,796 carried in the first 11 months, an increase of 6.2 percent over the 17,693,411 carried in the comparable period of 1967. In terms of revenue passenger miles, Eastern had flown over 10.9 billion during the year's first 11 months, 11.2 percent more than the previous year, placing the carrier in fifth place among the airlines of the free world. With available seat miles rising 18.6 percent over 1967, Eastern's average load factor for the January-November period was 56.3 percent as compared with 60 percent for these months in the previous year.

Important gains, however, were recorded by Eastern in air cargo, with a 27.7 percent jump in volume to 148,703,000 revenue ton-miles flown in the 11 months ended November 30, 1968. Air freight, contributing 102,725,000 ton-miles, was up 34.3 percent, and mail, with 37,520,000 ton-miles, was up 17.9 percent, while air express, with 8,458,000 ton-miles, up 4.2 percent, showed negligible change from 1967.

Earnings in the first 10 months of 1968 were disappointing, with a net after-tax loss of $4,010,000 as against $23,580,000 profit for the same period of 1967.

On December 10 Eastern filed with the CAB a proposed fare adjustment which it hoped could take effect on February 1, 1969. This would increase first-class fares by $3, coach and military standby fares by $2, and promotional fares by a proportionate amount on flights within the U.S., to its possessions and to Canada. It would also provide a new lower level promotional fare applicable during the same periods and under the same terms as present "Discover America" excursion fares.

Sixty-eight new aircraft were expected to be added to Eastern's fleet in 1968, bringing its jet fleet total to 205, with 83 more on order for delivery during 1969 and the early 1970s. Principal types acquired during the year were medium-range, large-capacity 4-engine McDonnell Douglas DC-8-61s, short-range DC-9-30s and "quick change" 3-engine cargo/passenger Boeing 727s. Retired from long and faithful service, most recently on the Air-Shuttle, were all 29 remaining piston-powered Constellations, one DC-4 and 6 DC-6s inherited from the Mackey merger, and 5 propjet Electras.

Notable among the new equipment orders placed during the year were orders for 25 Lockheed L-1011 advanced technology wide-bodied trijets (with options for 25 more); 4 long-range, large-capacity McDonnell Douglas DC-8-63s (making a total of 6 on order); and 11 extended-fuselage intermediate-range Boeing 727s.

To provide funds for its new aircraft and other acquisitions, Eastern arranged new financing amounting to $102,000,000. This included the sale of $50,000,000 in convertible subordinated debentures and the signing of 15-year leases on 10 of the new aircraft being delivered in 1968 and early 1969.

Eastern and McDonnell Douglas cooperated in a STOL demonstration program, flying the McDonnell Douglas 188 in New York, Boston and Washington.

During the late summer and fall, Eastern, in cooperation with McDonnell Douglas, demonstrated in cities on the Air-Shuttle routes a STOL (short take-off and landing) aircraft known as the "188." Equipped with highly sophisticated navigational instruments, this aircraft was flown extensively in the New York metropolitan area, and to Washington and Boston, with a view toward introducing an awareness of STOL capabilities and the concept of area navigation. Numerous representatives of federal, state, city and port authority aviation interests, of the press, and of the industry were taken on flights, and much general interest was stimulated in future planning for center-city STOLports and the possible solutions for some of today's air traffic congestion problems and airport-to-city surface transportation bottlenecks.

In support of its increased air services, and in anticipation of the larger numbers of passengers who will have to be accommodated on the new generations of larger aircraft expected in the 1970s, Eastern phased into operation in 1968 the world's largest and most modern reservations computer system. Put "on line" initially in midsummer was a bank of 3 IBM System/360 Model 65 computers, housed in Eastern's new Computer Sciences Building at its base in Miami.

These computers, and their related electronic data-processing equipment, will serve the airline's regional reservations offices in 10 locations throughout the United States, Canada and Puerto Rico, providing passenger name records via some 2,250 television-like cathode ray tubes equipped with keyboards in front of the reservations sales agents who will operate them. By year's end a new Northern Regional Reservations Office, largest in the world, was ready for partial occupancy at Woodbridge, New Jersey; new facilities for local reservations staff were in use at Montreal, Province of Quebec, and San Juan, Puerto Rico; a new Regional Reservations Office had been opened in the suburbs of Atlanta; and construction was well advanced on similar new facilities in Houston and on the outskirts of Chicago.

The unit passenger terminal which Eastern was building at Boston's Logan International Airport was to be ready for occupancy early in the spring of 1969, and elsewhere on the system new or enlarged cargo and passenger facilities were built or planned to cope with growing volumes of passenger and cargo business.

In another field, that of hotel and resort development, Eastern in 1968 added to its already established interests in the Mauna Kea Beach Hotel by joining with the Dillingham Development Corporation and Laurance S. Rockefeller's Olohana Corporation in a venture for the development of the Kohala Coast region of the island of Hawaii. Through establishment of a new Dilrock-Eastern Company, some $250,000,000 will be spent between 1968 and 1985 in developing an integrated recreational, tourist and residential complex encompassing 20 square miles of land stretching from the ocean shore to the summit of Mt. Kohala.

During the year a number of changes occurred in Eastern's management structure, all designed to strengthen the administrative team and prepare the company for the expected growth in years ahead. Important among these were the transfer of John B. Andersen to the post of vice president-customer services and of Frank Sharpe to a new assignment as vice president-new routes and aircraft implementation. Wilfred L. Cambre became division vice president-customer services operations and David B. McLaughlin was advanced to vice president-planning.

Thomas B. McFadden joined Eastern as its new vice president-marketing, and Maurice L. Kelley, Jr., as division vice president-advertising and merchandising; Henry J. Aneiro was promoted to division vice president-marketing research and development, while Frank M. Thompson became staff vice president-personnel relations and Lewis F. Huck filled the new post of vice president-real estate development. James R. Lynch was named corporate controller; Stephan E. Smiszko, treasurer. In the Operations Department, Captain John H. O'Neill moved up to division vice president-flight; Captain Michael J. Fenello, to division vice president-operational coordination; and Richard D. Eiland, to division vice president customer services-flight. Thomas J. Richert became vice president-engineering and maintenance, and Paul M. Johnstone, division vice president-engineering.

The Eastern Travel Club, initiated in 1967, continued to expand its activities and resort areas served and increased its membership to over 80,000 during 1968. Also, an intensive training program was conducted in every city to acquaint travel agents in the use of modern merchandising tools and techniques.

Most noteworthy of the marketing innovations of the year was the introduction on several major north-south routes of a concept called "Something Else." This involved an upgrading of the dining service, with choice of entree offered for the first time to coach-class passengers, special seat selection facilities also for coach passengers and numerous other amenities to implement the slogan "We make it easier to fly."

Recognizing its responsibilities as a good corporate citizen, Eastern in 1968 pledged cooperation with the JOBS program of the National Alliance of Businessmen and during the summer months provided meaningful job opportunities around its system to 280 underprivileged young men and women from the ghettos. Later in the year it began the selection and training of the first groups of so-called hard-core unemployed adults to be hired under a 2-year program designed to prepare them for permanent full-time jobs. Eastern's participation in this effort to bring members of minority groups into the mainstream of American life was one of the largest in American industry. Floyd D. Hall, Eastern's chairman and chief executive officer, served as the NAB's first chairman for the metropolitan New York City area, with E. W. Jacobson, vice president, devoting full time as metropolitan director.

FLYING TIGER LINE

In terms of new developments, the year 1968 was eventful for the Flying Tiger Line. The world's largest all-cargo carrier began phasing in its new $225,000,000 fleet of DC-8 Super 63F jet freighters and instituted a $25,000,000 program of facilities expansion and modernization. A new terminal management organization was launched. In route expansion, the airline moved a step closer to securing transpacific all-cargo route authority and sought to add 20 terminals to its domestic system. Major revisions in air-freight pricing concepts were proposed in a tariff filing with the Civil Aeronautics Board.

The first of FTL's new fleet of jet air freighters went into international service in July on a military contract flight from Travis Air Force Base, San Francisco, to Tan Son Nhut Air Base, Vietnam. Within 5 weeks, the carrier had 5 Super 8s in service, 2 of them leased from CP Air.

The fifth airplane was the one which inaugurated domestic DC-8 service on September 3 with a flight from Newark to Los Angeles via Chicago. Within days, the airplane had established new commercial cargo payload records. It moved 105,435 pounds on a nonstop flight from Detroit to Los Angeles, the first commercial freight payload ever to exceed 100,000 pounds. It had earlier set a new eastbound payload record with a load of 76,515 pounds out of Los Angeles, and broke it again the next day with a load of 79,360 pounds.

Average load into Los Angeles during the first 7 days of Super 63 operation was 85,000 pounds, and the eastbound daily average exceeded 57,000 pounds over the same period.

The impact of the DC-8 on Tiger operations is evident in the fact that during the first part of October actual miles flown domestically were 6 percent less than for the same period a year earlier, but ton-miles of freight flown were up 40 percent.

FTL was to have 10 of the huge freighters in its fleet by year-end; the remaining 9 were to be delivered in 1969.

Mechanized freight-handling systems were installed at the Los Angeles, Chicago, Newark and San Francisco stations during 1968, and plans were completed for installing similar equipment at all the remaining major domestic stations in 1969.

The custom-built system, manufactured by the Cochran Equipment Company, Salinas, California, is capable of cycling freight pallets at a rate of one every 2 minutes. Thus loading or unloading an 18-pallet DC-8-63F is accomplished in 30-40 minutes.

In conjunction with the installation of the system, freight stations were expanded at Los Angeles and Newark.

At midyear FTL instituted a new terminal management concept to match the speed, capacity and efficiency of its new DC-8 fleet. Freight stations in a given geographic region were consolidated, from an organizational standpoint, into independent terminal units or zones, under the direction of general terminal managers reporting directly to a single executive office in the corporate structure. Joseph J. Healy, former vice president of planning, assumed control of the program at the corporate level, with the new title of vice president and general manager-terminals.

Primary objective of the new arrangement was to achieve a more favorable system-wide traffic balance; initial results indicated a 36 percent improvement in this area over 1967, with a traffic balance toward year-end of 52 percent westbound and 48 percent eastbound.

The new terminals, established on a regional basis, are better able to shape their operations independently to the overall service requirements of their areas.

In April, Civil Aeronautics Board Examiner Robert L. Park made his recommendations in the board's Transpacific Route Investigation, and concluded that "the relevant facts clearly point to the Flying Tiger Line as the logical choice to operate . . . transpacific all-cargo service."

During the ensuing final hearings in the case, an indication of FTL's favorable position emerged when 12 of the 16 airlines involved in the case filed no opposition to Park's recommendation of FTL. Of the remaining 4, 2 abandoned earlier exceptions by not including them in the final briefs and the 2 "incumbent" carriers that did choose to comment went only so far as to assert they could handle the transpacific all-cargo needs together, thus obviating the need for additional service.

Additionally, the carrier filed for expansion of its domestic system to 20 more terminal areas. If granted, this would enable Flying Tiger to serve almost every major domestic market in the United States and would greatly expand its scope for proposed transpacific service.

Important revisions in air-freight pricing concepts were sought by FTL in a major tariff filing with the Civil Aeronautics Board in August. The board approved the new tariff in its entirety, with the exception of FTL's proposal to increase minimum rates.

Calling attention to a "tangled confusion of rates which have evolved in random, haphazard fashion during the formative years of the industry," the carrier advocated, and was permitted, such broad rate structure reforms as price incentives to volume users of air freight, whether direct shippers or forwarders, through new pricing concepts for both single and multicontainerized shipments; new rate incentives for shippers of heavy, dense freight; and elimination of special level-of-service tariffs such as economy, deferred, parcel post and the controversial blocked space, all of which have proved unprofitable for the carrier.

The CAB deferred ruling on FTL's proposal to introduce new minimum and under-1,000-pound rates for short-haul shipments, bringing them in line with the break-even costs incurred by the carrier.

The net effect of the new tariff, the airline said, would be to return a realistic profit for the carrier without creating any increase in its average rate yield of 13½ cents per ton-mile, already the lowest level in the industry.

FRONTIER AIRLINES

Further expansion of major long-haul nonstop routes and the consolidation of route gains and the resulting expansion through merger acquisitions made during the year were the major themes of Frontier Airlines' activities in 1968.

Following the successful assimilation of a major nonstop route of 780 miles between St. Louis and Denver, awarded to Frontier in the initial Pacific Northwest-Southwest Area Investigation in 1967, the Denver-based carrier added a 720-mile nonstop route between Denver and Las Vegas with service beginning in March 1968. This provided a one-stop operating authority over a 1,500-mile route between St. Louis and Las Vegas, which was being flown with Frontier's Super Arrow-Jet Boeing 727-200 aircraft. These stretched versions of the 727 carry up to 134 passengers in first-class and coach configuration. In the first part of 1968 the carrier acquired 3 of the $6,000,000 aircraft. They were being utilized primarily between St. Louis and Las Vegas via Denver and on a north/south route between Frontier-served points in the Dakotas and Arizona via Denver.

At year-end Frontier was operating 5 daily round-trip jet flights between Denver and St. Louis, 2 of them nonstop and 3 via intermediate cities. With the inauguration of Frontier's new route to Las Vegas, the carrier began service with 2 daily round-trip jet flights operated with Boeing 727 equipment, and in October added a third round-trip in this market.

As the first carrier to receive nonstop authority under a Subpart M of the Civil Aeronautics Board's Rules of Practice, the carrier was allowed to lift restrictions on its service between Denver and the winter resort of Phoenix, Arizona, to begin nonstop service. The carrier at year-end operated 2 daily round-trip flights between these cities with continuing services into the Dakotas and direct connecting jet services into Nebraska and Missouri.

Further route expansion was worked into Frontier's schedules with the October 27 schedule change extending the carrier's routes across the Mississippi River into Memphis, Tennessee, from Frontier-served cities in Arkansas, Oklahoma and Texas. With the addition of Memphis to the roster of Frontier-served communities, Frontier numbered 116 cities in 16 states of the Rocky Mountain West, Southwest, Midwest and Midsouth air linked by over 14,000 unduplicated route miles.

In the Route 81 Case decision, the Civil Aeronautics Board, in addition to giving Frontier an extension into Memphis, granted the carrier authority to realign certain route segments on the carrier's system in the states of Kansas, Oklahoma and Arkansas. In the major schedule change in the fall of 1968, the carrier incorporated more direct service between many of the cities in this area and provided jet-powered service throughout its 16-state system.

During 1968 the carrier phased out the last of its time-tested DC-3s and replaced it with the carrier's turboprop Convair 580 which carries 53 passengers at cruising speeds of 355 miles per hour. With the conversion of 10 of these aircraft in 1968, Frontier's fleet consisted of 32 Convair 580s, 3 turboprop Convair 600s and 8 Boeing 727s.

In addition to routes, Frontier added to its physical plant setup in Denver, Colorado. In the fall of 1968 a new $10,000,000 Maintenance/Operations Reservations Complex was completed at Stapleton International Airport. This houses the carrier's entire maintenance and overhaul base, the executive department for its flight and maintenance sections and a new $7,000,000 IBM 360 reservations system. This instant information computerized reservations system, which Frontier calls "Sentry," includes 181 cathode ray sets; 101 of them are located in Denver with the others in Frontier's central reservations offices in Dallas/Fort Worth, Phoenix and St. Louis. In addition, 59 electronic typewriters and a unique teletype system tie smaller Frontier-served cities into the system.

During 1968 Frontier expected to carry 2,500,000 passengers over 750,000,000 passenger miles to reflect nearly a 50 percent increase in revenue passenger miles and a 23 percent increase in passengers carried over the previous year.

HAWAIIAN AIRLINES

Hawaiian Airlines in 1968 set a passenger mark of nearly 1,500,000 passengers, which accounted for 64 percent of the total number of passengers carried by the 2 certificated airlines operating in the 50th state. It was the second consecutive year Hawaiian carried over 1,000,000 passengers.

Island-born John H. Magoon, Jr., celebrating his fifth year as president of Hawaiian Airlines, reported that the company in 1968 carried nearly 250,000 more passengers than in 1967.

Hawaiian's fleet of 4 DC-9s, including 2 115-passenger DC-9 Series 30s and 2 90-passenger DC-9 Series 10s, lifted the bulk of Hawaiian's traffic to major island destinations, assisted by a fleet of 8 Super 640 Jet Power Convairs. Six of the Jet Power Convairs carried 56 passengers each; the remaining 2 were a passenger/freighter carrying 30 passengers and one pure freighter. The company's lease on 2 60-passenger YS-11 propjet aircraft terminated in September in anticipation of the delivery of 2 more DC-9-30 aircraft early in 1969.

The company, in order to provide the additional lift that will be required by the increasing passenger market over the next 2 years, successfully concluded financing arrangements totaling $10,000,000 to cover the acquisition of 3 DC-9-30 aircraft. Two of these aircraft were to be delivered in the spring of 1969 and the third in the spring of 1970. Addition of these fanjets will enable Hawaiian to retire some of its less productive Convair 640 turboprop aircraft, thus improving service to the public while realizing the inherent economies of pure-jet aircraft.

Hawaiian Airlines stewardess Nellwyne Lum, shown with president John H. Magoon, Jr., models the airline's new stewardess uniform.

An excellent year-round on-time performance of 90 percent for all flights operated within 15 minutes of schedule, together with other passenger service innovations such as a pre-check-in system for the frequent local business traveler and visiting tour groups, strengthened Hawaiian's competitive position. With this intensified and increased operational activity, Hawaiian continued to maintain one of the industry's proudest records, having flown since November 1929 with not a passenger or crew member fatality during the entire period. By year-end more than 12,000,000 passengers had been carried over 2.5 billion passenger miles without a single fatality.

Hawaiian also worked closely with the overseas carriers CPA, NWA, Pan Am and UAL in promoting the growth of common fare business between the mainland and Hawaii's 2 gateway points, Hilo on the big island of Hawaii and Honolulu on the island of Oahu. This is sure to bring an ever-increasing number of travelers making use of inter-island travel under the plan, as it becomes a permanent part of the travel agents' package tours and as other leading mainland carriers are awarded routes between the West Coast and Hawaii as a result of the transpacific route decisions.

Hawaiian Airlines' revenues for 1968 from total passenger, cargo, ground services contracts and incidentals were estimated at over $19,000,000.

Hawaiian, which transports over 96 percent of all inter-island air freight traffic, totaled nearly 27,000,000 pounds in 1968. Though freight volume ton-miles decreased approximately 24 percent during 1968 because of the inauguration of direct Hilo-mainland service by the trunk carriers, total freight revenue decreased only 3 percent from 1967 partially because commodities lost to the overseas carriers were extremely low-yield and partially because of a freight-rate adjustment that became effective in April 1968.

LOS ANGELES AIRWAYS, INC.

Los Angeles Airways passenger traffic continued to grow at the rate of 35 percent per year as the company entered its 21st year of scheduled helicopter operations in southern California. Similar increases were recorded in the mail and express poundage carried. By mid-1968 the company had carried more than 2,000,000 passengers over 60,000,000 passenger miles. Mail and express totals reached the 90,000,000- and 40,000,000-pound mark, respectively.

On February 22, 1968, Los Angeles Airways completed Phase II in the development of a Mixed-Mode Transportation Center in the heart of the City of Pomona. On that date, scheduled operations were switched to the new downtown site from a temporary heliport 1½ miles west, where LAA's service to the Pomona Valley began early in 1948. Phase III contemplated transfer of service from the ground to the elevated facility, which will accommodate other modes of transportation and transportation-related activities at lower levels.

Following the loss of 2 aircraft during the summer of 1968, Los Angeles Airways leased 2 de Havilland Twin Otter aircraft to augment its fleet. These aircraft went into service on September 20, 1968, on the San Bernardino segment of the system. Purchase of 4 Series 300 advanced versions of the Twin Otter was being contemplated for integration into service early in 1969.

MODERN AIR TRANSPORT, INC.

During 1968 the aircraft of Modern Air Transport, Inc., were seen throughout the world. In addition to the normal domestic charters for Gulf American Corporation, Modern's parent company, and Military CAM flights throughout the United States, Modern flew transatlantic for Military Airlift Command to Europe, flew transatlantic and to the Caribbean on contract with Nordair of Canada, and flew 615 charters from Berlin, Germany, to 30 European cities on contract with 2 major tour operators in Berlin. The most significant journey for Modern was a transpolar flight across both poles flying longitudinally; the flight carried passengers for the Admiral Richard E. Byrd Polar Center.

Early in 1968 Modern received 2 additional Convair 990A aircraft bringing its fleet to 5. Three of the aircraft were modified to a new seating capacity from 134 to 139 seats. At year-end Modern was awaiting certification for an additional modification to bring the seating configuration to 149. In the spring of 1968, Modern began to build a new sales staff headed by Ralph Sacks as vice president of sales. Mr. Sacks joined Modern with over 20 years' experience with charter and supplemental airlines. Shortly after he joined Modern, he brought with him Ben Topfer, another veteran of airline sales, to be director of sales.

With this highly qualified sales staff joining the new management group organized in 1967 and headed by Morten Beyer, executive vice president, Modern intended in 1969 to become a major contender in the supplemental carrier passenger market. The team was marketing outstanding I.T. programs to Mexico, and Modern was to operate again in Europe for a Berlin tour operator. During 1968 the company operated 1,437 charters and expected to double this figure in 1969. It carried 296,727 passengers of which 90,000 were carried to Florida for the Gulf American Corporation.

Modern's Berlin base at Tegel Airport is completely self-sustaining with a complete maintenance facility capable of performing all types of maintenance work except overhaul, a passenger-handling and operations headquarters which handled 615 charters during the year, and a kitchen facility which prepared all of the meals for Modern's flights and for other carriers utilizing Tegel.

At Miami International Airport, Modern performs its own maintenance, including aircraft interior modifications, and during the year designed and manufactured an auxiliary engine-starting unit installation capable of providing air and electrical power to start its CV 990A engines. The prototype unit was to be installed early in 1969 after which 4 additional units were to be manufactured. During 1968 Modern performed outside maintenance on numerous large piston and jet aircraft for other carriers and during 1969 planned to increase its outside maintenance contracts to include minor overhauls.

At its Miami base, Modern established its own ground school for flight crews and cabin attendants and during the year performed pilot training on contract with NASA for CV 990 crews. Ten flight crews perform all of Modern's flying. All of these crews have been trained the Modern way in Modern's own facility.

At year-end the company employed 200 personnel and was completing plans to establish offices on the West Coast and in Canada and Europe.

MOHAWK AIRLINES

During 1968 Mohawk took delivery of 4 new BAC One-Eleven fanjets, bringing the fleet total to 14 One-Elevens, 18 FH-227 propjets and 4 Convair 440s. One of the nation's largest regional carriers, Mohawk at year-end was serving 77 cities via 38 airports in 10 states plus the District of Columbia and Canada. The airline was carrying more than 2,000,000 passengers per year along 4,500 unduplicated route miles.

Mohawk started 1968 by inaugurating jet flights on a new route serving Albany, White Plains and Washington, D.C. This was followed by a major schedule improvement affecting many of Mohawk's key markets: 6 new flights were added at Rochester, 2 at Syracuse, 6 at Elmira and 4 at Binghamton. Mohawk's One-Eleven "New Hampshire" was put in service in mid-March, giving Mohawk at that time the largest jet fleet of any regional airline.

April began with inauguration of Mohawk's "Gold Chip Service." Under this program, passengers are given Gold Chips (worth $1 in redemption or a complimentary cocktail in flight) when "ready tickets" are not posted, customer service personnel fail to smile, baggage is mishandled, cocktails are not available or a Mohawk employee is discourteous. The "Gold Chip" program, coupled with a major company reorganization, made April a banner month. Robert E. Peach was named chairman of the board while Russell V. Stephenson became Mohawk's new president.

Mohawk, which has proportionally more service in the New York area than any other airline, was thus most affected when an airport and airway congestion crisis centered there during the summer. Long an advocate of a major overhaul of the nation's air transport system, Mohawk took the leadership in calling congressional and public attention to the congestion problem. Mr. Peach was widely quoted in calling the air transport system "about as effective as a worn-out tire tube which has been patched up for more than a decade."

In direct expenses alone—crew pay, gas and oil, maintenance—the congestion added almost $1,000,000 to Mohawk's operating costs between June and September.

A broadside of novel inflight catering and decor was introduced by Mohawk in September with the kickoff of 6 new types of service called "Variety Flights." The service, offered on weekdays, involves 130 daily flight segments connecting 20 cities in the Northeast. Depending upon their destinations, Mohawk passengers have the chance to be on flights serving either strudel, pizza, champagne, beer or morning snacks.

Another feature of the new service is the return of "Gaslight" flights, one of Mohawk's most successful ventures of the early 1960s. Complete with Gay Nineties-clad stewardesses and decor, the flights offer beer and pretzels, cigars, singing and other reminiscences of the "good old days."

Mohawk introduced "Gaslight Service," featuring beer and pretzels, group singing and Gay Nineties trappings.

In addition to the Gay Nineties costumes, other Variety Flight stewardess attire includes "mod" pajamas (for Pajama Jet Flights), "mod" blouses and miniskirts (Utica Club Psychedelic Jets), and chefs' hats and overblouses (Pizza Jets).

In October, Mohawk's freight cartage outlook was boosted by introduction of "Hustlepak." This service provides counter-to-counter delivery for any package weighing less than 10 pounds and under 1 cubic foot in volume. Major feature of this new program is that the shipper can pick the flight for his package to go on, so that he knows exactly when the package will arrive.

Featured in a system-wide service expansion in October were 29 new "don't stop" flights—Mohawk's slogan for nonstop jet service—between cities in New York, Ohio, Massachusetts and Michigan.

The new flights, authorized in August and September by the Civil Aeronautics Board, replaced or supplemented previous multiple-stop service between Buffalo-New York/Newark, Rochester-New York/Newark, Syracuse-Cleveland, Hartford-Detroit and Boston-Rochester. Four new one-stop jet flights also went into service in October between Boston and Detroit and between Hartford and Cleveland.

System-wide, Mohawk's available seat miles were increased to almost 4,000,000 per day, a 20 percent rise over the carrier's capacity in October 1967.

Emphasized in the October schedule were increases in direct and connecting service for western "gateways" in Detroit, Cleveland and Pittsburgh. Because of air congestion in the New York area, Mohawk's passenger traffic at these cities increased as much as 52 percent over 1967.

Chicago entry, a major objective, took a positive turn when the CAB in October ordered an "immediate hearing" on Mohawk's proposal to serve the midwestern hub via Erie and Elmira from other points east. Mohawk also fixed its sights on further route expansion by applying for authority to serve the Twin Cities (Minneapolis-St. Paul), Atlanta and Houston from its eastern route structure. Rochester-Montreal routing received CAB approval and awaited approval by the Canadian Transportation Commission.

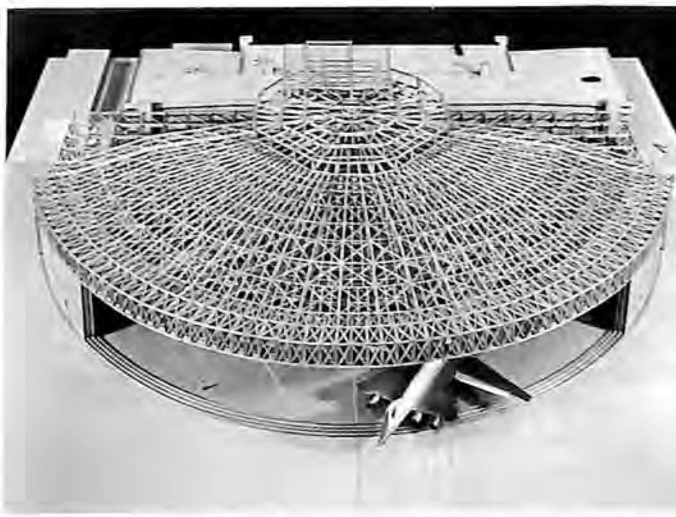
At year's end, plans were being made to evaluate an "area navigation" system which was installed in a One-Eleven fanjet. One potential advantage of the system is that it allows the pilot to control the en route flight of the aircraft rather than be dependent upon instructions from ground traffic controllers. The heart of the system is a computer that gathers information from ground or satellite navigation aids and displays it to the pilot, giving him the ability to steer his aircraft on a direct, airport-to-airport path rather than the circuitous routing between radio navigation aids used today.

The purchase of additional jet equipment was also being studied to complement Mohawk's proposed route expansions into long-haul markets, such as service to Minneapolis, Chicago and Atlanta. To be in operation by early 1969 was a fully computerized $3,000,000 centralized reservations system in Syracuse, planned to meet Mohawk's reservations needs through 1975.

NATIONAL AIRLINES

One key to National Airlines' successful 1968 was equipment. During the year National completed the largest jet fleet expansion and conversion program in its history to become one of the first all-pure-jet carriers.

In the first 6 months of 1968, 23 Boeing 727 long-bodied trijets and one McDonnell Douglas DC-8-61 jet joined National's fleet, doubling its size. In April the line retired the last of its Electra II turboprops.



National was building a superhangar (shown as skeletal model) capable of handling 2 Boeing SSTs or Boeing 747s.

Delivery of the aircraft brought National's fleet total to 53. Others included 2 additional Boeing 727-235s, another DC-8-61 and 13 each of standard Boeing 727s and DC-8s.

Conversion to all-jet, a lease agreement signed during the year with Trans World Airlines, and other factors, notably tight management, kept National's earnings up during a period when the industry's financial statements showed sharp drops under pressure of a cost-price squeeze.

National's fiscal year ended June 30. The airline recorded the second highest year of earnings in its history. Net income reached over $21,000,000, while operating revenues hit a record high at $224,000,000. The year's traffic figures also were up considerably. National carried nearly 5,000,000 passengers, an increase of 24 percent over the previous year. Revenue passenger miles rose 27 percent to 3.821 billion. Capacity increased 31 percent to 7.548 billion.

For the first quarter of its 1969 fiscal year, beginning July 1, National posted $3,699,000 in net income on operating revenues of $61,570,000. Traffic for the first 4 months was up 18 percent to 1,746,469. Revenue passenger miles increased 19 percent to 1.145 billion. Available seat miles, reflecting National's jet fleet expansion, rose to 3.14 billion.

Fleet expansion allowed National to increase service over its entire route system. At the beginning of the year the airline returned to Fort Lauderdale Airport. All-jet service was inaugurated in all of the airline's cities and the carrier began its first jet service in 7 cities.

To keep abreast of expanding capacity and traffic, National began construction of a $34,600,000 addition to its facilities at Miami International Airport. New buildings were to include one of the most modern maintenance structures in the industry, a $15,400,000 hangar capable of totally enclosing 2 supersonic transports, 2 Boeing 747s or 3 or more smaller aircraft. The circular cantilevered steel structure was to be supported from a central multistory core with 160,000 square feet of finished space for shop and administrative areas.

Other improvements included an inflight kitchen and additions to the existing general office and flight simulator buildings.

In addition to facilities improvements and expansion at sales offices and airports throughout the carrier's system, National opened 2 new offices: a governmental affairs office in Washington, D.C., and a regional sales center in Germany to enlarge its European sales efforts.

Construction continued throughout the year on the carrier's new $16,000,000 terminal at New York's John F. Kennedy Airport. Occupancy of the structure was estimated for mid-1969.

On July 1, 1968, National introduced a new inflight magazine, *Aloft,* which covers activities and attractions not only in National's home state of Florida but also over its entire system.

National, which at year-end was serving 42 cities in 15 states and the District of Columbia, sought authority to fly to 32 additional cities, 18 more states and 13 European countries and the Bahamas.

In 1968 National applied for links between the North Carolina Piedmont region and New York, Chicago and Miami and between the Twin Cities and the southeastern portion of the nation.

In October the airline's international route development efforts received a boost when National was endorsed by the Civil Aeronautics Board's Bureau of Operating Rights as the logical carrier to provide nonstop service between Miami and London.

National also was awaiting an impending final decision in the U.S.-Caribbean-South America Investigation, in which it had been recommended for extension of its southern transcontinental routes into the Bahamas.

NEW YORK AIRWAYS

New York Airways introduced the first regularly scheduled STOL operation in the metropolitan New York area in November 1968.

Two STOL aircraft, twin-motored de Havilland Otters with their higher speeds and greater operating efficiency, will enable New York Airways to accommodate the increasing public demand for its connecting services. Plans called for the operation of 2 Twin Otter STOLs daily starting at 7:00 a.m. and continuing through 11:20 p.m. linking the 3 major airports on a high-frequency shuttle basis. From 3:00 p.m. to 7:00 p.m. additional helicopter service will be available to link the downtown Wall Street heliport and the major airports. STOL aircraft will operate in the special New York Airways FAA-approved helicopter corridors, which make use of air space that is below the intermediate approach altitudes for fixed-wing aircraft yet high enough to reduce noise nuisances and attain safe terrain clearance.

Service from the Pan Am rooftop to Teterboro Airport was suspended on February 15, 1968.

As of December 1, for the year 1968, New York Airways carried 383,974 revenue passengers. Revenues for 1968 as of October 31, 1968, were $4,089,584.

Grover Loening, one of the nation's senior aviation consultants, was elected chairman of the board of New York Airways, Inc., on August 28, 1968. John E. Gallagher, executive vice president, was elected president and chief executive officer. He started with New York Airways as chief pilot when it was founded in 1952. Gallagher was graduated from St. Louis University in 1943 with a bachelor of science degree in aeronautical engineering.

NORTH CENTRAL AIRLINES

North Central Airlines began 1968 by celebrating its 20th anniversary, on February 24, in a unique way.

Five types of aircraft, representing the history of the airline since its beginning in 1948, were flown in formation for newsmen and photographers. Each of the planes was being used in 1968, or had been at one time, in the airline's fleet.

Leading the "stepped-up echelon" formation was one of the company's original Lockheed 10As, followed by a DC-3, Convair 440, Convair 580 and DC-9. Veteran North Central captains with formation experience flew the 5 aircraft. Although the planes varied greatly in speed and size, the pilots encountered little difficulty in holding the formation. Photographs of the event appeared in almost every major aviation publication in the United States and several others throughout the world.

Recapping North Central's 20-year history, the company began operation with 3 9-passenger Lockheed 10As, and at year-end 1968 had a fleet of Convair 580 propjets and 100-passenger DC-9 fanjets. The airline's original route system of 1,028 miles grew in 20 years to 7,500 miles; the cities served, from 19 to 90. North Central in 1968 carried almost as many passengers in one day as in its entire first year.

More than 2,500,000 passengers boarded NCA "Northliners" in the first 10 months of 1968, an increase of 30 percent over 1967. Passenger miles increased 35 percent in the first 10 months, to 430,236,000. A record 5,842,000 cargo ton-miles were flown for a 39 percent gain.

Recognized as the greatest achievement in its 20 years of service to the traveling public is the airline's perfect safety record. Since beginning operations in 1948, North Central by the end of 1968 had carried 18,600,000 passengers and flown more than 3 billion passenger miles without a single fatality or injury to any of its passengers.

Again in 1968, the airline was presented with the National Safety Council's highest aviation award, the Award of Honor. North Central has earned a safety citation every year since inaugurating scheduled service in 1948.

Another highlight of 1968 was the announcement that 5 additional DC-9 fanjets would be available for delivery in 1969 at the rate of one monthly between May and September. North Central at year-end was operating 10 DC-9s.

In making the announcement, Hal N. Carr, chairman of the board and president, cited the airline's traffic growth and anticipated new routes as the major reasons for enlarging the DC-9 fanjet fleet.

North Central had applications pending before the Civil Aeronautics Board for 17,200 additional miles to serve 29 cities in 11 new states, the District of Columbia and Manitoba, Canada. If approved, these routes would extend the airline's system north to Winnipeg; west to Denver; south to Dallas/Fort Worth and Houston, Louisville and North Carolina cities, Atlanta, and Miami; and east to Boston, New York/Newark, Philadelphia, and Washington/Baltimore.

Service inaugurated in 1968 included the addition of Rochester, Minnesota, as an intermediate point on a new route between Chicago and Sioux Falls, South Dakota. Also, North Central began daily nonstop flights between Minneapolis/St. Paul-Milwaukee and Milwaukee-Detroit with through-plane service east to Toronto and west to the Dakotas.

North Central's $15,000,000 general office and main operations base at Minneapolis/St. Paul International Airport neared completion.

Looking forward to 1969, North Central was to move into its new $15,000,000 headquarters complex at the Minneapolis-St. Paul International Airport.

First to be occupied was the main operations base. The base is composed of 3 hangar bays, each 250 feet wide and capable of accommodating 3 DC-9s. Located behind the bays are the shops, offices and storage areas for the base. An engine test cell building was being erected adjacent to the shops, with facilities for testing both jet and turboprop engines. At the west end of the building, another bay and more shops can be added when expansion is necessary.

The general office was scheduled for occupancy in April.

As the company entered 1969, North Central anticipated another dramatic growth year with the conversion to an all-turbine fleet of DC-9 fanjets and Convair 580 turboprops.

NORTHEAST AIRLINES

The year 1968 witnessed the nearing of completion of Northeast Airlines' equipment modernization and airline rehabilitation effort, which began in late 1965 under the ownership of Storer Broadcasting Company. New aircraft, new facilities, new routes and new marketing programs resulted in improved earnings performance as the airline moved toward its goal of financial strengthening as a basis for improved air transport service for the cities served by the airline.

During the year Northeast Airlines voluntarily relinquished its claim for subsidy and thus ended the era of subsidized trunkline carriers, a milestone for the Civil Aeronautics Board and a significant commitment for Northeast.

The move away from a dependence on subsidy necessitated an unprecedented effort to fully utilize the airline's existing route authority and a simultaneous concentration on developing new routes. During late 1967 and early 1968 Northeast initiated service in 19 new markets. The highlight of the year was the award to Northeast of a new route between Boston/New York and the Bahamas.

At the beginning of the year Northeast became the first airline to operate the Boeing 727-200. With this as the keynote of the equipment transition, the airline moved from its piston aircraft era to an all-turbine fleet. DC-9 jet service was instituted at Portland, Bangor, Presque Isle, Nantucket and Hyannis, achieving an integrated jet and turboprop service pattern throughout New England.

In a major service change, Northeast scheduled its first flights to Newark in 22 years. The new service, coupled with the start of Florida service from LaGuardia, brought a complete 3-airport Florida schedule for New York area "Yellowbird" customers.

A primary emphasis of the year was expansion of competitive capacity and a lowering of seat mile cost. At the end of the first 6 months, available seat miles had been increased 82.5 percent over 1967. The efficiency of the new equipment, combined with rigid attention to cost control, yielded a 22 percent decline in cost per available seat mile.

To fill the expanded capacity, the line heavily increased advertising and developed an "all-steak" menu for both coach and first-class passengers to Florida and the Bahamas. The hallmark of the line's 1968 marketing effort was a new emphasis on determining customer preferences and responding with an entire new cabin environment. During the year the airline replaced normal airline mini-silverware with full-size silver, replaced wool blankets with fur-like lap robes and replaced common magazines with unusual and interesting new publications.

For the first 6 months of 1968 Northeast reported a $5,000,000 profit improvement over 1967 adjusted to exclude subsidy. The air congestion crisis in late summer, combined with the normal seasonal deterioration, brought a marked decline in the company's full-year performance. When weighed against the prior year, however, the airline's economic improvement was among the best in the industry.

The commitment of the airline and its owners to the future of Northeast Airlines was seen in the action taken in March 1968 when the company became the first of the world's smaller airlines to order the new Lockheed L-1011 luxury trijets for delivery in 1972. During the year the airline ordered an additional 5 Boeing 727-200 trijets for delivery in late 1968 and 1969. The aircraft orders were accompanied by a commitment to the IBM PARS reservations system and to the construction of new facilities including a reservations building, a new hangar and new terminal facilities at Boston, Newark, Philadelphia, Tampa, Jacksonville and Miami.

To expand its sales opportunity, the airline opened a European sales office in London to encourage the use of "Yellowbird" services by the growing number of Europeans traveling to the United States.

In other organizational developments during the year, Northeast combined its reservations and station operations under a single airline executive. This new customer services department was structured to sharpen the effectiveness of efforts to apply new concepts in passenger handling and services consistent with the needs of the future. In another change, Northeast brought its stewardess activity under the marketing vice president. This change recognized the public contact role of the stewardess and placed this activity in the same organizational framework as advertising, public relations and sales.

Throughout the year the search for profitable new routes continued. As pointed out by Northeast's president, Northeast's future is more heavily dependent on winning new route authority than any other trunkline's future. The route gap separating Northeast from its competition widened continuously during the early 1960s and the airline is committed to closing the gap in the years immediately ahead.

Major routes being sought included an application to fly across the southern United States from Miami and Tampa to Los Angeles and San Francisco with intermediate stops at New Orleans, Houston and Dallas. In another east-west thrust, the line applied to fly from the East Coast to Milwaukee, Minneapolis/St. Paul, Portland and Seattle. Other applications involve new services to Omaha, Salt Lake City, North Carolina and Florida from the Twin Cities and Milwaukee, and to the Caribbean from major East Coast cities. A CAB examiner recommended that the airline be given a route from Boston to Bermuda. Another route from northern New England to Cleveland, Detroit and Chicago was approved for Northeast by the full CAB.

A major transition in leadership occurred in the fall when James O. Leet, formerly senior vice president, was named president to succeed F. C. Wiser, who moved to a senior position with Trans World Airlines. Earlier in the year George B. Storer, Sr., was named chairman of the board of directors, succeeding long-time Northeast official James W. Austin. In other personnel changes during the year, G. Ward Hobbs was named vice president of public affairs; Dan A. Colussy was appointed vice president of marketing; N. Ralph Tipaldi was named vice president-customer services; Major General Lewis E. Lyle was elected senior vice president-operations; Robert E. Griffin was named vice president-planning; Edward E. Swofford was appointed vice president of sales; and T. Bernard Slattery was elected vice president of the Mid-Atlantic Region.

NORTHWEST ORIENT AIRLINES

During 1968 Northwest Orient Airlines experienced growth and expansion in all phases of its operations.

The airline's fleet of fanjet aircraft increased to 85 by October, when the first of 16 Boeing 727-200 stretch-jets was delivered. The balance of the 727-200s were scheduled for delivery during the remainder of 1968 and 1969.

During October, Northwest Airlines placed an order for 14 new long-range McDonnell Douglas DC-10-20 luxury trijet transports and took options for another 14. Northwest was the first buyer of the intercontinental DC-10-20, which is capable of nonstop flights of up to 4,900 statute miles with a full passenger load. First delivery was scheduled for January 1973.

Northwest also had 10 Boeing 747 long-range jumbo jets on order and had reserved delivery positions for 6 U.S. SSTs.

Northwest ordered 14 McDonnell Douglas DC-10-20s and took an option on 14 more; first delivery was scheduled for January 1973.

Northwest was actively involved in several route cases before the Civil Aeronautics Board. In March a CAB examiner recommended that Northwest be certificated to provide service between Minneapolis/St. Paul and Los Angeles and between Minneapolis/St. Paul and San Francisco/Oakland, as a result of the Twin Cities-California Service Investigation. Northwest proposed a full range of first-class, coach and cargo services linking midwestern cities with California. Northwest was awaiting the board's final decision in this investigation.

A hearing was held on October 15 in the Northwest Airlines-Pan American interchange proposal for direct service between the Twin Cities and London via Detroit. It was anticipated that approval of the agreement could be obtained so as to permit the inauguration of this service by the spring of 1969.

Also during the year Northwest presented oral arguments to the CAB in support of its route application in the Transpacific Route Investigation. Northwest asked the CAB to award it a California-Hawaii-Orient route as the essential ingredient of an effective U.S. flag transpacific pattern fully competitive with foreign carriers.

During the year a CAB examiner recommended in the Gulf States Case that Northwest's routes be extended from Chicago to Nashville. In oral argument to the board, Northwest urged that it be authorized to bring the benefits of through-plane service from cities on its existing routes to Memphis and New Orleans as well.

The hearing in the Pacific Northwest-California Investigation was scheduled for 1969. In this proceeding, Northwest seeks to extend its routes beyond Seattle and Portland to San Francisco/Oakland, Los Angeles and San Diego.

Net earnings for the first 9 months of 1968 totaled $40,237,568, or $4.40 per share of common stock. Northwest's traffic statistics for this period revealed substantial increases over 1967. Nearly 8 billion available seat miles were provided to the public, compared with 6.8 billion during the first 9 months of 1967, an increase of 17.5 percent. Freight and mail and express ton-miles also reflected significant increases of 17.4 percent and 51.5 percent, respectively.

During 1968 Northwest made a number of fare filings with the CAB. One of the most significant of these was the extension of the popular Discover America excursion plan to April 1969, retaining the $200 transcontinental round-trip fare and permitting travel on Saturdays. Also filed were fare reductions to permit discounted travel on routes within the continental United States for passengers residing outside the western hemisphere, as an aid to the U.S. government's program to improve its balance of payments position; a special $215 tour fare between Chicago and Anchorage; and expansion of the 25 percent reduction from normal West Coast-Hawaii fares to include the parents of single servicemen and wives and parents of wounded servicemen stationed in Vietnam or Thailand and on rest-and-recreation leave or recuperating in Hawaii.

Northwest made significant fare adjustments in services to Hawaii during 1968, including the reduction of round-trip first-class fares between the West Coast and Hawaii. In the last few months of the year Northwest offered a greatly expanded and improved service from the mainland to Hawaii. Three round trips per day to the islands were featured, offering new one-plane services from many inland cities.

Service to New York's LaGuardia Airport was begun June 1. New direct, nonstop services were provided between Milwaukee and Atlanta and between the Twin Cities and Portland in 1968. Montana air service was greatly improved at midyear with the addition of 2 flights and the rescheduling of others to offer limited-stop services in the state. A new schedule for the Orient featured 6 new flights each week to Hong Kong as well as new flights for other cities on Northwest's routes within the Orient.

In December 1968 Northwest's enlarged Florida service included direct, nonstop flights from the Twin Cities to Atlanta, from Milwaukee to Tampa and from the Twin Cities to Miami. These new schedules also increased the availability of seats on Northwest's important Chicago to Florida services.

OVERSEAS NATIONAL AIRWAYS

A major fleet expansion and diversification into the hotel field highlighted the year for Overseas National Airways.

As 1968 began, ONA was operating an all-jet fleet of 2 DC-8-55s and 3 DC-9-30s. When the year closed, these had been augmented by 10 more turbine-powered aircraft.

A fourth DC-9-30 entered service in February, joining 2 other aircraft in the Air Force's Logair operation. For a brief period, a fifth DC-9-30, leased from a scheduled carrier, was operated on a route within Europe for Sudflug, a German charter carrier. During 3 months of operation, the latter aircraft was utilized an average of 10.4 hours daily and covered 400,000 miles with a 99.5 percent on-time record.

Two more DC-9-30s were ordered for delivery in March and April 1969.

The long-range jet fleet grew with the entry into service in October of ONA's first Super DC-8. Three more intercontinental DC-8-63s were on order for delivery in May and June 1969 and the spring of 1970. The 250-passenger aircraft were well accepted and the airline planned to phase out its 180-passenger DC-8s and standardize its fleet with DC-8-63s.

The major increment in the expansion program was the acquisition of 8 L-188 Electras. Formerly operated in passenger service by National Airlines, these aircraft were converted to cargo configuration by Lockheed Aircraft Services, which used a design for a cargo loading system—employing fore and aft doors—which ONA developed. The Electras were being operated in the Logair system and for commercial cargo charters within the United States and in the Caribbean area.

In summary, the ONA fleet grew from 5 to 15 aircraft during the year. With 4 more planes on order for 1969 delivery and another due the following year, Overseas National will be operating 20 aircraft by 1970.

Late in the year, Overseas National announced that it would be the first supplemental carrier to enter the hotel business. Through a new subsidiary, ONA Hotel Corporation, the airline will share in the ownership of a 400-room luxury hotel to be built in Nassau, the Bahamas. ONA's partners in the venture will be Hotel Corporation of America, which will operate the hotel, and Butlers Bank, Limited, of Nassau. Scheduled for completion in the fall of 1970, the hotel will be called the Sonesta Beach. ONA was planning other ventures in the hotel field to complement its growing fleet of aircraft.

A milestone in the company's marketing program was the introduction of a computer service for chartering groups. Called the ONAMATIC system, it relieves affinity groups of the administrative burdens associated with charter flights. Following an initial mailing to all members of a chartering organization, all payments are logged on an IBM 360 computer at ONA's headquarters in New York with complete reports furnished to the organization on a regular basis. The computer also prints out the passengers' tickets and provides an alphabetized manifest prior to departure. The computer service has been well received by both travel agents and groups.

Overseas National Airways also became the first airline to sponsor a racing car on the United States Automobile Club's championship schedule of races, including the Indianapolis 500. Mario Andretti, world-famed driver and 2-time USAC champion driver, is the "pilot" of the ONA cars and placed second in the 1968 standings.

ONA became the first airline to sponsor a racing car on the U.S. Automobile Club's championship circuit. Here ONA president G. F. Steedman Hinckley chats with ONA driver Mario Andretti.

A highlight of the year was the passage by the U.S. Congress of legislation clarifying the authority of supplemental carriers to operate inclusive tour charters. The signing of the bill by President Johnson in late September cleared the way for development of international inclusive tour charters, which had been restrained by prolonged litigation instituted by the scheduled carriers.

Overseas National's revenues for the year approximated $30,000,000, an increase of $10,000,000 over 1967. Contributing to the total were contracts for fiscal 1969 for $4,500,000 to perform international passenger charters for the Military Airlift Command, $10,500,000 for service in the Air Force's Logair domestic cargo system and $1,800,000 for providing terminal operations and cargo handling at the Navy's Quicktrans bases. The latter contract was being performed by a second new ONA subsidiary, Automated Terminal Services, which provides cargo handling services for both military and commercial customers.

OZARK AIR LINES

Repeating a common situation of the recent past, new planes, new routes and greater traffic were the story for Ozark Air Lines during 1968. It was the year that traffic continued to increase until 2 milestones were passed in one month. It was also the year that Ozark received new route authorities, and finally, it was a year highlighted by Ozark's phase-out of all piston-engine aircraft and the start of all-turbine operation.

From a traffic standpoint, Ozark again broke records, and then broke them again and again during the year. For example, with 174,690 passengers during March, a monthly all-time high was set, and a 25 percent increase was shown for the first quarter compared to the prior year.

This record, however, was quickly topped in April with 184,640 passengers, only to be topped again by a new milestone in June with 202,878 passengers. June was the first 200,000-plus month in the company's history, and with that total, Ozark carried more than 1,000,000 passengers in 6 months for the first time. It had been only 3 years earlier, in 1965, that 1,000,000 passengers in a year was reached.

In August, 3 new passenger traffic records were set. First, there was a new monthly high of 208,080; second, Ozark reached 2,000,000 passengers during a 12-month period for the first time; and third, a new daily boarding high was reached as 8,171 passengers boarded on August 30, beating the previous high set only weeks earlier, on June 28, with 8,168 passengers boarded.

The company's equipment story for 1968 started in February with delivery of the first McDonnell Douglas DC-9 Series 30. This was followed by 2 additional big jets in April and May, bringing Ozark's jet fleet to 9 (6 Series 10 DC-9 jets and the 3 new Series 30 models). In October the fleet was increased in size again as 2 more DC-9-10 jets were leased and immediately put into service.

Word of an even bigger fleet was announced during September, as 3 more Series 30 DC-9s were ordered for delivery in early 1969.

Highlighting the equipment program was Ozark's changeover to an all-turbine fleet with only its DC-9 jets and its FH-227B propjets in operation throughout the system. The last DC-3 was removed from schedule on October 26 when the final airport restricted to DC-3 traffic was replaced by a new facility, and the "Grand Old Lady" was retired quietly.

Routes—new, applied for, and favorably recommended—played a big part in the company's activities during the year.

Two new nonstop authorities were approved by the Civil Aeronautics Board, and service was inaugurated immediately. This included authority to serve between St. Louis and Chicago, recommended by the examiner in July, given final approval in September and put into schedule in October with 3 round trips daily. The trips were increased to 7 in November.

Inaugurated on the same day was new nonstop service between Kansas City and Springfield, Missouri. This had been recommended by the examiner in April and approved by the CAB in August.

Several favorable examiner recommendations were received on route requests pending before the CAB. This included Ozark's request to serve New York and Washington, D.C., from Peoria, which received the examiner's nod in August after hearings were held in June. This route had been granted to Ozark in November 1967 on a show cause order, but opposition put the proceedings into an expedited hearing.

Other favorable recommendations included routes from St. Louis to Memphis and from St. Louis to Dallas, both awaiting final CAB approval, and realignment of Ozark's system to change the pattern from 18 segments to 7.

Ozark also filed more route applications. These included a request to serve such cities as Columbus, Dayton, Cincinnati, Indianapolis and Louisville from Milwaukee, filed in March. In December 1967 the company had filed for new routes from Minneapolis/St. Paul to Boston, New York, Philadelphia, Baltimore, Portland and Seattle/Tacoma, which followed other requests for service to cities on both coasts, Canada and Alaska.

Ozark also introduced several new or expanded service programs during 1968.

Early in the year the company's cargo schedule was moved from day to night in order to provide convenient service for shippers. In May a new cargo facility was opened in St. Louis.

Following these changes, in August a new "Mini" cargo rate was introduced, allowing shipment of cargo weighing less than 10 pounds anywhere on Ozark's system for only $4. Then, as the company phased out the last of its piston-engine aircraft, an all-new, original plan was inaugurated to change over the company's Fairchild Hiller FH-227B propjets for all-cargo use during the night. Working with a plan developed by Ozark's director of cargo, one of the propjets is changed to the cargo configuration in less than 4 man-hours as all the seats are removed and interior protective bulkheads, a floor covering and cargo tie-downs are added.

Ozark went to a dual configuration on its jets in

May when first-class and coach seating was offered on the DC-9. This changed the seating capacity of the planes to 74 seats in the Series 10 and 99 seats in the Series 30. This includes 14 first-class seats in each.

In September, 2 new credit cards—Bankmark and BankAmericard—were added to those Ozark accepts, and in November new city ticket offices were added in Kansas City and Chicago.

Earlier in the year Ozark inaugurated service to Midway Airport again, thus providing flights to both Chicago airports and returning to a facility that had been abandoned several years before by almost all carriers.

Another innovation, a specially made Ozark cocktail, was introduced in April. With the "Go-Getter," as it is called, Ozark became the second carrier to offer its own original drink.

Finally, to top off another highly successful year for the carrier, the National Safety Council again presented Ozark its top safety award, the Award of Honor. One of 8 scheduled carriers to get the award during 1968, Ozark has received a safety citation from the council every year since its beginning in 1950.

PAN AMERICAN WORLD AIRWAYS

During 1968, its 41st anniversary, Pan American World Airways, Inc., marked 2 milestones in the history of aviation. The airline celebrated the 10th anniversary of its introduction of commercial jets and prepared for the introduction of the first 747 superjet service in late 1969.

On October 26, 1958, a Pan Am Boeing 707 took off from New York's Idlewild International Airport for Paris, the first transatlantic jet flight under the American flag.

During 1958-68 Pan Am's average revenue, or yield, per passenger mile on the New York-Paris run dropped from 7.25 cents a mile to just over 5 cents a mile. Lower rates and the speed and capacity of the jets served to broaden the market for international air travel. Pan Am carried an estimated 9,500,000 passengers in 1968, more than 3 times the 2,900,000 it carried in 1958.

More spectacular than the growth of passenger travel was the growth of Pan Am's air cargo. The jet decade led to an increase of 450 percent in tonnage carried by Pan Am; revenue ton-miles jumped nearly 600 percent to an estimated 678,720,000 revenue ton-miles in 1968.

Pan Am's fleet grew from 6 to 150 Jet Clippers in the decade. In the same time span, the number of Pan Am employees increased from 24,700 to 48,000.

Juan T. Trippe, dean of airline executives in the United States, retired as chairman and chief executive of Pan Am. In 1927, when Pan Am made its first flight under Mr. Trippe's direction, it had $300,000 in assets and a 90-mile route between Key West, Florida, and Havana, Cuba.

At year-end 1968, Pan Am had assets of more than $1 billion and a route system of some 80,000 miles linking the United States with some 84 lands and 122 cities.

Pan Am had on order 42 more subsonic jet transports including 25 Boeing 747 superjets. The airline also had on order 8 Concorde supersonic transports and 15 U.S. SSTs.

On July 15, 1968, Pan Am inaugurated the first scheduled service between New York and Moscow. This service was the result of a bilateral air agreement between the U.S. and the U.S.S.R. Pan Am's 4,907-mile weekly flight to Moscow leaves Monday and returns Tuesday.

The airline provided the largest commercial airlift for U.S. Military Airlift Command operations. In 1968 Pan Am added 7 long-range jet freighters to its air fleet in military support service. The additional aircraft brought to 18 the number of Pan Am jets committed to MAC service.

Twenty of these were Boeing 707-321C jet freighters capable of transporting up to 90,000 pounds of military mail, goods and equipment. The other 4 Jet Clippers, also 707s, are used in the government's rest-and-rehabilitation program, which provides American servicemen with 5-day furloughs after some 6 months of Vietnam duty.

R and R, started by Pan Am in March 1966 as a one-plane service, has grown into a major military support effort. The airline has carried more than 1,000,000 military passengers between Vietnam and Hawaii and other points in the Pacific.

Twice during 1968 Pan Am rushed medical equipment and supplies to disaster victims abroad. In July, 2,000 pounds aided victims of Costa Rica's volcanic eruption. In August nearly 6,000 pounds were flown to Iran for earthquake victims.

During 1968 Pan Am became the first U.S. airline to have its entire fleet of aircraft equipped and certified by the Federal Aviation Administration for Category II landings, a standard which permits planes to land when visibility along the runway is as low as 1,200 feet, 800 feet less than the previous visibility minimum.

During 1968 Inter-Continental Hotels, a wholly owned Pan Am subsidiary, opened 3 new hotels, 2 in Zambia and one in New Zealand; 10 more were under construction. When completed, the number of Inter-Continental hotels around the world will total 51.

A prime contractor for the U.S. Air Force, Pan Am's Aerospace Services Division was cited by the Society of American Value Engineers for modifications in a communications system that resulted in a saving of about $100,000 to the government of the United States.

The City of New York approved Pan Am's establishment and operation of a midtown waterfront heliport at the foot of East 60th Street in Manhattan. This new facility provides for convenient helicopter connections from midtown to the smaller airports surrounding the city. Mayor John V. Lindsay called it "an important step in the relief of the city's air congestion problems."

The Business Jets Division of Pan Am announced plans for construction of a new Fan Jet Falcon model, the Falcon 70, an airplane with increased range and more operational features than earlier models.

The Falcon 70 was in final design stages in mid-1968 and was scheduled to go into production in 1969 and be available for delivery to customers in 1970. The Business Jets Division also placed orders for 100 new Falcons bringing to 250 the number of twin-engine business aircraft put on order or option since 1964. The Business Jets Division sold 25 Falcons to corporate customers in the U.S. and Canada during the first 11 months of 1968 to bring total sales since 1964 to 104 aircraft.

PURDUE AIRLINES

Operating from Purdue University Airport, West Lafayette, Indiana, as one of the 13 U.S. supplemental air carriers, Purdue Airlines, Inc., was officially activated on May 1, 1968. The new company took over the DC-3 and DC-6B fleet and operations of Purdue Aeronautics Corporation.

Purdue University retained an interest in the new corporation and its operation, and ties with the Aviation Technology Department continued.

At year-end, Purdue Airlines was awaiting arrival of new McDonnell Douglas DC-9-30 aircraft. First delivery was expected in February 1969 with additional deliveries to follow in succeeding months. The planes were to replace Purdue's 74-passenger DC-6Bs.

Certificated for operations throughout the U.S. and Canada, Purdue Airlines (then PAC) flew more than 15,000,000 passenger miles in 1967; 1968 figures were not available at press time.

SATURN AIRWAYS

The year 1968 was one of great achievement for Saturn Airways and was perhaps the most significant year in the airline's 23 years of operation.

Saturn was one of the first supplemental carriers to add 250-passenger jet aircraft to its fleet. In late December 1967 the airline took delivery of its first Douglas DC-8-61F stretch-jet and then added another of these sky giants to its fleet in January 1968. These convertible superjets, each capable of carrying up to 250 passengers or 90,000 pounds of cargo, were being utilized in Military Airlift Command service and in Saturn's intercontinental commercial charter operations.

Continuing its program to standardize in the operation of one type jet aircraft, Saturn during 1968 acquired 2 DC-8-50 series jets on a lease/purchase arrangement. One of the 50 series jets was delivered to Saturn in November with the second scheduled for delivery in April 1969. Capable of carrying up to 180 passengers or 90,000 pounds of cargo, these 50 series jets plus the 2 stretch-jets will provide the fleet versatility necessary to compete favorably in the expanding commercial charter markets. Saturn's 1968 commercial charter operations with all-jet aircraft were highly successful, particularly in the prime transatlantic market.

In addition to the 4 convertible jets, Saturn was operating a fleet of 12 DC-6A cargo aircraft, used in commercial cargo operations and Logair service for the military. Logair is a daily scheduled cargo service operated for the Air Force through which supply requirements of all types are transported between Air Force bases in the continental United States. Saturn is one of the oldest and the largest operators in Logair, and on April 22, 1968, logged its 100,000,000th mile in domestic Logair service. The milestone was reached during a scheduled Logair flight between Hill Air Force Base, Utah, and Kelly Air Force Base, Texas.

Legislation authorizing foreign inclusive tour charter authority for supplemental carriers was signed into law by the President on September 26, 1968. Through these tours (both domestic and international), Americans of modest and medium income will have the opportunity to travel to foreign lands and resort areas which they might never visit except for the low-cost type of transportation that will be provided by Saturn and other supplemental carriers in their inclusive tour programs. Saturn expected to be operating a sizable number of such tours in 1969, particularly in the Hawaiian, Caribbean and European areas.

Personnel promotions during 1968 included the appointment of Harvey P. Barnard to the position of vice president and general manager; George M. Kamats was named treasurer-assistant secretary replacing E. P. Odenwalder, retired; Howard K. Howard was appointed assistant vice president-planning.

In the first 9 months of 1968 Saturn operated more than 669,000,000 passenger miles and over 118,500,000 cargo ton-miles. Operating revenues for the 9 months reached $25,898,582, representing a 43 percent increase over the same 1967 period. Saturn's expanding jet fleet and increased merchandising efforts in the commercial sales area were expected to substantially increase revenue during 1969.

STANDARD AIRWAYS

Standard Airways continued to be one of the leading innovators in the supplemental airline field. With the introduction of new selling techniques, packages and other marketing vehicles, substantial sales increases were realized in 1968 over the preceding year. Increased frequency of flight patterns along with computerized programming that lessened ferry mileage costs were also key factors in Standard's growth.

In 1968 Standard marked a major growth year with increased inclusive tour charter penetration into the Pacific. Standard, eighth in size of the nation's 11 active supplemental airlines in terms of seats available, received gross revenue increases of 14 percent in 1968 over 1967. Standard ranked approximately third among supplementals in terms of ITC revenues, first in charter travel to Las Vegas and first in sales incentive revenue. In addition, Standard was very active between major U.S. markets and Caribbean destinations.

Hawaii flights, departing from 20 continental points, terminate at Honolulu with a pattern of regularity allowing travel groups to come and go at most convenient times. This, combined with the securing of large blocks of excellent hotel accommodations, aids travel agents and group travelers in obtaining quick reservations.

A similar program to Las Vegas, the "Fare Deal," was initiated. Under this flexible program, Standard was able to minimize positioning costs and achieve maximum efficiency of operations in delivering DC-9 and 707 fanjet charter flights at a minimum per passenger air fare. This continuing program offers round-trip group fares that often run less than 50 percent per passenger compared with jet economy fares on most scheduled airlines. This, coupled with frequent departures from the eastern seaboard and midwestern points, made Standard a leader in Las Vegas service. A colorful "Fare Deal" sales kit providing details was made available.

New Caribbean plans encompassed availability of charter flights between East Coast cities and the Bahama Islands. These plans offer new group sales appeal, open up new markets and make available low pro rata jet fare combinations.

Standard Airways, one of the nation's oldest and most experienced permanently certificated U.S. supplemental airlines, has a history spanning more than 20 years and millions of safely flown passenger miles around the world. Although small in size, Standard ranked high in arranging inclusive group charters.

Standard's all-fanjet fleet included 3 160-passenger Boeing 707s. As certificated by the CAB, Standard Airways was authorized to fly charter flights between all 50 states and to points in Canada, Mexico and the Caribbean. Because of rapid expansion in 4 major markets and year-round business opportunities, Standard concentrated patterned operations to Hawaii, Mexico, Las Vegas and the Bahamas.

Standard Airways maintains headquarters in the Tower Building, Seattle, Washington. Fully staffed sales offices are located in Seattle, Los Angeles, Detroit, Chicago, Philadelphia and New York.

TRANS INTERNATIONAL AIRLINES

Trans International Airlines, the first all-jet supplemental air carrier, enjoyed another record year during 1968.

Early in the year the shareholders of TIA approved the merger of the company into Transamerica Corporation. The transaction called for the exchange of one share of Transamerica common stock for each 2 outstanding shares of Trans International Airlines common stock. On the basis of 6,300,000 shares of stock outstanding, the transaction was valued at approximately $143,000,000. On March 8, 1968, TIA became a wholly owned subsidiary of Transamerica Corporation with Glenn A. Cramer, president and chief executive officer of TIA, being elected to the board of Transamerica Corporation.

During its first year of operation a 250-passenger DC-8 operated by TIA flew more passenger miles than the total of all U.S. commercial planes combined 30 years earlier.

The jumbo-sized plane, almost two-thirds the size of a football field, flew a record-breaking 450,000,000 passenger miles in the 12-month period following its maiden flight on June 19, 1967. Flying an average of 15 hours a day, the DC-8 stretch-jet carried approximately 100,000 passengers in its first year, including several thousand military personnel to and from Vietnam.

Later in the year TIA completed proving flights required by the Federal Aviation Administration prior to placing its Boeing 727 trijet in service. Use of the 125-passenger plane on the 2,400-mile hop between the mainland and Hawaii enabled the company to reduce charter air fares up to 25 percent for smaller groups. The fare reduction significantly broadened the travel market and made vacation air travel economically feasible for many small groups for the first time.

Passage by the U.S. Congress on October 4, 1968, of an Administration-backed bill permitting supplemental airlines to fly low-cost package tours abroad marked the beginning of a new era in American travel, Glenn Cramer stated. He predicted that the congressional action will be a "major spur to travel both to and from Europe." The measure empowered the Civil Aeronautics Board to permit charter airlines such as TIA to fly "inclusive tours" conducted by tour operators to foreign countries.

Under the bill, travel agencies will be able to sell to individuals "package tours" abroad that include transportation on a charter airline, hotels and other services at 30 to 40 percent reduction.

TIA planned to fly inclusive tours conducted by tour operators to Europe, the Orient, South America and other parts of the world. The company's plans called for TIA to fly 10,000 people to the Far East on inclusive tours during a 40-week period starting in March 1969.

TIA, an Oakland, California, based carrier, was operating an all-jet fleet which included 3 DC-8 Super 61s, one DC-8 Super 63 and 2 Boeing 727 trijets. Delivery of the first of 4 DC-8 Super 63s was made in November, and an order was placed for 3 additional DC-8 Super 63s for delivery during 1969 as well as 3 330-passenger DC-10s scheduled for delivery in 1973 and 1974.

TRANS-TEXAS AIRWAYS

A new president, a new image and an accelerated effort toward growth and expansion highlighted TTA's accomplishments through the first 9 months of 1968 as the airline established record highs in passenger and cargo traffic and in total operating revenues.

Robert J. Sherer, a former financial executive with Bonanza and Air West, was named president of the airline in June.

TTA boarded 1,427,652 passengers through September 1968, for an increase of 36.24 percent over the same period in 1967. In 1967 the airline carried a total of 1,460,565 passengers, but projected figures for 1968 indicated that the total for the year should be nearly 2,000,000.

The airline's cargo ton-mileage increased 45.96 percent over the same period in 1967, to 3,182,191, and cargo pounds transported climbed to 29,324,-240, reflecting an increase of 38.44 percent on mail, freight and express.

TTA reported operating income of $1,147,000 through September 1968, compared to $457,000 for the same period in 1967. A net loss of $367,000, compared with $220,000 during the first 9 months of 1967, resulted from increased interest on loans.

The Houston-based regional service carrier placed its seventh, eighth and ninth 75-passenger DC-9s in service by October and expected delivery of 2 more 75-passenger Pamper-jets later in the year. Two 100-passenger versions of the DC-9 Series 30 were scheduled for delivery in January 1969 and a third Series 30 was expected in December 1969.

Negotiations were under way with McDonnell Douglas for a fourth 100-passenger plane, possibly for delivery early in 1970.

Completion of a $16,000,000 conversion program in which TTA's 25 Convair 240s were modified to turbine-powered Silver Cloud 600s coincided with the phase-out of all the airline's piston-engine aircraft, including 13 DC-3s and a single Convair 240, which were sold.

TTA took delivery of 5 more DC-9s and introduced a new 3-color exterior design.

At the same time, TTA launched the first aspect of its "new image" with the application of a striking new paint job to 4 DC-9s and 3 Convairs. Highlight of the 3-color design is a wide purple stripe located just above the windows and extending the entire length of the fuselage, flaring into 3 distinctive prongs on the tail section. The airline hoped to have most of its fleet painted by January 1969.

TTA in October inaugurated service to Wichita Falls, Texas, and began operating a new route from Dallas to Wichita Falls to Amarillo. Addition of the new city brought TTA's total service to 66 cities in 6 states and Mexico.

The airline tentatively added a hotel to its assets when its wholly owned subsidiary, Innternational, Inc., began negotiating for the purchase of the Hotel Tropicana in Las Vegas, Nevada. The purchase was to be completed by year-end.

Earlier in 1968 the company changed the state of its incorporation from Texas to Delaware when it merged with its wholly owned subsidiary, Texas International Airlines, Inc. It continued to operate under the name Trans-Texas Airways, however, using the former name only as a corporate title.

Potential route expansion came with CAB examiner initial decision recommendations that TTA serve a nonstop route from Dallas, Texas, to Albuquerque, New Mexico, and a second route, Denver, Colorado, and Salt Lake City, Utah, along 2 specific segments.

Decision on the Denver-Salt Lake City route and disposition of the Albuquerque case were expected in 1969.

TTA's 2 largest stations, Dallas and Houston, were to be relocated into new facilities in 1969. The airline leased a large terminal segment at Dallas' Love Field, with 6 gate lounges, 2 jetway boarding entrances and expanded office space. The Houston move was to take place with the opening of the city's new Intercontinental Airport, scheduled early in 1969; the Dallas station hoped to be in the new facilities sometime in January.

TRANS WORLD AIRLINES

Trans World Airlines in 1968 undertook a major growth program. TWA committed itself to extensive aircraft and ground facilities expansion and reorganized across the board. In the same year TWA's subsidiary, Hilton International Company, announced plans to expand its global network by 50 percent.

On the basis of figures for 10 months and estimates for November and December, the airline in 1968 offered the public 17.9 percent more available seat miles than in 1967 (up from 26 billion in 1967 to 30.7 billion in 1968) and flew 7 percent more passengers (from 12,600,000 in 1967 to 13,500,000 in 1968) and 8.3 percent more passenger miles (from 14 billion in 1967 to 15.1 billion in 1968).

In the field of cargo service, TWA estimated it increased its capacity 19.7 percent over 1967 (5.2 billion available ton-miles in 1968, compared with 4.3 billion in 1967) and flew 20.7 percent more cargo ton-miles (517,000,000 in 1968 compared with 428,000,000 in 1967).

Within the 3 categories of this cargo volume, freight ton-miles in 1968 rose an estimated 16.6 percent over 1967 (from 307,000,000 to 358,000,000), mail ton-miles increased 36.2 percent (from 105,000,000 to 143,000,000) and express ton-miles declined 1 percent (from 15,800,000 to 15,700,000).

During the year TWA resumed service to Colombo, Ceylon, and added several more eastern seaboard and inland U.S. cities to its transatlantic flight-origination pattern. Within the United States the airline introduced or expanded nonstop service between a variety of city pairs.

The airline took delivery of 24 Boeing jets in 1968, increasing its all-jet fleet to 197 by year's end.

A TWA commitment in March 1968 for 22 Lockheed 1011 trijets (plus 22 more subject to option) raised to 97 the number of subsonic aircraft in TWA's announced equipment program for 1969 and beyond. Of the 97 units, 65 were on firm order. TWA expected to take delivery of the first of its Boeing 747s in the fall of 1969 and its first L-1011 in the fall of 1971.

The subsonic equipment, related spare engines and parts on order and to be ordered represented a commitment of nearly $1 billion. TWA also held 6 delivery positions for the British-French Concorde supersonic transports and 12 positions for the U.S. SSTs. (TWA held first delivery position on the U.S. SSTs to be built by Boeing.)

The foundation for TWA's record flight equipment and ground facilities expansion was laid at the close of 1967 when TWA concluded an $800,000,000 financing program. The arrangements covered the airline's financial requirements through 1970 and by certain refinancing agreements broadened TWA's base for long-term borrowing.

On September 21 the special master in the Hughes Tool Company litigation recommended payment of $137,600,000 in damages to TWA. The recommendation was being reviewed by the U.S. district court judge who presided over the case since 1961; the court's findings were subject to appeal. The case originated with a TWA suit which charged that Toolco, while it controlled the airline, damaged TWA by violation of the antitrust laws.

By year's end Flight Wing One, which will double in size the Trans World Flight Center at New York's JFK Airport, passed the halfway mark to completion. A terminal planned from the ground up for the superjet era, the $20,000,000 addition to the Eero Saarinen-designed building was scheduled for dedication in the fall of 1969 preparatory to introduction of the Boeing 747s.

Ground was broken in June 1968 for TWA's $33,000,000 Technical Services Center at Kansas City International Airport. The center, double the size of TWA's main overhaul base, was designed to accommodate the jet giants of tomorrow. The airline in 1968 doubled its engine overhaul capacity through expansion of its engine plant at Kansas City International.

TWA was building a $33,000,000 Technical Services Center for its ordered Boeing 747s and SSTs.

The doors to the Trans World Flight Hostess Academy were scheduled to open in June 1969. Spread across a 34-acre campus in residential Overland Park, Kansas, the academy has a capacity for training 4,000 flight hostesses annually by 1980.

Meanwhile, TWA was moving forward on office, passenger and cargo terminal construction programs at many locations along its 48,105-mile, 4-continent system.

In mid-1969 TWA planned to throw the switch activating the world's largest multiprocessing computer system at the airline's new data-processing center in Rockleigh, New Jersey. The center will be the "brain" for TWA's centralized, fully automated reservations service, which ultimately will tie in the Hilton hotels.

TWA in 1968 introduced various technological and training advances, including utilization of 2 Lockheed JetStars as inflight simulators assigned to the TWA Jack Frye International Training Center in Kansas City. The cockpit of one was modified to simulate Boeing 707 instrumentation, the other the 727. TWA hoped to be first, in the summer of 1969, with a Boeing 747 simulator.

TWA's New York Pilot Training Center was in full operation. It provides recurrent training for all East Coast-based pilots, both domestic and international.

TWA will also be first with the Dalto Wide-Angle Virtual-Image Visual System for pilot training simulators. The DEC-4000 system will give TWA pilots a horizontal field view of 230 degrees, compared to the current 60 degrees.

The airline in 1969 will evaluate an experimental flight direction system, a color "head-up" display unit, which will give pilots instrument readings on a transparent glass screen mounted on the aircraft's windshield. It will afford pilots ability to fly on instruments while simultaneously looking out the windshield.

In early 1969 TWA's new Sales Training Center in New York was to shift into full gear. The center features the latest educational systems, such as closed-circuit TV, electronic responders and rear-screen projection. TWA expects to provide initial and refresher training for 10,000 to 12,000 persons a year at the Center.

In the spring of 1968 TWA reorganized worldwide from top to bottom. A key to the new organization was the consolidation of all customer sales and services functions within an expanded marketing department. On the regional level TWA divided its worldwide system into 8 geographical areas, each headed by a regional vice president-sales and services. A "Mister TWA" was installed at major cities in the world with broad authority for both sales and services. At the top was Blaine Cooke, senior vice president-marketing, who joined TWA in March 1968 from United Air Lines, where he was vice president-marketing services.

Mr. Cooke's appointment was the first in a series of major appointments in 1968. In July, Wayne G. English, former vice president of finance for Pullman, Inc., was named senior vice president-finance. In October, F. C. Wiser, Jr., former president of Northeast Airlines, joined TWA in the newly created position of executive vice president.

Other actions taken in 1968 by TWA in its building-for-the-future program included:

• Wells, Rich, Greene, Inc., was named on August 15 as TWA's agency for passenger advertising, with programs to unfold in early 1969.

• On October 1, TWA's 4,000 hostesses doffed the uniform look and donned new winter ensembles in their choice of sun gold, poppy orange or jungle green. (Summer outfits of blue, brown or green jackets with matching plaid skirts were to be introduced May 15, 1969.)

The Manila Hilton, opened in 1968, brought to 42 the number of hotels operated by Hilton International in 39 cities in 28 countries. The TWA subsidiary had 21 additional hotels either under construction or in the developmental stage.

By year-end 1968 TWA had conducted nearly 1,500,000 persons on its guided tours of the Kennedy Space Center and adjoining Cape Kennedy since the airline started its Visitor Services Program in mid-1966. TWA's contract for this program with the National Aeronautics and Space Administration was extended in March 1968 for 10 years. The airline since early 1964 has performed the base-support operations at the Space Center and also provides its medical services, both under NASA contracts.

Civil Aeronautics Board hearing examiners in 1968 recommended new route authority for TWA in 3 separate board cases. With authority recommended in the Transpacific Route Investigation, TWA would fly the Pacific via Hawaii, Japan, Taiwan, Guam and Korea between the airline's western termini of Los Angeles-San Francisco and its eastern terminus of Hong Kong (and thus bring the airline full circle around the world).

TWA also was recommended in the Reopened Pacific Northwest-Southwest Service Investigation to operate between Kansas City and Seattle/Tacoma-Portland, and in the Gulf States-Midwest Service Investigation to provide service between Houston and St. Louis.

In addition, TWA in 1968 applied for new international and domestic routes in a dozen other CAB cases. Cities which would be added to TWA's U.S. system through authority in these cases included Ontario, San Jose, San Diego, Salt Lake City, Omaha, Des Moines, Huntsville, Orlando, Cocoa Beach and Titusville.

TWA also asked the board in separate applications for authority to serve Johannesburg, South Africa, and to operate nonstop between Miami and London.

Also pending were TWA requests to operate nonstop between Boston, Hartford, Philadelphia, Baltimore and Washington on the one hand, and Norway, Sweden, Finland, Denmark, Belgium, Netherlands, Luxembourg, Switzerland, Austria, Yugoslavia, Greece and Turkey on the other hand.

UNITED AIR LINES

Five major programs marked 1968 for United Air Lines. They were introduction of the Boeing 737, a new short-range jet that made all-jet status possible; a multimillion-dollar order for the DC-10 jumbo jet; opening of a new flight training center at Denver; announcement of plans to expand the San Francisco Engineering and Maintenance Base; and introduction of a new stewardess ensemble.

Already the largest commercial airline in the world, United took delivery of its 300th jet in mid-October, edging even closer to operating an all-jet fleet, a status which was expected to be achieved early in 1969.

Introduction of the 737 into the fleet permitted United to begin phase-out of the DC-6. The 737 was being used to replace all of United's piston and turboprop aircraft. It can be flown over route segments as short as 100 miles, but can carry a payload of 32,000 pounds at ranges up to 850 miles. Cruising speed for the twin-jet is 500-550 miles per hour at 25,000-35,000 feet. A unique feature of the plane is the cabin width which is identical to the 4-engine Boeing 720 and 727 trijet.

United introduced the Boeing 737 to its fleet and edged closer to all-jet status, expected in 1969.

Planning for the future, United announced one of the year's largest purchase orders, 30 600-mile-an-hour McDonnell Douglas DC-10s with an option on 30 others. Total cost of the orders will be $465,000,000, including engines. The DC-10 will carry up to 266 persons and will be powered by 3 General Electric CF6/36 turbofan engines which produce a take-off thrust of 39,500 pounds each.

Anticipating the intricate pilot training that will be necessary for the subsonic jumbo jets and the supersonic transports, United during the year opened a new Flight Training Center at Stapleton International Airport at Denver.

The 289,000-square-foot complex includes 16 operational simulators, classrooms, administrative offices, a library and a cafeteria. Cost was $7,500,000 for construction with another $22,500,000 invested in capital equipment installed at the training center.

United in 1968 also made public its plans for a $160,000,000 expansion of the San Francisco Engineering and Maintenance Base over the next 10 years. The expansion will range from new hangars and specialized workshops to offices and ground equipment. Personnel requirements will grow from 1968's 12,000 persons working in the Bay area to 24,000 by 1975.

Planned construction stages included an estimated $100,000,000 for construction, tooling and equipment by the end of 1971; a $25,000,000 expansion in 1972-75; and $35,000,000 in 1976-80.

While United was further modernizing its ground facilities and its fleet, it also was taking steps in the fashion field to make certain its stewardesses matched the sophistication of its equipment.

A $3,000,000 stewardess ensemble was introduced, representing the largest contract of its kind in aviation history. The wardrobe, worn by United's 5,000 stewardesses, was designed by Jean Louis, a Los Angeles couturier known internationally for his work in the motion picture industry. Louis selected Miami Sands, Maliblue and Hawaiian Sunset as basic color schemes for the ensemble. It appeared on-line at midyear. United initiated the concept of women cabin attendants in 1930 and the new ensemble represented the 10th wardrobe change in the airline's history.

On the traffic front, United's 1968 operations showed increases in passengers, revenue passenger miles, and cargo volumes.

Estimates late in the year showed total passengers for 1968 reaching 27,284,000, an increase of 14 percent over 1967. The airline flew 22,352,000,000 revenue passenger miles during the year for a gain of 19 percent over 1967, while cargo ton-miles totaled 664,191,000 (including Military Airlift Command operations) for an 18 percent increase.

At year-end United's fleet included 25 Super DC-8s, 13 DC-8F jet freighters, 58 standard DC-8s, 86 Boeing 727s, 37 Boeing 727QCs (quick change), 19 Boeing 727-222s, 35 Boeing 737s, 20 Caravelles, and 21 Viscounts.

UNIVERSAL AIRLINES

Universal Airlines began operation of 2 250-passenger DC-8-61CFs in October 1968; they were being used in commercial and military passenger operations. In October, Universal commenced MAC international passenger trips to Europe under a fixed contract which was to run through June 1969.

The company started commercial passenger service with the DC-8s in the latter part of the year. Under its supplemental certificate, Universal was authorized to provide such service throughout the 50 states and to Mexico and Canada. Both inclusive tour programs and single-trip charters were being operated. Sales offices were maintained in New York, Chicago and Detroit.

Cargo carriage continued to be Universal's largest source of revenue in 1968. During the 12 months ended June 30, 1968, approximately 142,000,000 cargo ton-miles were flown. The company operated cargo airlift service during the year for the Department of Defense, including the U.S. Navy Quicktrans system and a portion of the U.S. Air Force Logair system.

During the year the company continued to provide a substantial parts distribution service for the automotive manufacturers General Motors, Ford and Chrysler. Universal's facility at Willow Run Airport near Detroit was the focal point of the automotive operation, but service was also provided between several other points in the eastern half of the U.S.

The company's modernization program progressed with delivery of Electra freighters in addition to the DC-8-61CFs. Completion of the Electra program in mid-1969 was to give Universal 13 of the planes in military and commercial service. The company was also acquiring 2 additional Argosy AW-650 turboprop aircraft for a total of 8 in its fleet. At year-end approximately 1,500 Universal employees were stationed at 14 locations from coast to coast in the United States.

WESTERN AIR LINES, INC.

A major expansion in Western's jet fleet broadened the base of the airline's service throughout its 44-city system which covers 12 western states, Alaska, Canada and Mexico.

The company's expansion was slowed somewhat by a delay in the delivery date of the Boeing 737 twin-jets and the 707-347C intercontinentals ordered by the company. By the end of 1968, however, 17 twin-jets and all 5 707s were in operation. Thirteen more 737s were scheduled for 1969 delivery, along with 6 Boeing 727-200s.

Delivery of the new planes allowed Western to retire the remaining DC-6Bs and Lockheed Constellations. Three of the company's 12 Lockheed Electras were converted to all-cargo and 5 to dual cargo-passenger configuration for use on Alaskan routes, replacing the Connies.

Net effect of these equipment changes was improvement in service and schedules throughout the system. This, in turn, allowed greater flexibility in aircraft maintenance scheduling.

Most of the new aircraft were delivered in time to handle adequately the big volume of passengers Western carried to Mexico for the Olympic Games. During the 24-day Olympic period, the airline carried more than 18,600 passengers on its Mexican routes. This included carrying the entire U.S. Olympic team, as well as members from many other national teams.

Another improvement in Western's service was on the Denver-Calgary route. As a result of a Civil Aeronautics Board recommendation, approved by the White House, Western was given authority to fly nonstop between the 2 cities. Previously these flights were required to stop en route at Great Falls.

Removal of this restriction and the inauguration of nonstop service with 4-engine 720B aircraft on December 1 were welcomed particularly by the oil industry, which constantly flies personnel between oil centers in Canada and the southwestern region of the United States.

In other route case developments, the CAB examiner in the Transpacific case recommended Hawaii routes for Western from most of the major U.S. cities served by the airline. A final decision in the case from the White House was pending.

A board examiner in the service to Albuquerque case recommended Western for Albuquerque routes from San Francisco and Las Vegas. That case was under consideration by the board.

An exemption authority was granted Western to fly nonstop between Minneapolis/St. Paul and Las Vegas, and Twin Cities-Phoenix-San Diego.

Western was awaiting the outcome of the Southern Tier case, in which it was seeking routes from California to Florida across the southern states.

The airline was participating in numerous other route cases, the most important being the Northern Tier case and the Omaha-Des Moines case. In the Northern Tier case, Western was seeking East Coast-West Coast route authority via the Twin Cities. The Omaha-Des Moines case also involved routes to eastern cities.

Changes in Western's board of directors included the election of Arthur F. Kelly as the airline's senior vice president of sales. He succeeded Alexander Warden, who retired as an active board member for reasons of health but remained as director emeritus.

On the financial side, Western earned a net profit of $10,721,000, or $2.19 a share, for the first 9 months of 1968. This compared with $10,959,000, or $2.24 a share, for the like period in 1967.

Operating revenues were $167,553,000, compared with $144,230,000. Expenses were up at $144,323,000, from $121,748,000. Load factor for the period was 57.1 percent, compared to 58.6 percent. The break-even point was 49.9 percent, versus 49.6 percent.

The number of Western employees increased to 8,781 from 7,188 a year earlier.

Western's fleet at year-end numbered 64 aircraft. This included 27 Boeing 720Bs, 3 720s, 5 707-347Cs, 17 Boeing 737-200 twin-jets and 12 Lockheed Electra IIs.

WORLD AIRWAYS, INC.

World Airways made noteworthy advances in all phases of its operations in 1968 and laid the groundwork for significant accomplishments in the years ahead.

In October the company announced plans for an exchange of the outstanding stock of World for stock in INA Corporation (Insurance Company of North America). World offers INA a unique opportunity to capture a prime position in the burgeoning travel market. World, on the other hand, will have access to the financial resources of the long-established and highly respected Philadelphia-based company for building and broadening the market potential for commercial services.

Earlier in the year World acquired First Western Bank and Trust Company, which has headquarters in Los Angeles. The bank has more than 80 branches throughout California and assets of approximately $900,000,000.

The future of inclusive tour charters was placed on a firm course when President Johnson signed into law legislation reaffirming the Civil Aeronautics Board's authority to sanction international inclusive tour charter flights by World and other U.S. supplemental airlines.

World and Berry World Travel of Kansas City, Missouri, signed a contract for the third consecutive year covering a 1969 program of inclusive tour charter flights to Hawaii, California and Las Vegas valued at approximately $9,000,000 in total tour revenues.

The schedule involved 113 round-trip tours with all flights to be operated with World's fleet of 707 intercontinental fanjet aircraft. It was more than double the first program of 1967.

In one of the largest programs of its kind ever undertaken, World took more than 2,000 vacationers to South America in February and March. Each flight transported participants on 2-week visits to Ecuador, Chile, Argentina and Brazil. An even more extensive program was planned for 1969 and beyond.

Another important step in World's jet fleet development plans took place during the third quarter. The Boeing Company rolled out the first 747 superjet, capable of carrying up to 490 passengers. Three of the 747s will be delivered to the company in the spring of 1971 and an option was taken on a fourth. World accelerated its planning and organizational activities in preparation for the 747 deliveries. A special department was established and its personnel were working closely with manufacturers and suppliers of ground support requirements.

World served as a Military Airlift Command contractor, receiving a guaranteed minimum award for international MAC operations and domestic Logair operations of $29,700,000. Of this total, $27,000,000 represented the amount for international MAC operations.

World again received the National Safety Council's highest safety award for airlines, the Award of Honor. World also had received the award for flight safety for the years 1964, 1965 and 1966. This outstanding safety record enabled World not only to enjoy the respect and compliments of the industry but also to realize reduced insurance rates.

New offices were opened for further development of commercial sales. The company opened its first Canadian office, in Toronto, in midyear. An office was also opened in Atlanta, Georgia, in November. Addition of these offices expanded World's international network of sales offices and representation to 7 nations plus Hawaii and coast to coast in the continental United States.

As part of its responsibilities to the community, World has long engaged in its own programs aimed at hiring underemployed minorities. Thus, when the National Alliance of Businessmen was formed at the urging of President Johnson to attack the problem nationwide, World accepted an active role. World's president, Edward J. Daly, was appointed metropolitan chairman for the Oakland/East Bay area. Substantial programs were made in the sector of JOBS (Job Opportunities in the Business Sector) as an increasing number of Oakland/East Bay firms joined NAB's continuing effort.

An Affirmative Action program was initiated in the third quarter. This program seeks to achieve equal employment opportunity in all aspects of employment with World, for both present and prospective employees. Purpose of the program is twofold: to provide maximum opportunity for present employees, and long-term job opportunities for the hard-core unemployed or underemployed residents of the Oakland/East Bay area.

In August 1968 President Johnson named Mr. Daly an incorporator of the National Housing Partnership. The partnership, authorized under a 1968 Act, provides a means for companies to share risks and gain tax benefits in investing in publicly supported housing efforts. It is designed especially to pump badly needed mortgage money into low-income projects and blighted areas in the cities.

In 1969 World begins its 21st year of growth and development. Under its present management for the past 18 years, World's fleet has grown from 2 war-surplus piston aircraft to 15 of the most advanced type of commercial jets. In the pending association with INA Corporation, the company fully expected to move ahead in the next 20 years with even greater achievements.

VERTICAL LIFT AIRCRAFT

Use of helicopters by the military and by industry, law enforcement agencies and foreign governments and operators increased markedly in 1968.

Helicopters have become an integral part of the Army, Navy, Marines and Air Force in Vietnam combat zones, and on the home front they continue as versatile rescue vehicles for the Coast Guard.

The armed helicopter proved itself on the combat team. Carrier based, the armed helicopters (Kaman Seasprite) were performing search and rescue flights for downed Navy airmen and, equipped with 200-foot hoist cables, were making rescue pickups in jungle areas.

The strike gunship (Bell HueyCobra) in one year of operation proved itself under heavy combat conditions. Also in one year, the light-observation turbine-powered Hughes Cayuse flew more than 125,000 combat hours.

In 1968 the Army's more than 3,300 rotary-wing aircraft continued to provide the mobility to move troops across rivers and over mountains, jungles and wasteland, and to provide fire support, reinforcement, resupply, evacuation, command and control, communications and intelligence information.

The Army's medical helicopters continued to set new records. From January to August 1968 the 100-plus helicopters accomplished over 140,000 medical evacuations. Since 1962 there have been over 322,000 medical evacuations.

To demonstrate the possible civilian application of the Army Medical Department's use of helicopters, in 1968 the Army Medical Department, with the cooperation of Vertical Lift Aircraft Council member companies, prepared a graphic exhibit of the Army's rescue helicopters in Vietnam and the civilian models of these Army helicopters as air ambulances, or medicopters, patrolling the U.S. highways and transferring accident victims to hospital heliports. This exhibit was first displayed at the 1968 American Hospital Association convention and later at other medical and trade association conventions.

Test demonstrations of the civilian application of the military medical rescue helicopters authorized under the Highway Safety Act of 1966 were being implemented with matching federal and state funds.

In 1967 Pennsylvania was the first state to conduct a helicopter highway test under the National Highway Safety Act. In 1968, there were these new funded programs:

• The City of Detroit and the University of Michigan had a $317,000 grant to increase the effectiveness of the Emergency Medical Service system through implementation of new and on-going technologies, which were to include TV surveillance of prime expressways, citizen band radio reporting, modified ground ambulance services, initiating use of the helicopter for accident reporting and medical services, paramedic training and computers for data storage.

• The State of California and the University of California at Los Angeles had a grant of $995,500, funded for 4 years, to develop a flexible, comprehensive methodology for evaluating and improving emergency medical service systems and to demonstrate its utility by examination of the existing system in the Los Angeles region.

• The State of Nebraska, with a grant of $315,000, through the cooperation of the Army National Guard and the university's College of Medicine, was seeking to expedite treatment by bringing the hospital's expertise to the helicopter and victim as soon as he is loaded aboard. The key is telemetering signals of the patient's vital functions and bodily conditions, via transducers and radio, to a central computer in Omaha, Nebraska. The computer reduces the data into meaningful form for the monitoring physicians, who then radio treatment instructions to the helicopter attendant.

• In other developments, a test was proposed to patrol the rural highways around Phoenix, Arizona; the New Jersey Highway Patrol ordered helicopters for highway patrol; and North Carolina was proposing a helicopter program to transport patients from outlying communities to the Durham Medical Center.

Other test programs without federal funds were in operation. In San Diego County, California, the American Oil Company was cooperating, as a public service, with county agencies in providing a helicopter highway patrol. In Indianapolis, Indiana, there was a unique combine of city, county and metropolitan governmental agencies providing what may be the first multi-office public service helicopter operation. And in January 1968 the Illinois State Toll Highway, financed by revenue bond, began operating a helicopter to patrol the 187 miles of 3 separate tollways. Almost 115,000,000 vehicles used this major commuter route for Metropolitan Chicago in 1968. Operating night and day, the helicopter, in addition to traffic survey and patrol, demonstrated the towing of a burning vehicle from an accident area, deplaned a policeman and dog to search for a lost child and controlled crowds using the helicopter's loudspeaker. Plans were being made to equip the helicopter as an ambulance.

In 1965, based on a Vertical Lift Aircraft Council survey, there were 34 hospital heliports in the country. At year-end 1968 there were 186 established and 38 proposed landing facilities for this modern aerial ambulance, the medicopter, to transport highway accident victims to the hospital, emergency cases from community hospitals to medical centers for specialized treatment and doctors and nurses to hospitals during heavy snows or when disaster strikes.

The 1968 Directory of Heliports/Helistops in the

United States, Canada and Puerto Rico, compiled by the Vertical Lift Aircraft Council, revealed that the number of established heliports had increased fivefold since 1960. The directory listed 1,892 heliports, of which 158 were proposed. Three new major city-center heliports were listed in the 1968 directory, at New York City, Seattle, Washington, and San Francisco, California. More than half of the heliports listed in the 1968 directory were privately owned, a fact which points to the need for more city-center, public heliports and the requirement for designation and marking of heliports on publicly owned airports. Progress in those 2 areas, VLAC said, can greatly increase utilization of the helicopter as a short-haul and intrametropolitan VTOL transport, as well as help alleviate current airport congestion.

Michigan's Superior Ambulance Service, serving a 75-mile radius of Detroit, was the first land ambulance service in the country to add a helicopter to its fleet. Superior found the ambulance helicopter excellent for the transport of persons with back or head injuries, for cardiac cases and for the transfer of patients from suburban or community hospitals to a medical center where specialized treatment is available.

The year marked the 20th anniversary of the New York Police Department's use of helicopters. At year-end more than 40 city police departments were operating helicopters. The crime 'copter, pioneered by the City of Lakewood, California, was providing 24-hour-a-day crime preventive patrol in more than 35 cities. Equipped with high-intensity searchlights, helicopters were used during the 1968 political campaigns to help provide maximum security for candidates during night parades.

Nearly 500 U.S. industries were operating helicopters. These companies represented a wide variety of American businesses including oil companies, manufacturers, construction firms, banks, radio and TV stations, automobile dealers, public utility companies, ranches and even such enterprises as bakeries and music stores. The corporate 'copter was also serving as a "good neighbor" in the community by assisting the police and fire departments in time of emergency, giving flight demonstrations to high school aviation classes, helping track down criminals and providing emergency transportation for doctors.

With this increased industry use and the continuing military requirement for helicopters, the Census Bureau reported that for the first 8 months of 1968 the number of units of helicopters exported was up 30.2 percent over 1967 and the dollar volume was up 79.7 percent.

Twelve of the 14 member companies of the Vertical Lift Aircraft Council had 83 models in production, ranging in size from one to 72 places. In addition, there were 21 flight test, research and development models.

Since 1965 the Chinook transport helicopter in Vietnam has recovered more than $1 billion worth of downed aircraft and the Sea Knight helicopter has airlifted Navy jets from repair bases back to their home bases. The Skycrane heavy-lift helicopter was credited with having retrieved 384 downed aircraft valued at $210,000,000.

The civilian application of these military heavy-lift helicopters was again demonstrated in heavy construction work in such operations as airlifting a complete ski lodge to a mountaintop, installing power-line poles and offshore unloading of cargo.

Fire chiefs reported that the average hook-and-ladder equipment can only reach 8 stories and that the helicopter offers potential in combating fires and rescuing tenants from modern high-rise buildings. The helicopter performed successfully in tests of these operations.

Following issuance of the August 31, 1966, Civil Aeronautics Board order to investigate and determine requirements for a proposed Washington/Baltimore service, 9 applications were filed. After hearings, on November 21, 1968, the Civil Aeronautics Board approved the application of Washington Airways, Inc., to provide service between downtown Washington, D.C., and the 3 area airports—Friendship International, Dulles International and Washington National. Washington Airways, Inc. (a consortium of Allegheny, American, Eastern, United, Trans World, Pan American, Northwest, Mohawk and Northeast airlines), was directed to inaugurate service January 21, 1969.

GENERAL AVIATION

The year 1968 was one of particular significance to the diverse general aviation community, which comprises all aviation in the United States with the exception of the airlines and military aviation. During the year, manufacturers showed an 18.4 percent increase over 1967 in dollar volume; use categories became increasingly apparent, particularly in the air taxi-commuter area; ab initio student starts were down slightly but 20,000 licensed pilots began upgrading their ratings under the GI Bill; the number of flights and total flying hours increased over the previous year but safety rates continued to improve; manufacturers increased their efforts in air-age education in the school system; and common problems facing air transportation resulted in the general aviation community's becoming more active in aviation affairs.

In 1968 general aviation aircraft manufacturers produced 13,698 aircraft with a value of $425,682,000 (manufacturers' net billings), an 18.4 percent increase over the previous year. Net profits declined slightly as the result of expanded manufacturing facilities and increased model lines. The labor force increased to more than 25,000 workers, up 1.3 percent over 1967. Of the aircraft produced, more than 2,000 were twin-engine types.

Export sales continued strong in 1968 with retail sales of $91,000,000 for 2,807 aircraft. The reason for continuing high exports was brought out in a statement by the Office of Aviation of the Department of State: "The competitiveness of American aircraft, their ease of operation and maintenance, their versatile uses, and their reliability is made evident throughout the world, constituting at least 85 percent of the world's general aviation fleet."

Even with normal attrition and aircraft temporarily ineligible, the general aviation fleet continued to grow. At the end of 1967, it was estimated at well over 114,000 by both the FAA and industry spokesmen. Industry estimate of the fleet at the end of 1968 was nearly 126,000 aircraft. More than 100 models were being offered, ranging from specialized agricultural aircraft to highly sophisticated reciprocating and turbine-powered aircraft.

General aviation continued to develop clearly defined areas in the use of aircraft. These were brought into focus in September 1968 when the FAA released data compiled for 1967 on use categories and number of hours flown by each. It also showed an increase in the total number of flight hours over what the FAA had previously estimated for 1967. The report showed business and executive flying at 5,000,000 hours; personal flying, 6,800,000; agricultural, 1,100,000; flight instruction, 5,700,000; air taxi-commuter, 1,700,000; industrial, special and others, 1,600,000, for a revised total of nearly 22,000,000 hours.

At the beginning of the year, there were some 200 air taxi or commuter organizations but the number grew to more than 270 by the end of the year. Many airlines increased their recommendation of such service to their own customers and several had working agreements with air taxi companies. More than 70 air taxi companies were offering scheduled service.

One reason for the rapid growth of the air taxi-commuter market was the availability of newly designed aircraft with high-density seating and low operating costs. Several such models were introduced in 1968 and acceptance was excellent.

During 1967, 159,399 student starts were recorded by the FAA. While for the first 11 months of 1968, only 140,000 student starts were recorded, 20,000 veterans who already were licensed began training under the GI Bill. Under the bill, veterans who already possess valid private pilot licenses may use their benefits to go on to commercial, multi-engine, instrument and AT ratings. This was proving a benefit to flight training schools since a veteran may need from 180 to 200 hours' training while the average ab initio student needs from 40 to 60. Flight training hours were up sharply although year-end data was not available at press time.

The midyear FAA traffic count at airports where control towers are maintained showed that for the second consecutive year an airport without airline service headed the list as the busiest civil airport in the world. Traffic movements are recorded by the FAA at only 515 of the nearly 10,000 airports in the United States. Three of the 4 busiest airports, according to tower traffic count, either have no airline service or average fewer than 7 scheduled departures a day.

General aviation hours flown in 1968 were estimated to be 25,000,000, a 14 percent increase over 1967, which showed a 26 percent increase over the previous year. Again, industry observers contended that this estimate, which carried general aviation aircraft more than 3 billion miles, is "conservative."

Manufacturers continued to emphasize air-age education in the nation's school system. While the number of schools offering some form of aviation education, ranging from actual flight training to information courses on aviation and aerospace, continued to increase, industry leaders made a greater effort to provide support material. Most major manufacturers had an education specialist on their staff, some having developed operating departments to work with the schools in the development of programs.

Not generally understood by the rank and file of the public is the essential nature of general aviation to the nation's total air transportation economy. Whereas the airlines provide scheduled service to about 550 places in the continental United States, there are more than 10,000 airports. The FAA has estimated that in intercity travel alone, general aviation carries at least 50 percent as many passengers as the airlines. General aviation is the connecting link between major air traffic hubs and the hundreds of other places which have infrequent scheduled airline service and the thousands of places which are completely dependent on general aviation to connect them by air with every other place in the nation where there are airports.

The year brought special problems to aviation, particularly that of congestion at hub airports. The continuing growth in the number of people traveling by air, either in their own aircraft or as fare-paying passengers, increased the strain during peak hours at some airports. Because of the public's lack of knowledge about the air transportation structure, certain segments of the aviation community were increasingly singled out as causing the congestion. As a result, every segment of the aviation community made a strong effort to get the true picture to the American public. While the problems still existed at year-end, equitable solutions appeared to be closer than during the crisis period in July.

CESSNA the capability company

Newest Cessna facility is at Strother Field, southeast of Wichita, Kansas, where high-volume two-place Model 150 is made.

Military and Twin Division, Wichita, manufactures commercial twin-engine models, plus military aircraft and subcontract work.

Largest of Cessna's plants is Commercial Aircraft Division, Wichita. Construction now under way will bring total square footage to 1,240,300. This plant produces twin-engine Super Skymaster and most single-engine aircraft.

Cessna produces more aircraft than any other company in the world.

Cessna is the leading producer of general aviation airplanes and also ranks high in manufacture of military aircraft and other products for defense.

Cessna is out front in the design and manufacture of fluid power components for farm and materials handling equipment.

Cessna is a leading source of airborne communications and navigations systems. And Cessna is also number one in the manufacture of propellers and aircraft power accessories.

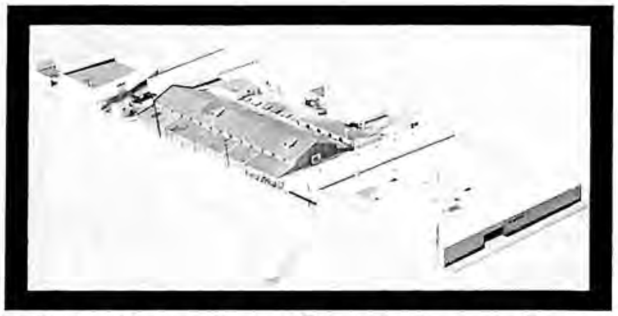
But Cessna's real business is building capability —capability with which to meet its real challenge to create enough people-plus-plant power to realize the full potential of world wide markets. In the past three years alone, more than 1,200,000 square feet of plant and office space has been added, bringing the total to more than three million square feet. A totally new plant has been added at Strother Field, southeast of Wichita, Kansas. A new Engineering center is well under way in Wichita. All of the seven principal company facilities have shared in a $23 million expansion and improvement program.

At the same time company people-power has been strengthened, expanded, enriched.

Cessna is building its own future...and the future of the communities of which it is a part...by building capability...a positive product of Cessna's faith in the future.

New Reims Aviation plant in France produces three Cessna models for markets in Europe, United Kingdom and North Africa.

Cessna Industrial Products, Ltd., Glenrothes, Scotland, produces fluid power products for overseas markets.



McCauley Division, Dayton, Ohio, is leading propeller producer, also produces variety of aircraft components.

Aircraft Radio Corporation, Boonton, N.J., provides airborne communication, navigation, and aircraft guidance systems.

Growing volume of fluid power products for farm machinery and industrial equipment is produced by Industrial Products Division, Hutchinson, Kansas.

Cessna

THE CAPABILITY COMPANY

An Aerospace Capabilities Report on Beech Aircraft Corporation

BEECH SUBCONTRACT CAPABILITIES...

used by major manufacturers for aerospace since 1943

The complete airframe for the Bell Model 206 JetRanger helicopter is manufactured by Beech.

Winner of an Army competition for its new light observation helicopter OH-58A and selected by the Navy as its new primary training helicopter (TH-57A), this turbine-powered JetRanger depends heavily on Beech manufacturing capabilities. Under contract with Textron's Bell Helicopter Company, Fort Worth, Texas, Beech will provide complete airframes which will include the following components:

Pylon cowling – one piece fiberglass construction.

Engine cowling – honeycomb fiberglass construction, hinged for engine accessibility.

Aft fuselage – titanium engine pan, aluminum honeycomb bulkhead. Forward bulkhead forms rear wall of fuel-cell compartment.

Tail boom – monocoque sheet metal tube, rolled and riveted. Riveted brackets support drive shaft and internal push-pull control rod.

Seat -- honeycomb, designed to 25G impact loads with energy absorbing yield beyond the design point.

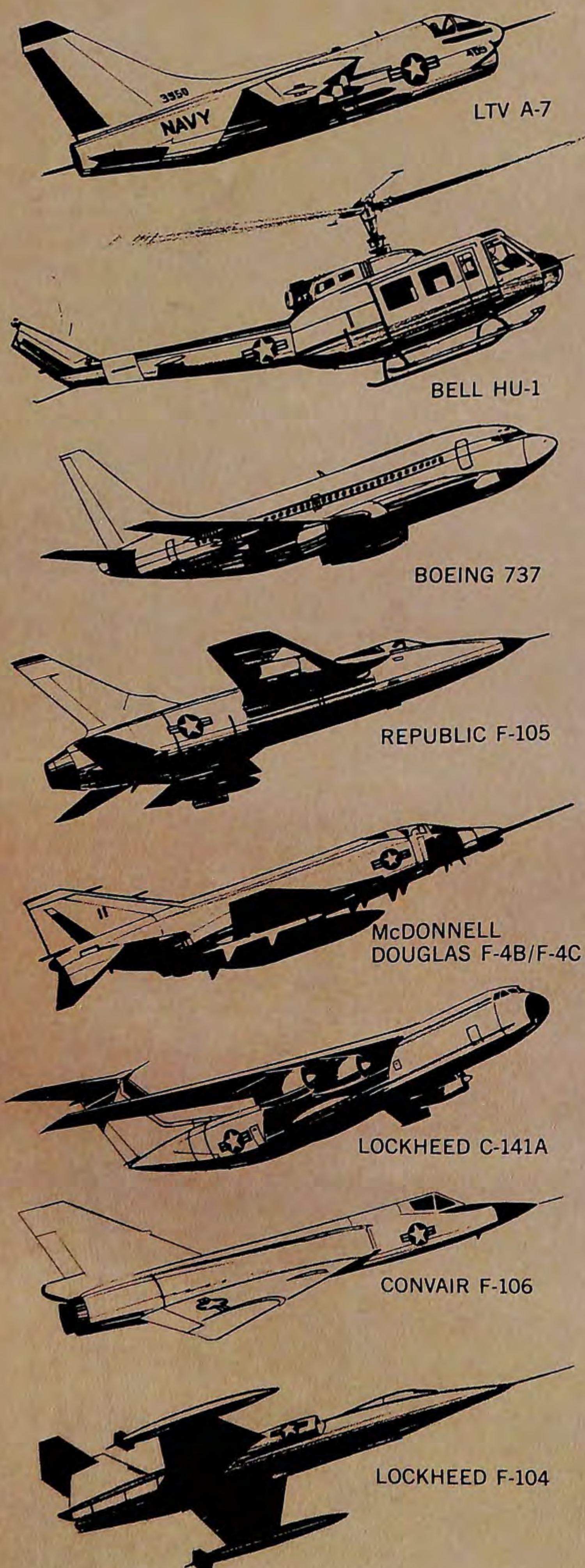
Main fuselage – unique "bathtub" design made of a single piece of one-inch thick aluminum honeycomb sandwich. Bulkhead attach angles are bonded to pan.

Skid gear – aluminum tubes bolted to round extruded crosstubes. Crosstubes are streamlined with Kydex fairing.

Turnover structural bulkhead – riveted sheet metal structure with integral column. It provides primary structural continuity between honeycomb roof and floor.

Bulkhead – aluminum honeycomb structure.

Doors – formed polycarbonate and lightweight metal shapes.



A brief history of Beech contributions to the United States Air Fleet . . .

Beech subcontract history started in 1943 with the production of 1,600 complete sets of wings for the Douglas A-26 Invader. Since then, nearly all major military aircraft manufacturers have used Beech capabilities for engineering, tooling and production. A partial list of the aircraft to which Beech contributed includes: F-94C, T2V, T-33, B-70, B-58, F-101, F-102 and F-84.

Current and recent production for both military and commercial aircraft is as follows:

LTV A-7—chemical milling.

Bell HU-1—honeycomb metal bonded panels (74 different types).

Boeing 737—metal-to-metal bonded honeycomb panels.

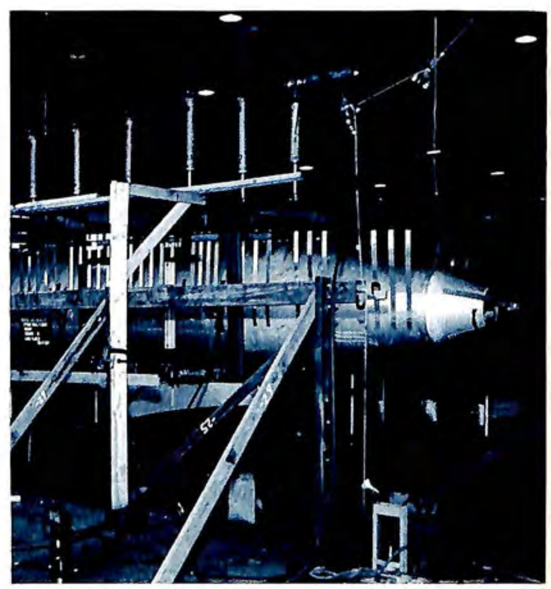
Republic F-105—ailerons and aft fuselage.

McDonnell Douglas F-4B/F-4C—ailerons, flaps, speed brake doors, spoilers and landing gear doors.

Lockheed C-141A—flaps, ailerons, nose landing gear doors, emergency exit doors and wing spoilers.

Convair F-106—aft fuselage, wing fences, radar compartment, windshield, canopy, missile bay doors, elevons, wing leading edges, wing tips, dorsal fairings and vertical fins.

Lockheed F-104—aft fuselage and fuel tanks.



Over 150,000 external stores have been produced for a wide variety of current military aircraft. Beech has furnished research, development and production on external stores ranging in tank capacity from 110 gallons to 1,700 gallons.

Beech Fields of Capability Cover the Spectrum of Aircraft and Flight Equipment...Research, Development and Engineering

From basic research through manufacture and testing, Beech Aircraft Corporation has the facilities and capabilities to accept complete systems management assignments.

A summary of Beech capabilities in Aircraft and Flight Equipment is shown in check-list form below. Complete information on specific facilities, related experience and personnel in any category is available upon request. This summary is similar in organization to the various R&D Source Information and Survey forms such as DD Form 558-2 issued by the Department of Defense, and AFSC Form 220.

AREA OF CAPABILITY	RESEARCH	EXPLORATORY & ADVANCED DEVELOPMENT	PRODUCT ENGINEERING
AIRCRAFT AND FLIGHT EQUIP			
AIRCRAFT INSTRUMENTS			
Flight Test		X	X
AIRCRAFT DESIGN			
Aerodynamics			
Aerodynamic heating at high Mach numbers	X	X	X
Transition from laminar to turbulent flow in boundary layers		X	X
Skin friction		X	X
Physical and chemical properties of air at high temperatures			X
Shock waves and their interaction with boundary layers		X	X
Supersonic pressure phenomena		X	X
Interference of aircraft components			
Inlet location			
Jet exit location			
Lift development			
Friction drag and aerodynamic heating	X	X	X
Maintenance of laminar flow			
Factors affecting boundary layer transition			
Gas Dynamics			
Hypersonic flow			
Temperature simulation			
Ballistic ranges			
Control Systems			
Mach number, angle of attack effects on static stability	X	X	X
Mach number, altitude effects on dynamic stability	X	X	X
Effective aircraft control through Mach number range	X	X	X
Stall improvements for high performance configurations	X	X	X
Stability augmenters			
Powered controls		X	X
Artificial stabilization and motion limiting		X	X
Human pilot control and tracking capabilities		X	X
Control through automatic pilots		X	X
Automatic tracking		X	X
Gyro		X	X
Special type aircraft (Aerodynamics)			
Lift augmentation		X	X
Research equipment and techniques		X	X
Targets			
AIRCRAFT STRUCTURES	X	X	X
Theory	X	X	X

AREA OF CAPABILITY	RESEARCH	EXPLORATORY & ADVANCED DEVELOPMENT	PRODUCT ENGINEERING
Design			
Aircraft loads	X	X	X
Vibrations and flutter	X	X	X
Structural materials applications	X	X	X
Structural techniques	X	X	X
Testing	X	X	X
Stress Analysis	X	X	X
Criteria	X	X	X
FLIGHT OPERATING PROBLEMS			
Special Techniques		X	X
Aircraft noise		X	X
Jet noise			
Boundary layer noise			
Propeller noise			
Effects of noise on structures			
Attenuation of noise			
Flight Safety		X	X
Meteorological aspects			X
Atmosphere turbulence			X
Icing problems			X
Environmental Protection			
Crew and equipment protection			X
FLIGHT SAFETY			
Approach visibility		X	X
Turbulence		X	X
Research equipment and technique			
Landing problems		X	X
Fire			X
Gust alleviation			X
Optimum flight paths		X	X
Airspeed measuring systems		X	X
Spin hazards and recovery		X	X
Engine performance and reliability			X
Thrust reversal			X
Foreign object damage to engines			X
Pilot escape	X	X	X
Ejection seats			
Capsules			
Escape systems components			
High altitude, high speed escape			

AREA OF CAPABILITY	RESEARCH	EXPLORATORY & ADVANCED DEVELOPMENT	PRODUCT ENGINEERING
Parachutes			
Crash survival		X	X
LIGHTER THAN AIR			
PROPELLERS AND ROTORS			
Application and performance studies			
Conventional, high subsonic	X	X	X
Vertical take off and landing			
Short take off, landing		X	X
Design and development			
Stability and control		X	X
Pitch change and control	X	X	X
Accessories			X
Test facilities			X
ROTATING—WING AIRCRAFT			
VULNERABILITY STUDIES		X	X
EXPANDABLE STRUCTURES			
Applications			
Re-entry		X	X
Ballistic		X	X
Landing Impact Devices			
Flotation Aids		X	X
Space Vehicles			
Atmospheric Vehicles			
Marine Structures			
SUPPORT TECHNOLOGY			
Erection and Stabilization			
Materials			
Structural		X	X
Non-Structural		X	X
Lubricants			X
Structural Analysis			
Basic Theory		X	X
Applied		X	X
MANUFACTURING PROCESSES			
Weaving			
Joining and Seaming	X	X	X
Coatings		X	X
Surface Finishes		X	X
Metalcraft		X	X

Extensive Beech Manufacturing Facilities . . .

The Beech machine shops occupying nearly 60,000 square feet, are equipped with standard and special machines oriented to the aerospace industry. These include milling machines with

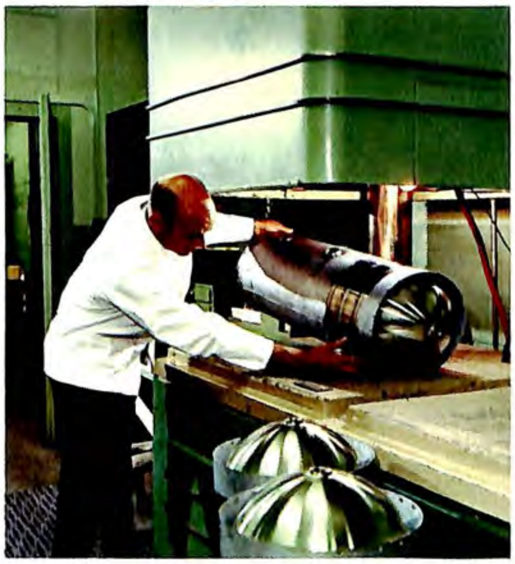
Examples of honeycomb structures produced at Beech:

SANDWICH STRUCTURES

Type of Core	Face Sheet Material	Adhesive
Paper Honeycomb	Formica Plastic (Wood Grain Pattern)	Bonded
Paper Honeycomb	Fiberglass	Bonded
Fiberglass Honeycomb	Fiberglass	Bonded
End Grain Balsa	Aluminum Alloy	Bonded
Aluminum Alloy Honeycomb	Aluminum Alloy	Bonded
Aluminum Alloy Truss Grid	None	Bonded
Titanium Alloy Honeycomb	Titanium Alloy	Brazed
Steel Honeycomb	Steel	Welded

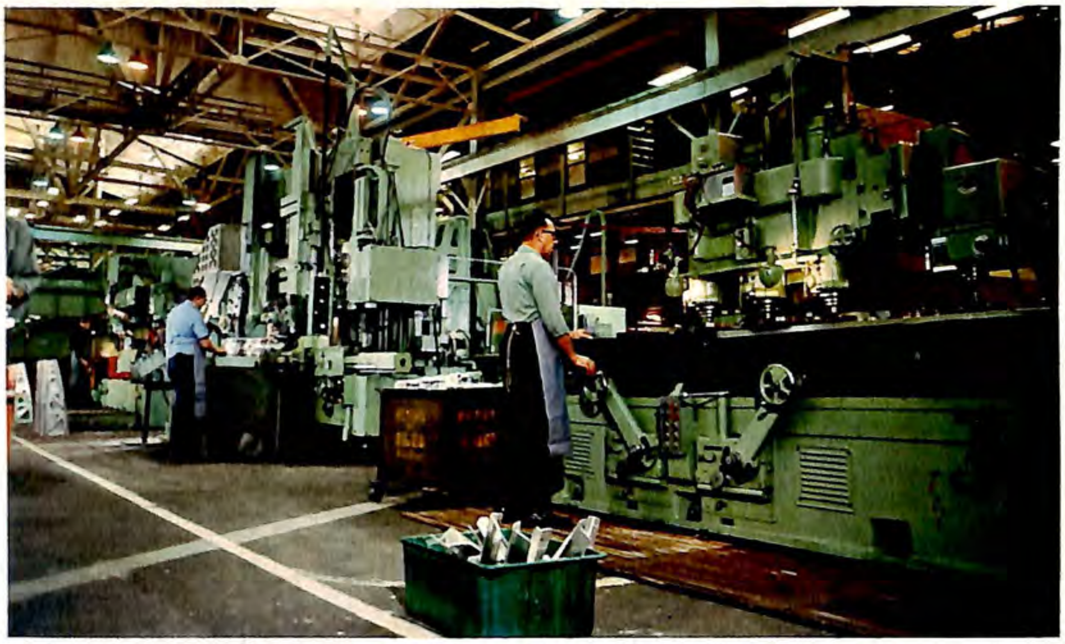
Chemical Milling for precision milling of aerospace metals (aluminum, magnesium, titanium, inconel, steel and stainless steel) to unconventional design specifications has developed to extensive capability at Beech. Among the largest in the U.S., 167,340 parts were produced here in 1967. Facilities include cleaning, rinsing and washing equipment. The tanks, in sizes up to 14 feet long and 14 feet deep, are equipped with automatically timed taper hoists.

The complete bonding facilities (metal-to-metal and metal-to-honeycomb) at Beech are capable of manufacturing assemblies of metal, reinforced fiber, plastic and paper. All layup of assemblies is accomplished under "clean-room" conditions. Techniques and tools have been developed for honeycomb core shaping by machining and crushing. More than 600,000 military and commercial metal bond assemblies have been produced here.

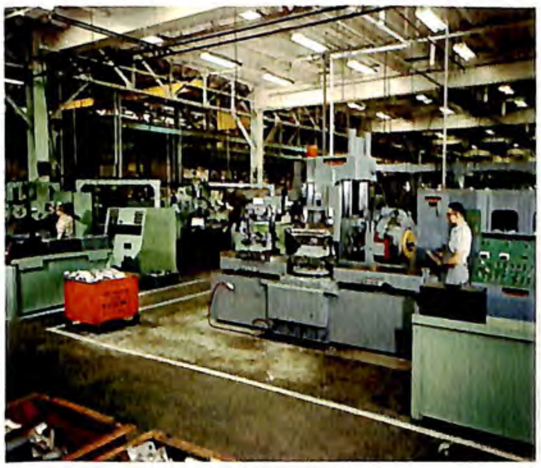


Complete X-ray facilities are available for internal examination of material. In addition, the best equipment available is used for inspection, including Fokker bond testers, tensile testers, peel testers, ultrasonic equipment, and various types of electronic and mechanical comparators, gage columns, gage blocks, angle computers, micrometers, etc.

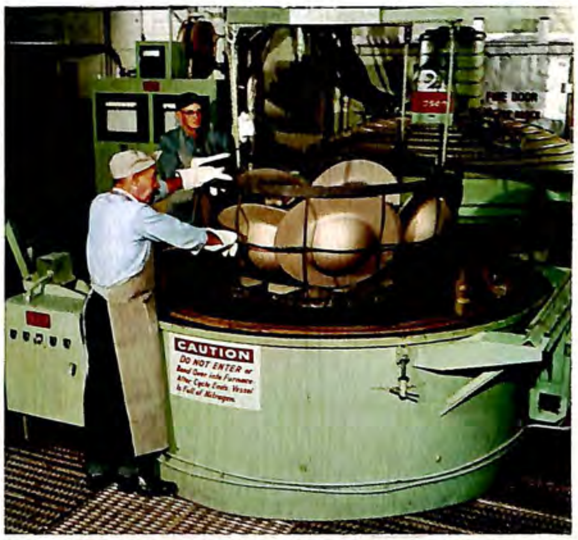
beds as long as 54 feet 8 inches, numerically controlled machines, profile milling, automatic lathes, drills, boring machines, broach machines, grinders, hones and planers.



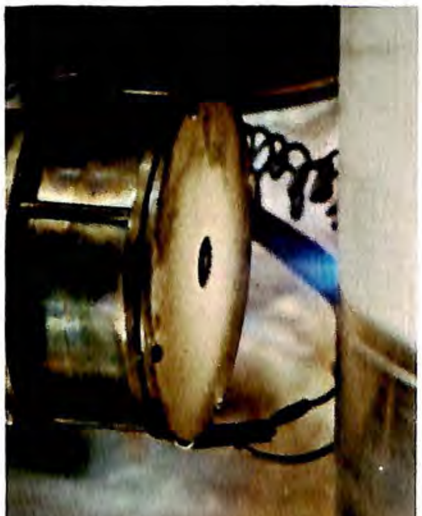
Beech machining capability extends beyond that provided by "off-the-shelf" equipment. The center machine—flanked by a three-spindle Hydro-tel and a large single-spindle Hydro-tel—has been specially adapted by Beech: It is a 72" King Vertical Turret Lathe with retro-fitted 2-axis tracing equipment, and accessories for spherical milling, drilling, angular boring, trepanning, and automatic program control. These functions are all in use in current production of highly sophisticated aerospace hardware.

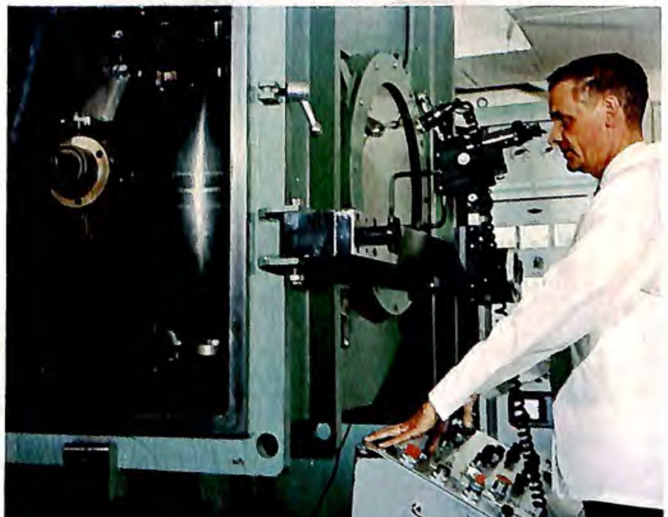


Numerically Controlled machines include the two Milwaukee Series "E" NC Mills shown on the right and the versatile Series II MilwaukeeMatic. These machines have full point-to-point positioning ability. Their special value is for turning out intricate and difficult parts, but their efficiency makes them competitive with conventional equipment on even the simplest parts. They are in daily production on commercial as well as military work.



This vacuum furnace, with automatic cycling controls and a molybdenum hearth for heat treating special space-age alloys up to 2800° F, will create vacuums up to 10^{-5} torr.





Beech electron beam welding equipment assures highly precise and dependable welding. It is especially valuable for welding the exotic materials used in the aerospace industry. This equipment is capable of welding material thicknesses from .0015" to over 2" with minimum distortion. Conventional and spot welding facilities are complete.

Complete brazing equipment comprises an important part of the weld shop facilities. Temperatures up to 2250° F can be obtained in batch-type brazing. The furnace equipment includes an endothermic generator, has provision for automatic cycling, and for either air or oil quenching.

. . . and capabilities that keep growing!

Large assembly areas are provided at each of the manufacturing plants. Overhead cranes having clearances up to 32 feet are available over a large portion of the assembly area. The Beech production riveting complement consists of approximately 67 riveting machines, including three photoeye-controlled high production General Drivmatic machines and three Chicago Pneumatic hot coin dimplers with throats up to 48 inches deep.

All types of surface treatments common to the aerospace industry are in use at Beech. Major processing facilities are available for iriditing, anodizing, alodine processing, nickel plating, chrome plating, cadmium plating, deoxidizing, hard coating, teflon coating, dry-film lubrication and dichromate processes. Vapor degrease, alkaline rinse, fresh water rinse and drying facilities are also available. In other areas specialized treatments, such as tumbling barrels, sand blast rooms, liquid honing, glass bead peening, etching, pickling, and passivating are provided.

Beech has complete tool design and fabrication facilities. The Tooling Division covers a total of 220,000 square feet. Equipment in the tool fabrication facility includes boring machines with table sizes ranging to 40 by 74 inches.

Two of these machines are in temperature-controlled areas. The tooling shop also has metal shapers, drill presses, grinders (surface, cylindrical and profile), lathes, milling machines, saws, including a traverse-type aluminum plate saw with a 4 by 12-foot capacity, and planers ranging in size up to 3 by 14-foot table.

Conversion of numerical data to master templates and forms is yet another in the broad spectrum of capabilities available at Beech. This spin-off from Beech's comprehensive Computer Section enables direct fabrication from numerical computer data.

Preparing for efficient production requires much more than merely building accurate tooling. To this end, Beech Aircraft Corporation maintains a highly skilled technical staff of Tool and Manufacturing Engineers, all of whom are a part of the Manufacturing Engineering Division.

Forming of sheet metal and extrusions is an important requirement of any aerospace facility. At Beech, forming capabilities have been developed to handle complex jobs in a wide range of materials.

Beech's aluminum sand foundry is used primarily for specialized designs and experimental castings.

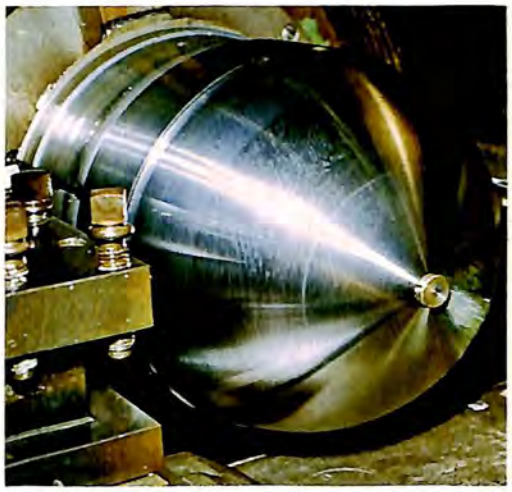
Heat-treating facilities include six aluminum heat-treat furnaces with capabilities of drop quenching and handling parts up to 9½ feet high, 8½ feet wide, and 24½ feet long. The facilities are furnished with aging furnaces having inside dimensions up to 8 feet wide, 6 feet high and 40 feet long.

Their capabilities include:

1. Pre-production Planning.
2. Producibility.
3. Manufacturing and Tooling Estimating.
4. Manufacturing Research and Development.
5. Manufacturing Methods.
6. Tool and Manufacturing Planning.
7. Equipment Engineering.
8. Conservation and Manufacturing Supplies Cost Control.

The intensive application of these professional skills—stressing manufacture with the most modern materials, equipment and methods—plays a vital role in Beech's ability to deliver high quality, on time, and at minimum cost.

In addition to the "in-plant" facilities, Beech Aircraft Corporation has available numerous accredited subcontracting tool shops that are experienced in fabricating precision tooling for the airframe and missile industry.



This Riemco power spinning lathe provides controlled roller pressures from 0 to over 350,000 pounds to the piece being formed. Blanks have been spun at room temperature, cryogenic temperatures and at elevated temperatures. This machine is capable of spinning aluminum and magnesium alloys from ¼ inch to 2 inches thick, and plain carbon steels from ⅛ inch to 1 inch thick. Stainless steels and high temperature-high strength alloys, including Rene 41 and Inconel 718, can be spun from 3/16 inch to ½ inch thickness.

A complete, experimental department is organized and equipped for the development and production of prototype articles. It is a complete entity in itself, staffed by highly qualified personnel.

Tooling quality is no accident—Here, the tool maker and a tool inspector work side-by-side in the final check-out of a large assembly fixture. Complete optical alignment equipment and extensive optical tooling experience are available for the most difficult tooling problems.

This is one portion of the large and well-equipped tool fabrication area. The large Lucas horizontal boring mill and King vertical turret lathe have capability for the largest as well as the smallest jobs, but capability is more than machinery—it is also experience. At Beech, on-the-job experience in tooling averages 11½ years per man, and **twenty-six** employees have served in tooling over twenty-five years!

The design and fabrication of pressure vessels and cryogenic storage systems are highly developed at Beech. This cryogenic storage system was designed and built by Beech under contract with North American. It was the **first** of 13 major subsystems aboard the Apollo spacecraft to be man-rated by NASA.

Proven quality of production and on-time delivery mark Beech leadership

Many unusual and difficult assignments have been given to Beech—in Space programs, in military systems and in commercial projects. Accomplishment of these assignments—to specification and on time—has given Beech an enviable reputation for dependable performance. This reputation is zealously guarded by an alert, aggressive, forward-looking Beech management. No intangible image of greatness, this is a solid, substantial hook you can hang your profit on—as Beech does.

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, Beech Aircraft Corporation, Wichita, Kansas 67201, U.S.A.

Ordinance facilities and capabilities of Beech have been amply proven by the production of thousands of these bomb dispensers and containers for the Army Ammunition Procurement and Supply Agency. These highly classified products are manufactured to ordinance standards in a complete, separate Beech facility.

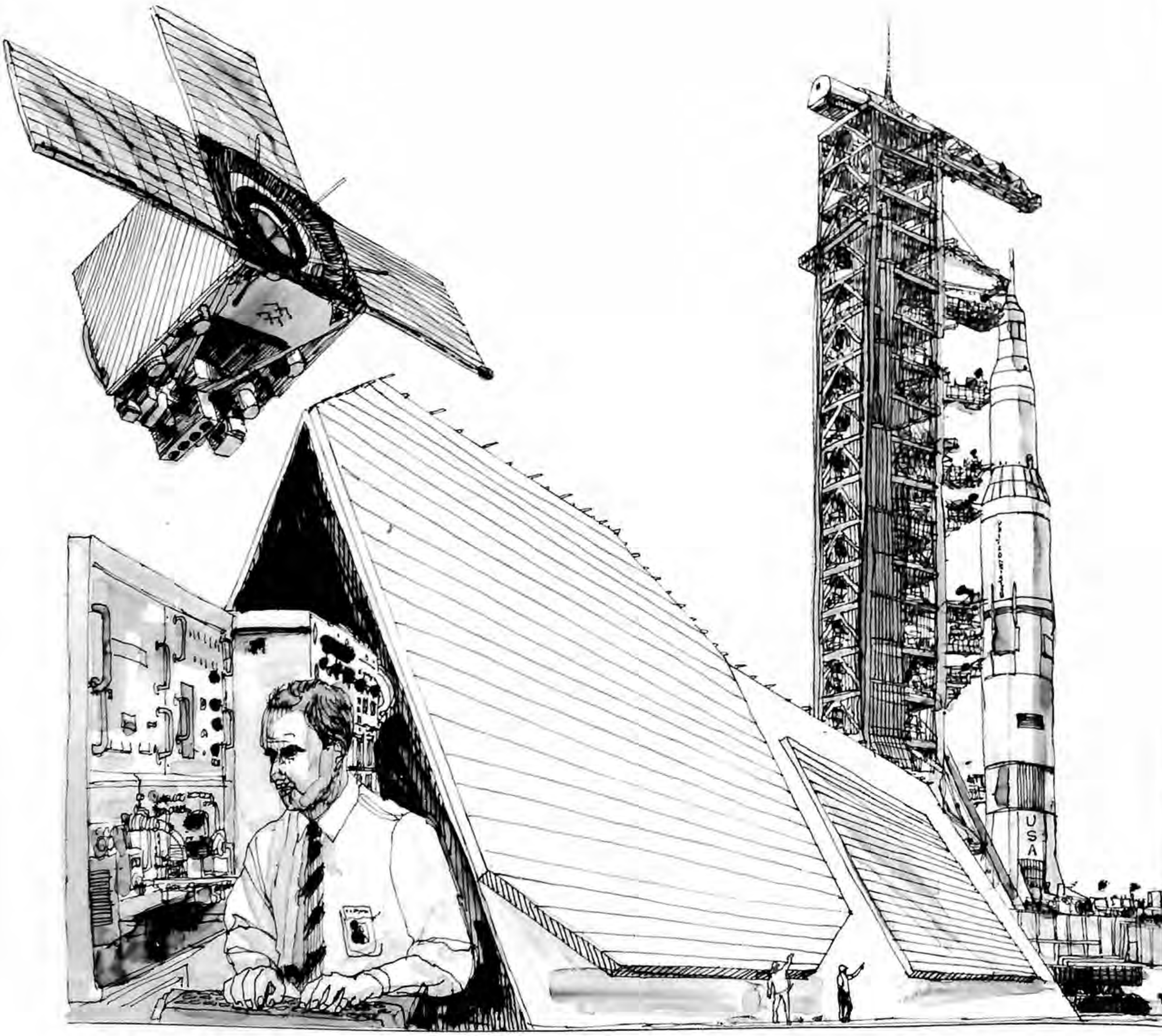
The never-ending search for highest reliability from all Beech-built products led to the design of this General Purpose Automatic Tester. It is shown here being applied to all functional areas, both electrical and mechanical, of an MQM-37A supersonic target missile produced by Beech for the U. S. Navy. The taped read-out will become a permanent record of the test, eliminating the chance of human error in reading, evaluating and recording.

Sandpiper, the first maneuverable rocket-powered supersonic target missile has successfully completed first tests for the U. S. Air Force. The test vehicle was a modified Beech AQM-37A missile powered by the nation's first operationally-designed hybrid rocket engine. The engine, developed and produced by United Technology Center, uses both solid and liquid fuels and has sustained flight of Sandpiper during tests for an extraordinary full five minutes.

For subcontract work to specification and on time... Look to Beech Capabilities!

Beech *Aerospace Division*

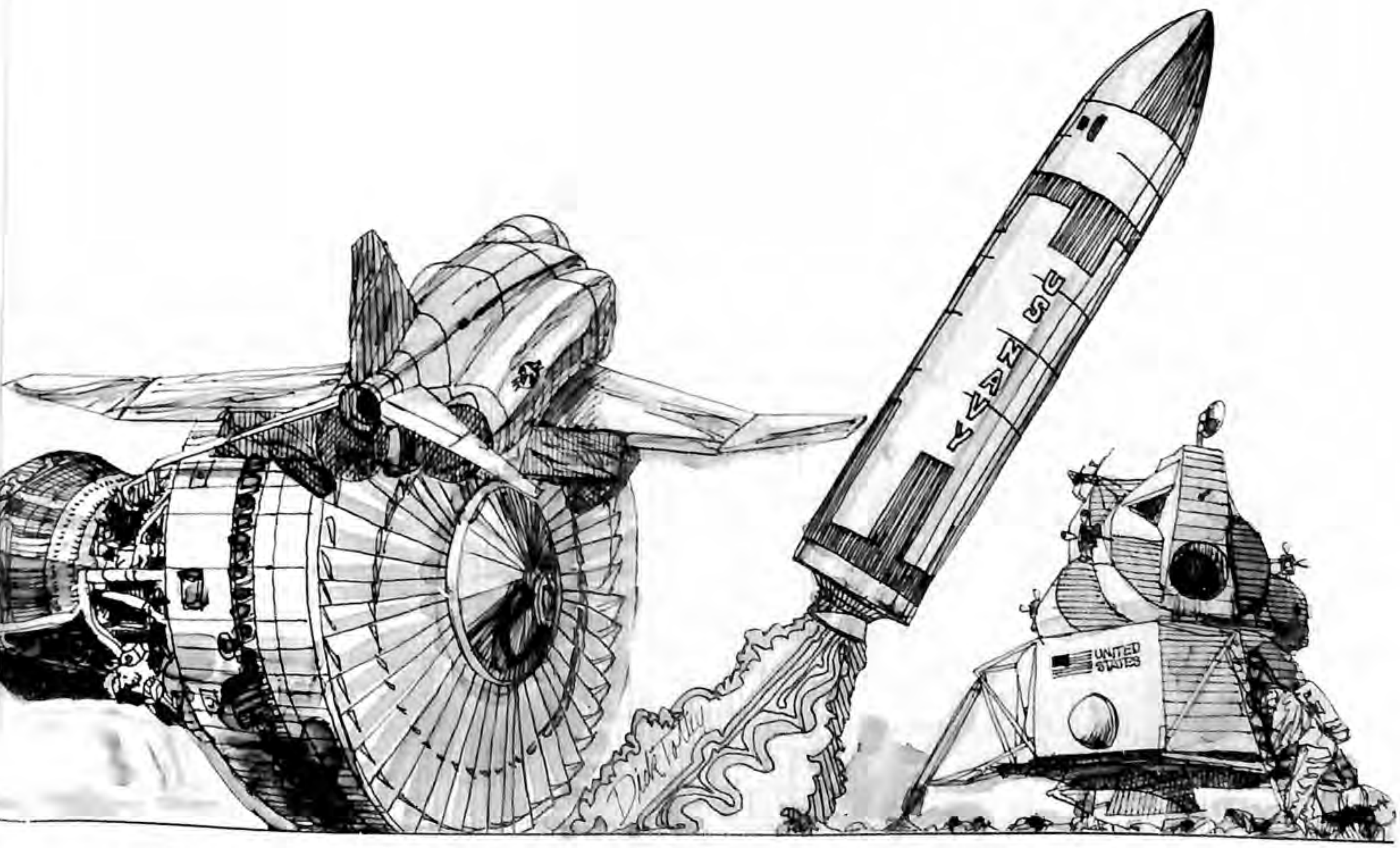
Beech Aircraft Corporation, Wichita, Kansas 67201. U.S.A.



Reference Section

AIA

The following pages, designed for reference use, contain specifications, performance and other data on some 700 products of the aerospace industry. In addition to the primary products—aircraft, missiles, spacecraft, launch vehicles, engines, targets, drones and sounding rockets—the AEROSPACE YEAR BOOK includes a section devoted to systems. The term *system* here denotes ground-based and airborne



aerospace equipment other than primary products, together with certain non-aerospace items produced by aerospace manufacturers. The systems section is intended to be representative rather than all-inclusive; although close to 200 systems are listed, they constitute only a fraction of the industry's extremely broad product line. For easier reference, missiles and spacecraft are organized by functional groups, such as surface-to-surface missiles and meteorological spacecraft. All other products are arranged in alphabetical order by name of the parent manufacturing company. The term *prime contractor*, as used throughout the reference section, refers to the builder of the product listed, regardless of whether it is a primary product or a subsystem, military or commercial.

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-P-7 WA turboprops; maximum gross weight 175,000 pounds.

Performance

Cruise speed 285 miles per hour; payload 45,000 pounds.

SUPER GUPPY (COMMERCIAL)

Prime Contractor: Aero Spacelines, Inc.

Remarks

The Super is the first of a fleet of Guppy aircraft in standardized configuration. In manufacturing the Super Guppy aircraft, the lower fuselage, wings, empennage and cockpit of B-377/C-97 airframes are utilized. Portions of the lower fuselage sections of Stratocruisers are joined to increase the plane length to 144 feet. Like its prototype sister ship, the Super Guppy has a swing-nose loading system, hinged on the left side to allow a 110-degree swing. New Super Guppy standardized features include increased horsepower, pressurized cockpits, installation of water-injection systems, anti-icing equipment and a cargo compartment equipped with closed-circuit television cameras to provide constant surveillance and cargo inspection from the cockpit area.

Specifications

Span 156 feet 8 inches; height to top of fuselage 37 feet; height to top of tail 48 feet; cargo compartment: maximum height 25 feet 6 inches, maximum width 25 feet 1 inch, constant section length 32 feet, overall length 111 feet 6 inches, maximum width at floor level 13 feet; plane length 144 feet; engines 4 Allison 501-D22C turboprops; maximum gross take-off weight 170,000 pounds.

Performance

Cruise speed 300 miles per hour; payload 50,000 pounds.

MINI GUPPY (TURBOPROP)

Prime Contractor: Aero Spacelines, Inc.

Remarks

To meet known and anticipated commercial market demand, Aero Spacelines, Inc., has scheduled construction of a fleet of outsize cargo aircraft standardized in one of 2 configurations, of which the Turbo Mini Guppy is one. Essentially, Mini Guppies are lengthened and modified versions of the B-377/C-97 airframes. Unlike the prototype piston-powered Mini with a swing-tail loading assembly, the new Mini will have a swing-nose loading system, hinged on the left side to allow a 110-degree swing, and a larger cargo compartment. Among other new features are increased horsepower, which adds significantly to range and payload, installation of water-injection systems, pressurized cockpits and anti-icing equipment permitting operation at higher, more efficient altitudes. Closed-circuit television cameras in the cargo compartment provide constant surveillance and cargo inspection from the cockpit area. The first new Mini was scheduled for roll-out early in 1969.

Specifications

Span 156 feet 8 inches; height to top of fuselage 26 feet 8 inches; height to top of tail 40 feet 9 inches; cargo compartment: maximum width 18 feet 4 inches, maximum height 15 feet 6 inches, constant section length 73 feet 2 inches, overall length 103 feet 2 inches, maximum width at floor level 13 feet 4 inches; plane length 135 feet 6 inches; maximum gross take-off weight 180,000 pounds; engines 4 Allison 501-D22C turboprops.

Performance

Cruise speed 325 miles per hour; payload 64,000 pounds.

MINI GUPPY (B-377MG)

Prime Contractor: Aero Spacelines, Inc.

Remarks

Designed for commercial airlift of large aircraft sections, helicopters, power packages, oil drilling equipment and related cargoes, the Mini Guppy is another modification of the Boeing 377 Stratocruiser. The aircraft made its initial flight on May 24, 1967.

Specifications

Span 156 feet 3 inches; length 132 feet 10 inches; height to top of fuselage 27 feet 6 inches; height to top of tail 38 feet 3 inches; cargo compartment: 18 feet 2 inches wide by 15 feet 5 inches high, total length 99 feet, constant section length 75 feet 10 inches; maximum gross weight 142,800 pounds; engines 4 Pratt & Whitney Aircraft R4360 piston-type.

Performance

Cruise speed 250 miles per hour; payload 32,000 pounds.

BEECHCRAFT KING AIR

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, 21 percent of the total turbine-powered aircraft market and 77 percent of deliveries in its class. Newest version has increased payload and performance among its refinements.

Specifications

Span 50 feet 3 inches; length 36 feet 6 inches; height 14 feet 8 inches; gross weight 9,650 pounds; engines 2 550 shaft horsepower Pratt & Whitney Aircraft PT6A-20 free turbines with reverse-pitch propellers optional.

Performance

Cruise speed, maximum cruise power, 256 miles per hour; 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, 27,200 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 10,400 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, 6-9 place 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. Queen Air B80 also has air ambulance and scientific research applications. An optional cargo door is available.

Specifications

Span 50 feet 3 inches; length 35 feet 6 inches; height 14 feet 2$\frac{9}{16}$ inches; gross weight 8,800 pounds; useful load 3,620 pounds—3,466 as Queen Airliner; engines 2 380-horsepower Lycoming IGSO-540-A1D.

Performance

Cruising speed 224 miles per hour; cruise range 1,200 miles standard, 1,560 with optional 264-gallon fuel tanks; rate of climb at gross weight 1,275 feet per minute; service ceiling 28,900 feet.

BEECHCRAFT 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 6-10 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, de-icing 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 2,765 pounds; engines 2 380-horsepower Lycoming IGSO-540-A1D.

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 gross weight 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 H18 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 4,055 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 6-9 place 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 2.5 inches; gross weight 7,700 pounds; useful load 2,788 pounds; engines 2 Lycoming IGSO-480-A1E6 rated at 320 horsepower.

Performance

Cruising speed 214 miles per hour; cruise range 1,060 miles with standard fuel, 1,655 miles with optional fuel; rate of climb at gross weight 1,300 feet per minute; service ceiling 31,300 feet.

BEECHCRAFT DUKE, MODEL 60

Prime Contractor: Beech Aircraft Corporation

Remarks

The Beechcraft Duke is a 4-6 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 10,100 feet and a cabin altitude of only 8,000 feet at 21,600 feet. A highly efficient environmental system includes optional air conditioning. Turbocharged engines and all-weather avionics as standard equipment afford fast, reliable, over-the-weather flight.

Specifications

Span 39 feet 3 inches; length 33 feet 10 inches; height 12 feet 4 inches; gross weight 6,725 pounds; engines 2 Lycoming TIO-541-E1A4 rated at 380 horsepower each.

Performance

Cruising speed 278 miles per hour; cruising range at 45 percent power, 204 gallons, 1,175 miles; rate of climb, 2 engines 5,200 pounds, 2,373 feet per minute; service ceiling, 2 engines 5,200 pounds, 35,800 feet.

BEECHCRAFT TURBO BARON

Prime Contractor: Beech Aircraft Corporation

Remarks

A combination of high speed and spectacular single-engine performance provided by twin 380-horsepower turbocharged Lycoming engines makes the Beechcraft Turbo Baron the fastest light twin in its class. The Turbo Baron was designed expressly for high-altitude instrument flight, yet it retains the 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 2,340 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 BARON D55

Prime Contractor: Beech Aircraft Corporation

Remarks

New exterior styling, including increased slope and area of windshield, and refined instrumentation highlight the Beechcraft Baron D55. Twin 285-horsepower fuel-injection engines make possible safe, reliable operation from improved or unimproved landing areas as short as 968 feet. Actual take-off ground run needed for the fully loaded Baron D55 is only 596 feet. Useful load of 2,225 pounds can include up to 6 people as well as 820 pounds of cargo.

Specifications

Span 37 feet 10 inches; length 28 feet 3 inches; height 9 feet 7 inches; gross weight 5,300 pounds; useful load 2,225 pounds; engines 2 Continental IO-520-C rated at 285 horsepower each.

Performance

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 BARON B55

Prime Contractor: Beech Aircraft Corporation

Remarks

A new silhouette enhanced by additional sweep to the windshield line and a new paint scheme distinguish the Beechcraft Baron B55. Lowest priced 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 1,864 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 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. Seating 5 in a useful load of 1,550 pounds, the Travel Air E95 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, radar and light-weight de-icing 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

Pacing the Bonanza line of single-engine, retractable-gear Beechcrafts is the Turbo Bonanza with a 285-horsepower turbocharged engine for high-altitude and high-speed performance. A maximum speed of 250 miles an hour at 19,000 feet and absolute ceiling of over 30,000 feet are possible. The 4-6 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 BONANZA V35A

Prime Contractor: Beech Aircraft Corporation

Remarks

Now in its 23rd year of production, the Beechcraft Bonanza has earned its place as a classic among single-engine aircraft, representing sales in excess of $160,000,000 with over 8,800 units produced. Refinements 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 Bonanza V35A seats 4-6.

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 BONANZA E33A

Prime Contractor: Beech Aircraft Corporation

Remarks

This new Beechcraft brings a choice of swept vertical fin and horizontal stabilizer to the new Bonanza line. The Bonanza E33A offers roomy comfort for 4-5 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 BONANZA E33

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 185-mile-an-hour cruise, range in excess of 1,100 miles, useful load of over 1,100 pounds and seating for 4-5 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 BONANZA 36

Prime Contractor: Beech Aircraft Corporation

Remarks

Expanding its line of high-performance, single-engine aircraft to 7, Beech Aircraft introduced the new Bonanza 36 in 1968. Aimed at the utility aircraft market, the Beechcraft Bonanza 36 accommodates 6 passengers or a useful load of 1,620 pounds. Ten inches longer than others of the retractable-gear Beechcraft single-engine line, the Bonanza 36 has double doors to provide a 12-square-foot opening on the right rear side of the cabin. Folding fifth and sixth seats and removable third and fourth seats quickly convert the new Beechcraft to cargo configurations.

Specifications

Span 32 feet 10 inches; length 26 feet 4 inches; height 8 feet 5 inches; gross weight 3,600 pounds; useful load 1,620 pounds; engine Continental IO-520-B rated at 285 horsepower.

Performance

Cruising speed 195 miles per hour; cruise range 980 miles, plus reserves; rate of climb 1,015 feet per minute at gross weight; service ceiling 17,800 feet.

BEECHCRAFT AEROBATIC BONANZAS

Prime Contractor: Beech Aircraft Corporation

Remarks

Aerobatic models of the Beechcraft Bonanza line, designated the Aerobatic Beechcraft Bonanza E33B and Aerobatic Beechcraft Bonanza E33C, were introduced in 1968. When operated in the acrobatic category of FAA regulations, the Aerobatic Beechcraft Bonanzas are licensed for such flight maneuvers as rolls, inside loops, Immelman turns, Cuban Eights, split "S" turns, snap rolls, spins and limited inverted flight. Four to 5 place in utility and business use, the aircraft are limited to pilot and one passenger during aerobatic maneuvers. Standard equipment includes shoulder harnesses for both front-seat passengers, quick-release cabin door and "G" meter.

Specifications

Span 32 feet 10 inches; length 25 feet 6 inches; height 8 feet 3 inches; gross weight (E33B) 3,050 pounds, (E33C) 3,300 pounds; useful load (E33B) 1,196 pounds, (E33C) 1,400 pounds; engine (E33B) Continental IO-470-K rated at 225 horsepower, (E33C) Continental IO-520-B rated at 285 horsepower.

Performance

Cruising speed (E33B) 185 miles per hour, (E33C) 200 miles per hour; cruise range, optional fuel, (E33B) 1,170 miles, (E33C) 1,080 miles, plus reserves; rate of climb (E33B) 930 feet per minute, (E33C) 1,200 feet per minute; service ceiling (E33B) 17,800 feet, (E33C) 18,300 feet.

BEECHCRAFT MUSKETEER SUPER

Prime Contractor: Beech Aircraft Corporation

Remarks

Performance leader of the Musketeer line of sport, training, business and pleasure aircraft, the Musketeer Super has a 200-horsepower fuel-injection engine and standard 4-place interior. Options include seating for 6, constant-speed propeller and left-side entry door.

Specifications

Span 32 feet 9 inches; length 25 feet; 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 MUSKETEER CUSTOM

Prime Contractor: Beech Aircraft Corporation

Remarks

Interior and exterior colors, fabrics and vinyl combinations are greater than ever before in the Beechcraft Musketeer. The Custom is capable of economical operation from paved or unimproved airports. Its 180-horsepower fuel-injection engine gives a top speed of 151 miles an hour and a range up to 860 miles, with a useful load of 1,085 pounds.

Specifications

Span 32 feet 9 inches; length 25 feet; height 8 feet 3 inches; gross weight Utility Category 2,030 pounds, Normal Category 2,450 pounds; useful load Normal Category 1,085 pounds; engine 180-horsepower Lycoming O-360-A2G.

Performance

Cruising speed 143 miles per hour; cruise range 860 miles; rate of climb 820 feet per minute; service ceiling 13,650 feet.

BEECHCRAFT MUSKETEER SPORT

Prime Contractor: Beech Aircraft Corporation

Remarks

Sport flying for 2 and pilot training, including optional aerobatic version, set apart the Beechcraft Musketeer Sport. Top speed is 140 miles an hour; range is about 900 miles. As in the entire Musketeer line, latest technology, including metal bonding, is employed for weight reduction, strength and optimum performance. Over 1,800 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 1 225-horsepower Continental O-470-13; retractable tricycle landing gear (same as for Bonanza); tandem cockpits under continuous canopy.

Performance (T-34A)

Maximum speed 189 miles per hour; maximum cruise speed 173 miles per hour; service ceiling 20,000 feet; maximum cruising range 737 miles.

T-42A INSTRUMENT TRAINER

Prime Contractor: Beech Aircraft Corporation

Remarks

The T-42A is the military counterpart of the Beechcraft Baron B55 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 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. 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 (RU-8D) configuration incorporating the APQ-86 SLAR radar installation. The U-8D is a high-performance, all-weather personnel transport for 6 persons, including one or 2 pilots. The all-metal, low-wing monoplane is readily adaptable for carrying litter patients as an air evacuation ambulance, or it can be used as a cargo transport or twin-engine trainer. A total of 206 U-8Ds were purchased from 1952 through the 1965 fiscal year.

Specifications

Span 45 feet 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 O-480-3, supercharged, fuel-injected, 6 cylinder, horizontally opposed; retractable tricycle landing gear with single wheels; dual controls side by side; 2 seats in pilot compartment, 5 in cabin.

Performance

Maximum diving speed 261 knots/301 miles per hour; maximum 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 prototype version of the Beechcraft corporate turboprop King Air. This 7-place command liaison utility transport was the first turbine-powered fixed-wing aircraft procured by the U.S. Army, and it served as the flying test-bed 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 nonpressurized, 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, 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 received a contract to produce 129 of the aircraft.

Specifications

Span 45 feet 10½ inches; length 35 feet 6 inches; height 14 feet 2⁹⁄₁₆ 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-10

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

A new concept in military air cushion vehicles under development by Bell, the SK-10 is designed for quick and efficient transport of personnel, supplies and equipment from a ship through the surf inland to an appropriate debarkation zone. With a 60-ton payload from stage lengths up to 100 nautical miles, it is designed to carry cargoes at 60 knots in sea state 3 or at 80 knots in sea state 1 regardless of water depth or submerged hazards. The craft utilizes an open-well deck with bow and stern ramps which expedite the loading and unloading of cargo. A total of 160 troops can be carried in the port and starboard superstructure with provisions for 320 additional troops on the cargo deck when no cargo is carried. With its flexible, air-actuated trunks extending 5 feet below the hard surface, the SK-10 will be able to operate within a landing ships dock (LSD) and an amphibious transport dock (LPD). Twin gas turbine engines, 12,000 shaft horsepower each, will drive 14.5-foot-diameter variable-pitch propellers plus a 12-foot-diameter lift fan which will be mounted in the hull and will generate the air cushion. The twin propeller arrangement is designed to permit high directional control during maneuvers. Two rudders will provide yaw control. A unique "puff-port" air-bleed system will provide lateral control, while pitch and roll trim can be varied by the operator during operation.

SK-5 (U.S. ARMY)

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

Three Bell-built SK-5 air cushion vehicles (ACVs), delivered to the U.S. Army in the spring of 1968, were deployed as a unit to Vietnam in May 1968 and based in the Mekong River Delta region. The high-speed, amphibious craft can be used for river patrol, reconnaissance, troop insertion, rescue, search and destroy and logistic support missions over water, land, mud, marsh, ice or snow. The 3 craft are the first to roll off Bell's new quantity production line and represent the Army's first ACV production buy. The armed and armored craft also are the first combat ACVs built exclusively in the United States to military specifications. They feature an improved control system, an expanded cabin door which will accommodate a jeep-size vehicle, addition of a self-contained auxiliary power unit and split hydraulic system, and high-strength flat sidedecks in place of the curved sidedecks of previous models.

Specifications

Length 38 feet 10 inches; width 23 feet 9 inches; height (skirt inflated) 15 feet 11 inches; cabin floor area 12 feet by 8 feet; gross weight 17,000 pounds; power plant 1 General Electric LM100 1,150 shaft horsepower marine gas turbine.

Performance

Maximum speed 60 knots; range 175 nautical miles at 50 knots; wave clearance at 40 knots 4.5 feet; obstacle clearance 3.5-foot solid wall, 5-foot earth mound, 5-6 foot vegetation, ditches up to 12 feet in width and 8 feet in depth.

SK-5 (U.S. NAVY)

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

Three Model 7232 SK-5 air cushion vehicles (ACVs), delivered to the U.S. Navy in 1966, have been operating in Vietnam since May of that year. The high-speed, amphibious craft, designated PACVs for Patrol Air Cushion Vehicles, have been utilized for river patrol, troop insertion, reconnaissance, rescue, search and destroy and logistic support missions. They have been instrumental in a number of Allied victories in the Mekong River Delta region and farther north in the area of Hue. The craft are modified SR. N5 Hovercraft produced in England by British Hovercraft Corporation Ltd.

Specifications

Length 39 feet; width 22.9 feet; gross weight 18,350 pounds; power plant 1 General Electric 1,000 shaft horsepower marine gas turbine.

Performance

Maximum speed 55 knots; obstacle clearance 3.5-foot solid wall, 5-foot earth mound, 5-6 foot vegetation, ditches up to 12 feet in width and 8 feet in depth.

X-14B 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, California, in October 1959. NASA replaced the original Armstrong-Siddeley Viper engines with General Electric J85 turbojets for increased thrust. The X-14B has improved thrust diverters and hover controls and a new digital computer Variable Stability System (VSS). Primary purpose of NASA's X-14B program is to research and define the stability and control system requirements for V/STOL aircraft. In addition, it has been used for test pilot familiarization and 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 2 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 3-engine hovering capability to provide an extremely versatile V/STOL research aircraft. The X-22A was rolled out on May 25, 1965; it made its first flight on March 17, 1966. It made its first vertical take-off and transition to conventional flight on March 1, 1967. The aircraft has completed the aerodynamics and structural demonstration program flights of the Variable Stability System. The X-22A was scheduled for delivery to the Navy for additional research.

Specifications

Span 39.2 feet; length 39.6 feet; height 20.69 feet; VTOL gross weight 15,980 pounds (standard day, 1 engine out); engines 4 General Electric YT-58-8D turboshaft 1,250 horsepower each.

Performance

Speed 325 miles per hour; endurance 3 hours; range 480 nautical miles.

47G-3B-1/47G-3B-2 HELICOPTERS

Prime Contractor: Bell Helicopter Company

Remarks

The 47G-3B-1 3-place utility helicopter was first delivered in January 1963. Its successor, the 47G-3B-2, joined the Bell commercial line in 1968. The 47G-3B-2 is a balanced, all-purpose utility and passenger vehicle with a supercharged engine to provide maximum gross weight capability at high altitudes and elevated ambient temperature conditions. Its 24-volt electrical system, with a 50-ampere generator, provides ample electrical power for operation of utility equipment and accessories. The hydraulic pump is located on the transmission to assure operation of hydraulic boost controls during power-off autorotation.

Specifications

Fuselage length 31.6 feet; overall length 43.2 feet; main rotor diameter 37.12 feet; normal gross weight 2,950 pounds; empty weight 1,794 pounds; useful load 1,045 pounds; engine Lycoming TVO-435 turbosupercharged, 270 take-off horsepower (47G-3B-1), 280 shaft horsepower at 3,200 revolutions per minute (47G-3B-2).

Performance

Maximum speed 105 miles per hour; cruise speed 81-93 miles per hour; maximum range at 10,000 feet 296 miles; rate of climb (47G-3B-1) 880 feet per minute, (47G-3B-2) 1,130 feet per minute; hovering ceiling IGE 20,000 feet; service ceiling 20,000 feet.

47G-4A HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The 47G-4A is a balanced, all-purpose utility and passenger vehicle capable of a wide range of operations at medium altitudes and elevated temperatures. Its 24-volt electrical system, with 50-ampere generator, provides ample electrical power for operation of utility equipment and accessories.

Specifications

Fuselage length 32.6 feet; overall length 43.2 feet; main rotor diameter 37.1 feet; normal gross weight 2,950 pounds; empty weight 1,777 pounds; useful load 1,085 pounds; engine Lycoming VO-540, 305 take-off horsepower.

Performance (at normal gross)

Maximum speed, sea level, 105 miles per hour; cruise speed 85 miles per hour; maximum range at 5,000 feet 259 miles; rate of climb 800 feet per minute; OGE hovering ceiling 3,900 feet; IGE hovering ceiling 7,700 feet; service ceiling 11,200 feet; certificated altitude 20,000 feet.

47G-5 HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The 47G-5 is Bell's economy model; it is well suited to utility and government work because it is FAA certificated in the basic configuration described below and in a stripped configuration for greater useful loads.

Specifications

Fuselage length 32.6 feet; overall length 43.2 feet; main rotor diameter 37.12 feet; normal gross weight 2,850 pounds; useful load 1,151 pounds; engine Lycoming VO-435, 265 take-off horsepower.

Performance

Maximum speed, sea level, 105 miles per hour; maximum rate of climb, normal gross weight, 860 feet per minute; OGE hover ceiling, normal gross, 1,350 feet; IGE hover ceiling 5,900 feet; service ceiling 10,000 feet; certificated altitude 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. 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, 1,100 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.

205A HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The 205A is designed to provide multiple capability as a 15-passenger transport, cargo transport, aerial crane, 6-litter ambulance, rescue vehicle and general utility helicopter. All of the configurations are designed as kits for providing quick conversion from one configuration to another. Initial deliveries (late 1968) were powered by the 1,100 shaft horsepower Lycoming T53-11A engine, pending availability of the 1,400 shaft horsepower Lycoming T53-13A for which the 205A was designed. Installation of either engine is permissible. The 205A evolved from the 204B commercial and UH-1 military helicopters. It is a reliable, versatile vehicle large enough to perform heavy-duty operations yet small enough for operation by a crew of one.

Specifications

Fuselage length 41.5 feet; overall length 57.1 feet; overall width 9.3 feet; overall height 14.4 feet; main rotor diameter 48 feet, tail rotor diameter 8.5 feet; normal gross weight 9,500 pounds; maximum useful load 4,305 pounds; engine Lycoming T53-11A or -13A with 1,100 or 1,400 shaft horsepower.

Performance (T53-13A)

Maximum speed, sea level, 138 miles per hour; maximum continuous cruise speed at 8,000 feet 137 miles per hour; maximum rate of climb, sea level, 2,635 feet per minute; OGE hover ceiling 15,400 feet; IGE hover ceiling 19,700 feet; service ceiling 20,000 feet; range at sea-level cruise 334 miles, at 8,000-foot cruise 404 miles.

206A JETRANGER

Prime Contractor: Bell Helicopter Company

Remarks

The Model 206A JetRanger is a 5-place, turbine-powered, light business and utility helicopter. Introduced to commercial service in January 1967, the 206A has found exceptional acceptance. It is in production by Bell and licensees. More than 450 have been built and are being used in 33 countries.

Specifications

Overall length 39.1 feet; overall width 6 feet 4 inches; overall height 9 feet 5 inches; normal gross weight 3,000 pounds; useful load 1,925 pounds; engine Allison Model 250-C18, 317 horsepower.

Performance (at normal gross)

Maximum speed, sea level, 150 miles per hour; cruise speed 131 miles per hour; range 392 miles at 8,000 feet; service ceiling 17,700 feet; hover ceiling OGE 3,350 feet, IGE 7,900 feet; rate of climb 1,450 feet per minute.

UH-1C/UH-1E IROQUOIS HELICOPTERS

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1C and UH-1E are 8-10 place military utility and armed helicopters, in service since June 1965. UH-1C is the Army version; UH-1E, the Marine Corps configuration. Both are derived from the Army UH-1B, in service since 1961. A new version of the C is the HueyTug. Introduced in 1968, the HueyTug (photo) is a retrofitted version of the UH-1C capable of lifting a 3-ton external payload. HueyTug uses a Lycoming T53 engine, has a 50-foot-diameter rotor and a maximum gross weight, with external load, of 13,500 pounds. Specifications listed are for the basic UH-1C.

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-1F IROQUOIS HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1F is the Air Force version of the Model 204 series. In service since March 1964, it seats 11 and is used as a missile site support vehicle.

Specifications

Fuselage length 41.5 feet; overall length 56.9 feet; main rotor diameter 48 feet; maximum gross weight 9,000 pounds; maximum payload plus fuel 4,098 pounds; engine General Electric T58-3, 1,272 shaft horsepower military rating, sea level.

Performance

Maximum speed at full gross weight 115 miles per hour; maximum still air range 352 miles; maximum sea-level rate of climb (full gross) 1,360 feet per minute; OGE hover ceiling 5,800 feet; IGE hover ceiling 9,600 feet; service ceiling 12,400 feet.

UH-1H IROQUOIS HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1H is an Army tactical troop transport with a standard mission payload of 11 troops. It became operational in 1967. The UH-1H is almost identical to the earlier UH-1D, in service with the Army since 1963, except that the D version employs a Lycoming T53-11 engine of 1,100 shaft horsepower.

Specifications (UH-1H)

Fuselage length 41.9 feet; overall length 57.1 feet; fuselage width 8.6 feet; main rotor diameter 48 feet; maximum gross weight 9,500 pounds; maximum payload plus fuel 4,181 pounds; engine Lycoming T53-13 of 1,400 shaft horsepower (sea-level take-off).

Performance (UH-1H)

Maximum speed at 9,500 pounds gross 127 miles per hour; maximum still air range 318 miles; OGE hover ceiling at full gross 1,100 feet; IGE hover ceiling 13,600 feet; service ceiling 12,600 feet; maximum rate of climb, sea level, 1,600 feet per minute.

UH-1N IROQUOIS HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1N is a twin-engine version of the single-engine UH-1H. In 1968 the U.S. Air Force ordered 76 of the twinned N versions, deliveries to start in 1969.

AH-1G HUEYCOBRA

Prime Contractor: Bell Helicopter Company

Remarks

The AH-1G HueyCobra is a 2-place, high-speed fire support helicopter in Army service; it incorporates stub wings for ordnance stores and a nose-mounted turret. The AH-1G has a 2-bladed, "door-hinge," 44-foot-diameter main rotor and a 2-bladed tail rotor. HueyCobra went into operational service in 1967.

Specifications

Fuselage length 44.4 feet; overall length 52.97 feet; fuselage width 3.5 feet; overall height 13.5 feet; maximum gross weight 9,500 pounds; maximum payload plus fuel 3,404 pounds; engine Lycoming T53-13, sea-level military rating of 1,400 shaft horsepower.

Performance

Maximum speed 219 miles per hour; maximum sea level rate of climb, full gross, 1,580 feet per minute; IGE hover ceiling 9,900 feet; service ceiling 12,700 feet; maximum still air range 387 miles.

AH-1J HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The AH-1J is a twin-engine version of the single-engine AH-1G. Late in 1968, the U.S. Marine Corps placed an order for 49 of the twinned high-speed weapons platforms.

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; maximum still air range 255 miles; maximum sea-level rate of climb 550 feet per minute; OGE hover ceiling 14,800 feet; IGE hover ceiling 18,000 feet; service ceiling 18,500 feet.

OH-58A OBSERVATION HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The OH-58A was named winner of the Army's reopened light observation helicopter competition; Bell received an order for 2,200 of the 5-place, turbine-powered aircraft, with deliveries to begin in 1969 and to continue through mid-1972. The OH-58A is a variant of the commercial JetRanger.

Specifications

Fuselage length 32.3 feet; overall length 41 feet; fuselage width 6.4 feet; overall height 9.5 feet; maximum gross weight 3,000 pounds; maximum payload plus fuel 695 pounds; engine Allison T63-700, 317 shaft horsepower sea-level military rating.

Performance (at maximum gross)

Maximum speed 150 miles per hour; maximum sea-level rate of climb 1,560 feet per minute; OGE hover ceiling 6,000 feet; IGE hover ceiling 10,900 feet; service ceiling 16,200 feet; maximum still air range 356 miles.

TH-13T TRAINING HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The TH-13T is a basic instrument trainer first delivered to the Army in December 1964. Still in production, it is a 2-place derivative of the Model 47.

Specifications

Fuselage length 32.3 feet; overall length 43.2 feet; main rotor diameter 37.1 feet; maximum gross weight 2,950 pounds; empty weight 2,057 pounds; engine Lycoming TVO-435-D1B supercharged, 270 horsepower.

Performance

Maximum speed 105 miles per hour; cruise speed 83-93 miles per hour; maximum still air range 235 miles; maximum sea-level rate of climb 900 feet per minute; OGE hover ceiling at maximum gross weight 10,500 feet; IGE hover ceiling 16,000 feet; service ceiling 16,800 feet.

TH-57 TRAINING HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

In 1968 the Navy selected the TH-57A, a variant of the commercial Model 206A JetRanger, as its light turbine training helicopter. The Navy ordered 40 of the craft and in the fall of 1968 introduced the first 5 of them to service at Naval Air Basic Training Headquarters, Pensacola, Florida.

Specifications

Fuselage length 31.2 feet; overall length 39.1 feet; fuselage width 6.4 feet; overall height 9.6 feet; maximum gross weight 2,900 pounds; maximum payload plus fuel 776 pounds; engine Allison 250-C18, 317 shaft horsepower military rating at sea level.

Performance (at maximum gross)

Maximum speed 150 miles per hour; maximum sea-level rate of climb 1,470 feet per minute; OGE hover ceiling 4,800 feet; IGE hover ceiling 8,700 feet; service ceiling 16,000 feet; maximum still air range 380 miles.

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 is in development with certification anticipated late in 1969.

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 sweptwing, multijet 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; 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 2 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.

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 construction 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 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 TF33 turbofans, 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 December 20, 1957) was America's first jet airliner to go into service. First commercial flight of this 4-engine jetliner was made by Pan American World Airways October 26, 1958, from New York to Paris with 111 passengers. The turbojet airplane was developed from the Boeing 707 sweptwing jet prototype, as was the KC-135 tanker series for the USAF. The -120 gave way later to the advanced 707-120B (first flight June 22, 1960; in service March 12, 1961), which incorporated turbofan engines of greater power, a redesigned wing and new control surfaces. The -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 146 have been sold to 6 airlines, including 3 (VC-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), JT3D-3 turbofans of 18,000 pounds thrust (-120B model); tricycle gear with 4-wheel bogie-type truck main units and dual nose wheels; payload up to 181 passengers.

Performance

Speed up to 600 miles per hour; range more than 3,000 miles; ceiling over 40,000 feet.

707-320 SERIES JETLINERS

Prime Contractor: The Boeing Company

Remarks

Designed to serve long-range routes of more than 4,000 miles, the 707-320 intercontinental jetliner went into service October 26, 1959. First flight was January 11, 1959. It was supplanted later by the 707-320B with a range of more than 6,000 miles nonstop with 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 7x11-foot forward cargo door, plus use of integral floor tracks and a cargo handling system, and some structural strengthening developed the -320B into a multipurpose jet, 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. About 520 have been ordered by 38 airlines, with more than 430 delivered.

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, 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 4-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 differs 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. Altogether, 154 of the series were built for 16 airlines.

Specifications

Span 130 feet 10 inches; length 136 feet 2 inches; height 41 feet 6 inches; 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 4-wheel bogie-type truck main units, dual nose wheels; payload up to 165 passengers.

Performance

Speed up to 615 miles per hour; range 3,300 miles; ceiling over 40,000 feet.

727 MEDIUM-RANGE JETLINER

Prime Contractor: The Boeing Company

Remarks

The 727, first American jet transport to depart from wing-mounted engine installation, has 3 engines grouped at the tail. Its 3-engine configuration was designed to give the best compromise between 4-engine power and reliability and twin-engine economy. In service since early 1964, it is designed specifically for medium-range routes, and it has a 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, the 727C (cargo/convertible) and the 727QC (quick-change cargo/convertible). More than 750 have been sold and more than 600 delivered.

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, 170,000 pounds); engines 3 Pratt & Whitney JT8D-1 or -7 turbofans, 14,000 or 14,500 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 up to 111,000 pounds, compared to 161,000 pounds for the 3-engine 727. Contrary to the trend in twin-jet airliners toward aft-mounted engines, Boeing placed the engines under the wings on the 737 for the advantages of easier maintainability, reduction in structure weight, additional passenger space in the cabin, better balance characteristics, simplified systems, more loading flexibility and better aerodynamic efficiency. Two versions of the 737 went into production in 1965, the 737-100 and the 6-foot-longer 737-200. More than 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 111,000 pounds (-100 and -200); engines 2 Pratt & Whitney JT8D-7 turbofans of 14,000 pounds thrust each (JT8D-9 of 14,500 pounds thrust optional); gear tricycle, dual-wheel units; payload 31,000 pounds (structural limit) or up to 107 passengers for -100, 32,500 pounds or up to 124 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 rolled from the factory on September 30, 1968, it became the largest commercial jetliner in history. It will enter commercial service in late 1969 following vigorous flight testing. Designed to carry up to 490 passengers in all-economy seating or 365 in mixed-class configuration over long ranges, this 625-mile-per-hour aircraft offers the opportunity for a combination of new standards in air travel. Its 185-foot-long, 20-foot-wide cabin permits spacious seating as well as such innovations as nurseries and lounges. In addition, a stateroom area 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. More than 150 have been sold.

Specifications

Span 195 feet 8 inches; length 231 feet 10 inches; height 63 feet 5 inches; wing sweepback 37.5 degrees; maximum ramp weight 710,000 to 733,000 pounds; engines 4 Pratt & Whitney Aircraft JT9D turbofans of 43,500 pounds thrust each; dual nose wheels, 4 4-wheel bogie-type main trucks; payload up to 490 passengers in all-economy or 220,000 pounds in all-cargo version.

Performance

Speed up to 640 miles per hour; range more than 4,000 miles; ceiling 45,000 feet.

KC/C-135 TANKER/TRANSPORT SERIES

Prime Contractor: The Boeing Company

Remarks

Shortly after Boeing's privately financed 707 prototype flew in July 1954, the 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 and reconnaissance aircraft. A total of 820 KC/C-135s were built. The tankers and some transports used water-injection turbojet engines; a "B" model using turbofans was developed and put into transport service by the 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 J57 turbojets of 13,750 pounds thrust (KC-135), 4 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 Administration signed a contract with Boeing for the construction of 2 prototypes of an 1,800-mile-per-hour passenger jetliner. Boeing originally planned a variable-sweep-wing configuration but announced late in 1968 that it favored switching to a fixed-wing design (photo) and that it would recommend the new program to the FAA and the airlines. Most of the SST will be built of an alloy of 90 percent titanium, 6 percent aluminum and 4 percent vanadium. First flight of the prototype was planned for 1972, and first deliveries to the airlines were expected in 1976 or 1977.

Specifications

Length 280 feet; span 142 feet; height at tail 50 feet; leading edge sweep 50 degrees; prototype weight 635,000 pounds; passenger capacity, production version, estimated 280 passengers; wing area approximately 7,000 square feet; engines 4 General Electric GE4, 60,000 pounds thrust each.

Performance

Cruise speed Mach 2.7, or 1,800 miles per hour, at 60,000-plus feet.

CH-46D SEA KNIGHT ASSAULT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The CH-46D is a medium assault transport helicopter currently in production for the Marine Corps. The tandem-rotor 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 1 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 13,276 pounds; engines 2 General Electric T58-10, each with 1,450 shaft horsepower.

Performance

Cruise speed at sea level 140 knots; mission radius 100 nautical miles; service ceiling 14,000 feet; payload at design gross weight 4,823 pounds, at maximum gross weight 6,998 pounds.

107 TWIN-TURBINE TRANSPORT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The Boeing-Vertol 107 is a multipurpose transport helicopter designed for commercial users requiring high performance, high load capacity and operational economy.

Specifications

Fuselage length 44 feet 7 inches; rotor diameter 50 feet; 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-47C CHINOOK TRANSPORT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The CH-47C 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 Chinook 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 45,700 pounds; empty weight 20,213 pounds; engines 2 Lycoming T55-L-11, each with 3,750 shaft horsepower.

Performance

Cruise speed at sea level 162 knots; mission radius 100 nautical miles; service ceiling 15,000 feet; payload at maximum gross weight, 10-nautical-mile mission, 24,000 pounds, 100-nautical-mile mission, 19,900 pounds.

107 MILITARY TRANSPORT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The 107 military transport helicopter is now in service with the Canadian Defence Force Air Rescue Service and Mobile Command, 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 for 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 11,281 pounds; engines 2 General Electric T58-8, each with 1,050 shaft horsepower.

Performance*

Cruise speed 130 knots; service ceiling 15,600 feet; mission radius 100 nautical miles.

***Note:** Specifications and performance listed are for the CH-113A Mobile Command helicopter. There are slight variations in the specifications and performance of the 107 helicopters used by other military customers.

UH-46D MEDIUM TRANSPORT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The UH-46D, a twin-turbine, tandem-rotor helicopter, is the key to the 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, Trainer and Commuter Versions)

Gross weight 1,600 pounds; empty weight 975-1,060 pounds; baggage 120 pounds; wing loading 10.2 pounds per square foot; power loading 16 pounds per horsepower; fuel capacity 26 gallons, with long-range tanks 38 gallons; wing span 32 feet 8½ inches; length 23 feet 9 inches; height 8 feet 7½ inches; engine 4 cylinder, 100 horsepower.

Performance

Maximum speed 122 miles per hour; cruise speed, 75 percent power at 7,000 feet, 117 miles per hour; range at cruise speed 475 miles, with long-range tanks 726 miles; rate of climb at sea level 670 feet per minute; service ceiling 12,650 feet.

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) 1,245 pounds; baggage 120 pounds; wing loading 13.2 pounds per square foot; power loading 15.3 pounds per horsepower; fuel capacity 42 gallons; engine Lycoming O-320-E2D; propeller all metal, fixed pitch, 76-inch diameter.

Performance

Top speed at sea level 139 miles per hour; cruise speed, 75 percent power at 9,000 feet, 131 miles per hour; cruise range, 75 percent power at 9,000 feet, 615 miles; optimum range at 10,000 feet 640 miles; rate of climb at sea level 645 feet per minute; service ceiling 13,100 feet; 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) 1,315 pounds; baggage weight 120 pounds; wing loading 13.2 pounds per square foot; power loading 15.3 pounds per horsepower; fuel capacity 42 gallons; engine Lycoming O-320-E2D; propeller all metal, fixed pitch, diameter 76 inches.

Performance

Maximum speed at sea level 140 miles per hour; cruise speed, 75 percent power at 9,000 feet, 132 miles per hour; cruise range, 75 percent power at 9,000 feet, 620 miles; optimum range at 10,000 feet 655 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.

CARDINAL, MODEL 177

Prime Contractor: Cessna Aircraft Company

Remarks

Cardinal and Model 177 are externally identical except for color styling; Cardinal (photo) is the deluxe version of the 177.

Specifications (Model 177)

Wing span 35 feet 7 inches; wing area 173 square feet; length 26 feet 11 inches; height (with depressed nose strut) 9 feet 1 inch; gross weight 2,500 pounds; empty weight (approximate) 1,365 pounds; baggage 120 pounds; wing loading 14.5 pounds per square foot; power loading 13.9 pounds per horsepower; fuel capacity 49 gallons; engine Lycoming O-360-A2F; propeller all metal, fixed pitch, 76-inch diameter.

Specifications (Cardinal)

Same as Model 177 except for approximate empty weight of 1,440 pounds.

Performance (Model 177)

Maximum speed, sea level, 147 miles per hour; cruise speed, 75 percent power at 9,500 feet, 135 miles per hour; cruise range, 75 percent power at 9,500 feet, 635 miles; optimum range at 10,000 feet 755 miles; rate of climb, sea level, 760 feet per minute; service ceiling 15,800 feet; take-off run over 50-foot obstacle 1,575 feet; landing run over 50-foot obstacle 1,220 feet.

Performance (Cardinal)

Same as Model 177 except for following: Maximum speed, sea level, 150 miles per hour; cruise speed 138 miles per hour; cruise range 650 miles; optimum range 770 miles.

MODEL 180

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 36 feet 2 inches; wing area 174 square feet; length 25 feet 9 inches; height 7 feet 9 inches; gross weight 2,800 pounds; empty weight (approximate) 1,545 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; 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 9 inches; height 7 feet 9 inches; gross weight 3,350 pounds; empty weight (approximate) 1,575 pounds; baggage capacity 350 pounds; wing loading 19.3 pounds per square foot; power loading 11.2 pounds per horsepower; fuel capacity 65 gallons; engine 6 cylinder, fuel injection; propeller constant speed, diameter 82 inches.

Performance

Maximum speed at sea level 178 miles per hour; cruise speed, 75 percent power at 7,500 feet, 169 miles per hour; cruise range, 75 percent power at 7,500 feet, 660 miles; optimum range at 10,000 feet 1,075 miles; rate of climb at sea level 1,010 feet per minute; service ceiling 17,150 feet; take-off run over 50-foot obstacle 1,365 feet; landing roll over 50-foot obstacle 1,400 feet.

MODEL 210 CENTURION

Prime Contractor: Cessna Aircraft Company

Remarks

The deluxe Model 210 Centurion brings many luxury and comfort features into the single-engine class of aircraft. These include specially trimmed and sculptured interior appointments, optional leather seats, heavy foam-padded carpeting and optional center-aisle consoles for storage.

Specifications

Span 36 feet 9 inches; length 28 feet 2½ inches; height 9 feet 7½ 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 (photo) available with increased performance.

MODEL 310N

Prime Contractor: Cessna Aircraft Company

Specifications

Gross weight 5,200 pounds; empty weight 3,141 pounds; baggage capacity 600 pounds; wing loading 29.1 pounds per square foot; power loading 10 pounds per horsepower; fuel capacity 102 gallons standard; engines 2 6-cylinder, fuel-injection IO-470-V-0; 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, 222 miles per hour; cruise range 777 miles; maximum range at 10,000 feet 966 miles; rate of climb at sea level 1,540 feet per minute (twin engine), 330 feet per minute (single engine); service ceiling 19,900 feet (twin), 6,850 feet (single); 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.

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 ½ inch; height 8 feet 10 inches; gross weight 2,800 pounds; empty weight (approximate) 1,570 pounds; baggage capacity 120 pounds; wing loading 16.1 pounds per square foot; power loading 12.2 pounds per horsepower; fuel capacity 65 gallons, 84 gallons optional; engine 6 cylinder, 230 rated horsepower; propeller constant speed, 82-inch diameter.

Performance (182)

Top speed at sea level 167 miles per hour; cruise speed, 75 percent power at 6,500 feet, 159 miles per hour; cruise range, 75 percent power at 6,500 feet, 685 miles; optimum cruise range at 10,000 feet 905 miles; rate of climb at sea level 980 feet per minute; service ceiling 18,900 feet; 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 approximately 1,625 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 3 inches; height (nose strut depressed) 9 feet 7.5 inches; gross weight 3,600 pounds; empty weight (approximate) 1,820 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 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 (photo) 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 4,400 pounds; empty weight (approximate) 2,650 pounds; baggage allowable 365 pounds; wing loading 21.9 pounds per square foot; power loading 10.5 pounds per horsepower; fuel capacity 93 gallons; engines 2 6-cylinder, fuel-injection IO-360s, 210 horsepower; propellers constant speed, full feathering, diameter 76 inches.

Performance

Top speed at sea level 199 miles per hour; cruise speed, 75 percent power at 5,500 feet, 191 miles per hour; normal range, 75 percent power at 5,500 feet, 760 miles; optimum range at 10,000 feet 965 miles; rate of climb at sea level 1,200 feet per minute (twin engine); service ceiling 19,500 feet (twin engine); take-off run over 50-foot obstacle 1,545 feet; landing ground roll over 50-foot obstacle 1,520 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 7 inches; gross weight 3,600 pounds; configuration 6-place; empty weight (approximate) 1,710 pounds; wing loading 20.5 pounds per square foot; power loading 12 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 6,500 feet, 164 miles per hour; cruise range, 75 percent power at 6,500 feet, 650 miles (optimum at 10,000 feet 800 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-T-25.

Performance

Maximum speed 408 miles per hour; cruise speed at normal rated power 368 miles per hour; gross weight landing speed 85 miles per hour; rate of climb at sea level 3,200 feet per minute; service ceiling 35,000 feet; range with maximum fuel 796 miles.

A-37 STRIKE AIRCRAFT

Prime Contractor: Cessna Aircraft Company

Remarks

The A-37 is being delivered to the U.S. Air Force for close air support work. Evolving from the T-37B jet trainer, the A-37 is equipped with armor plating, partial self-sealing fuel tanks and armament provisions, including a 7.62 minigun. The aircraft also has provisions for an access door under the fuselage for aerial cameras, a fire control and electrical system to accommodate all weapons for close-support missions and long-range fuel drop tanks. Two versions are in use by the USAF: the A-37A, which was formerly known as the AT-37D, and the A-37B (photo), which has the same performance as the A-37A but differs in several areas such as inflight refueling capabilities, higher engine thrust and increased structural capabilities.

Specifications

Gross weight 14,000 pounds; length 29 feet 4 inches; wing span 35 feet 9 inches; engines General Electric J85-GE-17A, total thrust 5,400 pounds; maximum external ordnance load 5,680 pounds.

Performance

Maximum speed 415 knots; gross weight take-off distance over 50-foot obstacle 2,650 feet; landing distance over 50-foot obstacle 2,350 feet; rate of climb 6,800 feet per minute; single-engine performance after lift-off at gross weights up to 11,700 pounds.

T-41 MILITARY TRAINER

Prime Contractor: Cessna Aircraft Company

Remarks

Cessna has produced T-41A trainers in which Air Force student pilots are receiving first flight instruction. The T-41A is a version of the Cessna commercial Model 172, which holds the world's flight endurance record by remaining in flight continuously for 64 days and 22 hours. The company 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. A third version, the T-41C (photo), is in use with the USAF Academy flight training program.

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 O-300-C; propeller all metal, fixed pitch, 76-inch diameter. T-41B is equipped with a 210-horsepower engine and a constant-speed propeller to supply higher performance. T-41C is essentially the same aircraft.

Performance

Top speed at sea level 138 miles per hour; cruise speed, 75 percent power at 7,000 feet, 130 miles per hour; cruise range, 75 percent power at 7,000 feet, 595 miles; optimum range at 10,000 feet 720 miles; rate of climb at sea level 645 feet per minute; service ceiling 13,100 feet; 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; 2 6-cylinder, fuel-injection engines, 300 rated horsepower at 2,700 revolutions per minute; propellers 3-bladed, constant speed, full feathering, 76.5 inches diameter; empty weight (approximate) 3,641 pounds; standard fuel capacity 106 gallons, 143 optional; seating 6-8; baggage allowable 930 pounds; wing loading 32.2 pounds per square foot; power loading 10.5 pounds per horsepower.

Performance

Maximum speed at 6,300 pounds gross weight at 16,000 feet 261 miles per hour; cruise speed, 75 percent power at 20,000 feet, 240 miles per hour, at 10,000 feet, 216 miles per hour; normal cruise range, 65 percent, 743 miles (100 gallons); maximum cruise range at 25,000 feet 1,140 miles (143 gallons); 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 11.58 feet; gross weight 6,800 pounds; engines 2 6-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 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, 276 miles per hour; cruise speed, 75 percent power at 20,000 feet, 255 miles per hour, at 10,000 feet 231 miles per hour; normal cruise range 955 miles (standard fuel); maximum cruise range at 25,000 feet 1,713 miles; rate of climb at sea level (twin) 1,700 feet per minute, (single) 300 feet per minute; service ceiling (twin) 26,000 feet, (single) 13,340 feet; take-off run over 50-foot obstacle 2,516 feet; landing run over 50-foot obstacle (6,500 pounds gross) 2,110 feet.

MODEL O-1E "BIRD DOG"

Prime Contractor: Cessna Aircraft Company

Remarks

Although currently not in production, the O-1 is still widely used by both the U.S. Army and the Air Force for liaison and observation duties. Formerly known as the L-19, the aircraft is able to operate from 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-2

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 (photo) is modified for psychological warfare roles. Two-engine reliability and ease of handling under varied power conditions are gained through its unique, centerline-mounted, opposed twin engines, one forward and one aft of the cabin between the twin tail booms.

Specifications

Wing span 38 feet; length 29 feet 9 inches; height 9 feet 4 inches; wing area 201 square feet; engines 2 6-cylinder, fuel-injected, 210 horsepower each.

Performance

Similar to commercial Super Skymaster version.

MODEL 230 AND 300 AGWAGON

Prime Contractor: Cessna Aircraft Company

Remarks

The Agwagon aerial application aircraft is being produced by Cessna in 2 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 7 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), 11 pounds per horsepower (Model 300); engine Continental O-470-R (Model 230), 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, (300 constant-speed 75 percent power at 6,500 feet) 320 miles; rate of climb at sea level for the 3 versions 710, 755, and 940 feet per minute; service ceiling 13,000 feet, 13,700 feet, and 15,700 feet.

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 pounds take-off, 40,000 pounds 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

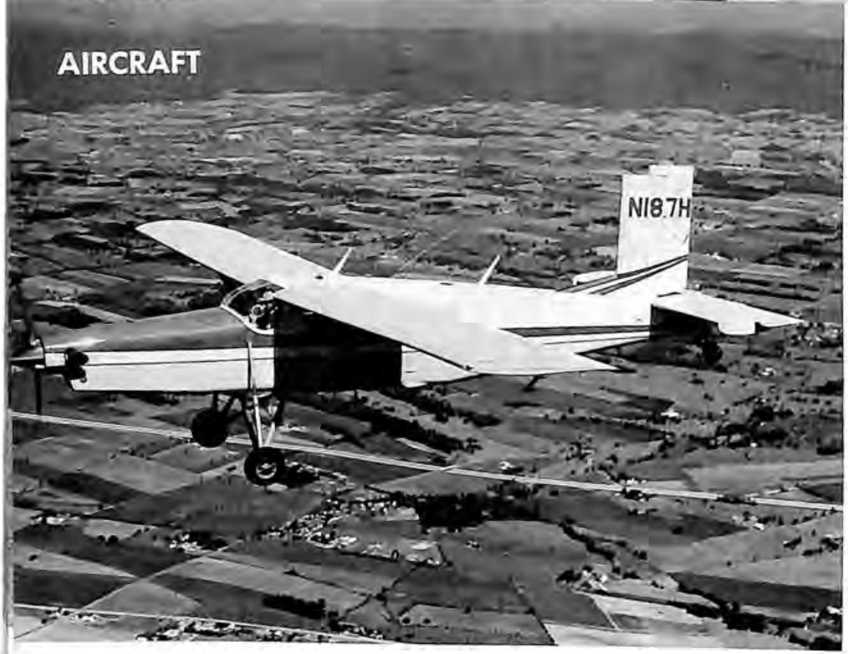
Fairchild Hiller has introduced the FH-227B, an enlarged and improved version of the F-27. With a 6-foot-longer fuselage, the FH-227B was designed to meet the requirements of short-haul airlines for additional capacity for both passengers and cargo. A second new freight area is offered in the aft section.

Specifications

Wing span 95 feet 2 inches; length 83 feet; operational weights: 45,500 pounds take-off, 45,000 pounds 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 side or both sides, depending on customer requirements. Interior configuration can be changed in a matter of seconds by one man without tools because of 4 T-rails built into the floor to receive passenger seats, cargo tie-down rings or stretchers. Arranged as a passenger aircraft, it can transport 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.

ARMED PORTER

Prime Contractor: Aircraft Division, Fairchild Hiller Corporation

Remarks

Fairchild Hiller has developed an armed version of its Heli-Porter for use in limited warfare and for other occasions calling for aerial patrols. The aircraft's STOL characteristics allow it to be operated from extremely small, unprepared fields and to fly at very slow speeds. Large double doors, which can be installed on either side or both sides, make it unsurpassed for paradrop purposes. Its interior can be changed in seconds by one man without tools because of 4 T-rails built into the floor to receive passenger seats, cargo tie-down rings or stretchers. As a passenger aircraft, it can carry 8 persons including the pilot. In its armed configuration, it can be fitted with guns, canisters, rockets, camera pods or target launchers under each wing and below the fuselage.

Specifications

Wing span 49 feet 10 inches; length 35 feet 9 inches; empty weight 3,300 pounds; gross weight (CAR Part 3) 4,850 pounds, (CAR Part 8) 6,100 pounds; useful load 3,385 pounds; wing area 310 square feet; 2 integral wing tanks have total capacity of 128 gallons.

Performance

Cruising speed 130 knots; range 450 nautical miles plus 30-minute fuel reserve; take-off run 305 feet at maximum gross weight on a standard day with no wind; landing roll 130 feet (under same conditions); service ceiling at maximum load 29,700 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-C18.

Performance

Cruise speed 128 miles per hour at sea level; maximum rate of climb 1,600 feet per minute; service ceiling 14,100 feet; range with maximum load 400 miles.

FH-1100 AIR AMBULANCE

Prime Contractor: Aircraft Division, Fairchild Hiller Corporation

Remarks

Proved by both the Korean and Vietnam wars, the air ambulance is gaining widespread use in the United States. Fairchild Hiller's FH-1100 air ambulance provides low-cost service with high-quality performance. This turbine helicopter, designed for a 2-plus-2 configuration (2 crewmen—pilot and medical attendant—and 2 patients), provides all the basic features required of an ambulance helicopter: twin internal litter capability, ease of entry for litters, room for an attendant, initial and operational costs within agencies' budgets and high speed. The double-decked twin litter, positioned behind the pilot, is easily removed through large double doors.

Specifications

Main rotor diameter 35.4 feet; tail rotor diameter 6 feet; length 28.3 feet; height 9.1 feet; empty weight 1,395 pounds; engine Allison 250-C18 gas turbine.

Performance

Cruise speed 128 miles per hour at sea level; maximum rate of climb 1,600 feet per minute; service ceiling 14,100 feet; range with maximum load 400 miles; useful load 1,355 pounds.

SL-4 HELICOPTER

Prime Contractor: 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 4-place craft, sister ship to the nonsupercharged L-4.

Specifications

Main rotor diameter 35 feet; tail rotor diameter 5.5 feet; length 29.1 feet; height 9.5 feet; empty weight 1,960 pounds; engine 1 Lycoming TIVO-540-A2A, 315 horsepower.

E-4 HELICOPTER (OH-23F)

Prime Contractor: Aircraft Division, Fairchild Hiller Corporation

Remarks

Built to meet the Army's high-altitude, rugged terrain requirements, the OH-23F is a 4-place utility helicopter. As a civilian craft, the E-4, it is in wide service in forestry work, missile site construction support, executive transportation and offshore oil rig supply.

Specifications

Main rotor diameter 35.4 feet; tail rotor diameter 5.5 feet; length 29.8 feet; height 9.8 feet; empty weight 1,813 pounds; engine 1 Lycoming VO-540, 305 horsepower.

Performance

Maximum speed 96 miles per hour at sea level; cruise speed 92 miles per hour; maximum rate of climb 1,920 feet per minute; service ceiling 19,300 feet; range with maximum load 225 miles.

F-105 THUNDERCHIEF FIGHTER BOMBER

Prime Contractor: 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 2 models—the single-seat F-105D and the 2-place F-105F. The F-105 is in service with the Tactical Air Force in the U.S., Europe and the Far East. Its speed, maneuverability and aerial firepower qualify it for use in counterair, close-support and interdiction roles in either limited or general war situations. The F-105 enables its pilot to perform a round-trip, low- or high-level bombing mission in any weather, day or night, over any terrain, without ever seeing the ground. The F-105 has been the "workhorse" in North Vietnam for strikes on heavily defended ground targets and has demonstrated a ruggedness equal to the Republic P-47 "Jug" of World War II. Its Vulcan 20-millimeter cannon has been particularly effective on all targets.

Specifications

Span 34 feet 11 inches; length (F-105D) 64 feet 3 inches, (F-105F) 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 October 23, 1953, at Edwards AFB, California. First flight of the YF-102A was December 20, 1954. First deliveries to the Air Force were in June 1955.

Specifications

Span 38 feet 1.6 inches; length 68 feet 5 inches; height 21 feet 2.5 inches; engine 1 Pratt & Whitney Aircraft J57-P-23 turbojet with afterburner, 10,000-pound-thrust class.

Performance

Speed supersonic; ceiling above 50,000 feet.

F-106A ADVANCED ALL-WEATHER INTERCEPTOR

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

The single-seat F-106A carries Hughes AIM-4F and AIM-4G missiles and Douglas AIR-2A special weapon equipped with a nuclear warhead. The F-106B is the 2-seat version of the F-106A, with all-weather capabilities and the same armament. First flight of the F-106A was December 26, 1956, at Edwards Air Force Base, California. First flight of the F-106B was April 9, 1958, at the same base. First deliveries of the F-106A to operational Air Force North American Air Defense Command squadrons were made in 1959.

Specifications

Span 38 feet 1.6 inches; length 70 feet 9 inches; height 20 feet 3.33 inches; engine 1 Pratt & Whitney Aircraft J75-17 with afterburner, 15,000-pound-thrust class; wing area 631.23 square feet.

Performance

Maximum speed 1,525 miles per hour; landing speed 167 miles per hour; other details classified.

CONVAIR 600/640

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

Convair 600 is the general designation for a Convair Liner 240 airframe modernized with Rolls-Royce Dart turboprop engines. The Convair Liner 340 or 440 airframe with Dart engines is designated Convair 640. Among improved performance features of the 600s are a payload increase of up to 2,850 pounds and a cruising speed increase of 50 miles an hour.

Specifications

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 to transcontinental flights. Its sister airliner, the Convair 880-M, offers increased range, fuel capacity and operating weights and shorter runway requirements. It has wing leading edge slats, power boost rudder and engines with increased thrust. Both Convair 880s can cruise at 615 miles an hour. In a first-class, 4-abreast seating arrangement as used by initial operators, the 880 carries 84 passengers. In a 5-across coach configuration, it 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 pounds per square foot at maximum 880 take-off weight of 184,500 pounds; engines 4 General Electric CJ805-3 turbojets with 11,200 pounds thrust each, (880-M) 4 General Electric CJ805-3B 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 .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-foot 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 serve also 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 CJ805-23B 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-foot 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. The aircraft is powered by 2 fanjet engines with afterburners. First flight of a developmental F-111A was in December 1964; first production aircraft were delivered to the Tactical Air Command in October 1967. Initial production order for 331 F-111As was announced by the Air Force in May 1967. The first detachment of F-111As was deployed to Southeast Asia in March 1968. By mid-May, these aircraft had flown more than 50 combat missions over North Vietnam, most of them at night and in bad weather.

Specifications

Span, wings extended, 63 feet, wings fully swept, 32 feet; height 17 feet; length 73 feet; engines 2 Pratt & Whitney Aircraft TF30-P-3 afterburning turbofans, each in 20,000-pound-thrust class.

Performance

Speed at altitude Mach 2-plus; speed at sea level Mach 1-plus; ceiling 60,000 feet; range transoceanic without refueling; inflight refueling capability.

RF-111A RECONNAISSANCE AIRCRAFT

Prime Contractor: Fort Worth Division of General Dynamics Corporation

Remarks

The 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 has 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, permits flexibility of deployment and utilization of many more bases. The RF-111A development program was announced by the Department of Defense in December 1965. First flight of the developmental aircraft was in December 1967.

Specifications and Performance

The RF-111A has essentially the same specifications and performance features as the F-111A, but its internal bay is used for special sensing and photographic equipment instead of weapons.

FB-111A STRATEGIC BOMBER

Prime Contractor: Fort Worth Division of General Dynamics Corporation

Remarks

The variable-wing FB-111A strategic bomber will replace the Strategic Air Command's C through F models of the B-52. 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 has the F-111A fuselage, but it has an additional 7-foot wing span to provide greater range. The FB-111A's landing gear is strengthened to support heavier gross weights. It will carry 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 in July 1967. Initial production order for 64 FB-111As was announced in May 1967. First flight of a production FB-111A was in July 1968.

Specifications

Span, wings extended, 70 feet, wings fully swept, 34 feet; height 17 feet; length 73 feet; engines 2 Pratt & Whitney TF30-P-5 afterburning turbofans; armament, conventional and nuclear, SRAM.

Performance

Speed Mach 1-plus at sea level, Mach 2-plus at altitude; ceiling 60,000 feet; range transoceanic without refueling; inflight refueling capability.

F-111C STRIKE AIRCRAFT

Prime Contractor: Fort Worth Division of General Dynamics Corporation

Remarks

The F-111C will be used by the Royal Australian Air Force for strike missions. The RAAF F-111C is outwardly identical to the U.S. Air Force FB-111A strategic bomber, but it is equipped with the U.S. Air Force F-111A avionic system. Australia has ordered 24 F-111Cs, 6 of which may be fitted for reconnaissance roles. First flight of an F-111C was in July 1968. The first of 24 F-111Cs ordered by Australia was turned over to the RAAF in September 1968.

Specifications and Performance

F-111C is outwardly identical to FB-111A but has essentially the same performance features as 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, Grissom Air Force Base, Indiana. They were designed and produced at the Fort Worth Division of General Dynamics. First flight was November 11, 1956. One hundred sixteen were produced. Air Force crews flying B-58s set 19 world speed and altitude records and won the Thompson Trophy, the Mackay Trophy (twice), the Bleriot Trophy, and the Harmon Trophy (twice). The design uses the delta wing pioneered by the Convair Division of General Dynamics.

Specifications

Span 56 feet 10 inches; length 96 feet 9 inches; height 29 feet 11 inches; gross weight 160,000 pounds; engines 4 General Electric J79 turbojets mounted in pods; engine thrust each 15,600 pounds 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 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 torpedoes.

Specifications

Span 72 feet 7 inches; length 43 feet 6 inches; height 16 feet 7 inches; power plants 2 Wright R1820 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 and 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, under zero-visibility conditions, by means of visual displays presented on viewing screens. In addition, the A-6A employs the Digital Integrated Attack Navigation System (DIANE), which frees the pilot from details that can be performed automatically and enables 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 created specifically 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 can detect, locate, classify, record and jam radiations from enemy weaponry. Its main mission is to support strike aircraft and ground troops by suppressing air-to-air, air-to-ground and ground-to-air electronically controlled weapons. The EA-6A, which has the same airframe as the A-6A Intruder, can function in all weather conditions. Development of a second-generation EA-6B craft with much greater capabilities is 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 for accommodating 2 additional crew members. Sustained low-altitude flight capability, spacious crew stations and armor plate protection are additional features of this newest addition to the Intruder family. The prototype EA-6B made its first flight May 25, 1968, with Grumman test pilot Don King at the controls; the flight lasted 1 hour 45 minutes.

Specifications

Span 53 feet; length 59 feet 5 inches; height 16 feet 3 inches; power plants 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 2-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 or as a 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 R1820-76 rated at 1,425 horsepower each.

Performance

Maximum speed 205 knots; best cruise 130 knots; maximum endurance speed 108 knots; range 2,850 nautical miles.

GULFSTREAM I

Prime Contractor: Grumman 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 and 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 in October 1966. In May 1968 the Gulfstream II became the first corporate jet to fly nonstop from New York to London. The east-to-west return trip was also nonstop.

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 RB163-25 turbofans rated at 11,400 pounds thrust each.

Performance

Speed up to 585 miles per hour; range 3,010 nautical miles; rate of climb 4,000 feet per minute; cruise altitude 40,000 feet.

C-2A GREYHOUND

Prime Contractor: Grumman 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 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 on-board 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 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 2 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, can observe the same displays as those seen by the bombardier/navigator in the simulated cockpit. Students can follow development of the A-6A navigation-attack problem on their own scopes, observing target identification, radar picture size, terrain features, atmospheric and interference limitations and optimum display selection. Capabilities of navigation and track radar can also be observed. Each console is also outfitted with navigational readouts.

Specifications

Span 78 feet 4 inches; length 67 feet 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 F-9F-8 Cougar outfitted for training purposes. The second seat is forward of the first and the aircraft is outfitted with 2 guns only. The TF-9J was the first jet trainer in the U.S. Navy Advanced Jet Training Command capable of transonic speed. Performance, range and combat capability very closely duplicate those of the F-9J. It is well suited to intermediate and operational jet training, transonic flight indoctrination, carrier operations, instrument and navigation training and gunnery and external store delivery training. Although the Cougar trainer is no longer in production, it is still in active service with the Navy and 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 construction parallels the S-2/C-1 series. The aircraft has all-weather capability, and its long-range detection equipment serves the fleet with early warning information regarding impending enemy attack. Equipment for vectoring friendly interceptors against specific targets is also on board. This aircraft is no longer in production but 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 R1820-82 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 minute.

MODEL 300

Prime Contractor: Hughes Tool Company, Aircraft Division

Remarks

The Model 300 is a 3-place aircraft designed for a wide variety of personal transportation and general utility assignments. Exceptionally smooth flight characteristics of the 3-bladed rotor have made this helicopter especially useful for aerial photography in addition to the traditional traffic and power-line patrol and construction site operations. Equipment includes litters, cargo racks, floats and external load sling. The Model 300 has a top speed of 87 miles per hour. A version especially equipped for law enforcement has successfully demonstrated its crime-suppression capabilities in Project Sky Knight, a federally sponsored experiment utilizing helicopters as round-the-clock aerial patrol cars. It is being used by nearly a score of law enforcement agencies for patrol work. Equipment includes 3-way police radio, siren, high-power public address system, litters and an internally controlled floodlight system which illuminates the average residential lot to daylight brilliance from 500-foot patrol altitude. Engineering refinements include Quiet Tail Rotor and exhaust muffler which make all-night patrolling possible without disturbing sleeping citizenry.

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 620 TH-55A helicopters to the Army through 1968; the company had contracts to build 396 more by April 1969.

Specifications

Crew 1; main rotor diameter 25 feet 3½ inches; length 28 feet 5 inches; height 8 feet 3 inches; design gross weight 1,670 pounds; useful load 660 pounds; engine Lycoming HIO-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 delivering the OH-6A light observation helicopter to the Army under contracts calling for 1,301 aircraft. This helicopter set 23 world records for rotorcraft including marks for altitude, speed and nonstop, nonrefueled, cross-country flight (2,215 miles).

Specifications

Length 30.3 feet; height 8.2 feet; main rotor diameter 26.33 feet; empty weight 1,180 pounds; design gross weight 2,400 pounds; useful load 1,520 pounds at overload gross weight of 2,700 pounds; engine Allison T63-A-5A (derated to 252.5 shaft horsepower).

Performance

Maximum speed 130 knots; cruise speed 123 knots; range 300-plus nautical miles (including reserves); rate of climb 1,550 feet per minute; endurance more than 3.5 hours (including reserves).

MODELS 500, 500S (STANDARD), 500M

Prime Contractor: Hughes Tool Company, Aircraft Division

Remarks

The Hughes 500 executive transport (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-wing 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. A companion Model 500S 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 500S may carry up to 950 pounds of internal cargo in the aft compartment; total personnel-carrying capability is 7 including pilot. Speed, performance, low maintenance and exceptional external and internal cargo-lifting capabilities enable the 500S to fulfill many roles in the fields of agriculture, forestry, construction, oil exploration and offshore supply. The Model 500M, an international military version of the OH-6A, offers a variety of modifications to meet owner requirements for power and performance.

HH-43B, HH-43F RESCUE/UTILITY HELICOPTER

Prime Contractor: Kaman Corporation, Aircraft Division

Remarks

The Kaman Huskie has a unique intermeshing rotor system and servo-flap control system. In service with the Air Rescue Service of the Air Force and with foreign governments around the world, the Huskie has demonstrated an ability to perform in jungles, mountains and remote corners of the world previously inaccessible to aircraft. The Huskie has established a record of safety and reliability far exceeding that of any other military aircraft ever in service.

Specifications

HH-43B powered by Lycoming T53-L-11B, HH-43F by T53-L-11A; 2 intermeshing, counterrotating, 2-bladed rotors, diameter 47 feet; height 12.6 feet; empty weight 4,585 pounds (B model), 4,620 pounds (F model); gross weight 6,100 pounds (both models); maximum gross weight 9,150 pounds (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), 303 statute miles (F model); rate of climb 2,000 feet per minute (B model), 1,800 feet per minute (F model); hover OGE 15,000 feet (B model), 18,000 feet (F model); service ceiling 23,000 feet (B model), 25,000 feet (F model).

UH-2A/B UTILITY/RESCUE HELICOPTER

Prime Contractor: Kaman Corporation, Aircraft Division

Remarks

This compact, high-speed, turbine-powered helicopter is used by the Navy and Marine Corps. The Seasprite carries a complete complement of the latest navigational and electronic flight aids including APN-130 Doppler, ASA-13A Air Mass Computer and a Kaman-developed autostabilization system. With all-weather instrumentation, retractable landing gear and water-alighting capabilities, the Seasprite operates on a 24-hour-day basis and at long ranges compatible with today's around-the-clock, dispersed-fleet operations. The UH-2 is used for search, rescue, gunfire observation, reconnaissance, plane guard, courier, personnel transfer, ship-to-ship resupply and tactical air controller operations. The UH-2 was first flown in June 1959, 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 pounds; overload gross weight 10,000 pounds; engine GE T58-8 with 1,250 shaft horsepower; single 4-blade main rotor, 44 feet diameter; 3-blade tail rotor, 8 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 Corporation, Aircraft Division

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 over-water rescue missions. Compact and able to operate from fleet vessels as small as destroyers, the UH-2C has completely self-contained navigation capability.

Specifications

Length 52.5 feet; height 13.6 feet; empty weight 7,390 pounds; gross weight 9,951 pounds; overload gross weight 11,614 pounds; main rotor, single, 4-bladed, 44 feet diameter; tail rotor, 3-bladed, 8 feet diameter; engines 2 General Electric T58-8, 1,250 shaft horsepower each.

Performance

Maximum speed 157 miles per hour; cruise speed 152 miles per hour; normal range 425 miles; ferry range 570 miles; rate of climb, sea level, 2,275 feet per minute; hover ceiling OGE 16,800 feet; service ceiling 18,400 feet.

LA-4 AMPHIBIAN

Prime Contractor: Lake Aircraft Corporation

Remarks

The Lake LA-4 is an all-metal, midwing, 4-passenger amphibian aircraft. It has retractable 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 O-360-A1A 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.

LEARJET 24

Prime Contractor: Lear Jet Industries, Inc.

Remarks

Certified in March 1966 as a growth version of the original Learjet 23, the "24" meets Air Transport Category requirements under Part 25 of Federal Air Regulations. Nearly 200 Learjets in corporate service by the end of 1968 had accumulated some 220,000 hours of flight, equivalent to 110,000,000 miles of travel. Learjets, which hold 22 internationally recognized performance records, have led the business jet industry in civil deliveries since 1965.

Specifications

Span 35 feet 7 inches; length 43 feet 3 inches; height 12 feet 7 inches; wing sweepback 13 degrees; take-off gross weight 13,000 pounds; pressure differential 8.78 pounds per square inch; engines 2 General Electric CJ610-4.

Performance

Maximum speed 560 miles per hour; stall speed normal landing weight 104 miles per hour; maximum range with 45-minute reserve 1,565 miles; maximum operational altitude 45,000 feet; single-engine service ceiling 26,000 feet; rate of climb at sea level 6,300 feet per minute; 2-engine take-off over 35-foot obstacle 2,550 feet; 2-engine landing over 50-foot obstacle 2,850 feet.

LEARJET 25

Prime Contractor: Lear Jet Industries, Inc.

Remarks

Certificated in October 1967, the Learjet 25 measures 4⅓ feet longer than the Learjet 24. It carries 8 passengers plus crew of 2. Offering essentially the same high performance statistics as the "24," the larger Learjet 25 provides certain advantages in load-carrying ability, range and other criteria. In February 1967 a standard production Learjet 25 was flown to 40,000 feet in 6 minutes 19 seconds, breaking the "time-to-climb" business jet record set previously by a Learjet 23.

Specifications

Span 35 feet 7 inches; length 47 feet 7 inches; height 12 feet 7 inches; wing sweepback 13 degrees; take-off gross weight 15,000 pounds; pressure differential 8.94 pounds per square inch; engines 2 General Electric CJ610-6.

Performance

Maximum speed 560 miles per hour; stall speed normal landing weight 110 miles per hour; maximum range with 45-minute reserve 1,800 miles; maximum operational altitude 45,000 feet; single-engine service ceiling 27,500 feet; rate of climb at sea level 5,600 feet per minute; 2-engine take-off over 35-foot obstacle 3,535 feet; 2-engine landing over 50-foot obstacle 4,020 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-7 Corsair II, which first deployed aboard the *Ranger* to the Pacific Fleet in late 1967. Designed in response to the Navy's request for a light attack aircraft with 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; 199 production aircraft were delivered by early 1968. The A model is equipped with the Pratt & 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.

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 (A-7B and -7E), Rolls-Royce/Allison TF41 Spey (A-7D and -7E).

Performance

Subsonic.

AIR FORCE A-7D

Prime Contractor: LTV Aerospace Corporation, a subsidiary of Ling-Temco-Vought, Inc.

Remarks

The Air Force began procuring the A-7D for tactical use in 1968. Described as capable of carrying and effectively delivering all types of non-nuclear munitions, the A-7D is 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. The Air Force A-7 is equipped with an avionics suit which gives the aircraft 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 a digital-computer-equipped avionics package. The first Air Force A-7 was test flown in Dallas in April 1968 and was scheduled to be operational within Tactical Air Command in 1969. The Air Force airplane includes an arresting hook for emergency landings or aborted take-offs, inflight refueling capability and folding wing sections, gas turbine self-starter, M-61 Vulcan 20-millimeter cannon capable of firing 6,000 rounds a minute and 8 store stations on the fuselage and wings.

Specifications

Wing span 39.73 feet; length 46.13 feet; height 16.7 feet; engine Allison/Rolls-Royce TF41-A-1 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 and RF-8G photoreconnaissance versions 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 395 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 becomes the H, and the E changes to the J. Future conversions will include the 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-P-20A, 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 was scheduled to undergo testing at Langley Research Center. Two of the tilt-wing assault transports were delivered in July and August 1965 to Edwards Air Force Base, California, where a 12-man pilot team from the Air Force, 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 one delivered in August 1966. Designed to operate from landing areas as small as 350 feet square, the XC-142A can carry 32 fully equipped combat troops or 8,000 pounds of cargo. With its wing tilted straight up, its 4 T64 turboprop 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 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-104 "S" SUPER STARFIGHTER

Prime Contractor: Lockheed-California Company

Remarks

Lockheed-California Company's F-104 prototype made its initial flight in February 1954. The multi-mission fighter-interceptor became operational with USAF in January 1958 and remains in service today with USAF's Air Defense Command. An advanced Starfighter version, the F-104G, was manufactured in the aviation industry's largest international production program for the air arms of 14 free world nations—Germany, Canada, the Netherlands, Belgium, Norway, Denmark, Italy, Spain, Greece, Turkey, Pakistan, the Republic of China, Japan and the United States. More than 2,400 Starfighters have been built, worldwide. Lockheed's newest Starfighter—the F-104 "S"—is being manufactured in Italy. The Italian Air Force has purchased 165 of the new Sparrow-missile-armed Starfighters for delivery beginning in 1969.

Specifications

F-104G: Span 21 feet 11 inches; length 54 feet 9 inches; height 13 feet 6 inches; gross weight 28,800 pounds; engine General Electric J79-11A, 15,800 pounds thrust with afterburner. F-104 "S": Same span, length, height; gross weight 31,500 pounds; engine General Electric J79-19, 17,900 pounds thrust with afterburner.

Performance

Speed Mach 2-plus; altitude above 100,000 feet.

P-2 NEPTUNE

Prime Contractor: Lockheed-California Company

Remarks

The P-2 Neptune made its first flight in May 1945, and today—more than 20 years later—it is ably performing its antisubmarine patrol mission for the U.S. Navy and for other free world nations. Steady refinements and new additions kept the P-2 modern and up to date through 7 models. Although the P-2 is gradually being replaced in the Navy by Lockheed's P-3A Orion, it still bears the insignia of 7 other nations, 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, anti-submarine 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, Australia and Norway. The new P-3C Orion with the A-NEW avionics system will be delivered to the Navy in 1969.

Specifications

Span 99 feet 8 inches; length 116 feet 10 inches; height 33 feet 9 inches; gross weight 135,000 pounds; engines 4 Allison T56-14, 4,591 shaft horsepower each.

Performance

Speed 413 knots; altitude above 30,000 feet.

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 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 1 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 Company 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/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 6 tons of electronic equipment to high altitudes, the planes were designed as aerial sentries, locating sneak raiders at interception points far 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: Span 123 feet; length 94 feet 4 inches; height 23 feet 9 inches.

Performance

Endurance approximately 18 hours.

XH-51A HELICOPTER

Prime Contractor: Lockheed-California Company

Remarks

The XH-51A is a 2-place helicopter developed by Lockheed-California in Burbank under a joint Army-Navy contract as a research vehicle for high-performance rotary-wing aircraft. First flight was announced in November 1962. The 4-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 PT6B-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 in 1964 under an Army-sponsored program from a "pure" XH-51A helicopter by the addition of stub wings and an auxiliary jet engine (mounted on left wing). In June 1967 the XH-51A compound 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 4,500 pounds; engines 1 Pratt & Whitney Aircraft PT6B-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 5 persons. The 3-blade XH-51N has the Lockheed-developed rigid-rotor system and retractable landing gear.

Specifications

Fuselage length 33 feet; rotor blade diameter 35 feet; weight 4,000 pounds; engine 1 Pratt & Whitney Aircraft PT6B-9 turboshaft produced by United Aircraft of Canada, 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 Administration type certificate. It was the first rigid-rotor helicopter to be certificated by the FAA. This type of rigid-rotor helicopter has a wide potential for transport, rescue and various military missions. As a light antisubmarine helicopter, it would be capable of rapid-action response from various Navy attack vessels. The similar Lockheed-built Army-Navy XH-51A has made landings on and 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 and 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 demonstrators.

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. It has reached 206 miles per hour in a slight descent.

U-2

Prime Contractor: Lockheed-California Company

Remarks

The U-2, originally proposed as an independent Lockheed project in 1954, has been in service with the Air Force and other government agencies since then. The planes furnish weather, 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 HELICOPTER

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 far faster than 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, and first flight took place there in September of that year. An extensive flight test program is under way. In January 1968 Lockheed received an Army go-ahead for production of 375 Cheyennes. Mission of this rigid-rotor compound aircraft is to escort troop-carrying helicopters in air mobile operations and to provide direct fire support in combat landing zones. The heavily armed AH-56A 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) 11,800 feet.

XV-4B HUMMINGBIRD

Prime Contractor: Lockheed-Georgia Company

Remarks

The XV-4B Hummingbird is a vertical take-off and landing (VTOL) midwing 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 570-mile-per-hour, 4-engine, multimission transport, stressing reliability and safety with double and triple backup systems; it is the only 4-engine executive jet. JetStars are in use around the world, flying 5 chiefs of state and other high government officials as well as 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. In addition, 2 Dash 8 JetStars are being employed by a major airline for airborne pilot flight training. The compact jetliner seats 10 passengers and a crew of 2. It is also available in a 19-place military version, which can be quickly transformed into a cargo-personnel transport with a 3,500-pound combined payload, or into a hospital plane.

Specifications (Dash 8)

Span 54 feet 5 inches; length 60 feet 5 inches; height 20 feet 5 inches; wing sweepback 30 degrees at 25 percent chord; maximum take-off weight 42,000 pounds; engines 4 Pratt & Whitney Aircraft JT12A-8s, 3,300 pounds thrust each.

Performance

Maximum speed 570 miles per hour; unrefueled range 2,342 statute miles with 8 passengers; certificated altitude 43,000 feet.

C-130E HERCULES TRANSPORT

Prime Contractor: Lockheed-Georgia Company

Remarks

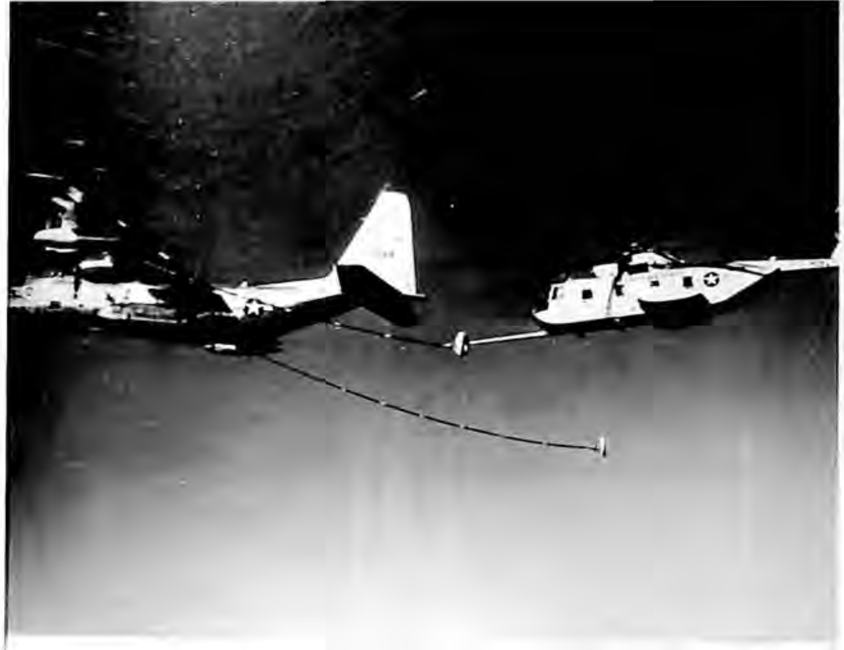
The C-130E is an advanced version of the C-130A and C-130B, embodying various structural and system modifications. Maximum payload has been increased to 45,000 pounds and this weight can be carried over 2,100 nautical miles. Using an overload take-off weight, the payload can be carried over 3,100 nautical miles. The C-130E is designed for the optional use of externally mounted wing fuel tanks. Use of these external tanks gives this model Hercules true transocean 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 propjets, 4,050 equivalent 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 worldwide service with the Aerospace Rescue and Recovery Service (ARRS) of the U.S. Air Force's Military Airlift Command. The HC-130H Hercules, equipped with a Fulton recovery system, can pick up as many as 5 humans in multiple pickups from land or sea and return home. Designed for all-weather search and rescue operations, the airplane can fly missions 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 inflight refueling techniques that not only made these flights possible, but also gave these Air Force rescue helicopters worldwide deployment and rescue capabilities. HC-130P has beefed-up outer wing tank areas, additional backup pumps and wing pods for refueling drogues. The 48-inch high-drag drogue is designed to accommodate the helicopters' lower speeds. Besides the unique Fulton system for surface-to-air retrieval of personnel, HC-130H/Ps are equipped 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.

EC-130E HERCULES

Prime Contractor: Lockheed-Georgia Company

Remarks

This new version of the military C-130E 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 4 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 T56-A-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-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 45,409 pounds. The airplane carries, as a standard, 5 pallets plus a ramp container. The pallets are made of phenolic-surfaced plywood and have a capacity of 10,000 pounds each. They measure 88 inches by 118 inches and can be stacked with cargo to a height of 102 inches. The cargo compartment features straight-in-and-out loading at the rear of the fuselage 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. Lockheed-382B is version without built-in loading system.

Specifications

Length 97.7 feet; height 38 feet; wing span 132.6 feet; maximum take-off weight 155,000 pounds; maximum net payload 45,409 pounds; crew 3; 4 Allison 501-D22 turboprop engines, driving 4-blade Hamilton Standard hydromatic propellers; fuel 52,492 pounds.

Performance

Maximum cruise speed 300 knots; range with maximum payload 2,050 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.

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 long aft of the wing. This increases the length of the cargo section by 100 inches. A new engine, the Allison 501-D22A, provides increased performance and reduced operating costs. Cruise speed at 25,000-foot altitude is 31 miles an hour faster than the standard Lockheed-100 Hercules commercial freighter. The -20 version of the air freighter provides a 14.8 percent reduction in cube ton-mile operating costs. A retrofit program is established whereby commercial Hercules now in airline service can be converted to the longer, faster model.

Specifications

Length 106 feet; height 38 feet; wing span 132.6 feet; maximum take-off weight 155,000 pounds; maximum net payload 49,036 pounds; crew 3; 4 Allison 501-D22A turboprop engines, driving 4-blade Hamilton Standard hydromatic propellers; fuel 52,492 pounds.

Performance

Maximum cruise speed 327 knots; range with maximum payload 1,900 nautical miles; take-off distance at 155,000 pounds gross weight 5,950 feet; landing distance at 130,000 pounds gross weight 4,760 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 the first jet to land in the Antarctic.

Specifications

Wing span 159.9 feet; length 145 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.

C-5A GALAXY CARGO/PERSONNEL CARRIER

Prime Contractor: Lockheed-Georgia Company

Remarks

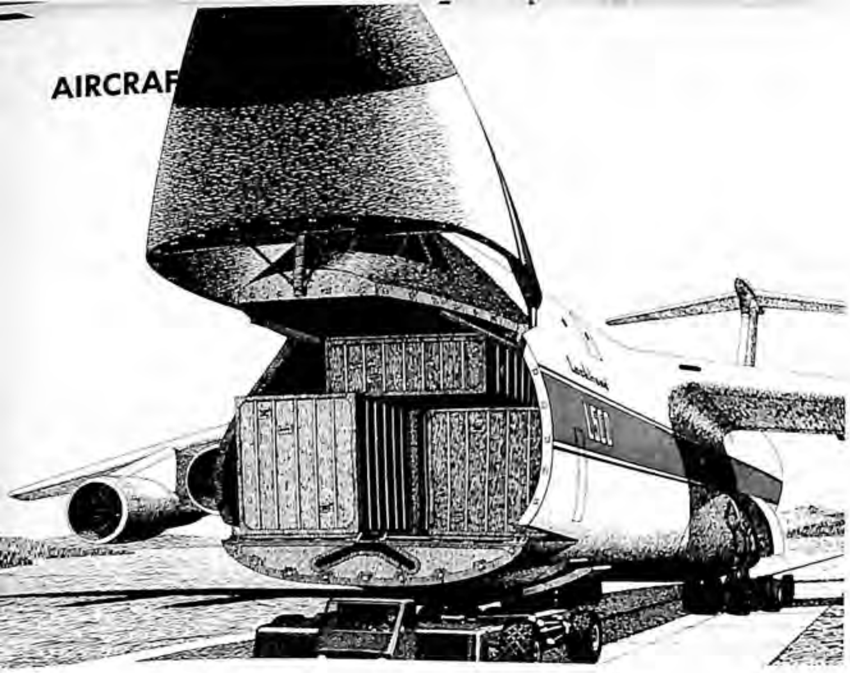
The primary mission of Lockheed's C-5A Galaxy, the world's largest aircraft, is to provide a significant increase in the Military Airlift Command's ability to airlift all types of combat and support forces. Basic requirements are for very high payload and cargo volume, intercontinental range, support-area airfield operations and air dropping of troops and equipment. Double-deck design provides a cargo compartment 19 feet wide, 13½ feet high and 121 feet long between ramps. Flight or relief crews, and support personnel for vehicles carried below, ride on upper deck. Prototype roll-out was in February 1968; first flight was in June 1968. Operational deliveries were to begin in 1969.

Specifications

Wing span 222.8 feet; length 247.8 feet; height 65.1 feet; wing sweep 25 degrees; gross take-off weight (2.5 g) 728,000 pounds; engines 4 General Electric TF-39 turbofans of 41,100 pounds thrust each; 4-wheel nose landing gear, 4 6-wheel bogie main landing gears.

Performance

Maximum cruise speed 470 knots; long-range cruise speed 440 knots; range with 220,000 pounds design payload 3,050 nautical miles; range with 112,600 pounds payload 5,500 nautical miles.



LOCKHEED 500-114M GALAXY

Prime Contractor: Lockheed-Georgia Company

Remarks

A civil derivation of the USAF C-5 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 126 feet in length. The main compartment takes 2 rows of containers or pallets on floor, plus an optional 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 8x8x10 standard, intermodal units. Maximum gross payload is 300,000 pounds. Visor nose permits all 3 rows of main deck pallets and containers to be transferred simultaneously. Design eliminates military transport's aft cargo doors.

Specifications

Wing span 222.7 feet; length 247.9 feet; height 67 feet; gross take-off weight 833,200 pounds; wing sweep at ¼ chord 25 degrees; engines 4 Pratt & Whitney Aircraft turbofans, 45,500 pounds thrust; 4-wheel nose landing gear, 4 independent 4-wheel bogie main landing gears.

Performance

Maximum cruise speed 480 knots; long-range cruise speed 444 knots; range with 300,000 pounds of cargo 2,800 nautical miles; direct operating cost at 2,800 nautical miles, maximum cargo, 2.35 cents per ton-mile.

LOCKHEED L-1011 JET TRANSPORT

Prime Contractor: Lockheed-California Company

Remarks

The L-1011 is a new-generation, wide-bodied, flexible-range trijet transport designed to handle airline needs in the 1970s and beyond. It will accommodate from 250 to 345 passengers and will operate economically on short- through transcontinental-range flights up to 3,260 miles. Passenger and range growth capabilities are inherent in the basic aircraft design, making the L-1011 a forerunner of a family of Lockheed jetliners. The 235-inch-diameter fuselage, nearly 20 feet across, permits a 2-aisle arrangement running the length of the cabin, 2-abreast seating in coach as well as first class, overhead storage compartments and a modern restaurant-style galley below deck. Two elevators will connect the 2 levels. Two of the 3 engines are mounted under the wings and the third is in the tail, using an S-shaped air inlet duct which permits vertical lowering of the engine for maintenance. The L-1011 avionic flight control system will feature fail-operative redundancy and all-weather landing capability. An all-purpose transport, the L-1011 is scheduled to enter commercial airline service in 1971.

Specifications

Fuselage length 177 feet 8 inches; height 55 feet 4 inches; wing span 155 feet 4 inches; wing sweepback 35 degrees; cargo volume 3,400 cubic feet; maximum payload 87,000 pounds; maximum gross take-off weight 409,000 pounds; engines 3 Rolls-Royce RB.211 turbofans of 3-shaft design.

Performance

Maximum cruise speed over 600 miles per hour; range with 56,200-pound payload at Mach .85 3,260 statute miles; take-off distance to clear 35-foot obstacle 8,750 feet.

MARTIN 4-0-4 AIRLINER

Prime Contractor: Martin Marietta Corporation, Baltimore Division

Remarks

The 4-0-4 is an improved version of the earlier Martin 2-0-2. It has a crew of 3 and carries 40 passengers. Tricycle landing gear and retractable passenger steps facilitate ground operations. One hundred three 4-0-4s were built in 1951 and 1952.

Specifications

Length 74 feet 7 inches; height 28 feet 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 & Whitney Aircraft R2800-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 miles 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.

B-57 BOMBER

Prime Contractor: Martin Marietta Corporation, Baltimore Division

Remarks

The B-57A, B and C are designed to destroy surface military targets during tactical operations. Speed brakes on either side of the fuselage permit steep dives and additional control during low-altitude operations and landing approaches. Tactical versions carry a pilot and 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 and modified a number of aircraft in 1966, 1967 and 1968 for service in Vietnam.

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 4 20-millimeter cannons or 8 .50-caliber machine guns which fire from the leading edges of the wings.

Performance

Speed over 600 miles per hour; range more than 2,000 miles; service ceiling over 45,000 feet.

F-4C PHANTOM FIGHTER-BOMBER

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The F-4C Phantom is an Air Force fighter-bomber aircraft, a 2-engine, 2-man, all-weather weapon system employed for the close support and attack mission of Tactical Air Command, PACAF and USAFE. Basic armament of the F-4C is 4 radar-guided Sparrow III air-to-air missiles carried semisubmerged under the fuselage; 2 additional Sparrow IIIs or 4 infrared-guided Sidewinders 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 May 27, 1963, less than 14 months after McDonnell received contractual go-ahead from the USAF. The first 2 aircraft were delivered November 20, 1963, and the last of 583 F-4Cs was delivered May 4, 1966. The F-4D Phantom has augmented the F-4C in the USAF inventory.

Specifications

Length 58 feet; span 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's McDonnell Aircraft Company

Remarks

The F-4B Phantom is a 2-place, twin-jet, all-weather fighter built for the U.S. Navy and Marine Corps. The Phantom has the greatest fire power 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's McDonnell Aircraft Company

Remarks

The RF-4B is a tactical, all-weather, multisensor reconnaissance aircraft that utilizes the same basic configuration and engines as the fighter and attack versions of the Phantom. McDonnell has designed and is building the RF-4B to increase the reconnaissance capability of the Marine Corps. Basically, the RF-4B differs from the RF-4C reconnaissance version in that (1) the RF-4B 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 2 camera stations. Cameras in the Air Force version can be repositioned only on the ground. The RF-4B has no armament capability.

Specifications

Length 63 feet; span 38½ feet; wing sweepback 45 degrees; engines 2 GE J79-8, 17,000 pounds thrust each.

Performance

Speed 1,600-plus miles per hour; ferry range 2,000 miles; forward-looking radar, utilizing its terrain following or terrain avoidance mode, permits operation at very low altitude over varying terrains.

RF-4C PHANTOM RECONNAISSANCE AIRCRAFT

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The RF-4C Phantom is a high-performance fighter-type aircraft with an effective tactical, all-weather, multisensor reconnaissance capability. The Air Force RF-4C incorporates optical, infrared and electronic sensors necessary 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 inflight 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 infrared 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's McDonnell Aircraft Company

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; it was flown later to Bitburg, Germany, as the forerunner of several squadrons of F-4Ds that replaced F-105 aircraft stationed in Germany. Two squadrons of F-4Ds were scheduled for delivery to the Royal Iranian Air Force late in 1968.

F-4E PHANTOM AIR SUPERIORITY FIGHTER

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The F-4E is a tactical strike fighter version of the F-4 Phantom. Like the preceding F-4C and F-4D series, it is a twin-engine, 2-place fighter capable of performing air superiority, close support and interdiction missions of the tactical forces using conventional or nuclear munitions. The F-4E has an internally mounted M-61A1 20-millimeter Gatling gun housed in the nose of the aircraft, an improved fire control system and engines with increased thrust. A Westinghouse-developed miniaturized radar installed in the nose enables retention of the radar-guided Sparrow III missile armament in addition to the gun. The multibarrel cannon, based on the Gatling-gun concept, is capable of firing shells at a rate of 100 rounds a minute. First flight of the production model of the F-4E was at St. Louis on June 30, 1967. On October 3, 1967, the first F-4E was delivered to the Tactical Air Command at Nellis Air Force Base, Nevada.

F-4J PHANTOM

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

An advanced version of the Phantom II series, the F-4J was the 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 produce 17,900 pounds thrust each 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's McDonnell Aircraft Company

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. The first F-4Ks were delivered to the Royal Navy at the RN station in Yeovilton, England, after a 4,700-mile transatlantic flight from St. Louis, on April 29, 1968.

F-4M PHANTOM AIR SUPERIORITY FIGHTER

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The McDonnell Douglas F-4M Phantom for the 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. 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 first F-4Ms were delivered to the Royal Air Force at Aldegrove, Northern Ireland, on July 20, 1968.

F-101B VOODOO INTERCEPTOR

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

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 2-place interceptor; the second crewman is a radar operator. The F-101B operates under all weather conditions to execute 2 primary missions: identification of unknown aircraft and then destruction if they are hostile. There are 15 squadrons of the F-101B Voodoo in service with the Air Defense Command and 3 squadrons 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 & Whitney Aircraft J57.

Performance

Speed 1,200-plus miles per hour; range 2,000-plus miles; service ceiling 55,000-plus feet.

188E STOL TRANSPORT

Prime Contractor: McDonnell Douglas Corporation's McDonnell Aircraft Company

Remarks

The 188E is designed to carry an 8-ton payload 575 miles, land safely with less than 500-foot ground roll on a 1,000-foot unprepared surface and return to its base with payload, without refueling. Flight safety for short-field operations and maneuverability at low speed is provided through cross-shaft interconnection of the 4 engines. The 188E can make steep turns and gear-down landing approaches at airspeeds as low as 50 knots. 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 mission 8 tons; troop capacity 55.

Performance

Cruise speed 250 knots; ferry range 3,500-plus miles.

A-3 SKYWARRIOR

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

The A-3 Skywarrior is a long-range bomber designed to perform various missions at high or low levels. Versions of the basic A-3 include the RA-3B photoreconnaissance aircraft, the TA-3B bomber-trainer and the EA-3B reconnaissance model. An inflight refueling system converts it to a high-speed jet tanker. First A-3 flight was October 28, 1952. It is the largest of the Navy's carrier-based aircraft. Wings and vertical tail surface fold for convenience in carrier handling. The A-3 was phased out of production in 1961.

Specifications

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: McDonnell Douglas Corporation's Douglas Aircraft Company

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. Nose-wheel 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: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

Several versions of the B-66 tactical bomber are in service with the Air Force. Produced in 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 WB-66D were produced at the Tulsa facility. The RB-66B is designed to be used with a wide selection of bomb combinations including the H-bomb. The RB-66C is a special-purpose reconnaissance plane. The WB-66D, last in the series, is a weather reconnaissance aircraft. Special features include a pressurized, air-conditioned compartment, inflight refueling system, and thermal-cyclic de-icing system.

Specifications

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: McDonnell Douglas Corporation's Douglas Aircraft Company

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, a self-contained ramp and an elevator located amidship permitting loading and unloading at both points. The last C-124 was delivered in May 1955.

Specifications

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 R4360-63A; 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: McDonnell Douglas Corporation's Douglas Aircraft Company

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 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: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

First of the modern, post-World War II airliners, the propeller-driven DC-6 series and their military counterparts are still giving service throughout the world. Powered by 4 Pratt & Whitney Aircraft R2800 engines, the DC-6 repeatedly set commercial records with its cruising speed of 315 miles an hour. It also introduced new levels of comfort to air travel with cabin pressurization and air conditioning. With an overall fuselage length of 100 feet 7 inches, the DC-6 carries up to 74 passengers. After 174 were produced, an enlarged version 5 feet longer to seat up to 102 was designed and designated the DC-6B. This design was the basis of the first commercial 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 types were produced. First DC-6 flight was February 15, 1946; first delivery was March 28, 1947.

DC-7 COMMERCIAL TRANSPORT

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

The DC-7, the most advanced piston-powered commercial transport built by Douglas, is in extensive use on long-range airways of the world. 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, over-water capabilities, the DC-7C is powered by 4 Wright R3350 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: McDonnell Douglas Corporation's Douglas Aircraft Company

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 a 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 259 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 6-foot increase in wing span, increased fuel capacity and redesigned engine pylons and ducted fan nacelles. Super 63 (photo) is a combination of the full fuselage extension of Super 61, with pylon and engine pod modifications of the Super 62. First flight of Super 61, March 14, 1966; Super 62, August 29, 1966; Super 63, April 10, 1967. Certification all Super Sixty Series models, 1967.

Specifications (Super 63)

Span 148.4 feet; length 187.4 feet; height 42 feet 4 inches; wing area 2,926 square feet; crew 3-5 plus cabin attendants; engines 4 Pratt & Whitney Aircraft JT3D-7, 19,000 pounds thrust each; design gross weight 353,000 pounds.

Performance

Level flight speed 600 miles per hour; maximum range 7,700 statute miles.

DC-9 JET TRANSPORT

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

The short- to medium-range DC-9 twin-jet is produced in 4 versions: Series 10, Series 20 (photo), Series 30 and Series 40. Series 10 fuselage is 104.4 feet long and will accommodate up to 90 passengers. Series 20, capable of operating from very short runways, is the same length as Series 10 but has the high-lift wing of the Series 30. Series 30, 119.3 feet in length, will carry a maximum of 115 passengers. Series 40, with more powerful engines, is 125.6 feet long and will accommodate up to 125 passengers. DC-9 is designed to operate from short runways. In normal operations, all versions of the DC-9 will take off on a 600-mile flight with 50 passengers and baggage from a runway of less than 5,000 feet and make 2 intermediate stops without refueling. The Series 20, Series 30 and Series 40 have the high-lift wing system of leading-edge slats and trailing-edge flaps for excellent short-field performance. First flight of Series 10, February 25, 1965; Series 30, August 1, 1966; Series 40, November 28, 1967; Series 20, September 18, 1968. Certification for Series 10 was awarded November 23, 1965; Series 30, December 19, 1966; Series 40, February 27, 1968.

Specifications

DC-9 Series 30: Span 93.4 feet; length 119.3 feet; height 27.4 feet; wing area 1,000.7 square feet; crew 2 plus cabin attendants; engines 2 Pratt & Whitney Aircraft JT8D-7 ducted turbofans, take-off thrust 14,000 pounds; maximum take-off weight 77,700 pounds.

Performance

Level flight speed 557 miles per hour; range at optimum cruise speed 1,430 nautical miles.

C-9A AEROMEDICAL AIRLIFT TRANSPORT

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

The first of 12 C-9A Nightingales was delivered to the Air Force on August 10, 1968, just 11 months and 10 days after Douglas Aircraft received a contract from the Air Force Systems Command's Aeronautical Systems Division on August 31, 1967. More than 40 ambulatory patients, 30 to 40 litter patients or a combination can be accommodated in a C-9A on 500-mile-per-hour flights between military hospitals. The transports, equipped to provide passengers with the same medical care and attention they would receive in a hospital ward, will be operated by the 375th Aeromedical Wing of the Military Airlift Command. The Nightingale is basically a standard DC-9 Series 30, but it has an 11-foot-wide cargo door and a special ramp to accommodate the boarding of patients on litters. Special features include accommodation of patients in either aft-facing seats or in rigidly suspended litters of 3 or 4 tiers. Other special features include provision for therapeutic oxygen, a medical suction system for use in keeping patients' air passages clear, an isolated special-care section, a central control station for the flight nurse and medical attendant stations. The boarding ramp and large door (81x136 inches) for boarding patients are hydraulically operated.

Specifications

Other than special features, the craft is an off-the-line DC-9 Series 30, with standard dimensions: wing span 93.4 feet; overall length 119.3 feet; overall height 27.4 feet.

Performance

Cruise speed 500-plus miles per hour; range 2,000-plus miles.

DC-10 JET TRANSPORT

Prime Contractor: McDonnell Douglas Corporation's Douglas Aircraft Company

Remarks

The multirange DC-10 is a 3-engine, advanced technology jetliner for use in the 1970s. It will accommodate 271 passengers in a typical mixed-class arrangement or more than 330 passengers in an all-economy configuration in a spacious fuselage 179 feet 8 inches long, 18 feet 9 inches wide and more than 8 feet high. Two of its powerful General Electric CF6/36-6 jet engines are mounted conventionally on pylons beneath the wings, and the third is installed above the aft fuselage at the base of the vertical stabilizer. Capable of economical operation over ranges from 300 to 3,200 statute miles, the DC-10 will carry its full passenger capacity nonstop on transcontinental flights in the United States and on West Coast-Hawaii flights. With its advanced technology engines, powerful high-lift system and high-speed airfoil design, the McDonnell Douglas trijet will be capable of making nonstop transcontinental flights from runways no longer than 7,950 feet in 90-degree temperatures. The DC-10 is scheduled to make its first flight late in 1970.

Specifications

Length 179 feet 8 inches; diameter almost 20 feet; height 57 feet 3 inches; wing span 155 feet 4 inches; engines, 3 General Electric CF6/36-6 high bypass ratio turbofans, each generating 40,000 pounds of take-off thrust; maximum gross take-off weight for long-range operation with full payload 410,000 pounds.

Performance

Level flight speed 600-plus miles per hour; payload 80,000 pounds; maximum range 3,200 statute miles.

EC-135N APOLLO RANGE INSTRUMENTED AIRCRAFT

Program Direction: Electronics Systems Division, Air Force Systems Command
Contractors: McDonnell Douglas Corporation's Douglas Aircraft Company (prime contractor for Apollo Range Instrumented Aircraft Program); The Bendix Corporation (major subcontractor for electronics); The Boeing Company (basic airframe)

Remarks
The EC-135N is an Air Force jet transport modified to play an important role in the Apollo lunar landing program. A fleet of 8 Apollo Range Instrumented Aircraft provides a highly mobile communications network which can be shifted quickly to allow coverage in areas where ground or sea stations cannot afford maximum radio and telemetry contact with Apollo astronauts. Most prominent addition to the transport is a huge protruding radome attached at the nose. The 10-foot-long bulb houses a 7-foot VHF and S-band parabolic dish antenna which will scan for a spacecraft, lock on to 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 September 19, 1966.

RANGER

Prime Contractor: Mooney Corporation

Remarks
The 4-place, retractable-gear Ranger features positive control for "wings level" flight attitude. Its 4-cylinder, 180-horsepower engine uses 91/96 octane fuel. The fuel is contained in 2 integral sealed tanks. A full trim tail gives maximum stability at low speeds and minimum drag at high speeds. Cabin construction features a welded chrome-moly steel tube frame structure. Electric gear retraction system is standard.

Specifications
Span 35 feet; length 23 feet 2 inches; height 8 feet 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 inch; engine 1 Lycoming O-360, 180 horsepower; propeller 74 inches, constant speed; fuel capacity 52 gallons.

Performance
Maximum level speed 179 miles per hour; maximum cruising speed at 75 percent power 172 miles per hour at 7,500 feet; stall speed 57 miles per hour; rate of climb 1,000 feet per minute at gross weight; maximum range 1,043 miles; service ceiling 17,200 feet.

STATESMAN

Prime Contractor: Mooney Corporation

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 Corporation

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 TIO-541-A1A; usable fuel 92 gallons.

Performance

Maximum level speed 256 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 and Canada) Mooney Corporation

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 340 miles per hour and has a 26,500-foot ceiling. Passengers enjoy air-conditioned and pressurized comfort. Its 2 705 shaft horsepower engines, full-span, double-slotted flaps and reversible propellers allow the Mooney MU-2 to get in and out of short airstrips.

Specifications

Span 38 feet 9 inches; length 33 feet 3 inches; height 13 feet; gross weight 8,930 pounds; useful load 3,600 pounds; engines 2 AiResearch TPE 331; fuel 295 gallons.

Performance

Maximum cruising speed at 10,000 feet 340 miles per hour; stall speed 74 miles per hour; rate of climb 2,000 feet per minute; maximum range 1,200 miles.

EXECUTIVE 21

Prime Contractor: Mooney Corporation

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.

Specifications

Span 35 feet; length 24 feet 3.1 inches; height 8 feet 4.5 inches; gross weight 2,740 pounds; empty weight 1,622 pounds; useful load 1,118 pounds; baggage 120 pounds; wing loading 15.4 pounds per square foot; 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-minute reserve; service ceiling 17,900 feet.

CHAPARRAL

Prime Contractor: Mooney Corporation

Remarks

A new addition to the Mooney line, the Chaparral features electric gear (up in 4 seconds, down in 3), a power quadrant which sets up power, propeller and mixture controls in ideal arrangement, electrically operated flaps, a completely new instrument panel and an annunciator panel to monitor the aircraft's vital systems.

Specifications

Wing span 35 feet; length 23 feet 2 inches; height 8 feet 4½ inches; wing area 167 square feet; maximum gross weight 2,575 pounds; empty weight 1,578 pounds; useful load 997 pounds; maximum baggage 120 pounds; engine Lycoming IO-360-A1A of 200 horsepower.

Performance

Maximum speed 197 miles per hour; maximum cruise, 75 percent, 193 miles per hour; rate of climb sea level 1,400 feet per minute; service ceiling 18,800 feet; stall speed, gear and flaps down, power off, 57 miles per hour; range 1,060 miles.

CADET

Prime Contractor: Mooney Corporation

Specifications

Wing span 30 feet; length 20 feet 4 inches; height at tail 6 feet 3 inches; gross weight 1,450 pounds; empty weight 942 pounds; useful load 508 pounds; baggage capacity 90 pounds; wing loading 10.17 pounds per square foot; engine Continental C-90-16F of 90 horsepower.

Performance

Maximum speed 129 miles per hour; maximum cruise, 75 percent, optimum altitude 124 miles per hour; service ceiling 17,300 feet; absolute ceiling 20,000 feet; take-off run 540 feet; landing roll 350 feet; rate of climb 640 feet per minute; stall speed, power off, 48 miles per hour; maximum range 615 miles.

XB-70A RESEARCH AIRCRAFT

Prime Contractor: Aerospace & Systems Group, North American Rockwell Corporation
Associate Contractor: General Electric Company

Remarks

The XB-70A was a high-speed, high-altitude, 6-engine experimental aircraft flown in research programs at Edwards AFB, California, under NASA management. Originally conceived as an intercontinental bomber, its development began in 1956 following a 2-company study competition. In 1963, the decision was made to produce only 2 aircraft, both to be used only for research programs. The first XB-70A was rolled out on May 11, 1964, and made its first flight on September 21 of that year. The second aircraft was completed on May 29, 1965, and made its maiden flight on July 17. On October 14, the No. 1 airplane first reached its design goal of Mach 3 at 70,000 feet. The No. 2 aircraft flew sustained Mach 3 for 32 minutes on May 19, 1966. On June 8, 1966, it crashed after a midair collision with one of its chase planes. The 2 XB-70 airplanes had accumulated 123 flights totaling more than 239 hours as of August 21, 1968. The program was terminated at year-end 1968.

Specifications

Span 105 feet; length 185 feet; height 30 feet; weight over 500,000 pounds; engines 6 General Electric YJ93 in 30,000-pound-thrust class; crew pilot and copilot.

Performance

Speed 2,000 miles per hour; altitude over 70,000 feet.

T-39 SABRELINER

Prime Contractor: 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, for use as a trainer or utility aircraft, the T-39B, a radar navigation trainer for the Air Force and the T-39D, a radar navigation trainer for the Navy. The T-39 was placed on the civilian market in October 1962. It is currently produced in 2 versions, the Series 40, which carries up to 8 passengers and a crew of 2, and the "stretched" Series 60, which carries up to 10 passengers and crew of 2. Both models are equipped with the more powerful Pratt & Whitney Aircraft JT12A-8 engine which develops 3,300 pounds of thrust. In photo, Series 60 left, Series 40 right.

Specifications

Span 44.5 feet; length 44 feet (Series 40), 46.9 feet (Series 60); height 16 feet; maximum gross take-off weight 18,650 pounds (Series 40), 20,000 pounds (Series 60).

Performance

Speed 560 miles per hour plus; range over 2,100 miles (Series 40), over 2,000 miles (Series 60); altitude 40,000 feet, certified to 45,000 feet (business version) with passengers.

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 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 being used for research in high-altitude brightness, micrometeorite collection, ultraviolet stellar photography, heat exchangers, atmospheric density measurements, horizon scanning and definition, advanced integrated data systems, air-breathing propulsion, supersonic decelerators and high-temperature leading edges. The No. 2 airplane (photo), which was fitted with twin droppable fuel tanks, coated with ablative material and modified as a ramjet test-bed, set an unofficial speed record of Mach 6.7, or 4,520 miles per hour, on October 3, 1967. The pilot was Major Pete Knight. Subsequently the aircraft was overhauled and placed in storage at the NASA facility at Edwards AFB. The No. 3 aircraft was destroyed in a fatal accident on November 11, 1967, in which Major M. J. Adams lost his life. More than 10 years of flight research had been completed without a fatality by the 3 aircraft prior to the No. 3 crash. As of September 28, 1968, a total of 197 X-15 flights had been made.

OV-10A BRONCO LIGHT ARMED RECONNAISSANCE AIRCRAFT

Prime Contractor: Columbus Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The OV-10A was the first aircraft designed specifically for counterinsurgency and limited-war operations. It is intended for use by the military services, allied foreign countries and the Military Assistance Program. Its mission capabilities include observation and reconnaissance, helicopter escort, limited ground attack, gunfire spotting, liaison, transport and training. The Bronco can operate from rough clearings, waterways and primitive roads as well as from 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 fuselage sponsons which contain 4 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, when operated in conjunction with the processing center 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 is used as a land- or carrier-based trainer to instruct Navy and Marine Corps student pilots from first jet flight to the advanced training phase. The 2-engine configuration 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 4 models, the A, C, D, and F. The F-100A, an air superiority fighter, is flown by the Air National Guard. The F-100C, with inflight refueling and bombing capabilities, is assigned to the Air Force's tactical fighter wings. The D and F fighter-bomber models are providing the Tactical Air Command with long-range nuclear striking power and supersonic air-to-air combat ability. In addition to its bomb armament and 4 20-millimeter cannons, the Super Sabre can be equipped to fire rockets and missiles, including the heat-seeking Sidewinder.

Specifications

Span 38 feet; length 47 feet; height 16 feet; weight 18,239 to 22,337 pounds according to model; engine J57, 10,000-pound-thrust class; crew, pilot, 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: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

The Aero Commander-100 is a 4-place, all-metal, high-wing, tricycle-geared monoplane equipped with a Lycoming O-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: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

The Aero Commander-200 is a 4-passenger monoplane, all metal, low wing cantilever design with a retractable tricycle landing gear. The aircraft is equipped with a 6-cylinder opposed IO-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 per 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.

LARK COMMANDER

Prime Contractor: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

The Lark Commander is a 4-place, single-engine, high-wing, all-metal aircraft designed for the businessman-pilot and for the leisure market. The aircraft was introduced in January 1968 and is in production at the Aero Commander Albany, Georgia, facility. Several paint combinations and interior decor selections are offered as standard.

Specifications

Span 35 feet; length 27 feet 2 inches; height 10 feet 1 inch; gross weight 2,450 pounds; empty weight with standard equipment 1,450 pounds; useful load 1,000 pounds; cabin length 8 feet 2 inches; cabin width 3 feet 4 inches; baggage 120 pounds; fuel capacity 44 gallons standard; engine Lycoming O-360-A2F rated at 180 horsepower at 2,700 revolutions per minute at sea level.

Performance*

Speed at best altitude 138 miles per hour; take-off over 50-foot obstacle 1,575 feet; take-off run 875 feet; initial rate of climb 750 feet per minute; stall speed 60 miles per hour; range 525 statute miles.

*All performances shown are based on full gross, standard atmospheric conditions at sea level unless otherwise shown.

DARTER COMMANDER

Prime Contractor: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

The Darter is an all-metal, high-wing, 4-place, single-engine aircraft designed for the trainer, pleasure and business-fleet markets. Several exterior color combinations are available. Darter was introduced January 30, 1968.

Specifications

Span 35 feet; length 22 feet 6 inches; height 9 feet 4 inches; cabin length 8 feet 2 inches; cabin width 3 feet 4 inches; baggage 120 pounds; gross weight 2,250 pounds; empty weight with standard equipment 1,280 pounds; useful load 970 pounds; fuel capacity 44 gallons; engine Lycoming O-320-A rated at 150 horsepower at 2,700 revolutions per minute at sea level.

Performance*

Speed at best altitude 133 miles per hour; take-off over 50-foot obstacle 1,550 feet; take-off roll 870 feet; initial rate of climb 785 feet per minute; stall speed 55 miles per hour; range 510 statute miles.

*All performances shown are based on full gross, standard atmospheric conditions at sea level unless otherwise shown.

JET COMMANDER

Prime Contractor: Aero Commander Division, 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; power loading 2.9 pounds per pound of thrust; engines 2 GE CJ610-1 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 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: Aero Commander Division, 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.

SHRIKE COMMANDER

Prime Contractor: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

Designed for the businessman-pilot or to be professionally flown, the Shrike can carry up to 7 people plus 350 pounds of baggage. Standard installations include separate passenger and cockpit entry doors, 4 individual chairs, choice of interior fabric decor and external paint combinations.

Specifications

Span 49 feet ½ inch; length 35 feet 1¼ inches; height 14 feet 6 inches; maximum gross weight 6,750 pounds; empty weight with standard equipment 4,520 pounds; useful load 2,230 pounds; maximum fuel capacity 156 gallons; engines 2 Lycoming IO-540-E1BA rated at 290 horsepower at 2,750 revolutions per minute at sea level.

Performance*

Speed at best altitude 215 miles per hour; take-off over 50-foot obstacle 1,375 feet; stall speed 68 miles per hour; initial rate of climb 1,450 feet per minute; service ceiling 17,500 feet; range 1,078 statute miles.

*All performances shown are based on full gross, standard atmospheric conditions at sea level unless otherwise shown.

COURSER COMMANDER

Prime Contractor: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

Standard executive seating for 8 occupants or up to 11 in high-density configuration. Has IFR capabilities. Available with pressurization (3.2 pounds per square inch). Baggage compartment, separated from cabin, permits loads up to 400 pounds in 60.8-cubic-foot area.

Specifications

Span 49 feet ½ inch; length 43 feet; height 14 feet 6 inches; maximum gross weight 8,500 pounds; empty weight with standard equipment 5,449 pounds; useful load 3,051 pounds; maximum fuel capacity standard 223 gallons, with auxiliary 283 gallons; engine 2 Lycoming IGSO-540-B1A with take-off power of 380 horsepower at 3,400 revolutions per minute at sea level.

Performance*

Speed at best altitude 240 miles per hour; take-off over 50-foot obstacle 1,780 feet; stall speed 82 miles per hour; initial rate of climb 1,282 feet per minute; service ceiling 27,500 feet; range 1,300 statute miles standard, 1,600 statute miles with auxiliary fuel.

*All performances shown are based on full gross, standard atmospheric conditions at sea level unless otherwise shown.

TURBO II COMMANDER

Prime Contractor: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

A pressurized turboprop aircraft with standard executive seating for 8 occupants or as many as 10. It has IFR capabilities and features fully reversible propellers as standard installation. A 400-pound-capacity baggage compartment is separated from the passenger cabin.

Specifications

Span 44 feet; length 42 feet 11.75 inches; height 14 feet 6 inches; maximum gross weight 9,450 pounds; empty weight with standard equipment 5,783 pounds; useful load 3,617 pounds; maximum fuel capacity (standard) 286.5 gallons, (auxiliary) 337.5 gallons; engines 2 Garrett AiResearch TPE 331-43 BL with take-off power of 575 shaft horsepower and 605 equivalent shaft horsepower each at sea level.

Performance*

Maximum speed at best altitude 290 miles per hour; cruise speed (normal) at 10,000 feet 280 miles per hour; take-off roll 1,660 feet; service ceiling 26,500 feet; range with auxiliary fuel 1,500 statute miles.

*All performances shown are based on full gross, standard atmospheric conditions at sea level unless otherwise noted.

AERO COMMANDER 500U

Prime Contractor: Aero Commander Division, 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: Aero Commander Division, 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 R1340-AN-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: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

The Ag Commander A-9 and Ag Commander A-9 Super are popular aerial application aircraft. With identical airframes, the Ag Commander A-9 and 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 O-540-B2B5 rated at 235 horsepower, (A-9 Super) 1 Lycoming IO-540-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 weight (A-9) 600 feet, (A-9 Super) 1,000 feet; landing distance (A-9) 447 feet, (A-9 Super) 800 feet.

QUAIL AND SPARROW COMMANDERS

Prime Contractor: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

These 2 aerial application aircraft are similar in airframe design and construction. They are designed for the application of both liquid and solid chemicals. Quail and Sparrow differ in hopper capacity, power and performance. In photo, Quail.

Specifications

Span 34 feet 9 inches; length 23 feet 6 inches; height 7 feet 7 inches. Quail: Gross weight 3,600 pounds; useful load 2,000 pounds; hopper capacity 210 U.S. gallons or 1,600 pounds; fuel capacity 40 gallons; engine Lycoming IO-540-G1C5 fuel injected, rated at 290 horsepower. Sparrow: Gross weight 3,400 pounds; useful load 1,800 pounds; hopper capacity 170 U.S. gallons or 1,400 pounds; fuel capacity 40 gallons; engine Lycoming O-540-B2B5 rated at 235 horsepower.

Performance

Quail: Maximum speed 120 miles per hour; working speed 90-100 miles per hour; stall speed 40 miles per hour; take-off distance at gross weight 800 feet; service ceiling 16,000 feet; ferry range at 50 percent power 300 statute miles. Sparrow: Maximum speed 119 miles per hour; working speed 90-100 miles per hour; stall speed 40 miles per hour; take-off distance 600 feet; service ceiling 14,000 feet; ferry range at 75 percent power 300 statute miles.

THRUSH COMMANDER

Prime Contractor: Aero Commander Division, Commercial Products Group, North American Rockwell Corporation

Remarks

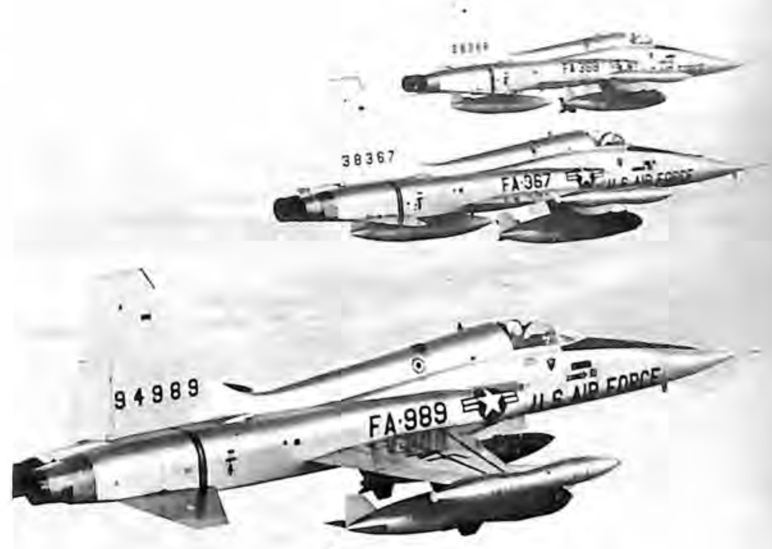
The Thrush Commander is the largest agricultural aircraft in production in the United States. It is a highly maneuverable aerial application aircraft designed specifically for precise application of liquid and solid chemicals. The all-metal-wing and -fuselage aircraft is delivered equipped with a 70-nozzle spray boom and all basic application devices installed. The Thrush has an average 60-foot swath width at normal application altitudes and has working speeds up to 110 miles per hour. Aircraft is eligible for FAR 23 and 21 certification.

Specifications

Span 44 feet 5 inches; length 29 feet 4½ inches; height 9 feet 2 inches; gross weight 6,900 pounds; hopper capacity 400 U.S. gallons or 3,280 pounds; fuel capacity 104 gallons; engine Pratt & Whitney Wasp R1340, 9 cylinder, supercharged, radial, rated at 600 horsepower at 2,250 revolutions per minute for take-off.

Performance

Maximum speed 140 miles per hour; working speed 95-110 miles per hour; stall speed 57 miles per hour; take-off distance at gross weight 775 feet; service ceiling 15,000 feet; ferry range at 50 percent power 470 statute miles.



AG COMMANDER B1A

Prime Contractor: Aero Commander Division, 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-fiberglass hopper with a top-loading 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 May 1968, 14 free world nations had received quantities of F-5s, with one other programmed to receive the aircraft. Single-seat F-5A fighters and twin-cockpit F-5B models are produced as well as a new RF-5A reconnaissance version. Utilizing the same basic design, the F-5B combines the combat capability of the F-5A with training capability. The aircraft provides close support of troops, interception, attacks on communications and supply lines and armed reconnaissance missions over enemy territory. It is produced by Northrop's Norair Division and is also being produced under special license in Canada and Spain.

Specifications

Span 26 feet 7 inches with wing-tip armament; length 45 feet; height 13 feet 2 inches; weight 13,000 pounds with full internal fuel; external load 6,200 pounds of air-to-air and air-to-ground weapons, reconnaissance and surveillance equipment and extra fuel; 2 20-millimeter cannons mounted in nose of F-5A and RF-5A; engines 2 General Electric J85-13 turbojets, 4,080 pounds thrust each (GE J85-15 engines with 4,300 pounds thrust each are being 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

The only U.S.-produced supersonic jet trainer, the T-38 is a twin-jet, low-wing monoplane. It is used as an advanced trainer by the Air Force and has been selected by NASA for astronaut space flight readiness training. The 1,000th T-38 was scheduled for delivery to the USAF in early 1969. A quantity of T-38s has also been delivered to the German Air Force. Featuring a very high degree of safety, 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 2 General Electric J85-5 turbojets; 2 independent electrical and fuel supply systems, one for each engine.

Performance

Speed Mach 1.2 (guaranteed), Mach 1.35 (highest attained); range 990 nautical miles; rate of climb over 30,000 feet per minute; ceiling 54,000 feet.

16H-1B PATHFINDER II

Prime Contractor: Piasecki Aircraft Corporation

Remarks

The 16H-1B is an advanced developmental shaft compound helicopter with 1 GE T58-5 turbine of 1,500 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, higher-powered equivalent with 3-bladed main rotor, 3-bladed controllable pitch ring-tail ducted propeller for propulsion, stability and antitorque control, stub wings and retractable main landing gear.

Specifications

Fuselage length 37.25 feet; wing span 20 feet; main rotor diameter 44 feet; empty weight 4,830 pounds; VTOL gross weight 8,121 pounds; STOL gross weight 10,500 pounds.

Performance

Maximum speed sea level 225 miles per hour; service ceiling 18,700 feet.

16H-3J PATHFINDER EXECUTIVE

Prime Contractor: Piasecki Aircraft Corporation

Remarks

A commercial twin-turbine configuration derived from the advanced developmental 16H-1A, the 16H-3J is a low-wing, twin-engine, shaft-driven compound helicopter powered by 2 United Aircraft of Canada PT6B-16 turbines. It features a ducted pusher propeller which provides forward thrust for fixed-wing-mode flight conditions. The same propeller, working in conjunction with controllable tail vanes, provides the antitorque force for hovering. In forward flight the rotor is unloaded, transferring the propulsion function to the tail propeller and the lift function to the wing. The 16H-3J provides the executive traveler door-to-door travel at greatly increased speeds over those of present-day helicopters. Seating capacity is 14 passengers in addition to the pilot.

Specifications

Fuselage length 42.9 feet; wing span 21.3 feet; main rotor diameter 44.2 feet; empty weight 5,925 pounds; gross weight 9,600 pounds.

Performance

Cruise speed 190 miles per hour; range 438 statute miles.

PA-25 PAWNEE C

Prime Contractor: Piper Aircraft Corporation

Remarks

The Pawnee was designed specifically 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 introduced in 1959; the present Pawnee C is equipped with a Lycoming O-540-B2B5 235-horsepower engine. In worldwide use it has earned the universal respect of ag-operators and their customers—farmers, municipalities and highway departments—and of ag-pilots for its handling ease and its unique "safety capsule" cockpit. The Pawnee may also be powered by a 260-horsepower Lycoming O-540-E engine with optional constant-speed propeller.

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 140B

Prime Contractor: Piper Aircraft Corporation

Remarks

The Cherokee 140B is a 2-4 place, fixed-gear sport/trainer powered by a Lycoming O-320-E2A 150-horsepower engine. Since its introduction in 1963 the Cherokee 140B has become one of the most popular aircraft for the fixed-base operator, flying clubs and 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 140B 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 D

Prime Contractor: Piper Aircraft Corporation

Remarks

The Cherokee D is the latest version of the Cherokee line of 4-place, fixed-gear aircraft introduced in 1961.

Specifications

Wing span 30 feet; length 23.5 feet; height 7.3 feet; wing area 160 square feet; wing loading 15 pounds per square foot; gross weight 2,400 pounds; empty weight 1,300 pounds; useful load 1,100 pounds; engine Lycoming O-360-A3A rated at 180 horsepower at 2,700 revolutions per minute.

Performance

Top speed 152 miles per hour; optimum cruising speed, 75 percent power 7,000 feet, 143 miles per hour; stalling speed (flaps) 57 miles per hour; take-off run 720 feet; rate of climb 750 feet per minute; service ceiling 16,400 feet; cruising range, 75 percent power optimum altitude, 725 miles; fuel consumption, 75 percent power, 10 gallons per hour.

CHEROKEE 235C

Prime Contractor: Piper Aircraft Corporation

Remarks

The Cherokee 235C can carry 4 passengers, 200 pounds of luggage and 84 gallons of fuel and still have weight left over. With its Lycoming O-540-B2B5 235-horsepower engine and its modern, low-wing design, the Cherokee 235C 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 235C incorporates many improvements, such as "shock-mounted" cowling, dynafocal engine mounting, increased soundproofing, a new, larger instrument panel that will accommodate even the most professional type of equipment, the Sports-Power console and a new paint scheme.

Specifications

Wing span 32 feet; length 23.7 feet; height 7.1 feet; gross weight 2,900 pounds; empty weight 1,467 pounds; wing area 170 square feet; wing loading 17 pounds per square foot; power loading 12.4 pounds per horsepower; fuel capacity 84 gallons; propeller either McCauley metal, fixed pitch, or Hartzell constant speed, both with 80-inch diameter.

Performance

Top speed 166 miles per hour; cruise speed at 75 percent power 156 miles per hour at 2,900 pounds gross; stall speed 60 miles per hour; 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, utility or air taxi use, it is offered with a choice of horsepower, 6- or 7-place seating and in a seaplane configuration. The 260-horsepower version uses a Lycoming O-540-E4B5 and the 300-horsepower version uses the IO-540-K with Bendix fuel injection. Cruising speed of 160 miles per hour in the 260-horsepower model is increased to 168 miles per hour at full 3,400-pound gross in the 300-horsepower version. Both models carry 6 passengers, 200 pounds of luggage and full fuel of 84 gallons, with a 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

The Arrow has a number of features which distinguish it from its companion craft, the Cherokee D. 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; it holds the world's altitude record for piston-powered light aircraft by attaining 30,203 feet. The Super Cub is certified on floats and skis and is used throughout the world for pleasure and for training, patrol, survey, agricultural and general utility work.

Specifications

Wing span 35.3 feet; length 22.5 feet; height 6.7 feet; gross weight 1,750 pounds; overload gross weight 2,070 pounds; empty weight 930 pounds; wing area 178.5 square feet; wing loading 10 pounds per square foot; power loading 11.6 pounds per horsepower; fuel capacity 36 gallons; propeller all-metal Sensenich with 74-inch diameter.

Performance

Top speed 130 miles per hour; cruise speed at 75 percent power 115 miles per hour; stall speed 43 miles per hour; 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.

POCONO

Prime Contractor: Piper Aircraft Corporation

Remarks

Designed specifically for the commuter market, Piper's new Pocono is an 18-place, short-haul airliner which has also attracted more-than-anticipated interest as an executive transport. Cabin height is 5 feet 8 inches; normal seating is 3 abreast, 2 on the right side of the aisle and one on the left. Standard airline-type floor mounting channels permit positioning of seats or cargo fasteners in any desired location.

Specifications

Wing span 51 feet; length 39.25 feet; height 15.75 feet; gross weight 9,500 pounds; empty weight 4,900 pounds; useful load (as 18-place) 4,600 pounds, (in cargo configuration) 4,350 pounds; engines 2 Lycoming TIO-720, 500 horsepower.

Performance

Top speed at 10,000 feet 242 miles per hour; cruise speed, 75 percent power 10,000 feet, 216 miles per hour; stall speed 74 miles per hour; rate of climb 1,630 feet per minute; single-engine ceiling 14,000 feet; range, economy cruise (55 percent) 810 miles.

COMANCHE C

Prime Contractor: Piper Aircraft Corporation

Remarks

The Comanche C is the latest version of the proven Comanche line of airplanes. The new Comanche C has a longer cabin that seats up to 6 people, more luxurious styling and a maximum gross weight of 3,100 pounds. Powered by either a Lycoming O-540-E carburetor induction engine or a Lycoming IO-540-D fuel-injection engine, the Comanche C cruises at over 180 miles per hour and has a range of 1,100 miles at 75 percent power.

Specifications

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 C

Prime Contractor: Piper Aircraft Corporation

Remarks

A longer cabin that seats 6 passengers, new luxurious styling, and even quieter operation are added to the already proven design of the Twin Comanche to make the Twin Comanche C. Powered by 2 Lycoming IO-320-B fuel-injection engines developing 160 horsepower each, the Twin Comanche C cruises at over 190 miles per hour at 75 percent power. If even better performance is desired for high altitude, the Turbo Twin Comanche C can cruise at 24,000 feet at 223 miles per hour at 75 percent power. It holds the light twin nonstop distance record. In photo, Turbo Twin Comanche C.

Specifications

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 120 gallons; propeller Hartzell constant speed, full feathering with 72-inch diameter.

Performance

Top speed 205 miles per hour (246 for Turbo); cruise speed at 75 percent power 198 miles per hour (240 for Turbo); take-off run 940 feet; landing roll 1,215 feet; rate of climb at sea level 1,460 feet per minute (1,290 at 10,000 feet for Turbo); service ceiling 18,600 feet (Turbo ceiling is 30,000-plus feet); single-engine ceiling 7,100 feet (17,000 feet for Turbo); cruising range at 75 percent power 1,200 miles (1,535 miles for Turbo).

AZTEC D AND TURBO AZTEC D

Prime Contractor: Piper Aircraft Corporation

Remarks

The Aztec D is powered by 2 Lycoming fuel-injection IO-540-C4B5 engines developing 250 horsepower each. It cruises at 210 miles per hour at its maximum gross weight of 5,200 pounds and will travel nonstop well over 1,000 miles. For even better, high-altitude performance, the Turbo Aztec D is equipped with 2 Lycoming fully modified IO-540-J4A5 engines which increase cruise speed to 250 miles per hour at 24,000 feet and give the Turbo Aztec D a ceiling of over 30,000 feet.

Specifications

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, 77-inch diameter.

Performance

Aztec D: Top speed 216 miles per hour; normal cruise, 4,000 feet, 210 miles per hour; intermediate cruise, 6,000 feet, 208 miles per hour; economy cruise, 6,400 feet, 204 miles per hour; long-range cruise, 10,200 feet, 195 miles per hour. Turbo Aztec D: Top speed 256 miles per hour; turbo cruise, 24,000 feet, 250 miles per hour; intermediate cruise, 24,000 feet, 236 miles per hour; economy cruise, 24,000 feet, 218 miles per hour; long-range cruise, 24,000 feet, 199 miles per hour.

PA-31 NAVAJO

Prime Contractor: Piper Aircraft Corporation

Remarks

Piper offers 2 models of the Navajo, the Turbo Navajo with 310-horsepower turbocharged Lycoming TIO-540-A engines and the Navajo 300 with IO-540-K engines. At full gross of 6,200 pounds, the Turbo Navajo will cruise at 247 miles per hour at 23,500 feet 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 those of 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-5B V/STOL VERTIFAN

Prime Contractor: Ryan Aeronautical Company

Remarks

The Ryan XV-5B Vertifan V/STOL jet utilizes 5-foot-diameter fans submerged in its wings for vertical flight. Powered by 2 General Electric J85 engines, the aircraft's speed range includes capabilities of zero speed in hover to more than 450 knots in conventional jet mode. Under NASA contract, the XV-5B was renovated and modified by Ryan and commenced ground tests June 24, 1968, at San Diego. First conventional flight was made July 15, 1968; ferry flight to NASA-Ames Research Center was on July 18, 1968. First vertical flight was August 2, 1968. After initial flight testing by Ryan, XV-5B was delivered to NASA-Ames for use in V/STOL research programs. Major modification for NASA use was movement of landing gear outboard of wing fans. The aircraft was formerly the U.S. Army XV-5A, which accomplished a highly successful flight test program.

Specifications

Span 29.83 feet; length 44.52 feet; height 14.75 feet; empty weight including instrumentation 9,150 pounds; maximum gross weight 12,326 pounds; engines 2 General Electric J85.

Performance

Maximum speed in jet mode (demonstrated) 456 knots; maximum speed in fan mode (demonstrated) 90 knots; maximum sideward speed in fan mode 29 knots.

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) and 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 R1820, 1,525 horsepower.

Performance

Maximum speed 123 miles per hour; service ceiling 9,500 feet; range 280 miles.

SH-3A/D ANTISUBMARINE HELICOPTER

Prime Contractor: Sikorsky Aircraft

Remarks

The SH-3A antisubmarine warfare helicopter made its first flight March 11, 1959, after development under the 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, Spanish, Italian and Brazilian navies and for the Japanese Self Defense Forces. The S-61A, without the antisubmarine warfare gear, has been produced for the Danish Air Force and the Malaysian Air Force and for commercial use. The RH-3A, a version of the SH-3A fitted with towing hook, is used by the U.S. Navy as a mine countermeasures aircraft. Still another version, the VH-3A, is used to transport the President of the United States and other government officials.

Specifications

Empty weight 11,865 pounds; useful load 6,761 pounds; engines 2 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 30 passengers. The aircraft is powered by twin turbine engines and can continue flight to normal landing with one engine inoperative. The S-61L has been flown in scheduled passenger service by Los Angeles Airways since 1962. S-61Ns have been delivered to San Francisco & Oakland Helicopter Airlines in the 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, the North Sea and the waters off Malaysia. 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 CT58-140-2, 1,500 horsepower each.

Performance

Maximum speed 150 miles per hour; service ceiling 12,200 feet; range 265 miles.

S-61R HELICOPTER

Prime Contractor: Sikorsky Aircraft

Remarks

The S-61R, a member of the S-61 series marked by a rear cargo door, made its first flight June 17, 1963. The S-61R was selected by the Air Force as both transport and rescue vehicle, the former called 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 Recovery 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 are provided by a rear ramp and cargo door. Power is supplied by 2 gas turbine engines. Primary mission of the CH-3E is cargo and troop transport. It has approximately the same performance as the HH-3E but is not equipped with tip tanks, armor plating or aerial refueling probe. Another search and rescue version of the S-61R, the HH-3F, is being produced for the 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; alternate gross weight 22,050 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 2 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 Administration for commercial operations. The FAA certificate permits it to carry a pilot, a copilot and 11 passengers. It can operate from land, water, ice, snow, swamp, mud or almost any other surface. The first flight took place May 22, 1958. Besides its Coast Guard application, the S-62 is used in airline and industrial operations. It is especially useful to the oil industry in supplying offshore drilling platforms.

Specifications

Empty weight 5,083 pounds; normal gross weight 8,100 pounds; useful load 3,017 pounds; engine General Electric T58-8, 1,250 horsepower.

Performance

Maximum speed 110 miles per hour; service ceiling 11,200 feet; range 463 miles.

S-64 SKYCRANE

Prime Contractor: Sikorsky Aircraft

Remarks

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 pickups 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 or repair shop, can be attached to the S-64 fuselage. Such vans are produced by Sikorsky for use with the Army S-64s. The Skycrane is produced also for commercial operators in such fields as oil drilling and ship-to-shore cargo transportation.

Specifications

Empty weight 18,969 pounds; normal gross weight 38,000 pounds; alternate gross weight 42,000 pounds; useful load 19,031 pounds; engines 2 Pratt & Whitney Aircraft JFTD-12A, 4,500 horsepower each.

Performance

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, exceeding 12 tons. The CH-53A, with a crew of 3, can accommodate 38 troops. It has been used to retrieve other aircraft and to deliver equipment and supplies. The HH-53B and HH-53C, rescue and recovery versions produced for the U.S. Air Force, have 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 T64-12, 3,435 horsepower each, (HH-53B) 2 GE T64-3, 3,080 horsepower each, (HH-53C) 2 GE T64-7, 3,435 horsepower each.

Performance

Cruising speed 172 miles per hour; maximum speed 195 miles per hour; service ceiling 22,000 feet; range 250 miles (with auxiliary tanks 780 miles).

SA-26AT CORPORATE AIRCRAFT

Prime Contractor: Swearingen Aircraft

Remarks

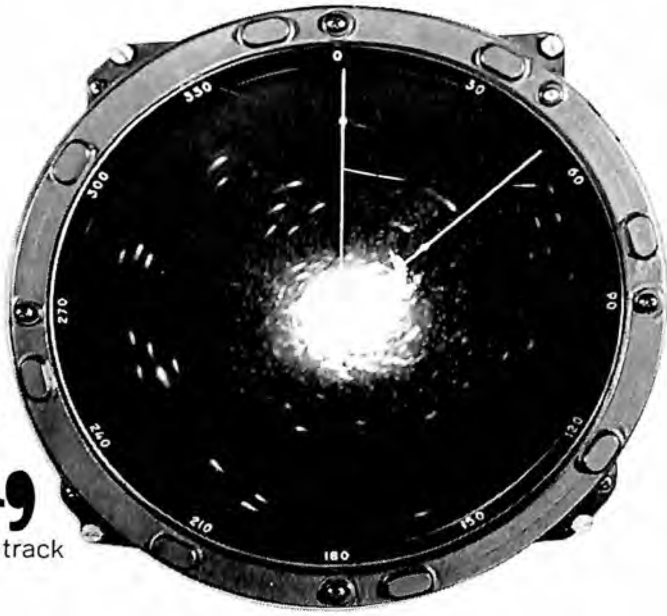
The SA-26AT, or Merlin IIB, is an 8-10 place, pressurized, twin-engine airplane designed for corporate use. It has a cylindrical fuselage with a pressure differential of 7 pounds per square inch. The Merlin IIB is powered by 2 Garrett AiResearch TPE 331-1-151G turbine engines equipped with propeller reversing and synchronization features and rated at 665 shaft horsepower. The Merlin IIB made its initial flight August 25, 1967, and was type certified June 12, 1968.

Specifications

Span 45 feet 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 10,000 pounds; design empty weight 6,150 pounds; design landing weight 9,300 pounds.

Performance

Speed at 15,000 feet 295 miles per hour; range at 27,500 feet 1,785 miles with 45-minute reserve; rate of climb at sea level 2,570 feet per minute; service ceiling at full gross weight 29,900 feet; single-engine service ceiling 12,500 feet (with pressurization and full accessory load); stall speed 87 miles per hour.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MINUTEMAN ICBM

Weapon System Integrator: The Boeing Company; technical direction by TRW Systems Group, TRW Inc.

Associate Contractors: Thiokol Chemical Corporation (first-stage engine); Aerojet-General Corporation (second-stage engine, all models; third-stage engine, Minuteman III); Hercules Incorporated (third-stage engine, Minuteman I and II); Autonetics Division, Aerospace & Systems Group, North American Rockwell Corporation (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 deployed in 7 western states. The force, which now consists of a mix of Minuteman I and II, will evolve to a mix of Minuteman II and III missiles over the next few years. Minuteman is a 3-stage, solid-fuel missile which can be launched from blast-proof underground launch facilities within seconds after a command is received. Multiple-channel communications connect an underground launch control center, manned by 2 SAC officers, with 10 launch facilities. Minuteman II (photo) has a larger second-stage engine, improved guidance system, greater range and payload capabilities, more flexible targeting and increased survivability. Minuteman III has an improved third stage and a new reentry system, providing greater accuracy and payload. Minuteman carries a nuclear warhead.

Specifications

Minuteman I: (WS-133A)—Model LGM-30A, length 54 feet, Model LGM-30B, length 55.9 feet; weight approximately 65,000 pounds; diameter approximately 6 feet at first-stage interstage.

Minuteman II: (WS-133B)—Model LGM-30F, length 59.8 feet; weight approximately 70,000 pounds.

Minuteman III: Model LGM-30G, length 59.8 feet; weight approximately 76,000 pounds.

Performance

Minuteman I: Range 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.

Minuteman III: Range improved.

TITAN II ICBM

Program Management: Ballistic Systems Division, Space and Missile Systems Organization (SAMSO), Air Force Systems Command
Prime Contractor: Martin Marietta Corporation, Denver Division (systems integration, base integration, airframe)
Associate Contractors: Aerojet-General Corporation (propulsion); AC Electronics Division, General Motors Corporation (guidance); GE Missile and Space Vehicle Division (reentry vehicle); TRW Systems Group, TRW Inc. (technical direction)

Remarks

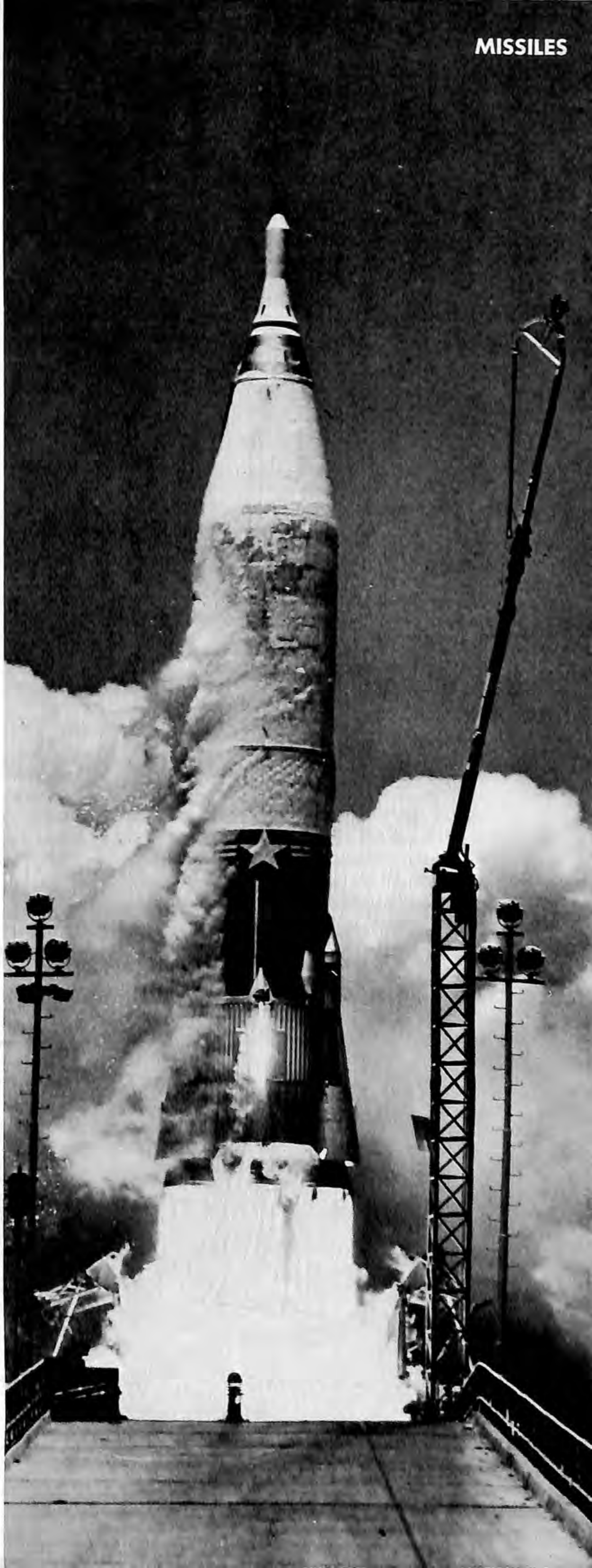
Titan II is an intercontinental ballistic missile operated by the USAF's Strategic Air Command. SAC has 54 operational missiles at 3 bases. Largest of the U.S. ICBMs, Titan II is equipped with sophisticated penetration aids. It is a 2-stage weapon with 430,000 pounds of rocket thrust in its first stage 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 & Systems Group, North American Rockwell Corporation (engines); General Electric Company, Burroughs Corporation, and American Bosch Arma Corporation (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 3 basic versions, the Series D, Series E and Series F. Series D missiles were emplaced in "soft," aboveground launch sites. Series E missiles were installed in aboveground "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 ABRS (Advanced Ballistic Reentry Systems) program, the Nike-Target program and satellite programs.

POSEIDON FLEET BALLISTIC MISSILE

Prime Contractor: Lockheed Missiles & Space Company
Associate Contractors: Hercules Incorporated and Thiokol Chemical Corporation (power plants); General Electric Company and Sperry Rand Corporation (guidance and fire control); Nortronics Division of Northrop Corporation (missile check-out)

Remarks

The Poseidon C3 missile has its roots in Polaris technology, but it is larger and much more advanced. It is 6 feet in diameter as opposed to Polaris' 4½ feet, and, at 34 feet, it is 3 feet longer than the A3 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 A3 Polaris and will be twice as accurate. These factors, coupled with the use of new penetration aids, will make Poseidon 8 times as effective as Polaris. Plans call for equipping 31 of the 41 Fleet Ballistic Missile submarines with Poseidon C3 and the remaining 10 with Polaris A3. The first flight test of Poseidon (C3X-1), on August 16, 1968, was a "complete success," according to the U.S. Navy, and all test objectives were met.

POLARIS FLEET BALLISTIC MISSILE

Prime Contractor: Lockheed Missiles & Space Company
Associate Contractors: Aerojet-General Corporation and Hercules Incorporated (power plants); General Electric Company and Hughes Aircraft Company (guidance and fire control); Nortronics Division of Northrop Corporation (missile check-out)

Remarks

The third-generation Polaris A3 became operational with the Navy in September 1964. It was preceded into service by the A1 version, which had a range of 1,200 nautical miles, and the A2, with a 1,500-nautical-mile range. While A2 was an outgrowth of A1, the A3 is a 90 percent new missile. Among many innovations was a switch from the "champagne bottle" shape of the earlier missiles to a simple, bullet-shaped configuration. The A3, with a range of 2,500 nautical miles, arms 28 of the 41 Polaris submarines; the remaining 13 will carry the A2 weapon. The A1, operational since November 1960, has been retired from fleet duty but will find utility as a booster in developing and testing missile and space programs. All 3 versions of the Polaris are 2-stage, solid-propellant, inertially guided ballistic missiles which can be fired from submerged or surfaced submarines, from surface ships or from land bases. There are 336 A3 and 208 A2 missiles assigned to the Atlantic Fleet, which operates 34 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 Division

Remarks

Pershing is a 2-stage, surface-to-surface ballistic missile which is 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. In early 1966 the Army awarded a $66,000,000 contract to Martin Marietta for development of new-generation ground support equipment to increase Pershing system reliability and firing rate. Mounted on wheels instead of tracks, the new system, identified as Pershing 1-A, includes major improvements centered on a new programmer/test station, a fast-reacting erector-launcher, automatic countdown and fault isolation and a battery control central. Pershing 1-A went into production under a $52,000,000 contract issued in November 1967.

Specifications

Length 34½ feet; diameter 3.3 feet; weight approximately 10,000 pounds; speed supersonic; trajectory ballistic; propulsion 2 stage, solid propellant; guidance inertial; warhead nuclear.

Performance

Range 100-400 nautical miles.

SERGEANT SURFACE-TO-SURFACE MISSILE

Prime Contractor: UNIVAC Salt Lake City, a division of Sperry Rand Corporation

Remarks

The Sergeant is reliable, mobile and simple to operate; with its ease of maintenance and degree of immunity to countermeasures, it represents an Army weapon system comparable in general field worthiness to the shorter-range unguided rockets. Sergeant has been purchased and deployed with U.S. and Federal Republic of Germany troops. Status: operational.

Specifications

Length 35 feet; diameter 31 inches; weight 10,000 pounds.

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 Antimissile Research Tests in Australia) program. SPARTA is part of Project Defender, sponsored by the Defense Department's Advanced Research Projects Agency. Equipped with solid-propellant upper stages and reentry payloads, the Redstones were assembled and launched at Woomera, Australia. Chrysler also provided the payloads and assisted in launch support. Other Redstones have been reactivated for Project Defender. Programs utilizing Redstone for new missions are under consideration.

Specifications

Length 69 feet; diameter 70 inches; weight 60,970 pounds.

Performance

Range 200 nautical miles; 75,000 pounds thrust.

MACE SURFACE-TO-SURFACE MISSILE

Prime Contractor: Martin Marietta Corporation, Baltimore Division
Associate Contractors: Allison Division of General Motors Corporation (engine); Thiokol Chemical Corporation (booster); Goodyear Aerospace Corporation (ATRAN guidance) (A version); AC Spark Plug Division, General Motors Corporation (inertial guidance) (B version)

Remarks

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

Sweptwing 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 & 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 supporting fire. Lance is built by the Michigan facility of LTV Aerospace's Missiles and Space Division. It is the first Army missile to use packaged, storable liquid propellants. Major components of the missile 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 a longer-range version is under way for the Army, and the company has performed exploratory work for the Navy to determine whether Lance can be used as a ship-launched, amphibious support system.

SHILLELAGH ANTI-ARMOR GUIDED MISSILE SYSTEM

Prime Contractor: Aeronutronic Division, Philco-Ford Corporation

Remarks

Shillelagh is a tank-fired, surface-to-surface, anti-armor guided missile system which is standard armament on the Army's General Sheridan Armored Reconnaissance Vehicle. A lightweight guided missile system, Shillelagh is designed to give U.S. armor field superiority over enemy armored vehicles and tanks, troops and field fortifications. Aeronutronic is producing Shillelagh for the U.S. Army Missile Command. A "fifth buy" production contract for $100,000,000 was awarded to Aeronutronic in 1968. Shillelagh utilizes an infrared command guidance system, giving it extremely 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 entering the fifth year of production by Aeronutronic at the Army's Lawndale, California, Missile Plant, Shillelagh is used also in the compact turret version of the Army's M60 A1E2 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. 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. Aeronutronic also produces the tank-mounted Shillelagh guidance and control equipment.

Specifications

Length approximately 45 inches; diameter 152 millimeters; weight approximately 60 pounds; warhead, shaped charge.

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 2.7. The Honest John is capable of carrying either a nuclear or a high-explosive warhead. Honest John is operational.

Specifications

Length 24.8 feet; diameter 30 inches; weight 4,500 pounds.

Performance

Range 21 miles; maximum speed Mach 2.7.

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 or angle between target course and his weapon. If he keeps the crosshairs centered, signals transmitted through the 2-wire link automatically correct the missile's course. TOW can be carried by troops and fired from a simple lightweight launcher mounted on a tripod. It can also be mounted on a variety of ground vehicles, including the M113 armored personnel carrier. TOW is undergoing service testing by the U.S. Army.

DRAGON MEDIUM ANTITANK ASSAULT WEAPON

Prime Contractor: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation

Remarks

Dragon is a medium antitank assault weapon designed for use by the infantryman. Light enough to be carried by one 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). An Army contract calling for production engineering and production of the Dragon, with a planned total value of $133,000,000, has been awarded to McDonnell Douglas Astronautics Company. First manned firing was conducted successfully on July 5, 1968.

SUBROC ANTISUBMARINE MISSILE

Prime Contractor: Goodyear Aerospace Corporation
Subcontractors: Aerospace Systems Division, Singer-General Precision, Inc. (major portion of guidance system); AiResearch Division, The Garrett Corporation (auxiliary power system); Thiokol Chemical Corporation (manufacture and loading of propellant)

Remarks

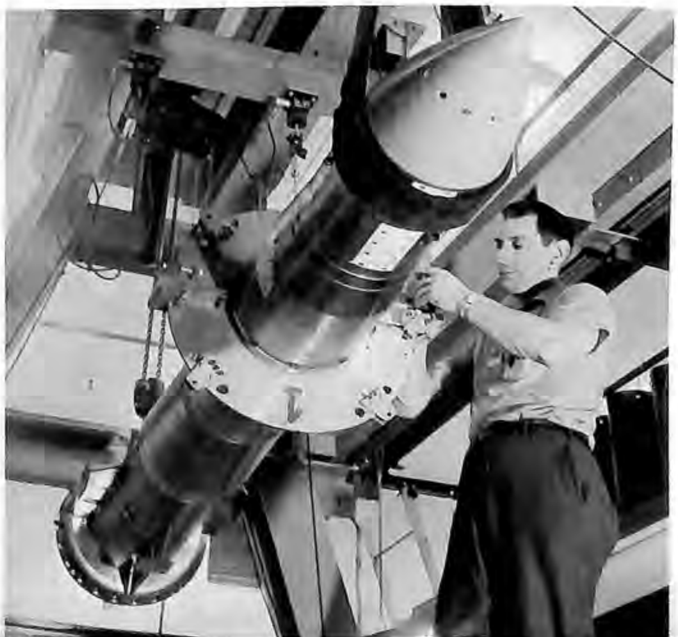
Subroc, an underwater-to-air-to-underwater antisubmarine missile, has been developed by Goodyear Aerospace Corporation for the Naval Ordnance Systems Command, formerly the Navy Bureau of Weapons, under technical direction of the Naval Ordnance Laboratory, White Oak, Maryland. It is being manufactured 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.



MK 46 MOD 1 ANTISUBMARINE TORPEDO

Prime Contractor: Honeywell Inc.
Subcontractors: TRW Inc.; Clevite Corporation

Remarks

The MK 46 Mod 1 is the Navy's latest lightweight ASW torpedo. It is an active-passive homing high-speed torpedo propelled by a liquid (monopropellant) fuel hot-gas piston-cam engine. It can be launched from aircraft, helicopters, ASW vessel torpedo tubes and ASROC. It is capable of seeking, acquiring, attacking and destroying the latest deep-diving, high-speed nuclear submarine.

Specifications

Approximate dimensions: length 101 inches; diameter 12¾ inches; weight 508 pounds.

MARK 46 ANTISUBMARINE TORPEDO

Prime Contractor: Aerojet-General Corporation
Subcontractor: The 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, from the torpedo tubes of antisubmarine vessels, from conventional or drone helicopters or by ASROC (antisubmarine rocket). The Mark 46 is in production at Aerojet's Electronics Division, Azusa, California.

Specifications

Approximate dimensions: length 101 inches; diameter 12¾ inches; weight 570 pounds.

ASROC/TERRIER

Prime Contractors: Honeywell Inc. (ASROC); General Dynamics Corporation (Terrier)

Remarks

The ASROC/Terrier system is a new concept in shipboard weaponry. It combines the ASROC (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 2 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 Contractors: Western Electric Company (Sentinel system prime); Martin Marietta Corporation (Sprint missile); Bell Telephone Laboratories (system design and development)

Remarks

The Sprint missile is one of the major components being developed for the Army's Sentinel missile defense system. Its mission is to intercept ICBM warheads, or the warheads of medium-range missiles which might be launched from submarines, after they have entered the earth's atmosphere. Reaction time is a major consideration, since these missiles approach the earth at velocities over 17,000 miles per hour. Sprint's time of flight—from launch to intercept—is only a matter of seconds. The missile is designed to be "popped" from its launch cell rather than flown out under its own power. A gas generator placed under the missile ejects it like a dart from a blowgun. The Sprint booster ignites after the missile is aboveground. At the same time, the missile pitches over on a trajectory that takes it to the vicinity of the computer-calculated intercept point. Fine adjustments are made in flight via radar signals from the ground.

Specifications

Length 27 feet; diameter 4.5 feet at base; configuration cone-shaped; propulsion 2 stage, solid propellant; guidance command via ground radar; warhead nuclear; type surface-to-air interceptor.

Performance

Speed hypersonic; other details classified.

SPARTAN ANTIMISSILE MISSILE

Prime Contractors: Western Electric Company (Sentinel system prime); McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation (Spartan missile); Bell Telephone Laboratories (system design and development)

Remarks

Spartan is the longer-ranging of the 2 missile components of the Sentinel missile defense system, which also includes a battery of tracking radars and computers on the ground. Spartan complements the Sprint weapon to provide the Sentinel system with a wide variety of intercept ranges and altitudes. The nuclear-armed Spartan is capable of intercepting incoming missile warheads at ranges of "several hundred miles"; Spartan intercepts are made outside the earth's atmosphere. Spartan, like Sprint, is being developed under the supervision of a special Sentinel System Command at the Army's Redstone Arsenal, Alabama. The Army's largest missile, Spartan made its first test flight on April 1, 1968. Spartan testing continues at Meck Island, north of Kwajalein Island in the Pacific, where the first model of the Raytheon Sentinel Missile Site Radar has been constructed.

Specifications

Three stages, all solid-propelled; first stage length 11 feet, second stage length 16 feet; overall missile length approximately 55 feet; basic stage thrust about 450,000 pounds.

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 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, improved and self-propelled systems are in production.

Specifications

Weight 1,275 pounds; length 198 inches; span 47.4 inches; solid propellant; high-explosive warheads.

Performance

Speed supersonic.

SAM-D AIR DEFENSE SYSTEM

Prime Contractor: Raytheon Company

Remarks

SAM-D (Surface-to-Air-Missile-Development) will be an Army air defense system for use in both battlefield and continental air defense against high-performance aircraft and short-range missiles. SAM-D can be deployed as a battery to provide circular defensive coverage or as a fire section to provide coverage over a sector. A fire section will consist of one fire control group and several launchers and may be detached from the major control elements for autonomous operations. A battery in the field will be mounted on approximately 12 vehicles and will include these main elements: fire control, launchers, battery control and communications groups. A fire control group contains a radar, a radar/weapons-control computer, communications and prime power on the same vehicle. The multifunction phased array radar will perform all the functions requiring several radars in other systems. It will detect targets, track them, track and issue guidance commands to the missile in flight. The battery control group will coordinate firings within a battery and serve as a communications center. It houses a computer for handling high data rates, processes and coordinates information between radars and passes on fire control information. The launcher group will carry several of the single-stage, solid-propellant missiles in launching-shipping containers. The missile is cradled within the canister or container, supported by teflon-coated launch rails. At launch, the motor blast shatters the rear plastic cover and the missile breaks through the forward plastic cover. The missile can carry either a high-explosive or a nuclear warhead. It is segmented into nose, guidance, warhead, motor and control sections. In photo, minimum fire unit in travel mode.

TARTAR SHIPBOARD 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 semiactive homing guidance system is made up of several interrelated units constructed to form the basic airframe of the missile. Each unit houses a major part of the homing and control system. The auxiliary power supply uses the hot gases from solid grain fuel to generate its own electrical and hydraulic power.

Specifications

Length 15 feet; diameter 1 foot; weight, 1,500 pounds.

Performance

Range over 10 miles; speed supersonic.

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-firepower defense against air attack. It also has a surface-to-surface capability. It is a 2-stage weapon with a solid-fuel rocket booster; the missile is powered by a 40,000-horsepower ramjet engine. It is operational with the Navy's fleet of missile cruisers which includes USS *Chicago*, USS *Galveston*, USS *Little Rock*, USS *Oklahoma City*, USS *Albany*, USS *Columbus* and the first nuclear-powered cruiser, USS *Long Beach*.

Specifications

Length 20 feet; diameter 30 inches; weight over 3,000 pounds; booster 10 feet long.

Performance

Range over 65 nautical miles; speed classified.

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 8 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
Principal Subcontractor: Raytheon Company (guidance and control)

Remarks

Chaparral is an adaptation of the Sidewinder 1C air-to-air missile system to a ground-to-air configuration to provide maximum air defense against low- and medium-flying aircraft in forward battle areas. In production by Aeronutronic at Anaheim, California, for the U.S. Army Missile Command, Chaparral utilizes the Sidewinder 1C in a multiple mount on the highly mobile M730 vehicle to insure rapid deployment for defense of forward battle areas. Production began in April 1966 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 and flatbed trailers, or it can be ground mounted. The missiles are aimed by a gunner in a turret mount, and they 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 weapons systems to be included in new air battalions being organized to provide field commanders with low-altitude air defense. The M730 is a lightweight, fully tracked vehicle capable of extended cross-country travel over rough terrain and of high-speed travel over improved roads. During 1968, production testing of Chaparral was conducted by the Army Test and Evaluation Command's Air Defense Board at Fort Bliss, Texas.

Specifications

Length 114 inches; diameter 5 inches; launch weight 185 pounds; solid propelled; infrared guided.

STANDARD SHIPBOARD MISSILE

Prime Contractors: Pomona Division of General Dynamics Corporation (guidance, control and airframe); The Johns Hopkins University Applied Physics Laboratory (consultant to Ordnance System Command)

Remarks

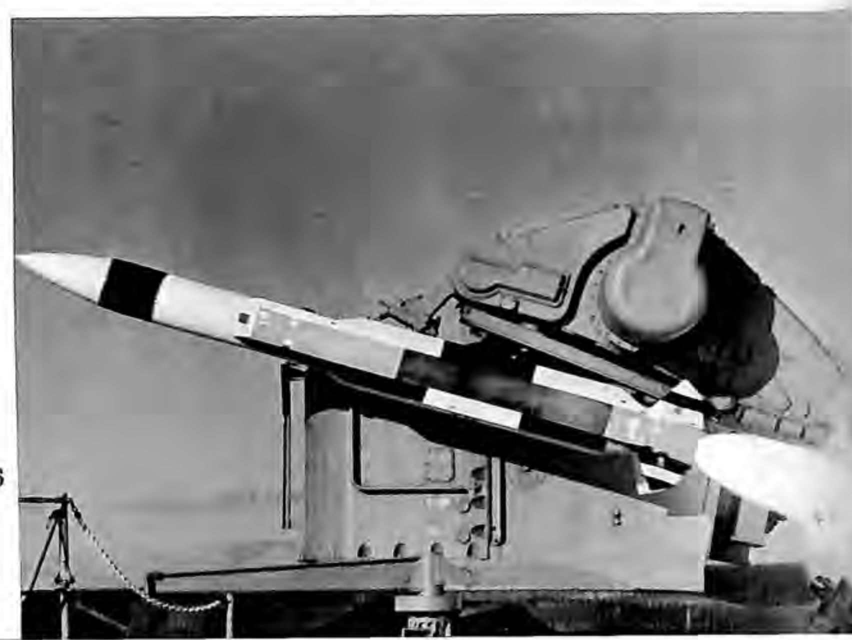
The Standard Missile program implements the Navy's concept of a standardized shipboard missile system for defense of the fleet against surface and aerial threats. Primary objectives in attaining the performance improvements are maximum reliability and overall economy, all to be achieved with simplified 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 (ER) 27 feet, (MR) 15 feet; diameter 1 foot.

Performance

Speed supersonic; range (ER) 35-plus miles, (MR) 15-plus miles.



SEA SPARROW SURFACE-TO-AIR MISSILE

Prime Contractor: Raytheon Company

Remarks

Sea Sparrow (AIM-7E) is in production for use by the Navy and the armed forces of NATO nations with basic point defense missile systems.

Specifications

Length 12 feet; maximum diameter .67 foot; span over fins 3.3 feet; launch weight 450 pounds; guidance semiactive radar homing.

SRAM (SHORT-RANGE ATTACK MISSILE) AGM-69A

Weapon System Integration Contractor: The Boeing Company
Major Subcontractors: Lockheed Propulsion Company; Singer-General Precision, Inc.; Litton Industries; Autonetics Division, Aerospace & Systems Group, North American Rockwell Corporation; Sylvania Electronics; Unidynamics; Stewart-Warner Electronics Division

Remarks

SRAM is a supersonic air-to-ground missile with nuclear capability which will be carried by the FB-111 fighter-bomber and late model B-52 strategic bombers. The missile will be capable of penetrating sophisticated enemy defenses after launch from its carrier aircraft. The program is in design, development and evaluation stage.

STANDARD ARM

Prime Contractor: Pomona Division of General Dynamics Corporation

Remarks

Standard ARM is an air-launched guided missile system 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 include the Navy's A-6 and the Air Force's F-105. The initial version of Standard ARM is in production.

Specifications

Length 14-plus feet; diameter 1 foot.

Performance

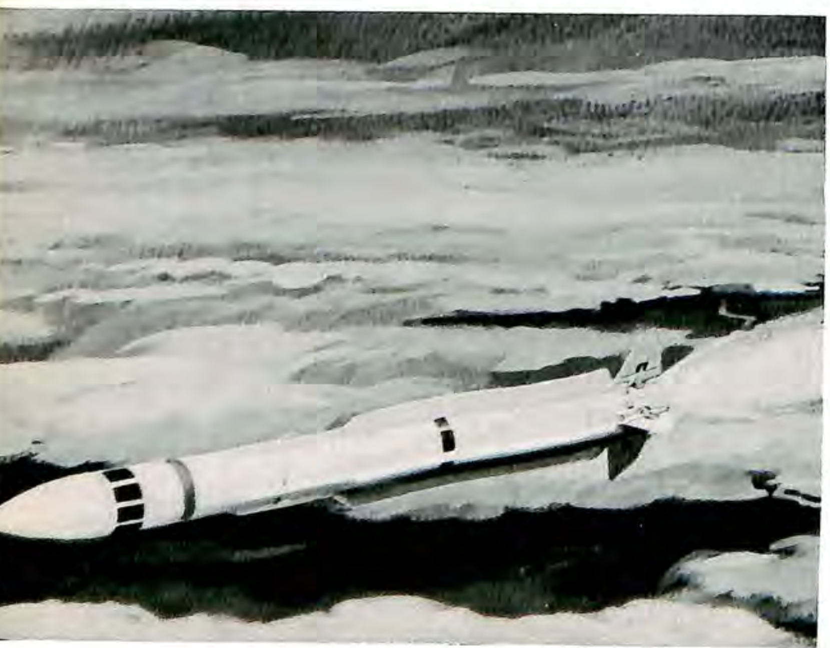
Speed supersonic; range classified.

SHRIKE ANTIRADAR MISSILE

Prime Contractors: Texas Instruments Inc.; Sperry Farragut Company
Subcontractor: Rocketdyne Division, Aerospace & 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 Astronautics Company, McDonnell Douglas Corporation
Associate Contractor: General Electric Company (propulsion system)

Remarks

ADM-20C Quail is a decoy missile used by the B-52 as a penetration aid during strategic bombing missions. Carried in "quick load" clip-in packages, Quail degrades hostile air defense systems by its ability to simulate the flight and radar signature characteristics of the parent aircraft. Powered by the 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 Division, Aerospace & Systems Group, North American Rockwell Corporation
Principal Subcontractors: Pratt & Whitney Aircraft (J52 turbojet engines); Autonetics Division, Aerospace & Systems Group, North American Rockwell Corporation (guidance and controls)

Remarks

The AGM-28 Hound Dog is a B-52-launched air-to-surface strategic missile operated by the USAF Strategic Air Command. Nearly 30 SAC bases throughout the United States are equipped with the double-sonic missile. The B-52 carries 2 inertially guided Hound Dogs—one under each wing. Capable of carrying a nuclear payload, the Hound Dog can be used as a penetration aid for the bombers or 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

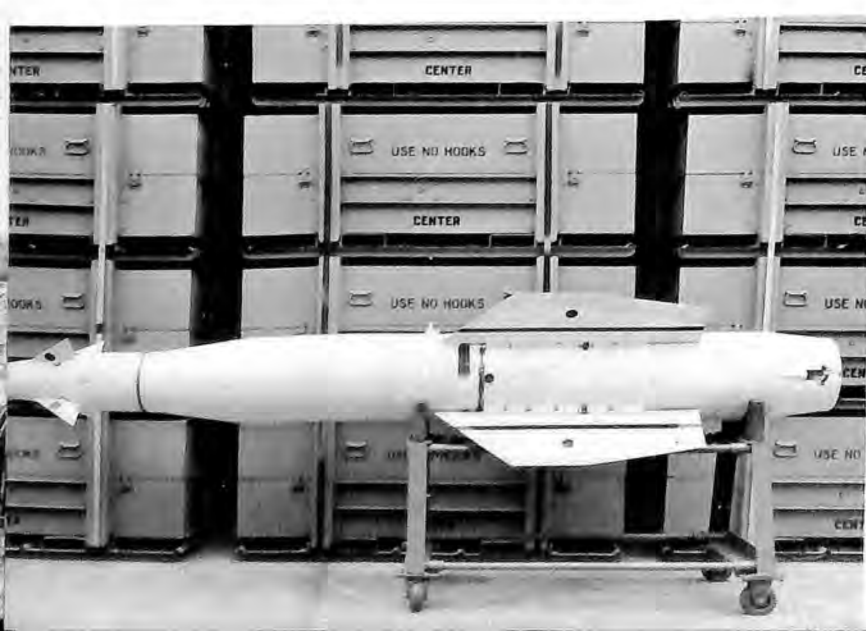
Prime Contractor: Maxson Electronics Corporation

Remarks

Extremely accurate and reliable, the Bullpup is launched more than 2 miles away from surface targets such as airfield installations, train or truck convoys, tanks and bridges. Tracking flares in the tail enable the pilot to "follow" the missiles while sending commands for changes in direction. Bullpup reaches speeds near Mach 2. Simplified design and production reliability permit the missile to be handled as a "round of ammunition" with no prefiring check-out required. Very little ground support is required. The missile can be loaded on aircraft ready for firing in about 5 minutes using only normal bomb-handling equipment or special ground handling equipment.

Specifications

Length (AGM-12B) 10.5 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) 1,000-pound conventional warhead; range (AGM-12B) 3-6 miles, (AGM-12C) more than 6 miles; propulsion prepackaged liquid rocket; guidance radio command, controlled by pilot.



CONDOR AIR-TO-SURFACE MISSILE

Prime Contractor: Columbus Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

Condor, designated AGM-53A, is a rocket-powered, conventional-warhead guided missile designed for use with current and future Navy aircraft. The Condor system relies on closed-circuit television and a command link between missile and airplane for guidance which will provide Navy pilots with a stand-off capability. 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 & Systems Group, North American Rockwell Corporation

Remarks

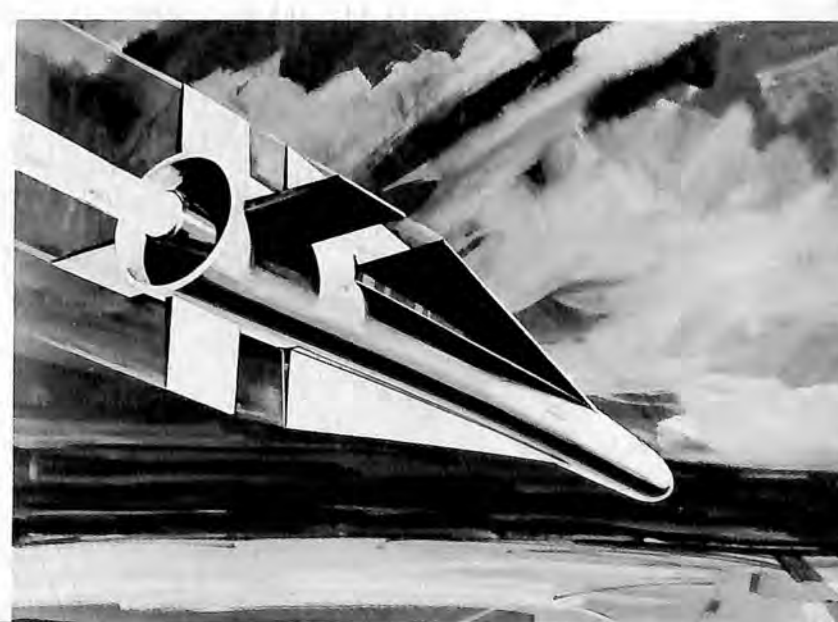
Hornet is a rocket-powered air-to-surface missile system designed for use on tactical aircraft. The missile depends on a television guidance system which locks on and automatically guides it to previously identified mobile or stationary targets.

MAVERICK AIR-TO-SURFACE MISSILE

Prime Contractor: Hughes Aircraft Company

Remarks

Maverick is a highly accurate, TV-guided air-to-surface weapon designed to knock out enemy tanks, armored vehicles and field fortifications. In operation, the pilot selects a target on a TV screen in his cockpit, locks the missile's guidance system on it and launches the weapon. The pilot can then leave the area while Maverick continues on its way to the target, guided by an electrooptical TV homing device in its nose. Maverick is being developed for use by Air Force tactical aircraft, including the A-7, F-4 and F-111.



ZUNI AIR-TO-SURFACE MISSILE

Prime Contractor: Naval Weapons Center

Remarks

One of the earlier Navy missiles, Zuni is used on fighter and attack aircraft as a ground-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 Division

Remarks

A guided bomb with a range of several miles, Walleye weighs approximately 1,000 pounds and is television guided. The missile was developed by the Naval Weapons Center, China Lake, California, and is being produced by Martin Marietta's Orlando Division. In artist's conception, Walleye is launched from Navy A-4 aircraft.

SPARROW AIR-TO-AIR MISSILE

Prime Contractor: Raytheon Company

Remarks

Developed and produced by Raytheon's Missile 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. Current models have greater performance capabilities than the original model because of a series of engineering and design changes. Sparrow has an advanced fire control system which consists essentially of a radar in the nose of the aircraft, a fire control computer and cockpit displays and controls. The radar searches for, acquires and tracks the target. 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 Air Force and Imperial Iranian Air Force and is 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 AIR-TO-AIR MISSILE

Prime Contractor: Missile Systems Division, Raytheon Company
Associate Contractors: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (propulsion); General Electric Company (guidance)

Remarks

The Sidewinder AIM-9D is a second-generation, supersonic, infrared target detection, air-to-air missile. It is capable of being launched from an aircraft flying at subsonic or supersonic speeds. The original Sidewinder AIM-9B became operational in Navy carrier jet squadrons in June 1956. Since then, advanced engineering and design have resulted in a more advanced missile with even greater capabilities than earlier models. The Sidewinder AIM-9D missile is being used on Marine Corps and Navy aircraft, including McDonnell's F-4B/F-4C supersonic dual-purpose fighter. Sidewinder AIM-9D system capabilities provide the pilot a number of combat advantages heretofore unobtainable with air-to-air weapons.

Specifications

Overall length 9.5 feet; maximum diameter .42 foot; span over fins 2.1 feet; launch weight 185 pounds.

Performance

Speed Mach 2.5.

SIDEWINDER LOW-ALTITUDE PERFORMANCE (LAP) SYSTEM (AIM-9E)

Prime Contractor: Aeronutronic Division, Philco-Ford Corporation
Subcontractor: Communications and Electronics (C&E) Division, Philco-Ford Corporation

Remarks

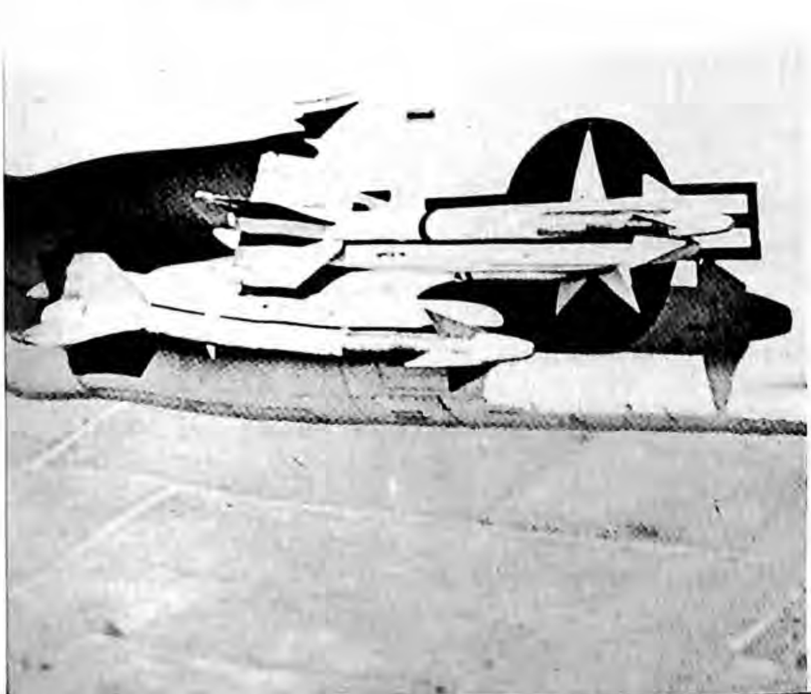
The Sidewinder LAP is an advanced version of the Standard Sidewinder 1A, the free world's first air-to-air guided missile system. In this new version, which is for the Air Force, modifications have been made to the system's "seeker," the electro-optical device at the front end of the Sidewinder which homes in on heat emitted by a target.

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 & 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: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation
Major Subcontractor: Aerojet-General Corporation

Remarks

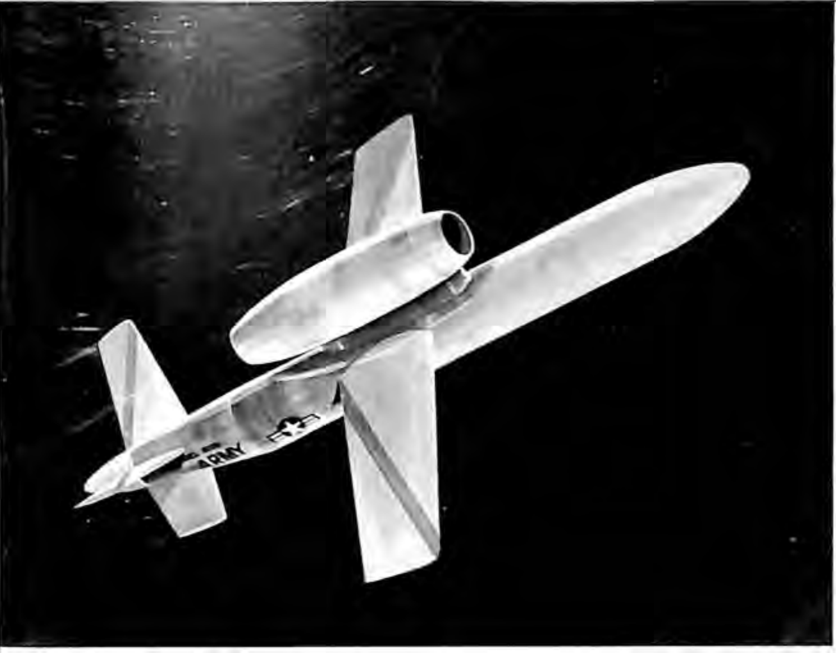
The AIM-2A Genie is an air-to-air rocket with a solid-propellant motor capable of carrying a nuclear warhead. McDonnell Douglas builds the Genie weapon system for the USAF's Air Defense Command. It is carried on the F-101B Voodoo and the F-106 Delta Dart.

Specifications

Length 9 feet; width 1 foot 5 inches; weight 830 pounds.

Performance

Classified.



MODELS 1025, 1025-TJ TARGET MISSILES

Prime Contractor: Beech Aircraft Corporation

Remarks

The Model 1025 was designed principally for programs involving developmental and evaluation testing and personnel training on surface-to-air and air-to-air weapon systems. Model 1025 has been successfully employed with such systems as Hawk, Sparrow, Terrier, Tartar, Sidewinder, Nike Hercules, Nike Ajax and Redeye. Model 1025-TJ is a newer, turbojet system which provides "out of sight" targets for surface-to-air and air-to-air weapon systems. It is a remote-controlled, recoverable target missile capable of speeds of more than 400 knots for a duration of more than 90 minutes. It was designed for such weapons as Hawk, Mauler and Redeye.

Specifications (Model 1025)

Span 155 inches; length 181 inches; diameter 17¾ inches; weight 664 pounds; engine McCulloch turbosupercharged, 125 horsepower, with Beech constant-speed propeller.

Specifications (Model 1025-TJ)

Span 142.8 inches; length 204 inches; diameter 17¾ inches; weight 999 pounds without launch booster; engine 1 Continental 321-2 turbojet.

Performance (Model 1025)

Maximum speed 305 knots; service ceiling 40,000 feet; endurance 82 minutes on station.

Performance (Model 1025-TJ)

Maximum speed Mach .8; service ceiling in excess of 40,000 feet; endurance 1 hour plus.

AQM-37A TARGET MISSILE

Prime Contractor: Beech Aircraft Corporation

Remarks

This supersonic target missile simulates enemy threat systems for air-to-air and surface-to-air missile evaluation and training. The target provides active or passive radar area augmentation for simulating threat systems by means of an optical Luneberg lens or traveling wave tube installation. A chemical flare is provided for missions which require infrared augmentation. Two miss-distance indication systems are also available. The target is normally air launched, but 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 1 Rocketdyne liquid-propellant engine with 630 pounds thrust.

Performance

Maximum speed Mach 3; service ceiling 90,000 feet.

SANDPIPER TARGET MISSILE MODEL 1069

Prime Contractors: Beech Aircraft Corporation; United Technology Center

Remarks

This new supersonic target missile system is designed to simulate a wide variety of aircraft and missile threats of the 1970s. Beech Aircraft is under contract to the 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 development of the production model Sandpiper and establishment of aircraft compatibility. Test launches are to be from the F-4 series aircraft.

Specifications (Production Sandpiper)

Body diameter 10 inches; length 180 inches; weight 600 pounds; highly swept, clipped delta wing and forward-mounted canards for pitch control; full span ailerons; symmetrical vertical stabilizers on each wing tip.

Performance

Maximum speed Mach 4; service ceiling 90,000 feet.

BIKINI SURVEILLANCE SYSTEM

Prime Contractor: Republic Aviation Division, Fairchild Hiller Corporation

Remarks

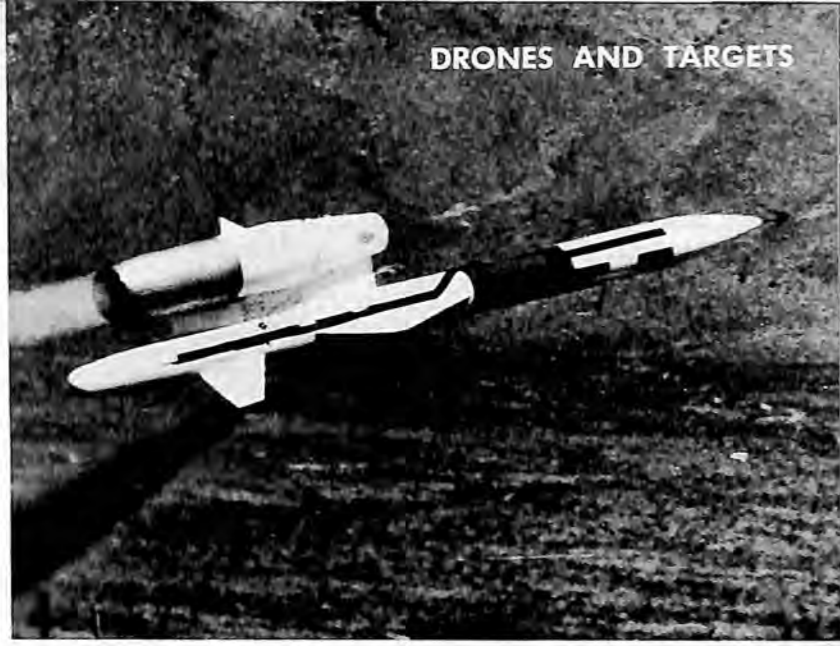
The Bikini aerial drone surveillance system was developed for the Marine Corps to provide combat units with quick-response, short-range reconnaissance. Designed to be operated from unprepared advanced positions by battalion or brigade personnel with only a minimum of special training, the highly mobile 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 9x9 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.



QH-50 DASH DRONE HELICOPTERS

Prime Contractor: Gyrodyne Company of America

Remarks

The DASH (Drone Antisubmarine Helicopter) Weapons System provides destroyers with a flexible, deliberate, long-range attack capability against submarines. An unmanned helicopter, DASH permits a destroyer to attack a submarine without itself coming into lethal range. The series included the QH-50A, original evaluation prototype for the DASH system, first flown in 1960 and later used as an aerial target; the QH-50B, a manned version built only as a developmental aircraft; the QH-50C, first of the operational drones, which was introduced to the fleet beginning in 1962; and the final model of the series, the QH-50D, which has simplified avionics and greatly increased range capability and load-carrying capacity. Deliveries to the Japanese Maritime Self Defense Force commenced in 1967. In 1968 the D successfully performed surveillance/reconnaissance missions by means of a TV camera. Auxiliary fuel tanks provide a flight endurance of 4 hours. The addition of weapons and sensing devices gives a multimission capability.

Specifications (D)

Rotor system coaxial; fuselage length 7 feet 3 inches; height 9 feet 8.5 inches; rotor diameter 20 feet; rotor blades molded fiberglass; weight 1,035 pounds; normal gross weight 2,350 pounds; power plant 1 T50-BO-12 turboshaft, normal rating 300 horsepower.

Performance (D)

Maximum speed sea level 92 knots; hovering ceiling 11,500 feet; service ceiling 16,000 feet; vertical rate of climb at sea level 1,230 feet per minute; operational radius over 30 nautical miles.

MQM-42A GUIDED TARGET MISSILE

Prime Contractors: Columbus Division, Aerospace & Systems Group, North American Rockwell Corporation (airframe and guidance/control); Rocketdyne Division, North American Rockwell Corporation (booster rocket)
Associate Contractor: The Marquardt Corporation (ramjet engine)

Remarks

The MQM-42A Roadrunner was developed for the Army Missile Command as a low-unit-cost, dual-purpose target missile capable of operation at up to twice the speed of sound and at very low and high altitudes. It is used primarily for realistic training of crews of the Hawk-type anti-air warfare batteries of the Army Air Defense System. The 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 in-flight 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 .9-2.1; service ceiling 60,000 feet.

MQM-74A TARGET DRONE

Prime Contractor: Northrop Corporation

Remarks

A new low-cost, variable-speed target drone aircraft, the MQM-74A was designed by Northrop Corporation's Ventura Division for Navy use to fill the gap between low-speed and supersonic targets now in service. The small, jet-powered aircraft provides realistic training to increase proficiency of military gunnery and antiaircraft missile crews and is suitable for exercising a wide range of operational missiles. It provides realistic simulation of limited warfare aircraft speeds and maneuvers. Featuring ease of handling and high reliability, the MQM-74A is capable of flying both visual and out-of-sight missions. The Luneberg lens passive radar 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, 322 pounds fully fueled for flight with provisions for adding 2 15-pound wing-tip pods; launch standard zero-length from ground or shipboard; guidance radio control; power plant 29-pound-weight, 121-pound-thrust turbojet Williams engine.

Performance

Variable speed 200 to 400 knots; service ceiling 40,000 feet; endurance .5-1.5 hours; recovery by parachute.

SD-1 SURVEILLANCE DRONE

Prime Contractor: Northrop Corporation

Remarks

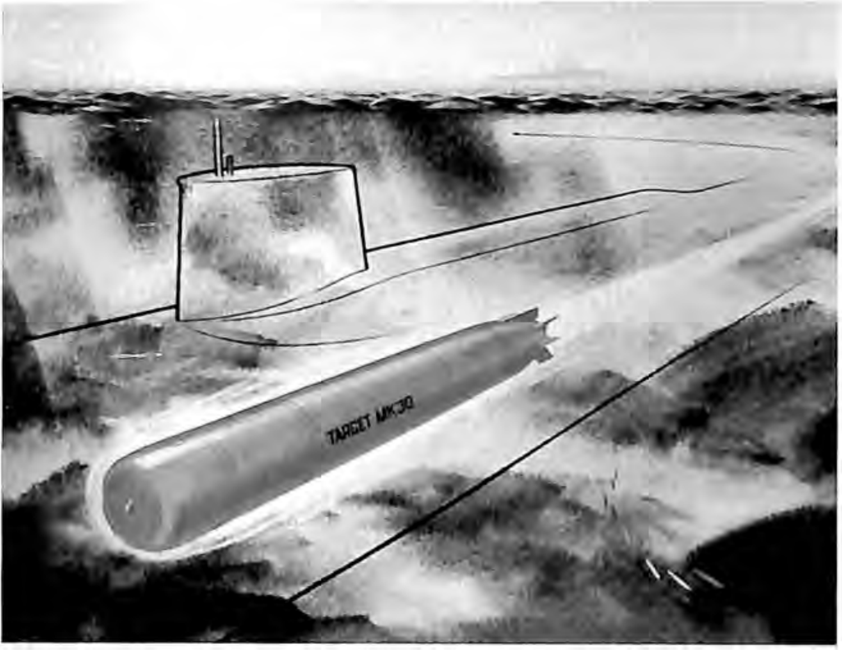
Developed for the Army Signal Corps by Northrop Corporation's Ventura Division, the propeller-driven SD-1 is currently in use by the armed forces of several NATO member countries. The small, mobile, radio-controlled aircraft travels with Army field units by truck and trailer including ground launcher and 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 photoreconnaissance. 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 is processed and prints are 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

The Mark 30 Mobile ASW Target, to be used for antisubmarine warfare training, is under development for the U.S. Naval Ordnance Systems Command by Northrop Corporation's Ventura Division. The target will simulate the size, sound and performance of a full-scale submarine. It is torpedo-shaped. The underwater target is intended to free fully manned submarines from use as targets during mock antisubmarine warfare exercises. It may be launched from either 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 preprogrammed target will travel at changing speeds, direction and depth; it 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 by either 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; power plant 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 Air Force as a target for antiaircraft training. Under its general, international designation, KD2R-5, it is 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 speed-up kit, tow darts, altitude hold device and auxiliary decoder in addition to beacons, smoke cylinders and flares. Rugged construction and simplicity of maintenance permit multiple missions in rapid sequence. All versions are recoverable by parachute, and the target contains flotation equipment for operation at sea.

Specifications

Span 11 feet 6 inches; length 12 feet 7 inches; height 2 feet 7 inches; launch rotary, zero-length or catapult; power plant 2-cycle, 4-cylinder, air-cooled McCulloch engine.

Performance

Speed 175-207 knots; rate of climb 3,060 feet per minute; ceiling 24,000 feet; flight endurance 60 minutes.

LOCAT (LOW COST AIR TARGET)

Prime Contractor: Aeronutronic Division, Philco-Ford Corporation

Remarks

LOCAT (Low Cost Air Target) is an extremely low-cost, high-speed, rocket-powered military air target developed under company funds by Aeronutronic during 1968. The expendable air target pops up from its ground launch site like a clay pigeon at a shooting range and attains speeds in excess of 500 miles per hour within seconds. The 15-foot-long LOCAT fuselage is made of rolled paper tubing. The nose cone and fins are made of glass-reinforced plastic. The LOCAT paper fuselage is coated with aluminum to provide a radar signature for missile tracking and targeting purposes. The LOCAT booster motor consists of 3 2.75-inch FFARs (Folding Fin Aircraft Rockets) of the type used as armament on some military aircraft.

Specifications

Length 15 feet; weight 155 pounds; outside diameter 9.6 inches; tri-fin configuration provides 20.5-square-foot target when viewed by the gunner during flight.

Performance

Designed for altitudes of 1,000 feet, with 10,000 range, and flight time of 17 seconds, this can be adjusted through use of different launch angles which will vary range from 2,000 to 11,000 feet, altitude from 300 to 2,000 feet and flight time from 4 to 24 seconds. Speed or velocity can be varied from 345 to 520 miles per hour. An IR signature is also provided by LOCAT for use with low-altitude air defense systems employing infrared homing missiles.

BMTS (BALLISTIC MISSILE TARGET SYSTEM)

Prime Contractor: Raytheon 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 portable Terrier launcher, a mobile control van and a family of 5 unguided target missile configurations. The target missiles all employ a Nike M-5 booster. One configuration is single stage with a payload attached directly to the Nike M-5 booster. The other 4 configurations are 2-stage, employing either a dummy motor or a Cajun or Apache motor as the second stage, depending upon the desired trajectory range. The payload can include cross-section augmentation, telemetry, tracking aids, electronic countermeasures equipment, miss-distance indicators and other devices dictated by mission requirements. Total ground range, apogee altitude and velocity can be controlled to produce simulations of a wide variety of threat tactical ballistic missiles. There have been 2 successful flights of approximately 180 miles, the longest overland flights made with an unguided target missile.

Specifications

Length, reentry vehicle, 13.5 feet; length with booster 26 feet; maximum diameter 17.2 inches; wing span 5 feet (first stage), 2.5 feet (second stage); launch weight 1,600-2,000 pounds; guidance fin-stabilized free rocket.

Performance

Speed at burnout 2,000-6,000 feet per second; ground range 12-175 nautical miles.

RYAN FIREBEE JET TARGET DRONE (MQM-34D ARMY; BQM-34A NAVY, AIR FORCE)

Prime Contractor: Ryan Aeronautical Company

Remarks

The Ryan Firebee is a remotely controlled, variable-speed, highly maneuverable, subsonic aerial target. It is a multipurpose vehicle, having heavy payload and target-towing capability. Towbee, long-burning infrared tow, and banner tow targets can be streamed behind Firebee for surface-to-air, missile and automatic weapons firings. Increased Maneuverability Kits added to the basic Firebee make possible 6g turns at bank angles up to 78 degrees. Low-altitude performance down to 50 feet over water and 100 feet over land is accomplished with the addition of the Radar Altimeter Low Altitude Control System (RALACS). Ryan has delivered more than 3,700 Firebee target systems to the military services since 1947. Firebees have supported development of nearly every surface-to-air and air-to-air missile weapon system in the U.S. military arsenal.

Specifications

Speed 175-600 knots TAS; altitude 50 feet to 60,000 feet; endurance up to 114 minutes; range more than 1,200 kilometers; payload up to 1,000 pounds; reliability over 10,000 flights; air or ground launchable, parachute recovery system; carries both active and passive radar augmentation; infrared flares; scoring systems; traveling wave tube for radar size variation.

RYAN SUPERSONIC FIREBEE II JET DRONE (BQM-34E NAVY)

Prime Contractor: Ryan Aeronautical Company

Remarks

The Ryan supersonic Firebee II, BQM-34E, under development for the Naval Air Systems Command, started its flight test program in 1968 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 J69-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 BQM-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 1,405 pounds; gross weight 1,852.7 pounds; useful load includes 160.8 pounds augmentation equipment and 286.9 pounds internal fuel and oil. Subsonic configuration: empty weight 1,468.5 pounds; gross weight 2,316.2 pounds; useful load includes 160.8 pounds augmentation equipment and 686.9 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, a division of Sperry Rand Corporation

Remarks

In 1967 Sperry won a contract from the U.S. Air Force for a new, lightweight, supersonic tow target. Called the "Bandito," the target was given the designation TDU-9B. Contract value was $1,900,000. The contract was won by Sperry Utah, which, later in 1967, was incorporated into the company's UNIVAC Division. The major advantage in Bandito is the electrical constant infrared developed by Sperry as a target for heat-seeking missiles. CIR is an electrical heater which emits radiant energy in the infrared spectrum. Power is supplied by a Ram Air Turbine (RAT) capable of producing 28 volts direct current at a constant power rating of 1,700 watts. The entire target system is provided with electrical interlocks to prohibit target operation while in the stowed position under the tractor aircraft.

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 & Systems Group, North American Rockwell Corporation; S-IVB stage, McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation; instrument unit, IBM Corporation; propulsion, all stages, Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

The superbooster used to send American astronauts to the moon under NASA's Project Apollo, Saturn V is a 3-stage vehicle, 364 feet tall, which is capable of placing a 285,000-pound payload in earth orbit or sending 100,000 pounds into a lunar trajectory. The first, or basic, stage, known as S-IC, is 33 feet in diameter and 138 feet long. Its key component is the mighty F-1 rocket engine which develops 1,522,000 pounds of thrust in a single chamber. Five such engines, fueled with kerosene and liquid oxygen, give the first stage a launch output of 7,600,000 pounds to start the 6,400,000-pound vehicle on its journey. The lunar mission profile begins with launching of the Saturn V space vehicle at Cape Kennedy, Florida, with the first stage reaching full thrust 3 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 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

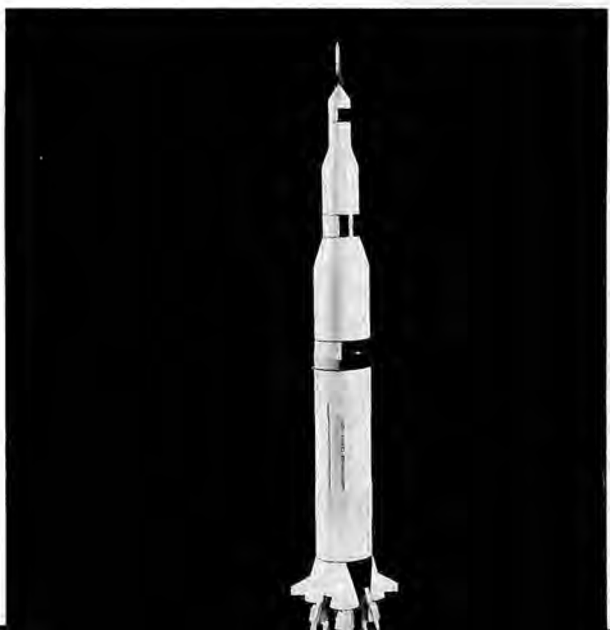
The S-IC is the first-stage booster for the Saturn V launch vehicle. Close to 10,000 Boeing employees are working at 6 sites in the United States on this largest and most powerful booster stage in the free world. Most of the major subassembly and vertical assembly tasks are accomplished at NASA's Michoud Assembly Facility in New Orleans. Burning liquid oxygen and kerosene, the S-IC propels the 3-stage Saturn V and the Apollo spacecraft during the first 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 were ground test versions. Three production versions had flown by the end of 1968.

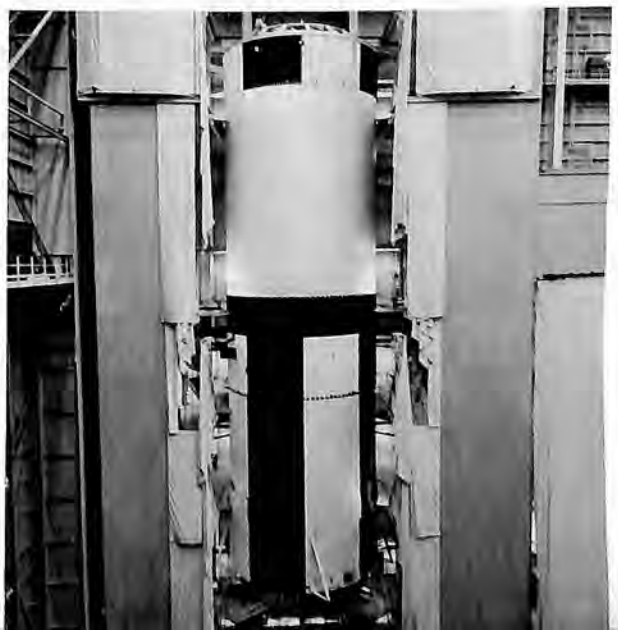
Specifications

Length 138 feet; diameter 33 feet.

Performance

Thrust 7,600,000 pounds, produced by 5 Rocketdyne F-1 engines; lunar voyage firing endurance 150 seconds.





S-II STAGE

Prime Contractor: Space Division, Aerospace & Systems Group, North American Rockwell Corporation
Major Subcontractors: Acoustica Associates (controllers); American Brake Shoe Company (hydraulic pumps); Consolidated Electrodynamics Corporation (tape recorder); Electrada Corporation (test conductor console); Electroplex, subsidiary Borg-Warner Corporation (logic modules, power supplies); Fairchild Precision Metal Products (cryogenic lines); B. H. Hadley (disconnects); W. O. Leonard, Inc. (vent valves); Parker Aircraft Company (hydraulic systems); Solar Division of International Harvester Company (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 in 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 225,000 pounds thrust each, the S-II develops a total thrust of 1,125,000 pounds. The S-II is powered by a combination of liquid hydrogen and liquid oxygen propellants. The 4 outer engines gimbal. The fifth engine, which is centered, is fixed.

Specifications

Height 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: McDonnell Douglas Astronautics Company, 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 serves as the upper stage of the Saturn IB vehicle. Propellant capacity is the same for both versions. In the Apollo applications program, an S-IVB stage will be used as a manned orbital workshop for missions lasting 28 and 56 days. The earlier S-IV stage, powered by 6 Pratt & Whitney Aircraft RL10 engines producing 90,000 pounds thrust, was used on Saturn I.

Specifications

Length 58 feet; diameter 21.7 feet; engine Rocketdyne J-2; propellants liquid oxygen/liquid hydrogen; propellant capacity 230,000 pounds.

Performance

Thrust 225,000 pounds maximum.

SATURN IB

Contractors: Marshall Space Flight Center, NASA, engineering and systems assembly; first stage (S-IB), Chrysler Corporation Space Division; second stage (S-IVB), McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation; propulsion first and second stages, Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

Saturn IB was used in the early test phase of the Apollo lunar landing program, through Apollo 7, the first manned mission, in October 1968. It also figures in NASA's plans for the follow-on Apollo Applications program. The 2-stage Saturn IB is larger and more powerful than Saturn I. Major changes are in the first stage (S-IB), which has been redesigned by Chrysler to eliminate 10 tons of weight, and in the use of the Douglas S-IVB as top stage in place of the earlier S-IV stage.

Specifications

Length 224 feet with Apollo payload and escape tower; weight approximately 1,300,000 pounds; first stage (S-IB) 80.3 feet long, 21.4 feet in diameter; second stage (S-IVB) 58.4 feet long, 21.7 feet in diameter.

Performance

Saturn IB first stage (S-IB) is powered by 8 Rocketdyne H-1 engines, each producing 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 225,000 pounds of thrust at altitude. Saturn IB is capable of placing approximately 20 tons in earth orbit and 2.5 tons in lunar orbit.

TITAN III

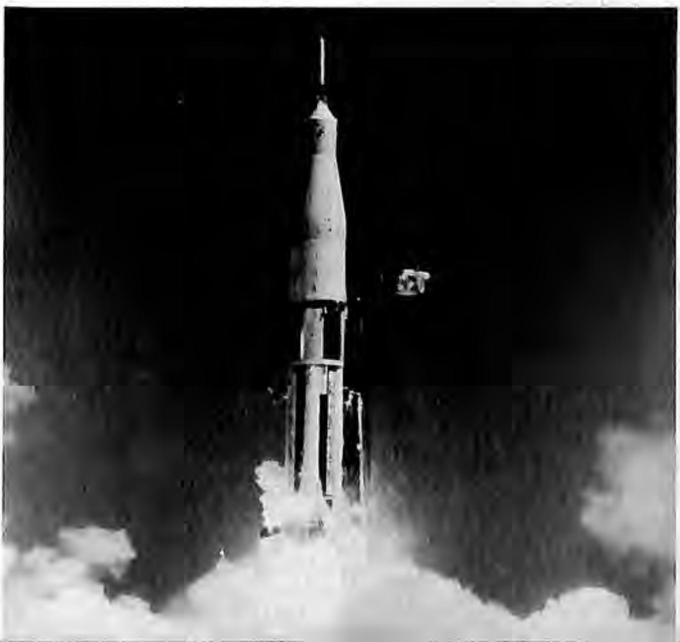
Program Management: Air Force Systems Command's Space Systems Division of the Space and Missile Systems Organization (SAMSO)
Major Contractors: Martin Marietta Corporation, Denver Division (systems integration, airframe, flight test); Aerojet-General Corporation (liquid propulsion); AC Electronics Division, General Motors (guidance); United Technology Center (solid-propellant boosters); The Ralph M. Parsons Company (launch facilities design and engineering); 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 26,500 pounds into earth orbit, and up to 5,000 on escape missions. The largest version which has flown to date, Titan III-C (photo), produces a lift-off 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; MOL version will be about 170 feet tall; diameter of all stages 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 Systems Organization (SAMSO)
Major Contractors: Martin Marietta Corporation, Denver Division (systems integration and airframe); Aerojet-General Corporation (propulsion); AC Electronics Division, General Motors Corporation (guidance)

Remarks

Transtage is a switch engine spacecraft capable of delivering multiple payloads to multiple destinations as needed. Its missions have included deployment of 26 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

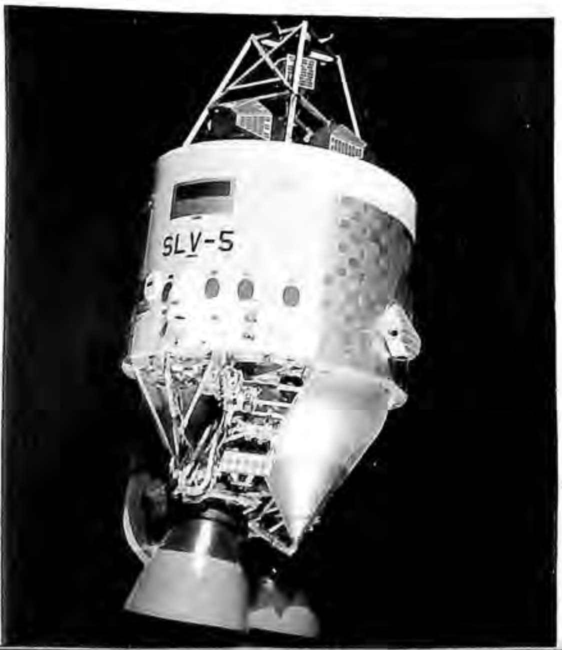
Transtage is 10 feet in diameter; with the standard payload fairing utilized for unmanned missions, it is 33 feet long; weight, fueled but not including payload, is 28,000 pounds. It is capable of 10 or more starts in space.

ATLAS SLV-3

Prime Contractor: Convair Division of General Dynamics Corporation
Associate Contractors: Rocketdyne Division, Aerospace & 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 uprated and identified as SLV-3A for use with an Agena upper stage, and as SLV-3C for use with a Centaur upper stage. Fifty-six SLV-3s were produced for various National Aeronautics and Space Administration and Air Force missions. Of the 54 flown, 52 were successful for an overall booster reliability of 96 percent. The missions included Lunar Orbiter, Orbiting Astronomical Observatory, Orbiting Geophysical Observatory, Applications Technology Satellite, Gemini Target, Precision Recovery Including Maneuverable Entry, Burner II and a variety of special Air Force missions.



SLV-3A AND SLV-3C

Prime Contractor: Convair Division of General Dynamics Corporation
Associate Contractors: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation; General Electric Company; Acoustica Corporation

Remarks

The SLV-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 for SLV-3A. Assigned missions include Surveyor, Applications Technology Satellite, Orbiting Astronomical Observatory and a Mariner Mars flyby. The SLV-3C with a Centaur upper stage 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 & 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

Centaur is a high-energy upper stage currently using an Atlas first stage of similar diameter and construction. Centaur's first mission was Surveyor, to soft-land instruments on the moon prior to manned landings. Centaur is a high-specific-impulse vehicle powered by 2 15,000-pound-thrust liquid hydrogen and liquid oxygen engines. 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: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation
Associate Contractors: Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (liquid propulsion); Thiokol Chemical Corporation (solid propulsion); Western Electric (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), while its predecessor was conical. Total thrust is essentially the same as that for the Thrust Augmented Thor, but Long Tank Thor gets its increased payload capability from a burn time of 216 seconds, 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: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation
Associate Contractors: Aerojet-General Corporation (propulsion system, second stage); Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (first-stage propulsion); Allegany Ballistics Laboratories (third-stage propellant motor); Western Electric (first- and second-stage guidance)

Remarks

The Delta launch vehicle is an economical, reliable and accurate 3-stage vehicle used for launching space probes and earth-orbital missions. Its first stage is a modified Thor. Liquid propellants are used in the first and second stages, and the third stage is powered by solid propellants. Delta has placed in orbit the majority of U.S. scientific and communications satellites, including Tiros, OSO, Explorer, Telstar, Relay, Syncom, ESSA and BIOS payloads.

Specifications (DSV-3C Delta)

Length about 93 feet; diameter 8 feet; lift-off weight 114,000 pounds; thrust 172,000 pounds (first stage), 7,575 pounds (second stage), 6,100 pounds (third stage).

Performance

Payload 875 pounds in a 500-nautical-mile circular orbit.

THRUST AUGMENTED DELTA

Prime Contractor: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation
Associate Contractors: Aerojet-General Corporation (second-stage propulsion); Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (first-stage propulsion); Thiokol Chemical Corporation (strap-on propulsion)

Remarks

The Thrust Augmented Delta (TAD) was introduced in 1964 as a more advanced, more powerful version of the standard Delta. Its added performance is derived from 3 "strap-on" solid-propellant rocket motors that bring TAD's first-stage lift-off thrust to 330,000 pounds—almost double the 172,000-pound-thrust capability of the standard Delta. Addition of the solids enables TAD to boost heavier payloads higher and farther. TAD 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 Communications Satellite Corporation's history-making Early Bird, first link in a proposed worldwide communications network.

Specifications

Length about 90 feet; diameter (maximum including solid boosters) 14 feet 2 inches; lift-off weight 143,164 pounds; thrust 330,000 pounds (first stage), 7,575 pounds (second stage), 6,100 pounds (third stage).

Performance

Payload 1,000 pounds in a 500-nautical-mile circular orbit.

THRUST AUGMENTED IMPROVED DELTA

Prime Contractor: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation
Associate Contractors: Aerojet-General Corporation (second-stage propulsion); Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (first-stage propulsion); Thiokol Chemical Corporation (strap-on propulsion)

Remarks

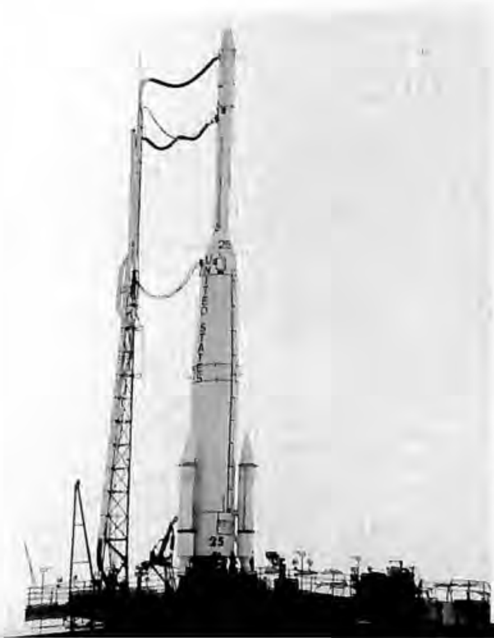
The Thrust Augmented Improved Delta (TAID), introduced in 1965, is an advanced version of earlier Delta models, incorporating features and performance that meet the demand of current and future space progress requirements. Adaptable as either a 2-stage or a 3-stage vehicle, the TAID can carry a wide range of spacecraft, including communications satellites, specialized scientific capsules and navigation, meteorological, experimental and other types of payloads into near-earth orbits or moon orbits or into deep space. The TAID, both as a 2-stage and as a 3-stage vehicle, can be used with or without strap-on thrust augmentation boosters.

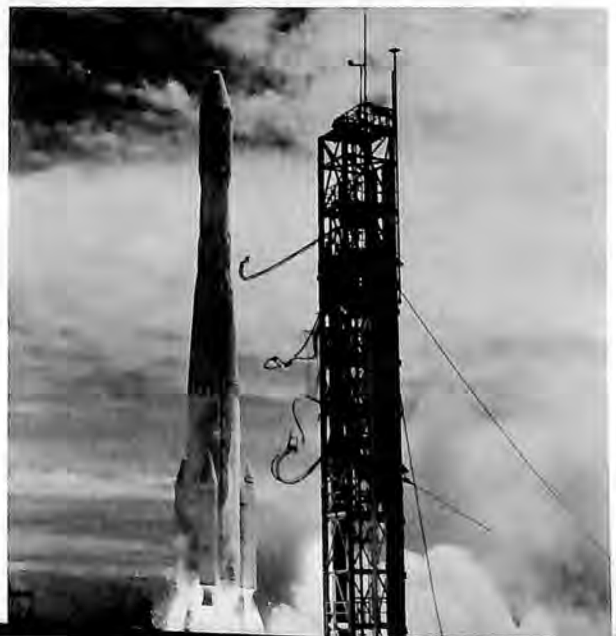
Specifications

Length about 90 feet; diameter (maximum including solid boosters) 14 feet 2 inches; lift-off weight (with solid boosters) 149,461 pounds; thrust 333,000 pounds (first stage), 7,550 pounds (second stage), 5,650 pounds (third stage).

Performance

Payload 1,120 pounds in a 500-nautical-mile circular orbit.





THRUST AUGMENTED LONG TANK DELTA

Prime Contractor: McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation
Associate Contractors: Aerojet-General Corporation (second-stage propulsion); Rocketdyne Division, Aerospace & Systems Group, North American Rockwell Corporation (first-stage propulsion); Thiokol Chemical Corporation (strap-on propulsion)

Remarks

The Long Tank Delta (LTD), which made its debut August 16, 1968, when it orbited the ESSA VII weather satellite, is the latest and most powerful version of the Delta series of launch vehicles introduced in 1960. This model is launched as either a 2-stage or a 3-stage vehicle by utilizing the Thrust Augmented Long Tank Thor as a first stage. As a result, the overall vehicle length is 14½ feet greater than that of the Thrust Augmented Improved Delta and propellant capacity is increased. The LTD also includes a new, higher-energy, third-stage motor. Space assignments for the LTD include the lofting of communication, meteorological, scientific, navigation and experimental payloads into near-earth orbits or moon orbits or into deep space.

Specifications (DSV-3L Long Tank Delta)

Length about 106 feet; diameter (maximum including solid thrust augmentation) 14 feet 2 inches; liftoff weight (with solid thrust augmentation) 199,416 pounds; thrust 330,000 pounds (first stage), 7,550 pounds (second stage), 10,000 pounds (third stage).

Performance

Payload 1,580 pounds in a 500-nautical-mile circular orbit.

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 & 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 restarts in space; in the modified target vehicle version, it also had 2 secondary engines to provide small changes in velocity and position in orbit. In the Gemini Agena, a control system could handle 96 commands from the astronauts or from ground stations. Agena is used as an upper stage with the Thor, Augmented Thor, Atlas and Titan boosters; it has played important roles in such military and NASA programs as Discoverer, Samos, Mariner, OGO, Lunar Orbiter, Ranger and Orbiting Astronomical Observatory.

Specifications

Length 19-40 feet depending on version, Gemini version 25 feet; diameter 5 feet; all-inertial guidance.

Performance

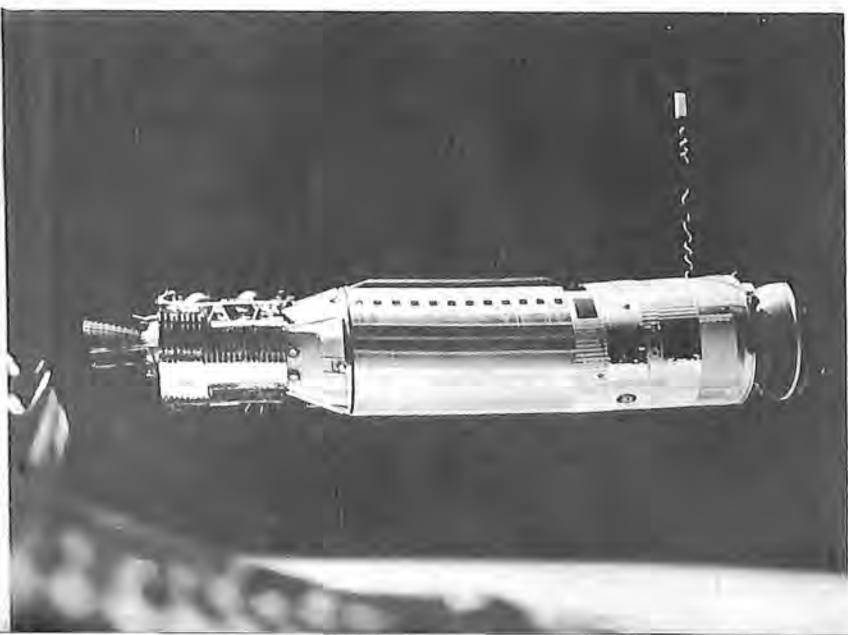
Atlas-Agena 5,000 pounds in 300-mile orbit.

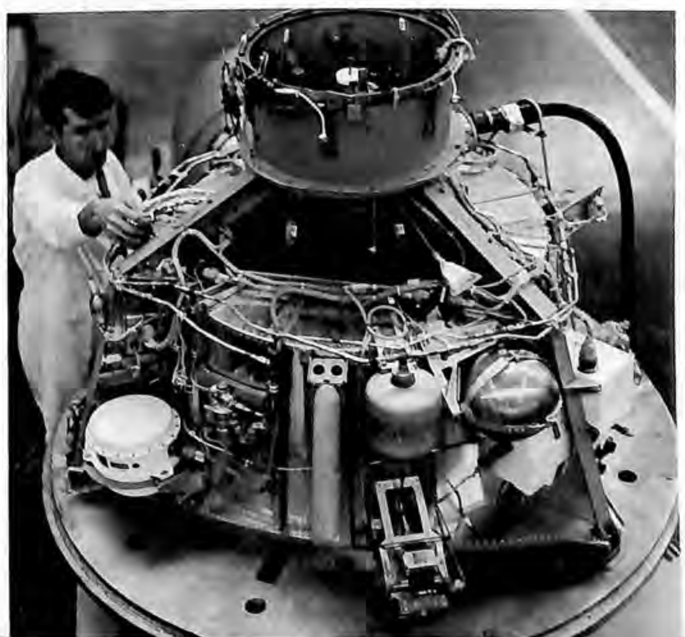
BURNER II

Prime Contractor: The Boeing Company
Major Subcontractors: Thiokol Chemical Corporation (solid rocket motor); Honeywell Inc. (preprogrammed inertial guidance system); Walter Kidde & Company (reaction control system)

Remarks

Burner II is a launch vehicle upper stage developed by Boeing for the Air Force Space Systems Division. It is the first solid-fuel upper stage with full control and guidance capability developed for general space applications. Burner II was designed for use with the Thor booster, but 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. Six Thor-Burner II combinations have been launched successfully from Vandenberg Air Force Base, California. The third launch placed 2 unclassified satellites in earth orbit. A SECOR satellite, built for the 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.





ATHENA REENTRY TEST VEHICLE (STANDARD)

Prime Contractor: Atlantic Research Missile Systems Division
Associate Contractors: Propulsion: Thiokol Chemical Corporation, first stage; Thiokol and Hercules Incorporated, second stage; Aerojet-General Corporation, third stage; Hercules Incorporated, fourth stage; Atlantic Research, spin rockets; Hercules, boost-assist motors and retro motors

Remarks

The Athena reentry vehicle, conceived to simulate the reentry environment 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 the United States' first inland range for the overland test of multistage vehicles. Athena is launched from Green River, Utah, along the Army's White Sands Missile Range, reaching altitudes of over 1,000,000 feet before descending on White Sands, New Mexico, some 470 miles downrange. The Army's highly instrumented range had monitored 103 flights by the end of July 1968, in a program of 149 launchings scheduled through 1969. The program is under the direction of the Space and Missile Systems Organization (SAMSO), Air Force Systems Command.

Specifications

Three or 4 stages, all solid propellant; overall length 50 feet; diameter 31 inches; weight 16,000 pounds at launch; unguided boost, midcourse correction.

Performance

Velocity in excess of 15,000 miles per hour at reentry; range more than 470 miles; ceiling in excess of 1,000,000 feet; it is successfully yielding high degree of reentry space physics data and subscale systems test data.

ATHENA H REENTRY TEST VEHICLE

Prime Contractor: Atlantic Research Missile Systems Division
Associate Contractors: Thiokol Chemical Corporation or Aerojet-General Corporation (first-stage propulsion); Thiokol Chemical Corporation and Hercules Incorporated (second-stage propulsion); Aerojet-General Corporation (third-stage propulsion); Atlantic Research Corporation and Thiokol Chemical Corporation (spin rockets); Hercules Incorporated (boost-assist motors and retro motors)

Remarks

The Athena H reentry vehicle is an uprated version of the Standard Athena, capable of flying larger payloads at ICBM velocities over the inland test range from Green River, Utah, to White Sands Missile Range, New Mexico. The program is under the direction of Air Force Systems Command, Space and Missile Systems Organization (SAMSO).

Specifications

Two or 3 stages, all solid propellant; overall length 61 feet; diameter 40 inches; weight 32,000 pounds at launch; unguided boost, midcourse correction.

Performance

Athena H will provide ICBM reentry environments for payloads up to 400 pounds and IRBM environments for payloads up to 1,000 pounds; apogees in excess of 1,000,000 feet will be obtained over the 470-mile range.

APOLLO COMMAND AND SERVICE MODULES

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 Victor 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); Singer-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 Brothers, 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); Weber Aircraft (spacecraft couches)

Remarks

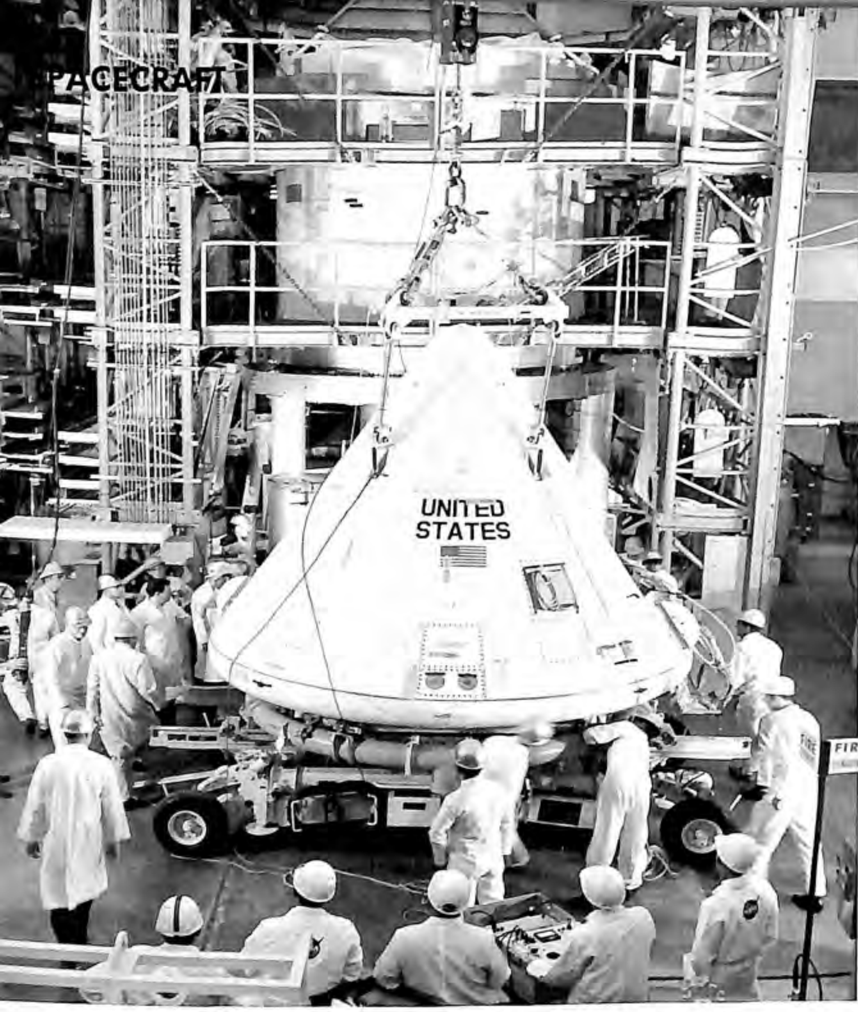
Project Apollo is the United States' program to place Americans on the moon for scientific exploration and safe return to earth. The Apollo program is directed by the National Aeronautics and Space Administration. Technical management of the Apollo spacecraft is under NASA's Manned Spacecraft Center, 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 engine and its propellants for return from the moon and for mid-course corrections. It contains the electrical system, reaction control engines and part of the environmental control system. Propellants and various systems 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 10 feet 7 inches; diameter (at the base) 13 feet; launch weight 13,000 pounds (approximately); outer structure stainless steel honeycomb bonded between stainless steel alloy sheets; inner compartment primarily aluminum honeycomb bonded between aluminum alloy sheets; insulation: a 2-layer microquartz fiber insulation separates the walls of the inner and outer structures; environment shirt-sleeve temperature of about 75 degrees, 100 percent oxygen.

Service Module Specifications

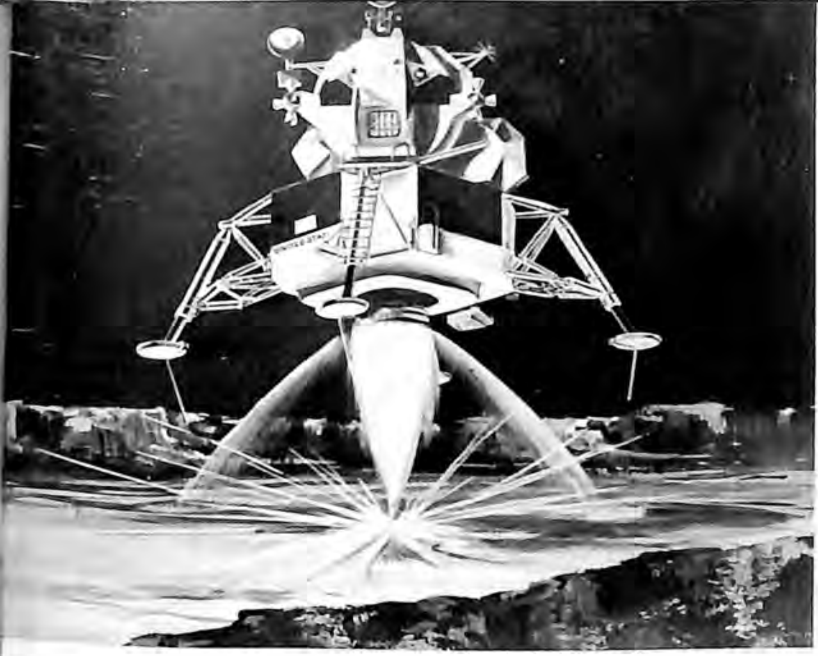
Shape cylindrical; height 22 feet (including engine); diameter 13 feet; construction mostly aluminum alloy; outside skin is honeycomb bonded between aluminum sheets; launch weight 55,000 pounds (approximately).



A

B

In Photo A, an Apollo Command Module, built at North American Rockwell's Space Division plant in Downey, California, is lowered onto a dolly for transportation to Cape Kennedy. In Photo B, the combined Command and Service Modules are hoisted into the vertical assembly stand at Cape Kennedy for mating with other components of the Saturn V/Apollo stack.



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 approximately 10,000 pounds of thrust. Vehicle orientation is provided by 16 100-pound-thrust rocket engines located in quads at 4 locations on the ascent stage. The LM can land in the automated mode, utilizing a landing radar as the sensing device and a computer to update engine thrust; or it can be controlled by the astronauts, either completely or in conjunction with the 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-pound-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 Douglas Astronautics Company, McDonnell Douglas Corporation
Associate Contractors: Honeywell Inc. (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 & 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 for 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 is scheduled for further use, in a modified version, in the USAF's Manned Orbiting Laboratory project.

MANNED ORBITING LABORATORY

Major Contractors: General Electric Company, Missile and Space Division, Space Systems Organization (experiment integration); McDonnell Douglas Astronautics Company, McDonnell Douglas Corporation (laboratory module and Gemini B spacecraft)

Remarks

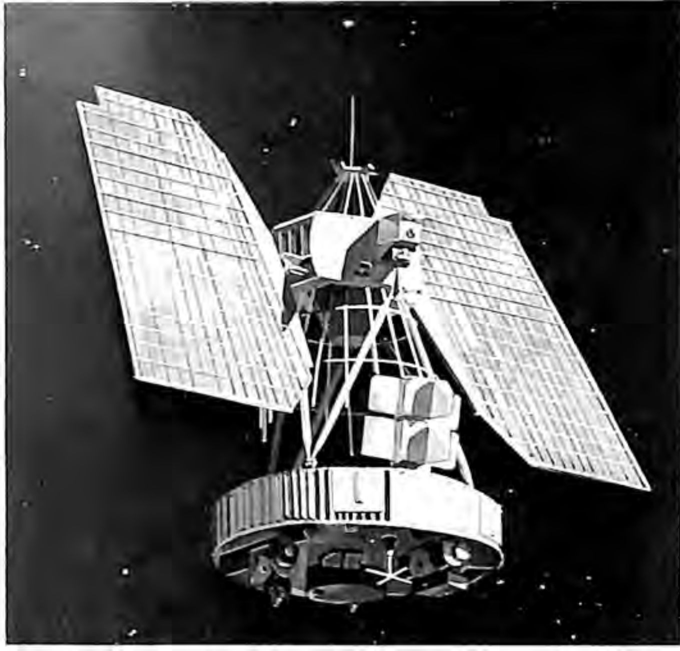
The U.S. Air Force Manned Orbiting Laboratory (MOL) program is the largest Department of Defense space program. Its objectives are to learn more about what man is able to do in space and how that ability relates to defense requirements, to develop technology and equipment which will help advance manned 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—consisting of the Gemini B, a 41-foot laboratory vehicle, and the Titan III booster—has been established. First flight by a 2-man crew is planned for 1972. 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.

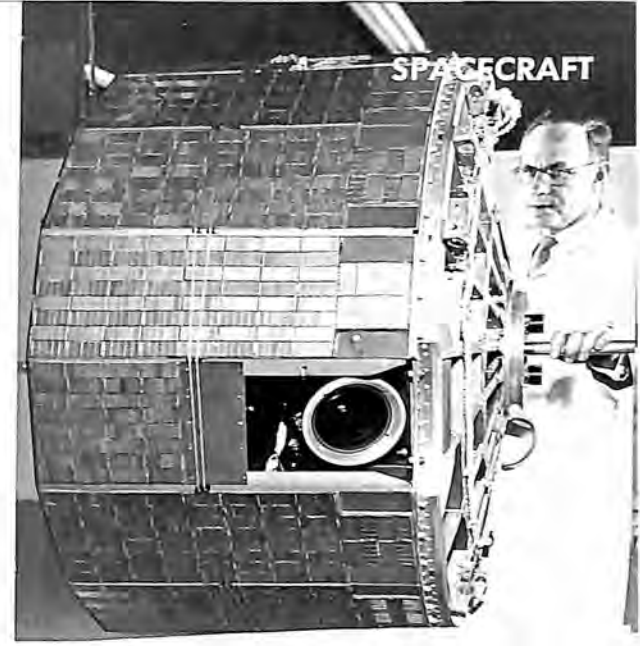
BIOSATELLITE

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 reentry. 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, Space Systems Organization
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's 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, launched May 18, 1968, was destroyed in flight by the Range Safety Officer because the launch vehicle had veered off course. 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

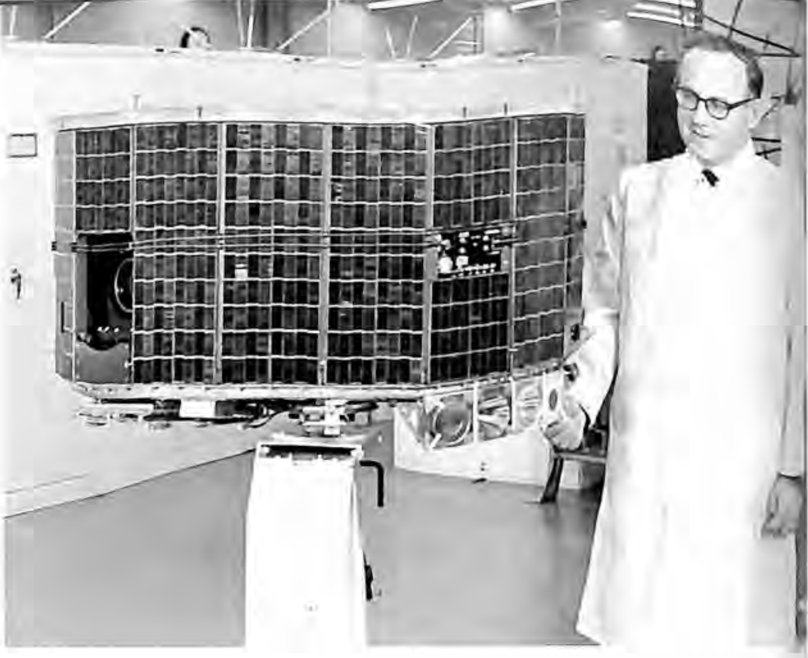
Prime Contractor: RCA, Defense Electronic Products, Astro-Electronics Division

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. A late 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: RCA, Defense Electronic Products, Astro-Electronics Division

Remarks

A second-generation follow-on to the Tiros Operational System (TOS) weather satellites, Tiros M is being developed by RCA for NASA's Goddard Space Flight Center. Eventual user and sponsor of the satellite after it becomes operational will be the Environmental Science Services Administration. The first Tiros M research and development flight was scheduled for 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 nighttime 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 48x40x40 inches, with 3 solar panels, each 36x63 inches; weight approximately 670 pounds.

ESSA

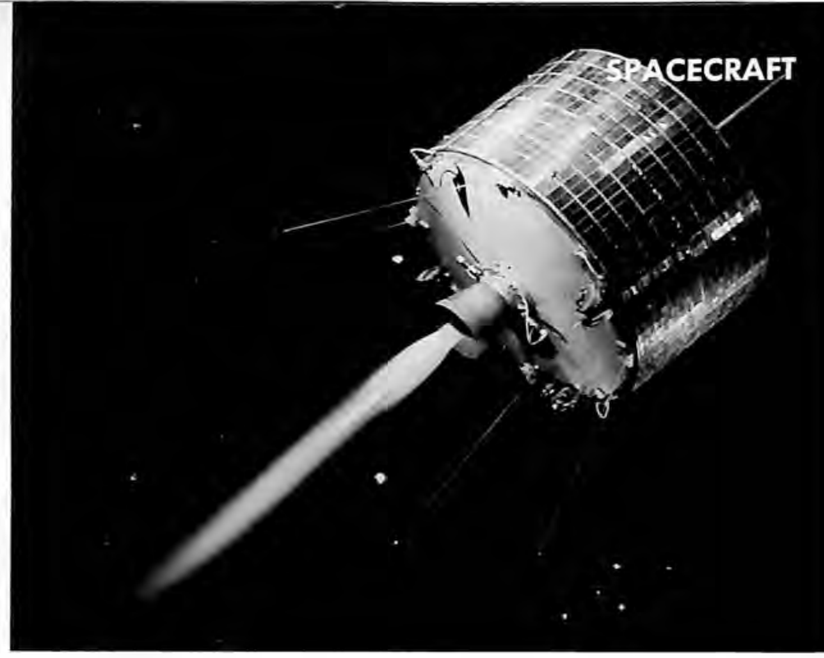
Prime Contractor: RCA, Defense Electronic Products, Astro-Electronics Division

Remarks

ESSA (Environmental Survey Satellite), the world's first global operational weather satellite, is designed and built by RCA under the technical direction of NASA's Goddard Space Flight Center for the Environmental Science Services Administration, of which the U.S. Weather Bureau is a division. The first ESSA satellite was launched successfully on February 3, 1966. It carried 2 conventional Tiros-type television cameras in a rolling wheel configuration. ESSA 2 was 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), ESSA 6 and ESSA 7 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

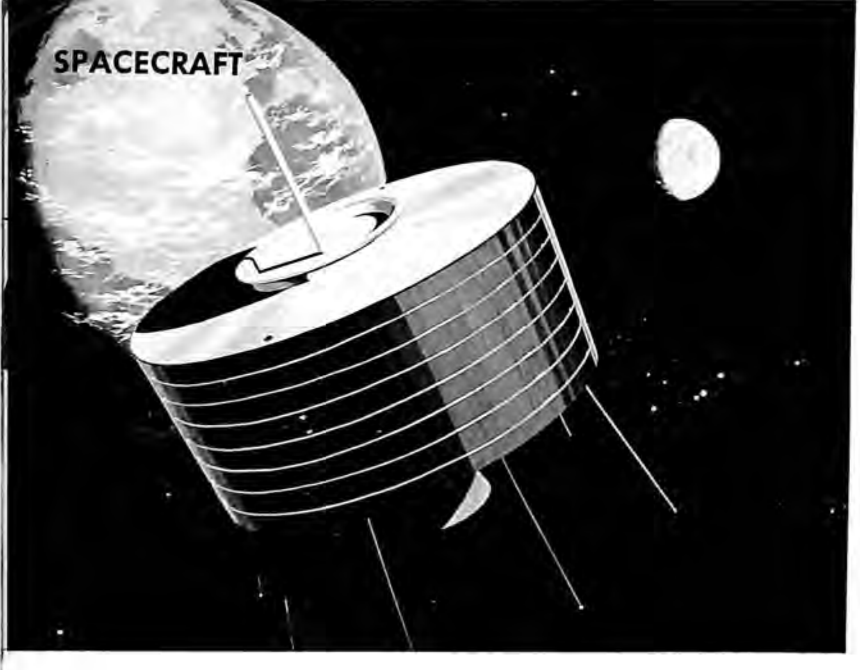
A synchronous communications satellite, Early Bird was launched April 6, 1965, by the U.S. Communications Satellite Corporation as agent for a world consortium of more than 40 participating nations. The satellite was injected into a synchronous orbit 22,300 miles above the equator over the Atlantic Ocean. The 85-pound spacecraft has capacity for 240 2-way telephone channels or simultaneous 2-way television between Europe and North America on a 24-hour-day basis. It can also handle teletype and facsimile 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 3 such spacecraft can form a TV-telephone network providing 24-hour-a-day 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.

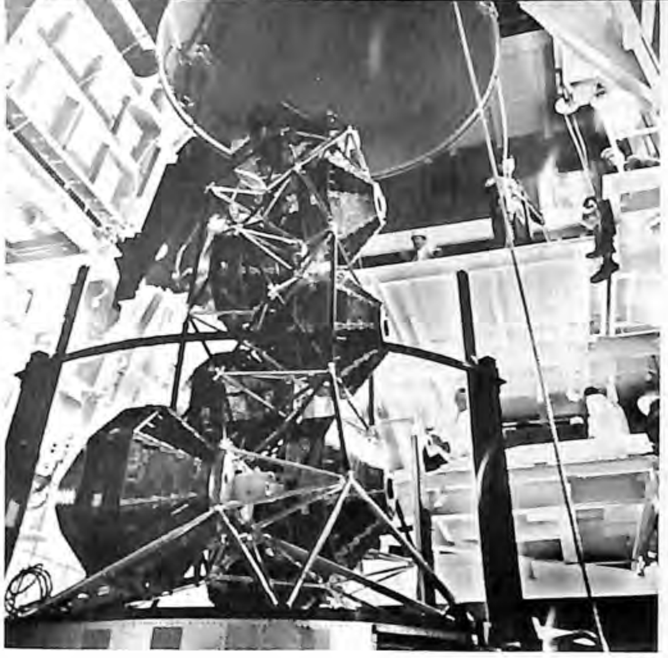
INTELSAT III

Prime Contractor: TRW Systems Group, 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 Defense Communications Division, United States; Mitsubishi Electric Corporation (MEC), Japan; Société Anonyme de Telecommunications (SAT), France; Sylvania Electronic Systems, United States; Lockheed Aircraft Corporation, United States; Aerojet-General Corporation, United States

Remarks

Intelsat III is the first wholly commercial communications satellite system to operate on a global scale. TRW will build 6 flight spacecraft for initial operational use in 1969. Each satellite will handle a minimum of 1,200 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 and 78 inches high and weigh about 270 pounds, not including the apogee motor.



INITIAL DEFENSE SATELLITE COMMUNICATIONS SYSTEM

Prime Contractor: Space and Re-Entry Systems Division, Philco-Ford Corporation

Remarks

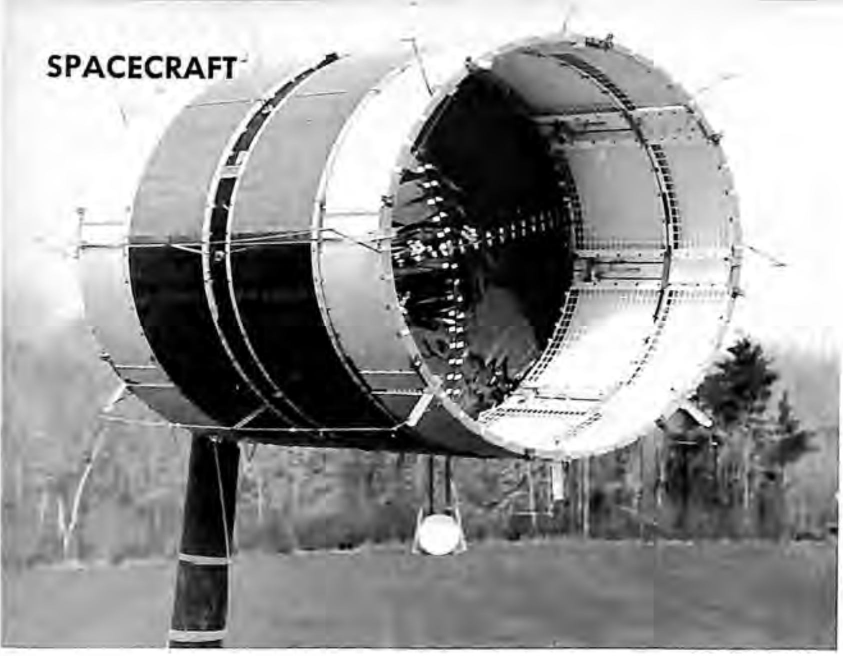
In late October 1964, Philco-Ford Corporation was assigned prime contractor responsibilities for designing, developing and assembling both the satellites and the multiple-launch dispensers for the Initial Defense Satellite Communications System. Under the overall direction of the Defense Communications 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 IDSCS satellites (plus a gravity-gradient experimental satellite) into near-synchronous equatorial orbit at an altitude of approximately 21,000 statute miles to initiate the network—19 months from the start of hardware design. On January 18, 1967, 8 additional satellites were launched and on July 1, 1967, 4 more were sent into orbit. On June 13, 1968, 8 more satellites were placed into orbit, bringing the total in operation to 25.

TACCOMSAT

Prime Contractor: Hughes Aircraft Company

Remarks

TACCOMSAT is the tentative name for an experimental tactical communications satellite being built for the Air Force by Hughes. The satellite is designed to provide tactical communications among military units in the field, aircraft and ships at sea. As tall as a 2-story house, TACCOMSAT is the largest communications satellite built; it weighs 1,600 pounds. The spacecraft carries a cluster of antennas whose powerful signals can be picked up by all types of terminals, including those with antennas as small as 1 foot in diameter. The spin-stabilized satellite carries 3 antenna systems; included are 5 helical UHF antennas, 2 microwave horns for X-band communications and a biconical horn for telemetry and command. Being built under contract with the USAF's Space and Missile Systems Organization, TACCOMSAT was scheduled for delivery late in 1968. It was to be launched, early in 1969, into a 22,300-mile synchronous orbit by a Titan III-C launch vehicle.



LINCOLN EXPERIMENTAL SATELLITES

Prime Contractor: Massachusetts Institute of Technology Lincoln Laboratory

Remarks

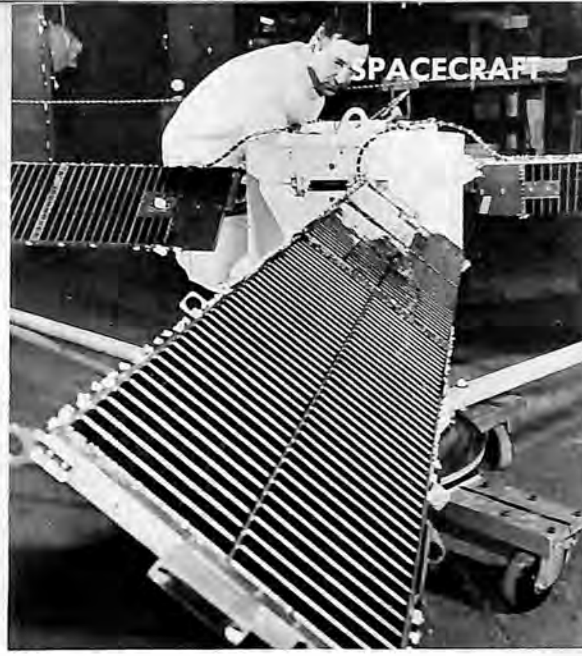
The LES (Lincoln Experimental Satellite) spacecraft are designed and built by the M.I.T. Lincoln Laboratory in Lexington, Massachusetts, as part of the Laboratory's Air Force-sponsored program in space communications, to test realistically, in orbit, advanced devices and techniques being developed for possible use in military satellite communication systems. LES-1, -2 and -4, launched in 1965, operated at X-band (approximately 8,000 MHz) and included the first all-solid-state communication satellite transmitters and the first "electronically despun" (earth-sensing and antenna-beam-switching) systems. LES-3, a UHF-band radio signal generator launched in December 1965, helped to establish design criteria for LES-5, the first communication satellite to operate entirely in the government-allocated UHF-band (225-400 MHz), with the first UHF-band satellite antenna system that generates circularly polarized radio signals to minimize fading and communications drop-outs and to allow a surface terminal to use a very small, simple antenna such as a whip or stub monopole. Launched July 1, 1967, LES-5 (photo) was designed to aid in the development of a tactical communications satellite (TACCOMSAT) system for the Department of Defense. LES-6, launched September 26, 1968, is a much more sophisticated, synchronous-orbit, UHF-band satellite, with substantially greater effective radiated power than LES-5, in combination with a number of new station-keeping, orientation and propulsion systems. LES-6 has a unique, high-efficiency electrical power supply system that eliminates power converters and regulators.

RELAY

Prime Contractor: RCA, Defense Electronic Products, Astro-Electronics Division

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 22, 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

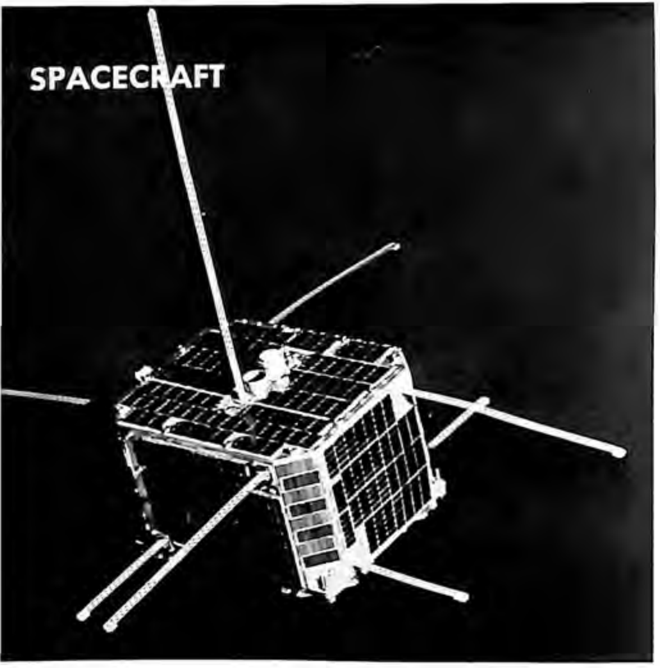
The first active-repeater communications satellite, Telstar demonstrated the feasibility of transmitting television images and telephone, telegraph and radio messages on a global basis. Launched by a Delta booster, Telstar first went into orbit July 10, 1962. Telstar II was orbited May 7, 1963. Both satellites were highly successful. NASA provided launch vehicles and tracking facilities on a reimbursable basis.

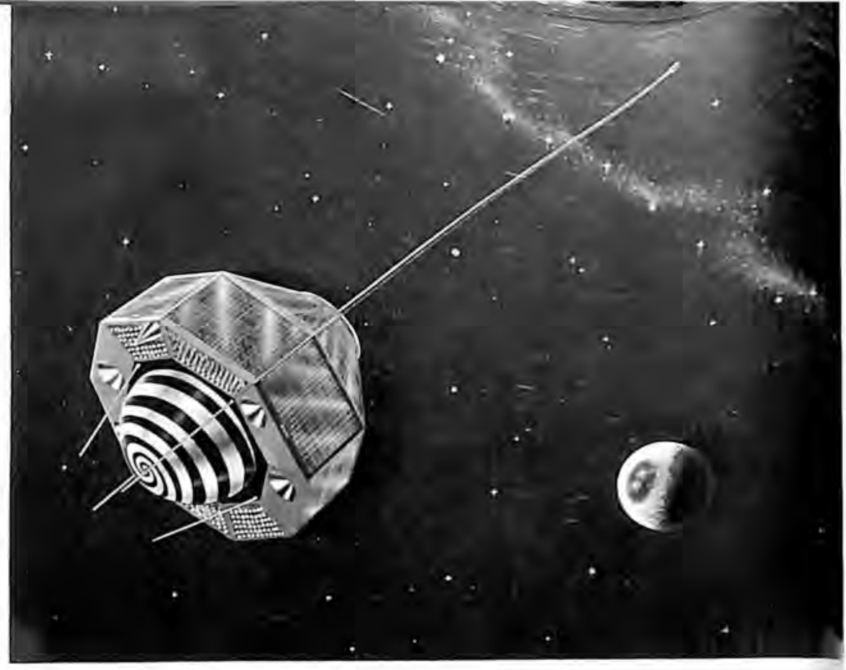
U.S. NAVY NAVIGATION SATELLITE

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory
Associate Contractor: RCA, Defense Electronic Products, Astro-Electronics Division

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 about 100 pounds, in near-circular orbits at 600 miles altitude. The satellites, once known as Transit, are launched by a Scout booster. A number of operational navigation satellites (known as Oscar) have been launched to enhance the Navy's worldwide 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 satellite carries 2 transmitters for telemetering, Doppler signals and memory readout. 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's Astro-Electronics Division is responsible for manufacture of operational satellites.





GEODETIC SECOR

Prime Contractor: Cubic Corporation

Remarks

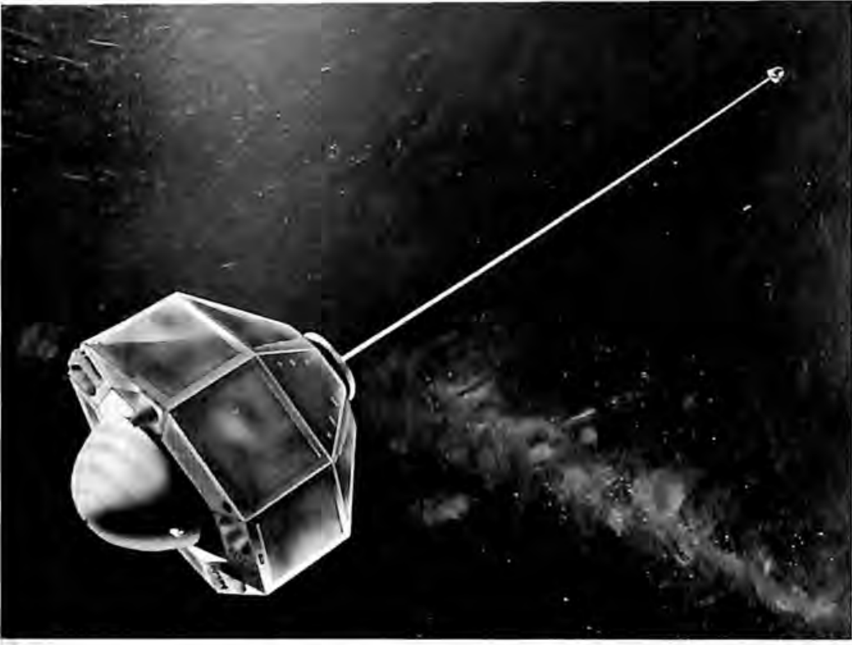
Geodetic SECOR (Sequential Collation of Range) is an all-weather geodetic survey system in operational use for establishing a global survey network. It uses the successive positions of artificial satellites in space to determine locations on the earth's surface with exactness over long distances. The system consists of a satellite and 4 ground stations, 3 at geographical points whose coordinates have been surveyed accurately and the fourth at an unknown location. Radio waves are flashed from the ground stations to the satellite and returned. The position of the satellite at any 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 1 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 I

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

Primary objective of GEOS I 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 I 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.



GEOS II

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

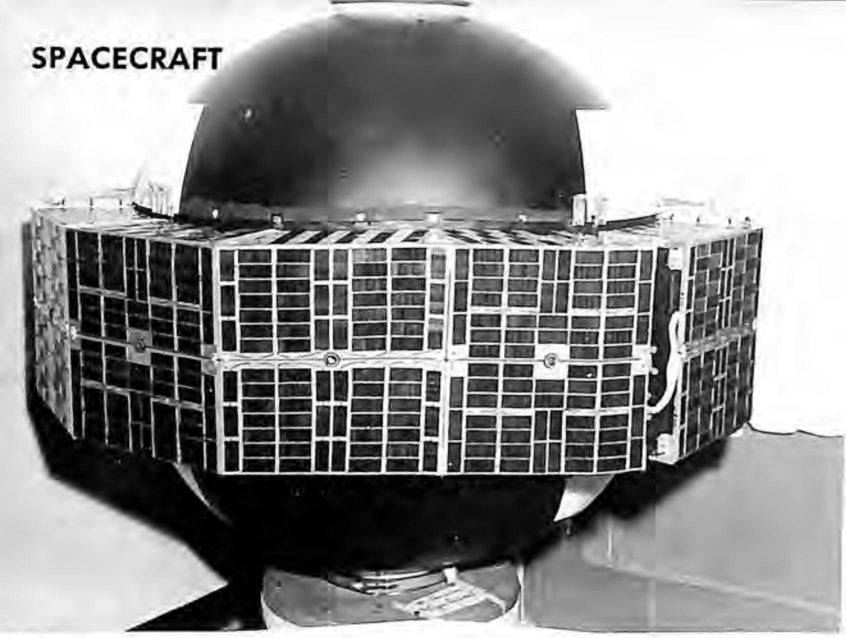
GEOS II is designed to contribute to the development of a more precise model of earth's gravitational field and to improve knowledge of the size and shape of the earth by establishing the location of a set of worldwide tracking stations whose positions are known with an accuracy of 36 feet or better in a unified geocentric coordinate system. The 48-inch-diameter, 460-pound satellite was launched January 11, 1968, from the Western Test Range aboard an Improved Delta launch vehicle. It carries 6 geodetic systems—flashing light beacons, Navy radio Doppler system, an Army radio range transponder, a NASA range and range rate transponder, a C-band transponder and laser corner reflector panels. The satellite is gravity-gradient stabilized using a motorized extendible boom and an end mass having an eddy-current type damper. GEOS II was launched to contribute to the completion of the NASA-managed United States National Geodetic Satellite Program (NGSP). The program was designed to satisfy the nation's requirements in satellite geodesy and is a coordinated undertaking involving NASA, Department of Commerce (Coast and Geodetic Survey) and the Department of Defense, as well as many nongovernmental scientists and organizations. Scientists of other nations also participate in NGSP. Overall responsibility for GEOS II is under NASA's Office of Space Science and Applications.

LINCOLN CALIBRATION SPHERE (LCS)

Prime Contractor: Massachusetts Institute of Technology Lincoln Laboratory
Associate Contractor: Rohr Corporation

Remarks

The Lincoln Calibration Sphere is a rigid, hollow, aluminum sphere with a projected area of exactly 1 square meter and a polished surface that is exactly spherical to within a few thousandths of an inch. In orbit, it serves as a durable, stable primary standard for direct calibration of large radio and radar systems, reducing uncertainties in estimated system sensitivity from several decibels to a few tenths of a decibel. The LCS weighs 75 pounds and is made of ⅛-inch aluminum sheet stock, spun into 2 hemispheres which are joined to an internal equatorial band by 440 equally spaced aluminum screws and then machined from a precision template and hand polished to a high gloss. Designed by the M.I.T. Lincoln Laboratory in Lexington, Massachusetts, under Air Force contract with support from the Advanced Research Projects Agency, it was fabricated by the Rohr Corporation of Chula Vista, California. LCS-1 was launched from Cape Kennedy May 6, 1965, aboard a USAF Titan III-A into a circular, 32-degree inclination orbit at an altitude of 1,500 nautical miles. Post-launch radar observations confirmed pre-launch measurements. Launch problems have frustrated subsequent efforts to place LCS-2 and LCS-3 in lower-altitude orbits where they would have been accessible and useful to a larger number of radar facilities than is LCS-1.



ANNA I-B

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

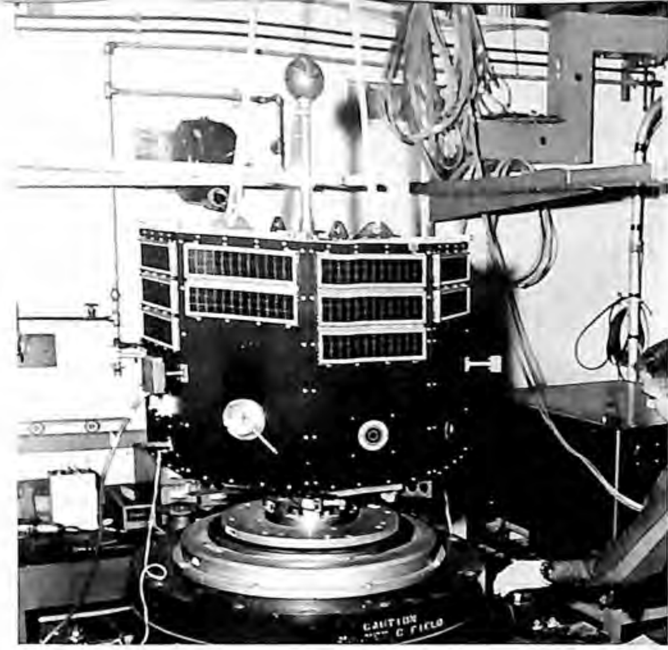
ANNA is a geodetic research satellite with primary missions of measuring the strength and direction of the earth's gravitational field, locating the center of the earth's mass and marking off positions on the earth. ANNA weighs 350 pounds, is 36 inches in diameter and is powered by a band of solar cells, 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 has 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.

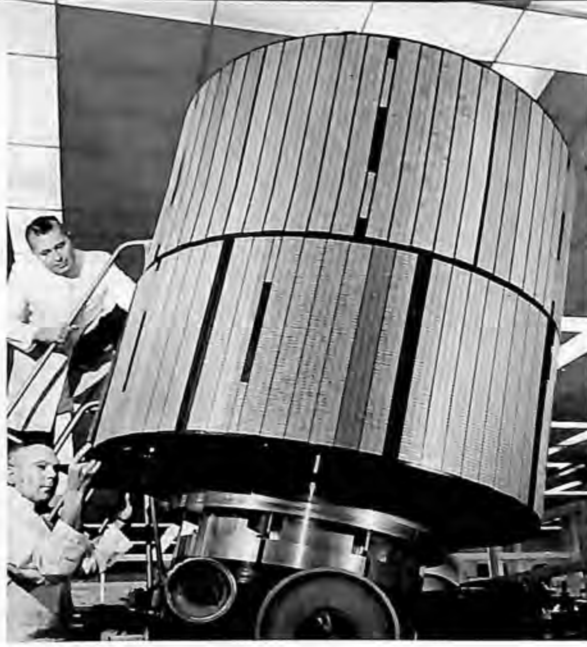
NUCLEAR DETECTION SATELLITES (VELA)

Prime Contractor: TRW Systems Group, 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 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 1969.





EXPLORER SERIES

Program Direction: National Aeronautics and Space Administration

Remarks

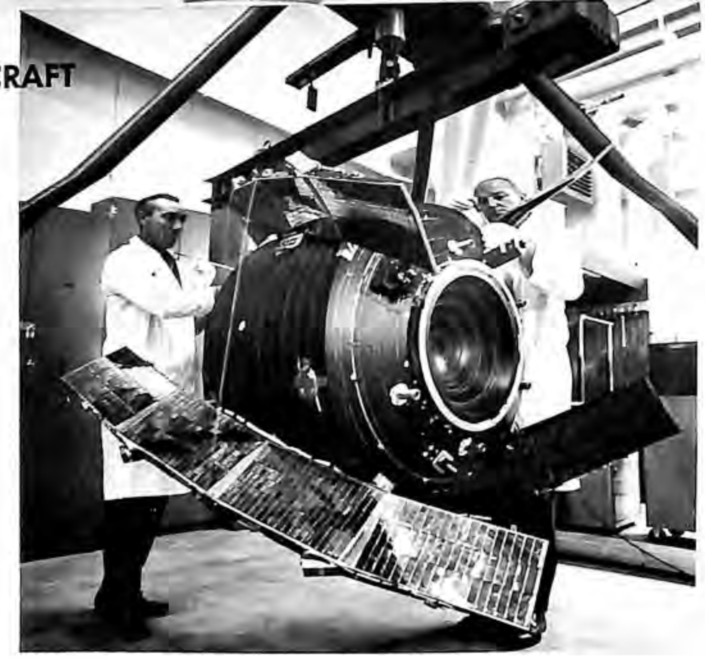
Explorer is not a specific spacecraft but a code name given a series of satellites of different configurations and with varying payloads and assignments. Typical of the series is Explorer XXXI, Direct Measurement Explorer (photo), launched with the Canadian Alouette II on November 28, 1965, on a Thor-Agena 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 went into an orbit with an apogee less than a mile more than Alouette's and with a perigee of less than a mile lower. The orbits were some 1,850 miles high at apogee and 310 at perigee. Explorer XXXI was built for NASA's Goddard Space Flight Center, Greenbelt, Maryland, by the Applied Physics Laboratory of The Johns Hopkins University. Four Explorers were launched in 1968.

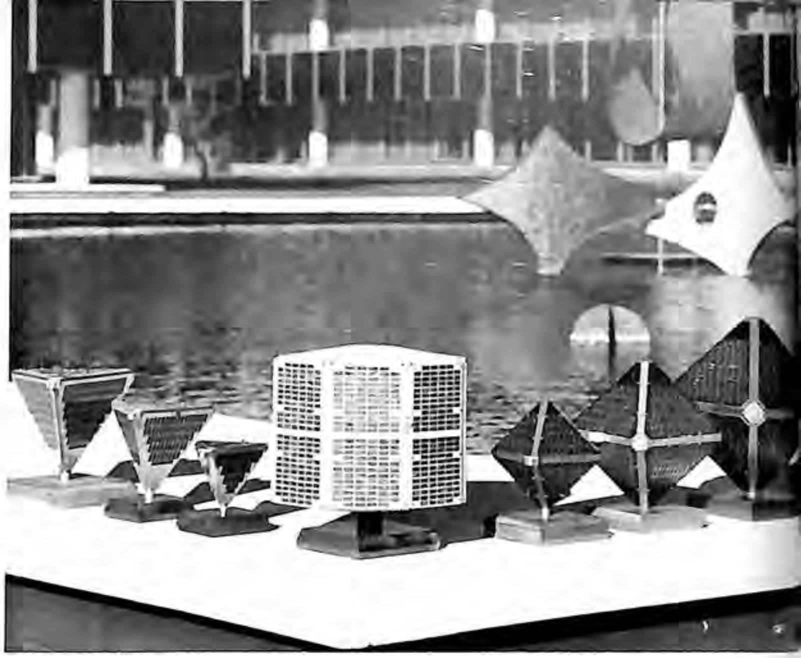
APPLICATIONS TECHNOLOGY SATELLITE

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 tightrope walker's balancing poles to stabilize the spacecraft. The program is managed by NASA's Goddard Space Flight Center. Four of 5 ATS spacecraft in the original contract have been launched; the last was slated for launch in 1969.





RADIO ASTRONOMY EXPLORER

Program Direction: NASA, Goddard Space Flight Center

Remarks

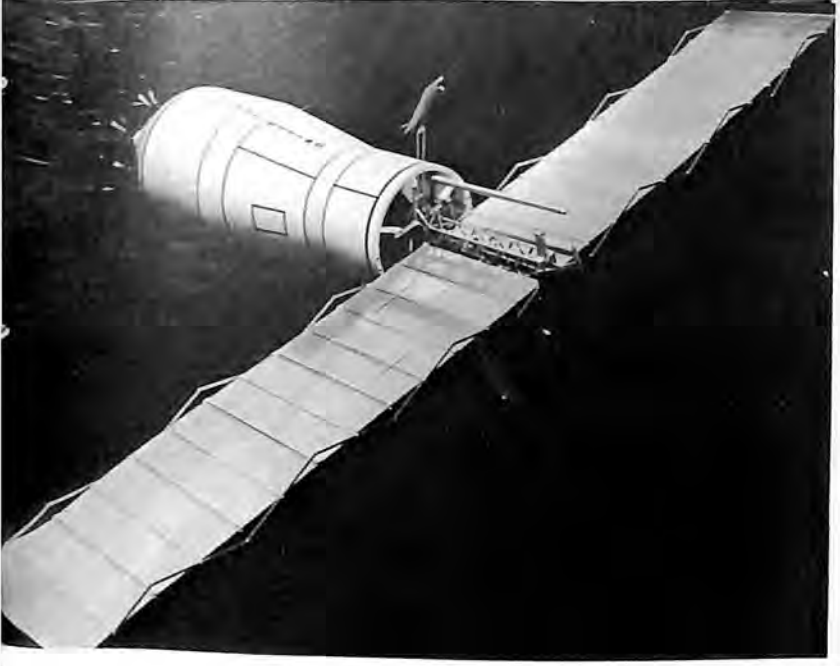
The Radio Astronomy Explorer is investigating low-frequency (long wavelength) radio emissions from the sun and its planets as well as from galactic and extragalactic sources. The spacecraft weighs about 420 pounds. It is equipped with a dipole antenna (120 feet from tip to tip) and 2 V-shaped antennas. These antennas consist of 4 750-foot-long elements which form a large "X," with the spacecraft in the center. The V-shaped antennas are also providing gravity-gradient stabilization. The RAE program, as planned, calls for a series of 4 spacecraft. The first was launched July 4, 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 3⅚ hours.

ENVIRONMENTAL RESEARCH SATELLITES

Prime Contractor: TRW Systems Group, 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, such as the Testing and Training Satellite for the Apollo Manned Program. One unique feature of the satellite is its capability to function without a battery on some missions. The key to this advantage is the design which permits solar cells, fastened to all exterior surfaces of the vehicle, to maintain a nearly constant exposure to the sun within about 15 percent. The ERS includes a small satellite, measuring only 6.5 inches on a side and weighing 1.5 pounds, up to the largest version, a 20-inch cylinder weighing 100 pounds. Some 14 satellites have been launched since 1962 for a variety of missions and sponsors. The 8-sided version has been designated the OV5 and has become 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

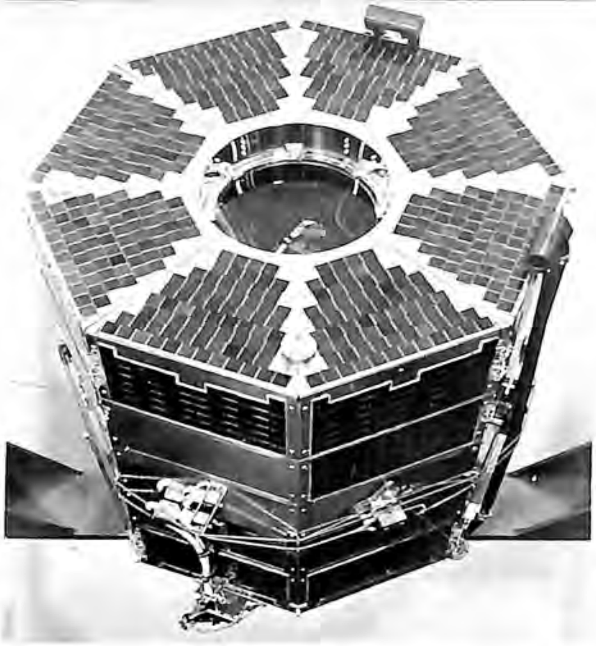
The mission of Pegasus, the Meteoroid Technology Satellite, was to define the magnitude and direction of medium-size meteoroids in the near-earth space environment. Three Pegasus spacecraft were sent into varying orbits, 300 to 500 miles high, transmitting meteoroid detection information on a daily basis 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 1 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, were still operational and returning useful data in 1968, at which time they were turned off.

OV1 (AEROSPACE RESEARCH SATELLITE)

Prime Contractor: Convair Division of General Dynamics Corporation
Associate Contractor: Allegany Ballistics Laboratory (propulsion system)

Remarks

The OV1 is a simple, versatile vehicle now regularly placing scientific experiment packages in near-earth orbits at minimum cost and on a typical 12-month schedule from experiment assignment to orbit. Since 1960 Convair has integrated experimental packages into suborbital and orbital research vehicles.The first of 50 Scientific Passenger Pods were flown in 1961. These purely ballistic vehicles carried experimental packages on suborbital flights lasting as long as 40 minutes. Both recoverable and nonrecoverable pods were flown; several recoverable pods were flown a second time. Today, experiment integration continues to be an important aspect of the OV1 program. OV1 requires no specialized booster; it can be flown on Scout, Thor, Atlas, Titan or Saturn launch vehicles. Atlas, for example, can launch 3 individually programmed OV1s in one flight, resulting in distinct orbits tailored to the demands of the scientific experiments aboard each OV1 satellite. Equipped with its own rocket motor and control subsystem, OV1 orbits up to 220 pounds of scientific experiments in each OV1 satellite. Standard electronic subsystems in the satellite handle all payload power, data storage and telemetry requirements. Other payloads, up to 600 pounds, are also being flown on the OV1 propulsion module.



OV2 SATELLITE

Prime Contractor: Northrop Corporation

Remarks

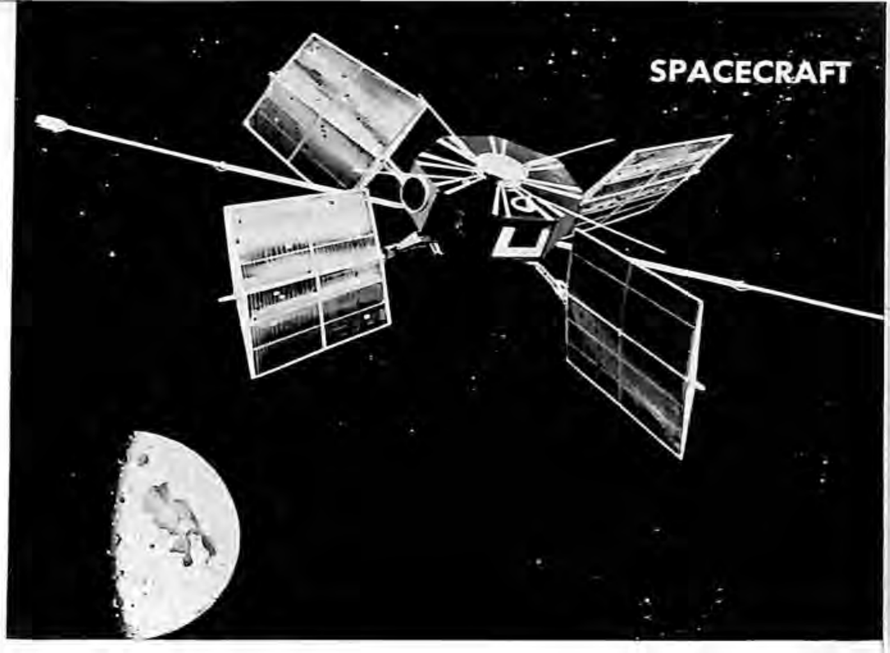
The OV2 is a low-cost, near-earth space research satellite developed and built by Northrop Systems Laboratories for the USAF Office of Aerospace Research. The satellite is a secondary payload for Titan III-C test flights. Three of the satellites, each with diverse applications, were designed by Northrop. The first 2 OV2 satellites failed to orbit because of 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 Division

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; 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 29x29 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

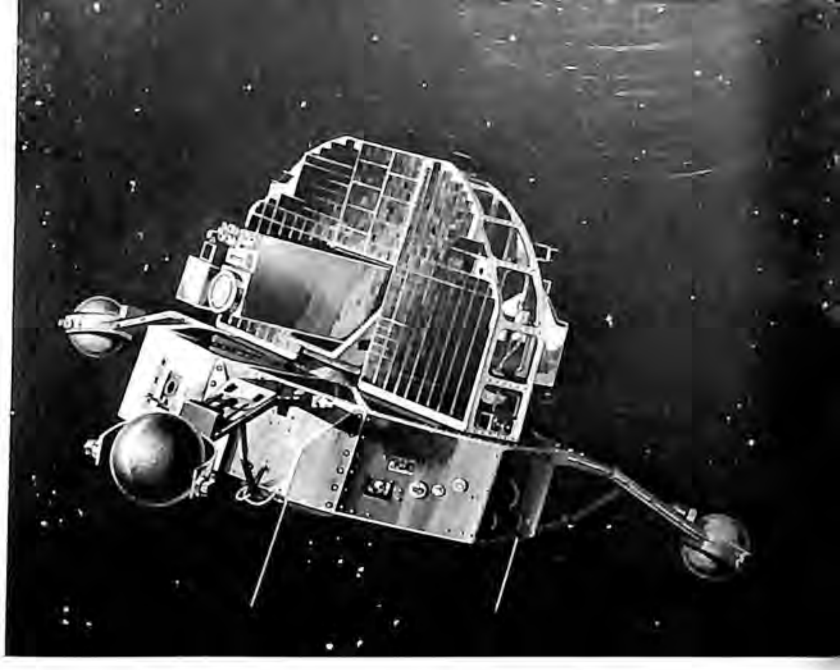
The Navy's 430-pound DODGE satellite, whose primary mission is to explore gravity-gradient stabilization at near-synchronous altitude, was launched successfully from Cape Kennedy July 1, 1967, aboard a Titan III-C rocket. DODGE carries 10 booms that can be radio commanded to extend or retract along 3 different axes. Data from in-orbit experiments are expected to provide fundamental constants to determine satellite attitude with respect to the earth. DODGE also carries a number of commandable magnetic damping devices and 2 television cameras to determine satellite attitude. Less than a month after launch, the satellite was stabilized in space by means of gravity-gradient boom and damping systems. On July 25, 1967, one of the satellite-borne cameras (22-degree field of view vidicon) took the first color pictures of the full earth ever made, from a near-synchronous altitude of 18,700 nautical miles. The color photograph, a composite of 3 pictures made through red, green and blue filters, was transmitted by the satellite to the Applied Physics Laboratory's Howard County, Maryland, communications station. During the first year, several experiments were conducted by means of on-board systems; on the first anniversary of DODGE in orbit, the research satellite continued to be stabilized and was successfully performing its experiments and providing data. Computer techniques are being used to automate data from the satellite and to enhance picture quality, where required.

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 July 19, 1967, with the primary objective of investigating 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 interplanetary dust distribution and solar and galactic cosmic rays, as well as for a study of the magnetohydrodynamic wake of the earth in the interplanetary medium at the lunar distances.



ORBITAL SCANNER

Prime Contractor: Honeywell Inc.
Subcontractors: RCA (communications and data handling); Lockheed Missiles & Space Company (radiometer); Control Data Corporation (attitude determination); Gulton Industries Inc. (on-board power); Spectrolab Division of Textron Electronics Inc. (solar panels); Allied Research-Mellonics (data reduction and analysis)

Remarks

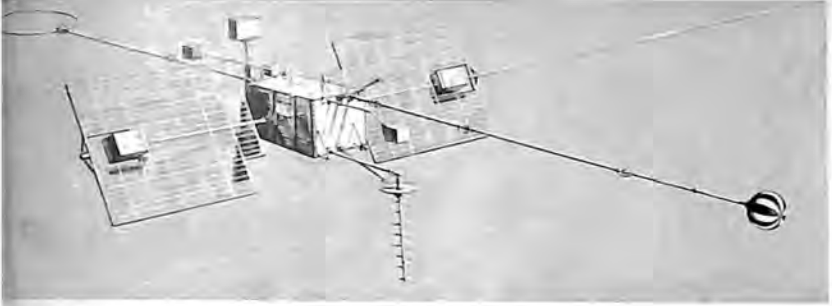
Orbital Scanner is an automated research satellite proposed to map a new artificial horizon on a global basis for use as a more stable reference by future spacecraft guidance, navigation and pointing systems. The present reference point, the earth's limb, may not provide the accuracies necessary to conduct all the precision pointing experiments required in future communications, weather, earth resources observation, reconnaissance and astronomy missions. 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 and over a year's period to assure complete data in all seasonal conditions.

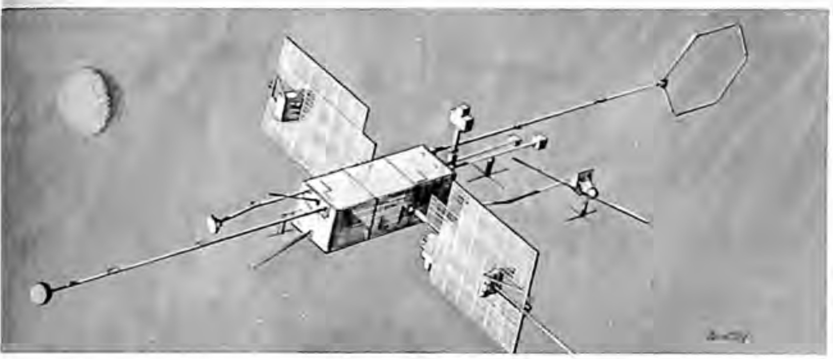
ORBITING SOLAR OBSERVATORIES

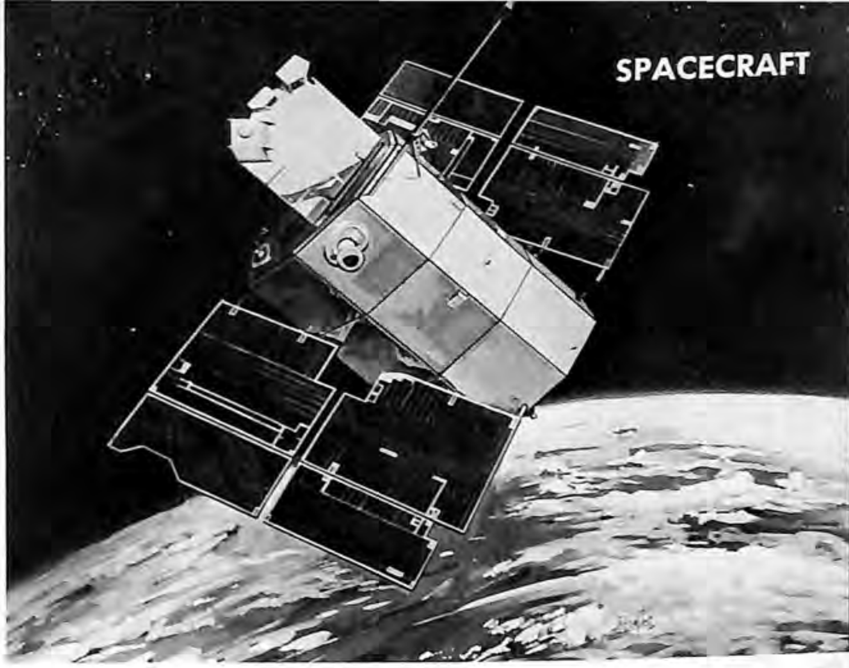
Prime Contractor: Ball Brothers Research Corporation

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 extrasolar sources. The 2-section space observatory is stabilized because the lower section, the "wheel," spins as a gyroscope at a near constant 30 revolutions per minute. The upper fan-shaped section, the "sail," is joined to the wheel by a connecting shaft and remains pointed toward the sun during the OSO daytime. Experiments in the 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. The 4 OSOs launched successfully have exceeded their 6-month design goals. OSO I, launched March 7, 1962, returned data for nearly 18 months; OSO II, launched February 3, 1965, for approximately 9 months. OSO III, March 8, 1967, and OSO IV, October 18, 1967, continue to send back scientific information. The OSO program will continue through the launch of 3 additional spacecraft. In photo, artist's concept of OSO IV in orbit.







ORBITING GEOPHYSICAL OBSERVATORY

Prime Contractor: TRW Systems Group, 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 in order to attain a better understanding of earth/sun relationships and of earth itself; and to design and develop a standard observatory-type spacecraft of a basic system design that can be used repeatedly for various missions. OGO has a main body 6 feet long, 3 feet wide and 3 feet deep weighing 1,200 pounds. It has 2 solar paddles, each 6 feet wide and 7.5 feet long, and 6 booms on which experiments can be 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. Five OGOs have been launched and one more is planned.

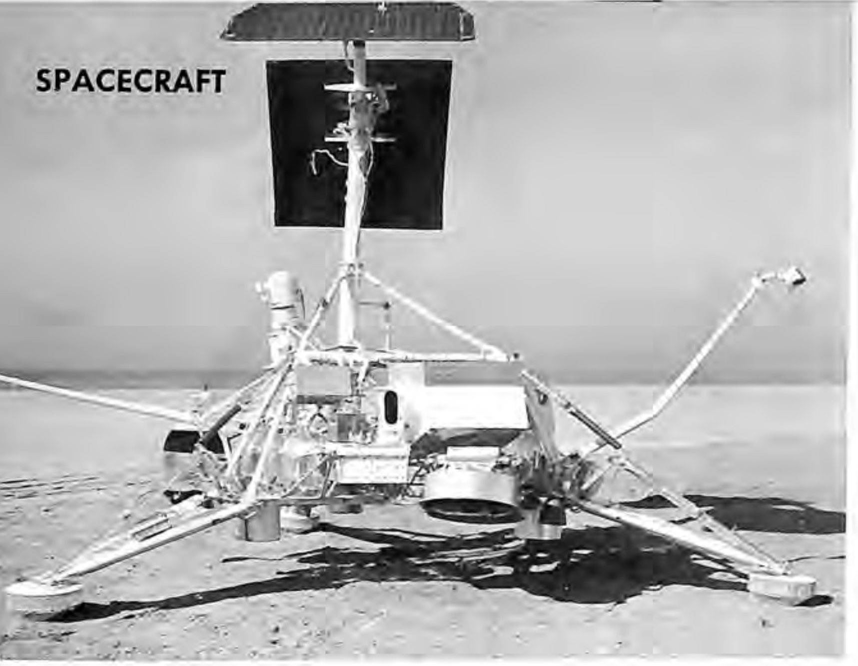
ORBITING ASTRONOMICAL OBSERVATORY

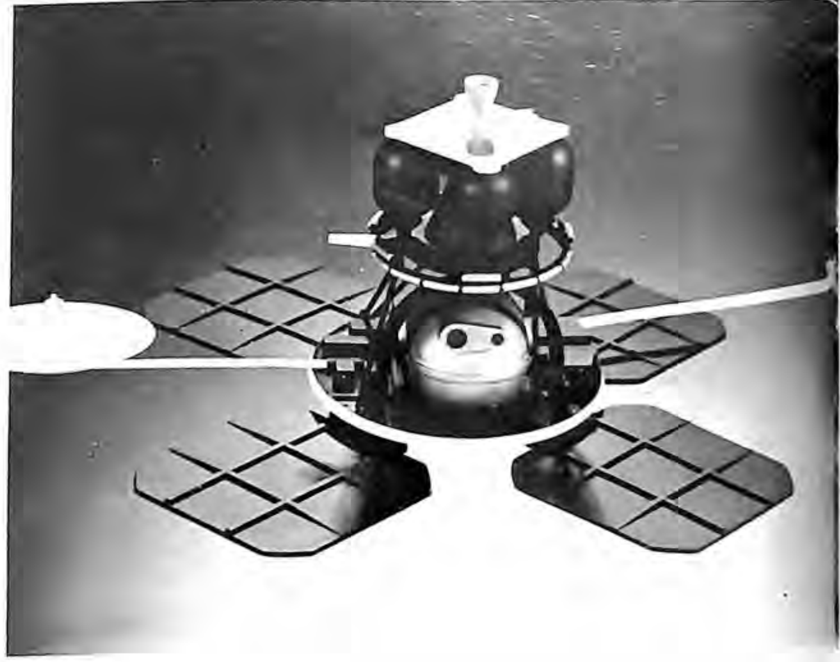
Prime Contractor: Grumman Aircraft Engineering Corporation

Associate Contractors: Westinghouse Electric Company (electronic components); General Electric Company (stabilization and control); Kollsman Instrument Corporation (star trackers); International Business Machines Corporation (data processor); Hughes Aircraft Company and Avco Corporation (communications equipment)

Remarks

NASA's Orbiting Astronomical Observatory is a large (4,500 pounds), earth-orbiting satellite capable of lifting a number of telescopes and astronomical experiments above the earth's atmosphere, which obscures cosmic radiations of interest to astronomers. Solar paddles provide up to 1,800 watts maximum of power. OAO is launched by Atlas-Centaur. The second of 4 OAOs was launched December 7, 1968, and at year-end was operating successfully.





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)

Remarks

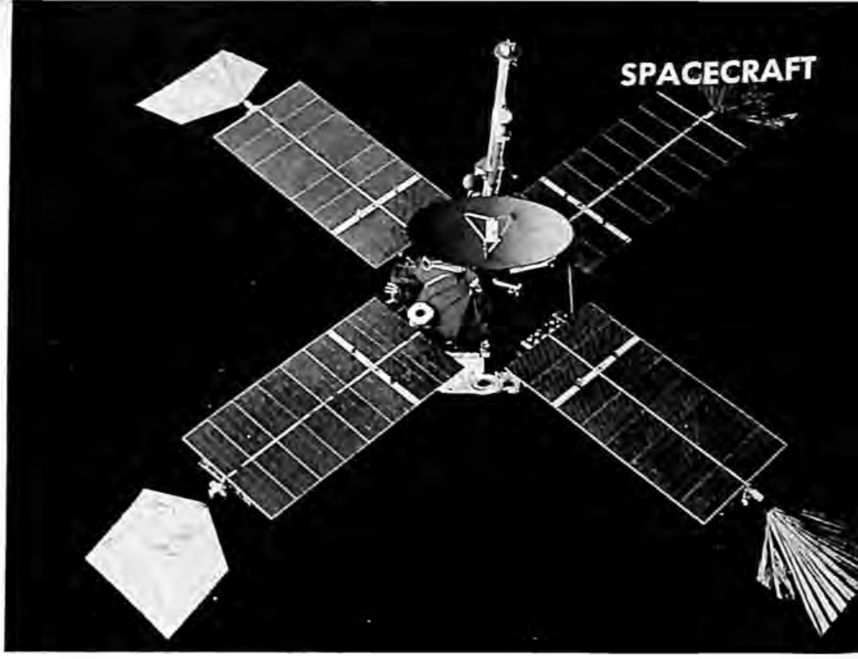
The Surveyor Project, concluded in 1968, was the National Aeronautics and Space Administration's series of unmanned lunar soft-landing spacecraft. Of 7 Surveyor flights conducted between June 1966 and January 1968, 5 were successful. The Surveyor missions certified 4 Apollo landing sites near the moon's equator and transmitted to earth more than 87,000 high-resolution television pictures of the lunar surface showing details as small as $\frac{1}{50}$ inch. All 7 Surveyors were launched by the Atlas-Centaur rocket combination into near-perfect lunar trajectories. At injection the Surveyors weighed about 2,200 pounds; at touchdown on the moon, about 620 pounds. The Surveyors utilized radar-controlled, rocket-powered soft landings. All 5 successful spacecraft—Surveyors I, III, V, VI and VII—carried TV cameras, some equipped with color filters to provide the representative colors of the lunar surface and others with polarizing filters. Mirrors mounted on the spacecraft provided stereoscopic views of the moon's surface. The Surveyors also measured the magnetic content of the surface, analyzed the chemical composition of the surface, dug trenches, broke rocks and performed bearing strength tests. Other pictures taken from the lunar surface included the planets Venus, Mercury and Jupiter, the sun's corona during an eclipse and the phases of the earth and star constellations. Surveyor VI conducted the first controlled movement of a spacecraft across the lunar surface by firing its rocket motors upon command from earth.

LUNAR ORBITER

Prime Contractor: The Boeing Company
Major Subcontractors: Eastman Kodak (photographic system); RCA (electrical power and communications equipment)

Remarks

In less than 1 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. Five candidate Apollo landing sites have been selected from the information provided by Orbiters I, II and III and Surveyor I. The final 2 flights in the program were essentially 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, 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 teamed with Langley Research Center to operate the spacecraft during each mission.



PIONEER

Prime Contractor: TRW Systems Group, TRW Inc.

Remarks

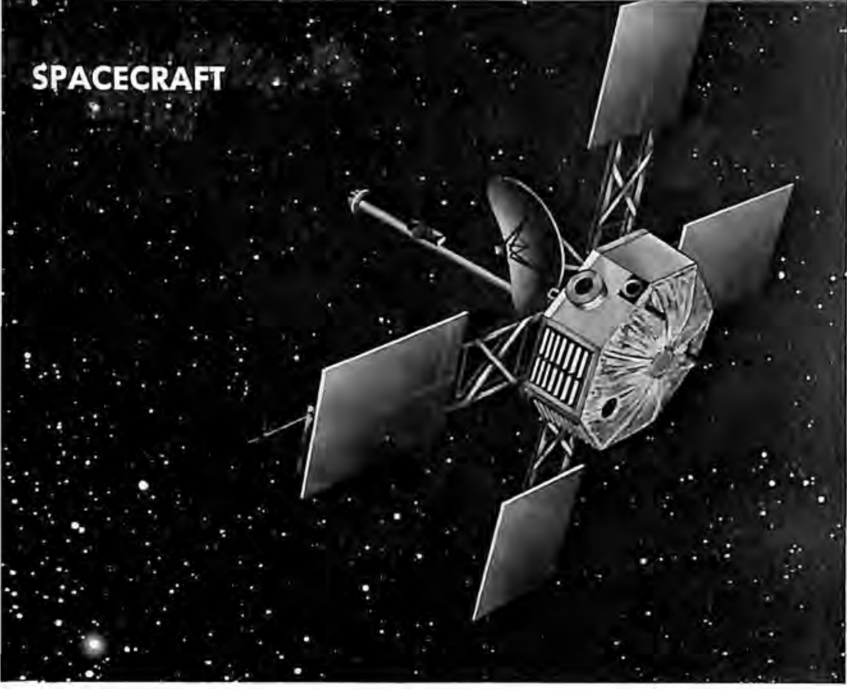
Pioneer is an interplanetary spacecraft designed to operate in solar orbit and send data on interplanetary magnetic fields, radio propagation effects of the sun, plasma spectrometry, ionization levels and solar, high-energy and medium-energy particles. Pioneer is cylindrical, 35 inches long and 37 inches 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 4 sun sensors, orients the spin-stabilized spacecraft normal to the ecliptic plane. More than 10,000 solar cells provide 60 watts of electrical power. Pioneer 6, launched December 16, 1965, went into a solar orbit some 20,000,000 miles closer to the sun than earth. Pioneer 7, launched August 17, 1966, attained an orbit more than 13,000,000 miles farther from the sun than earth. Pioneer 8 was launched December 13, 1967. It provided new insights into the earth's magnetic tail. The spacecraft are performing exceptionally well and returning vast amounts of valuable data on the solar environment. Pioneer 9 was launched successfully November 8, 1968. Two remaining Pioneers were on the launch schedule, one of them in 1969.

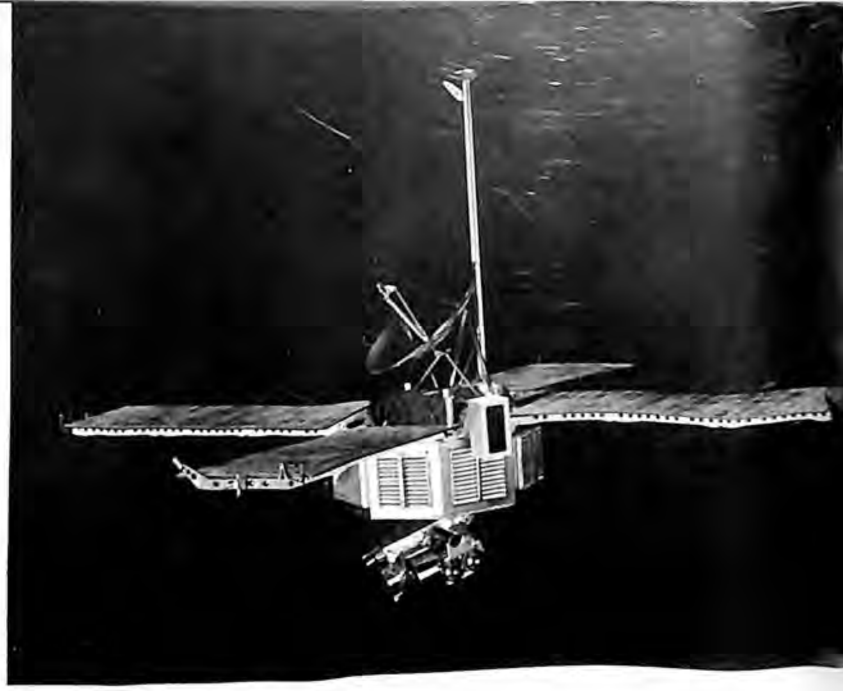
MARINER IV

Prime Contractor: Jet Propulsion Laboratory, California Institute of Technology
Associate Contractors: General Dynamics/Astronautics and Lockheed Missiles & 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 to conduct scientific observations of the planet Mars, to develop equipment and techniques for carrying out planetary explorations, and to make 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 288-day flight. Closeup pictures of the Martian surface were successfully transmitted to earth over a distance of 150,000,000 miles. Two years later, after traveling 1.3 billion miles in solar orbit, Mariner IV again was 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 IV continued to operate until December 20, 1967, when the mission was terminated during the spacecraft's 1,118th day of flight. Mariner's supply of nitrogen gas for attitude control had been depleted on December 7, and, during the final week of its mission, the spacecraft was pelted by hundreds of micrometeoroids.





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 540 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 midcourse propulsion guidance system, a central control and sequencer system, solar panels and battery, an 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 flyby of Venus on October 19, 1967, at an altitude of 2,540 miles. Among science data gathered during the mission was the determination of the surface pressure of the Venusian atmosphere at about 75 to 100 earth atmospheres.

MARINER MARS 1969

Prime Contractor: Jet Propulsion Laboratory, California Institute of Technology
Associate Contractor: General Dynamics/Astronautics (prime contractor to Lewis Research Center for Atlas-Centaur launch vehicle system)

Remarks

The National Aeronautics and Space Administration was to launch 2 900-pound Mariner unmanned spacecraft, F and G, on flyby missions to Mars in 1969, between mid-February and mid-April, the launch period. The spacecraft were to arrive at Mars between the end of July and mid-August. The first spacecraft was to be launched as early in the period as possible, the second as late as possible. The arrival dates will not be less than 5 days apart. All scientific experiments aboard the Mariner '69 are planet-oriented with particular emphasis on providing data on the atmosphere and surface of Mars. The experiments aboard Mariner '69 will measure the infrared spectral energy from the lower atmosphere, measure thermally emitted energy from the surface of Mars, detect the presence and scale height of atmosphere constituents, photograph the Mars disc and surface, determine atmospheric surface pressure and density, and refine accuracy of the earth and Mars orbits, Mars mass, earth-moon mass ratio and the astronomical unit. The 2 spacecraft were to fly by Mars at a closest approach distance of approximately 2,000 miles. The 2 camera systems, wide angle and narrow angle, aboard each spacecraft will provide narrow-angle photographs of the disc of Mars as it revolves in front of the spacecraft during approach, and both wide- and narrow-angle pictures of the planet's surface during the near-encounter flyby. Best resolution of the full disc pictures will be about 15 miles.

SV-5D PRIME (PRECISION RECOVERY INCLUDING MANEUVERING ENTRY)

Prime Contractor: Martin Marietta Corporation, Baltimore Division

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 mounted in a special honeycomb base. Two movable flaps on the underside of the tail provided control in pitch and roll axes during atmospheric flight, and reaction jets were 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 Division

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. It will then 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 and 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 reenty spacecraft. Flight testing was scheduled to begin in 1969.

HL-10 LIFTING BODY VEHICLE

Prime Contractor: Northrop Corporation

Remarks

The HL-10 was designed and manufactured by Northrop's Norair Division under contract to NASA and was configured at the Langley Research Center, Hampton, Virginia. It is an experimental wingless lifting body designed for high-altitude flights within the earth's atmosphere. The HL-10 varies primarily from the first Northrop-built M2-F2 lifting body vehicle in that it is flat on the bottom and has 3 vertical fins, whereas the M2-F2 vehicle is flat on the top and has 2 vertical fins. The modified half-cone shape of the HL-10 lifting body provides a useful volume-to-surface area and achieves aerodynamic stability and lift from the body alone, eliminating the need for wings. The HL-10 was first flown successfully in late 1966; it was later equipped with a rocket engine for powered flights, which started late in 1968.

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 from 45,000-foot altitude 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 designed and manufactured 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 Ames Research Center in California. The basic lifting body is a half-cone altered by blunting the nose and adding tail fins. The M2-F2 was first dropped successfully from a special pylon attachment on the wing of a B-52 bomber flying at 45,000 feet, and was piloted to a conventional airplane-type landing at Edwards, California, on July 12, 1966. Fifteen successful flights were made before a landing accident caused the craft to be repaired and largely rebuilt. It was scheduled to be returned to service in 1969.

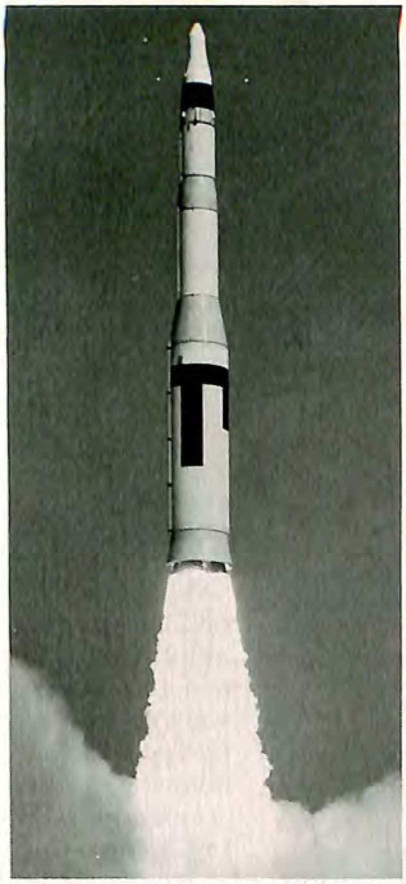
Specifications

Length 22 feet 2 inches; width 9 feet 7 inches; height 8 feet 10 inches; minimum weight 4,600 pounds; maximum weight 8,000 pounds; controls 1 pair thick rudders, 1 pair flaps on upper surface of boat-tail, 1 full-span pitch flap on lower surface of boat-tail. Upper flaps aid in pitch control and are interconnected with rudders for roll control.

Performance

Average flight time approximately 4 minutes from 45,000 feet; first flight touchdown speed approximately 195 miles per hour.

737, world's newest short-haul jet



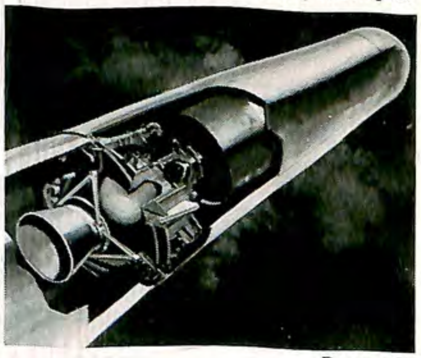
U.S. Air Force Minuteman ICBM

727-200 trijet airliner

NASA's Boeing-built Lunar Orbiter

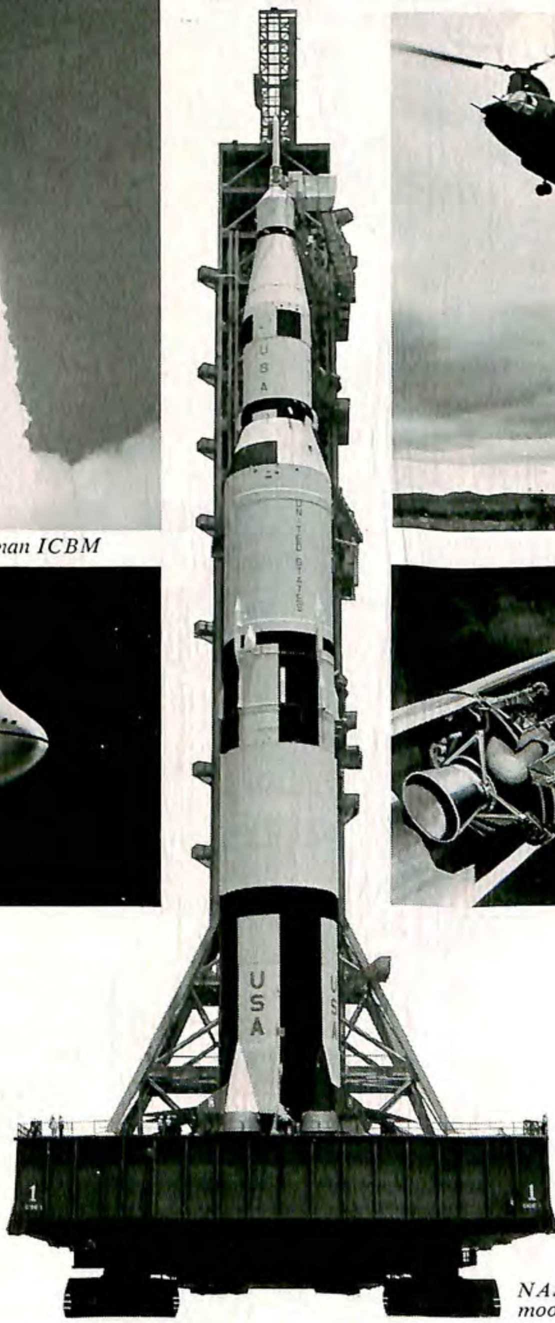
Boeing helicopter

747, world's largest commercial jet



Burner II

Capability has many faces at Boeing.



NASA's Apollo/Saturn V moon rocket

Boeing 737, the world's most advanced short-range jetliner, is 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 far 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 360 to 490 passengers, and usher in new era of spaciousness and comfort in jet travel. Deliveries begin this year.

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.

727-200, long-body version of standard 727, world's most popular jet, seats up to 178 for maximum profit on high-density routes.

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, launched first Americans on voyage to moon and return. 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.

BOEING

We are many things to many people.

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LOW INLET HYDRAULIC PUMP

Prime Contractor: Aerospace Division, Abex Corporation

Remarks

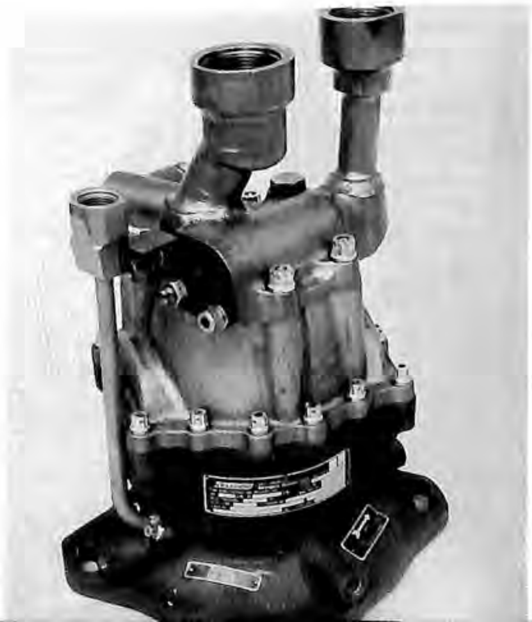
With the current interest in low inlet pump capability (2.5 to 5 PSIA), Abex Aerospace has brought about a number of design innovations aimed at lowering the minimum safe inlet operating pressure. When inlet pressure is less than that required to fill the piston bores completely, some axial piston pumps require a boost pump to induce fluid into the bores to insure complete filling and thereby maintain full flow and pressure. A boost pump, even as an element of the main pump, has several disadvantages, among them increased complexity, weight and size. In addition, the boost element is deadheaded at zero flow and total heat rejection is increased. Most important, the boost pump answer to low inlet requirement represents a large series-risk element in the overall reliability of the pump design. Recognizing these disadvantages, Abex Aerospace has concentrated on research aimed at optimizing its flow valving and porting so that rated flow is maintained at inlet pressures as low as 5 PSIA, and more than 50 percent flow is achieved by extending the intake stroke duration to allow time for complete filling. The simplicity and logic of the low inlet design can be applied to any new pump requirement at a great reduction in weight. For example, in a 2.5-3-cubic-inch-per-revolution size, the weight saving is over 6 pounds. In addition, the reliability advantages of this design over boost pump concepts cannot be overstated.

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 to generate electrical power for the spacecraft. In photo, technicians examine one-quarter-scale model.



URIPS (UNDERSEA RADIOISOTOPE POWER SUPPLY)

Prime Contractor: Aerojet-General Corporation, San Ramon Facility

Remarks

URIPS is a radioisotope-powered electrical generator designed by Aerojet for long-duration undersea power applications. It will supply 1-watt power (3 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 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. An operational low-thrust (50 micropounds) engine was launched on board the ATS-D spacecraft August 1968. The 2 Resistojets performed successfully in nearly continuous operation for the orbital life of the spacecraft. The Resistojet on the ATS-C was used to change the spin-rate of the satellite in orbit. Micropound thrust measurements for the engine in space compared well with preflight ground thrust calibrations. The propellant used in these systems was ammonia. The propellant specific impulse was increased by over 50 percent by the engine's Resistojets operating with about 5 watts of electric power. A second operational Resistojet system will be utilized on the ATS-E to maintain this gravity-gradient stabilized spacecraft on station. The thrust level of this station-keeping system will be 50 micropounds and will be fueled with 3 pounds of liquid ammonia for 3 years' operation. A Resistojet system developed for NASA's Lewis Research Center, capable of 3-axis attitude control and multidirectional station keeping, has a 60-pound ammonia storage capability.

COLD GAS AMMONIA CONTROL SYSTEM

Prime Contractor: Avco Corporation, Space Systems Division

Remarks

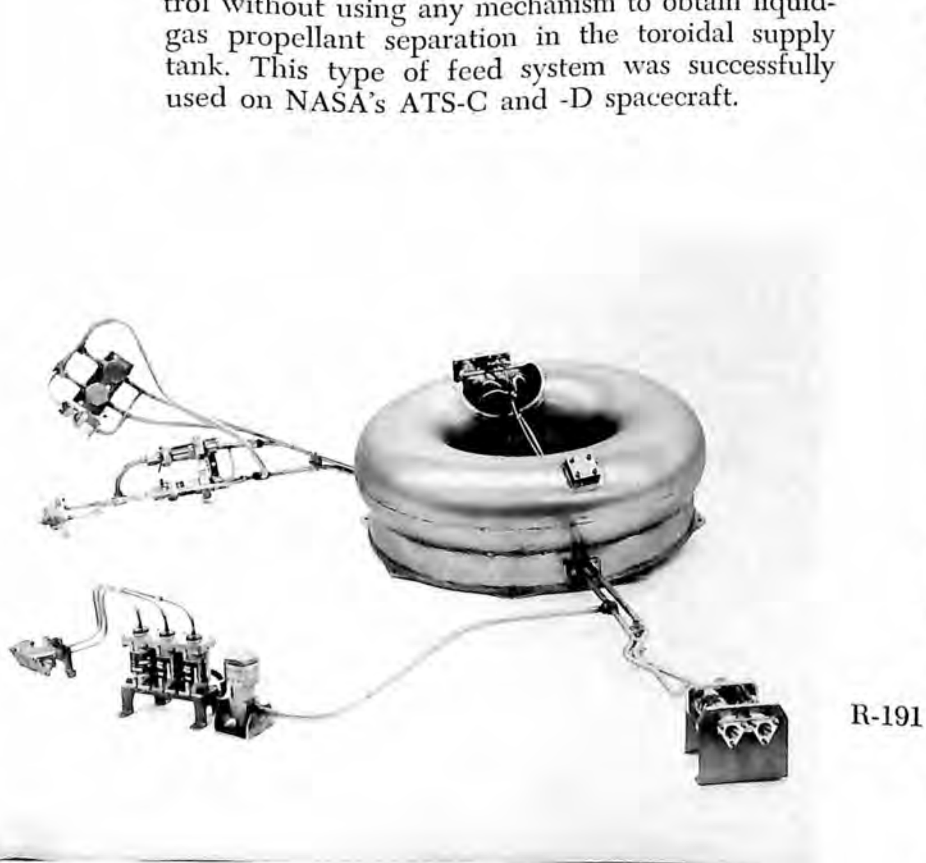
An operational cold gas (specific impulse of 95 seconds) ammonia control system was developed for the M.I.T. Lincoln Laboratory for use on the LES-6 Air Force spacecraft launched in 1968. The system was designed to provide spacecraft spin-up, spin control, attitude control and station keeping. Thrust levels were 5 to 40 millipounds. Use of the low-pressure (125 pounds per square inch) liquid-ammonia propellant offered significant system weight savings over the standard-type cold gas nitrogen systems. A principal system feature was the zero-g propellant feed and control system which provided plus/minus 10 percent thrust pressure control without using any mechanism to obtain liquid-gas propellant separation in the toroidal supply tank. This type of feed system was successfully used on NASA's ATS-C and -D spacecraft.

AIR CUSHION LANDING GEAR

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The Air Cushion Landing Gear (ACLG) is a system designed to replace conventional aircraft landing gear with an annular jet air cushion. First flown on a modified LA-4 Lake amphibian August 4, 1967, it embodies a pneumatic bag mounted beneath the fuselage. A continuous air feed from an on-board power source maintains bag inflation while producing a distributed jet flow at its base. The escaping jets create cushion pressure in the cavity contained by the bag beneath the aircraft whenever it is close to the take-off or landing surface. Air clearance beneath the bag is minimal, but considerable surface irregularities are tolerable because of the resilience of the flexible material itself. The bag is retractable and the total system weight is less than high flotation wheel gear. The ACLG provides improved tolerance to the take-off and landing maneuver and environment with no compromise of performance while enabling aircraft to land on or take off from a surface of any softness including water. Footprint pressure is in the region of 1 to 2 psi. Other significant features are crosswind capability, kneeling, distributed support, high energy absorption and damping and cushion braking.



JET FLYING BELT

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

A jet-powered version of Bell's famed Rocket Belt, the Jet Flying Belt began its preliminary flight test program at the company's main plant near Niagara Falls, New York, in August 1968. The program included an extensive series of man-rating and preliminary endurance, speed and range tests conducted in tethered and free flight modes. Sponsored by the Defense Department's Advanced Research Projects Agency (ARPA) under a U.S. Army Aviation Materiel Command (AVCOM) contract, development of the Jet Belt began in January 1966. The system is powered by a high bypass turbojet engine mounted vertically on a fiberglass corset which, when strapped to the operator's back, distributes the weight comfortably on his hips. Thrust from the engine is channeled equally through 2 nozzles which are pointed downward behind the operator's back. The operator has complete freedom of flight, including forward, backward, sideward, rotating and hovering maneuvers. Believed to be the world's smallest fanjet engine, the Jet Flying Belt's power plant features a high thrust-to-weight ratio and low specific fuel consumption, prime reasons that the Jet Belt's range and endurance are substantially greater than its rocket-powered predecessor. The Jet Belt's range and endurance are being measured in minutes and miles.

Specifications

Power plant 1 Williams Research Corporation WR-19 bypass turbojet approximately 2 feet in length and 1 foot in diameter; fuel JP4; control motorcycle-type hand grips giving varying degrees of thrust and deflection to the thrust nozzles; ignition solid-propellant cartridge.

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 or remotely controlled from a parent vehicle. 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.

GRAVITY METER 2 (BGM-2)

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

Bell's motion-stabilized gravity measuring system is designed for precision gravity measurements in a high motion environment on the sea or in the air. A primary application of the system is the rapid acquisition of gravity data for locating high-probability sites for offshore oil wells. The lightweight system was developed to military specifications. It consists of a gravity sensor mounted on a 2-axis gyro-stabilized platform, associated electronics and data-handling and recording equipment tailored to meet the requirements of each application. The heart of the gravity sensor is the Bell Model VIIB inertial accelerometer. Bell's earlier BGM-1 has been delivered to the Gravity Division of the U.S. Naval Oceanographic Office, which has demonstrated the high precision capabilities of the system in a variety of sea states. Operational suitability for airborne use of Bell's gravity systems has been demonstrated during flight tests conducted in a Navy P-3A aircraft.

Specifications

Range 966 to 994 gallons; accuracy .1 mgl (static), 1 mgl (operational); weight 445 pounds; acceleration environment vertical and horizontal, 100,000 mgl for periods up to 15 seconds.

SIMPLIFIED AIRCRAFT INSTRUMENT LANDING SYSTEM (SAILS)

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

Bell's Simplified Aircraft Instrument Landing System (SAILS) utilizes an airborne monopulse tracker in conjunction with a ground beacon to provide aircraft guidance information for use by the pilot under all weather conditions. This permits low-altitude approaches for landing in remote areas or guidance to Computed Air Release Point (CARP), including determination of release point for cargo and/or troop drops. The airborne subsystem determines range, elevation angle and azimuth angle, from which computations are performed to provide glide slope and azimuth information for aircraft instrumentation display. Range-to-go and a range-zero indicator also are presented to the pilot and navigator. Test demonstrations of the system have been performed at Bell's main plant near Niagara Falls, New York, Wright-Patterson Air Force Base and Pope Air Force Base.

Specifications

Beacon weight 15 pounds, including batteries; total airborne weight 30 pounds; frequency X-band.

Performance

Glide slopes of zero to 12 degrees are selectable by pilot as are approach courses of zero to 360 degrees; acquisition range in excess of 20 miles; beacon offset from CARP or selected touchdown point of zero to 2,000 feet in elevation, of plus-or-minus 12,000 feet fore and aft and plus-or-minus 12,000 feet right or left; 2-week standby capability on beacon.

STABILIZED PLATFORM SYSTEM FOR SATURN VEHICLES

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

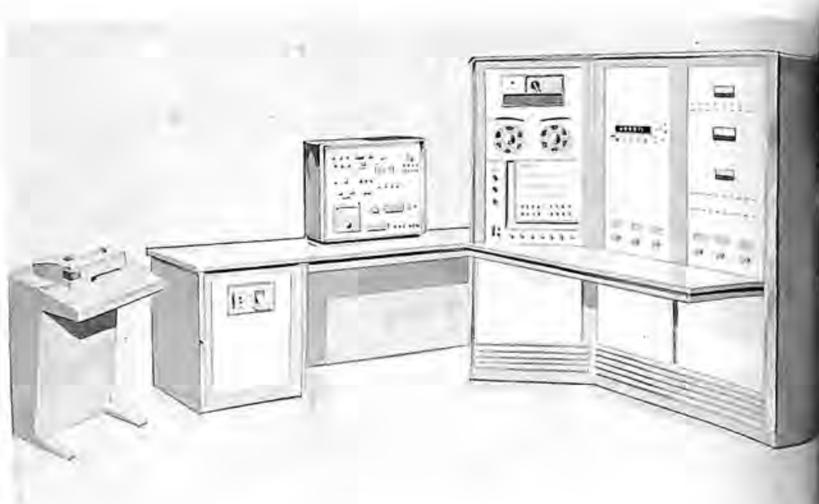
The Saturn rocket's ST-124 stable platform provides guidance and second-stage cutoff information, and velocity and attitude control signals. The platform operates in conjunction with 2 other major subsystems—a general-purpose digital guidance computer and an analog control computer with associated sensors and actuators—to form the complete Saturn guidance and control system. An on-board data adapter handles interface requirements. The system uses either 3-gimbal or 4-gimbal platforms, depending upon the particular Saturn mission. Mounted to the stable inner element, or inertial gimbal, are 3 single-degree-of-freedom gyros, 3 pendulous-gyro-accelerometers and 2 preflight leveling pendulums. Gyros and accelerometers are gas floated. The gyro wheel is supported in the beryllium cylinder, which, in turn, is supported by the hydrostatic gas-bearing, with both radial and axial centering. All platform structural members and most of its components are made of beryllium, thereby affording considerable weight saving as well as greatly improved stability over a wide range of temperatures. The system has performed successfully on Saturn I, IB and V launches.

MODEL 200 SERIES AUTOMATIC AVIONIC TEST STATION

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

The Bendix Model 200 series automatic avionic test stations have been designed specifically to meet the testing requirements of commercial airlines' avionic shops and of electronic equipment manufacturers' production lines. Model 200 test stations are being used for 707, 727 and DC-9 avionic systems testing. The range of the units' stimuli and measurement devices insures capability to test all the present-generation avionics systems. The test stations are modular in construction, and component devices have been selected so that possible additional testing requirements for the 747, 1011 and SST avionic systems can be satisfied with a minimum amount of additional hardware. The test stations are of 3 types: analog, pneumatic and RF. Each of them may be built as a free-standing test station with its own control section or as any combination of the 3 with each type sharing a single control section. Primary component of the control section is a third-generation digital computer with a resident compiler that enables the operator to test units without programming object coded test tapes. Test tapes are written only in a high order language such as the standard airline language, ATLAS (Abbreviated Test Language for Avionics Systems). By using the resident compiler with the station's teletypewriter, the test station may be operated in a semiautomatic mode. In this mode the operator can conduct or modify tests by communicating with the test station in an abbreviated English test language, such as ATLAS, via the teletypewriter keyboard. Provision is also made on the control panel for a manual mode of operation. In this mode the computer is bypassed, and the technician is able to manually select stimuli and measurement devices and connect them to the unit under test.



13A5410 ELECTRONICS SYSTEM TEST SET

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

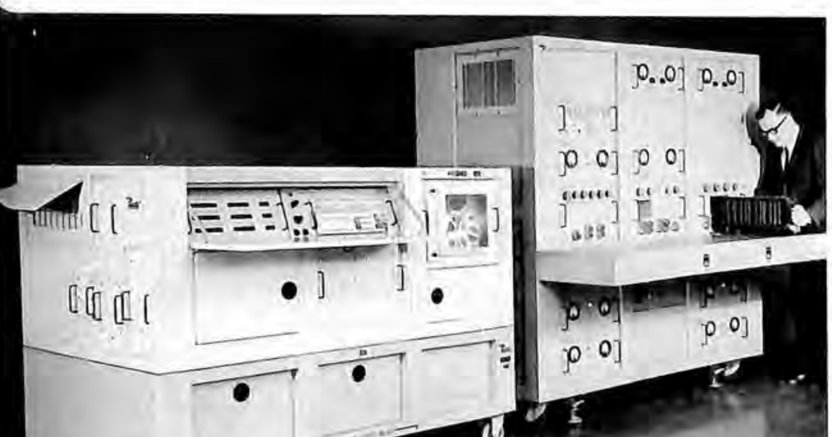
The 13A5410 Electronics System Test Set (on right in photo) is used in conjunction with the AN/GSM-133 Check-out Sequence Programming Set (left) to provide a completely automatic tape controlled test facility to check out the all-weather landing system in the Lockheed C-141 StarLifter. The same test facility will also provide Military Airlift Command field shops support for the automatic flight control system in the Lockheed C-5A Galaxy aircraft. This general-purpose analog test station is housed in a 3-bay cabinet and contains all of the loads, stimuli, switching, and AC and DC power supplies necessary to test the 12 line replaceable units (LRUs) which make up the all-weather landing system. A shelf running across the entire width of the cabinet provides a working area and a holding platform for the LRU under test. This shelf is at the right height to enable the LRUs to be plugged directly into the connections of the 3 LRU drawers that interface between LRUs and the 13A5410 Test Set main frame. The 3 LRU drawers contain stimuli relays, fixed loads, low-level test points, digital data transfer logic and all necessary wiring required to adapt the LRU under test to the test complex. Changes which may be required in the test program can be accomplished in the LRU drawer and/or on the test tape. In the case of the C-5A requirements, all of the special loads, stimuli, relays, etc., necessary for check-out of the C-5A automatic flight control system are contained in a Honeywell adapter. This adapter will interface all of the C-5A automatic flight control LRUs to the 13A5410 Test Set main frame.

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 Contractors: The Bendix Corporation, Navigation & Control Division; The Boeing Company, Commercial Airplane Division

Remarks

The Precision Approach and Landing System, which in 1965 won Federal Aviation Administration approval to permit large commercial jet aircraft to make fully automatic landings, and later, approval for use in Category II conditions, makes extensive use of transistorized equipment and microelectronics. A complete system for automatic landings comprises an improved autopilot coupler (which locks the aircraft's autopilot to the instrument landing system beam at the airport) and amplifier computer, 2 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 pitch control of the airplane. Upon receiving the appropriate signals from the altimeters, it puts the airplane in the landing attitude and reduces its rate of descent to 2 feet per second for the touchdown. The yaw damper and automatic throttle system, tied in to the autopilot, provide precise lateral and airspeed control. Operation of all components is monitored constantly during final approach, 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 Administration at its research center in Atlantic City, New Jersey. Microwave radio signals—beamed to the plane from both sides of the landing strip—put an electronic image, or "picture," of the runway on a semitransparent screen in the cockpit. The pilot "sees" the runway through his normal line of vision from a distance of about 10 miles with the plane at an altitude of some 5,000 feet. At a distance of about 7 miles from touchdown, the runway, appearing as a pattern of separate beacons resembling runway lights, comes into focus on the screen and becomes increasingly defined as the distance decreases. The system comprises a series of ground-based microwave beacon-transmitters, airborne direction-finding equipment and the head-up display. The beacons, along each side of the runway, form a pattern similar to runway lights. Each beacon transmits 1-microsecond pulses approximately 120 times per second to small, fixed, wide-angle microwave antennas installed in the aircraft nose. The airborne direction-finding receiver determines the immediate angular position of all the beacons with respect to the longitudinal and lateral axes of the aircraft, and simultaneously presents these positions on the aircraft's head-up display. The display consists of a cathode ray tube, which presents the processed beacon pulses as coordinated images; an optical system, which collimates the images at infinity; and a combining mirror, which is positioned in the pilot's line of sight.

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

ADC-600 AIR DATA COMPUTER FOR F-111

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

The ADC-600 Air Data Computer for the supersonic F-111 immediately and precisely converts information on the physical properties of the air through which the plane is flying into data for operation of such subsystems as autopilots, flight instruments and navigation systems. The highly refined, analog, central air data computer exhibits controlled dynamic response, high accuracy and static probe error compensation capability in providing the F-111 aircraft systems with a wide range of information. The basic computing mechanism and repeater modules provide shaft rotations for 88 electromechanical devices such as conductive plastic potentiometers, synchros, encoders and switches. Shaft outputs include altitude, Mach number, true airspeed, total pressure, dynamic pressure, indicated airspeed, true temperature, pressure altitude and angle of attack, all corrected for probe errors. Of 88 output provisions, 66 are implemented and 22 are reserved for growth potential. The unique design philosophy applied to the ADC-600 makes the sensors and the 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 and easily maintained, and it incorporates monitoring and self-test capabilities. It achieves good balance between the weight and size economy of single packaging, on the one hand, and the design flexibility of modular construction and separate packaging, on the other hand.

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 and to jet and turboprop transports in commercial and military operations. PB-60 engineering and design permit the installation of identical components in different aircraft through adjustment provisions for system gains and function grouping of electronic units and modules. Convenient front connectors facilitate troubleshooting, 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 PB-60 system.

ADC-1000 DIGITAL AIR DATA COMPUTER

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

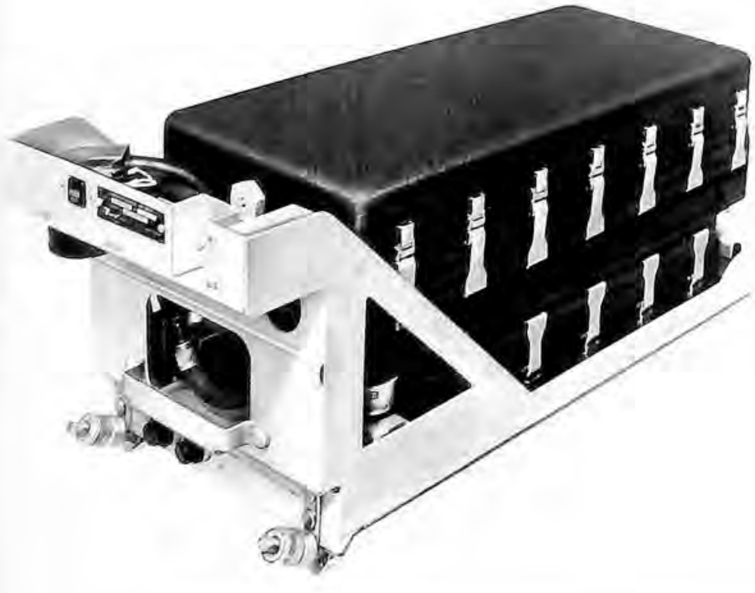
The ADC-1000 is a highly refined, analog, central air data computer with controlled dynamic response, high accuracy, static probe error compensation capability and adequate outputs to supply all aircraft system requirements for air data information. The computer is applicable to supersonic aircraft requiring digital or digital plus analog output signals for subsystem use. This unit is available as a single-package computer for digital outputs and as a dual-package computer for hybrid installations. The computer receives pressure probe inputs of static pressure and total pressure, a total temperature probe input and an angle-of-attack input from a synchro transmitter. The digital computational section is a special-purpose microelectronic digital computer designed for high-speed calculation of air data parameters. The programming and memory sections are readily changed to provide growth and to allow flexibility when flight-test-derived parameters dictate function modification. The digital computer is programmed to include a self-test program in addition to the normal computational program.

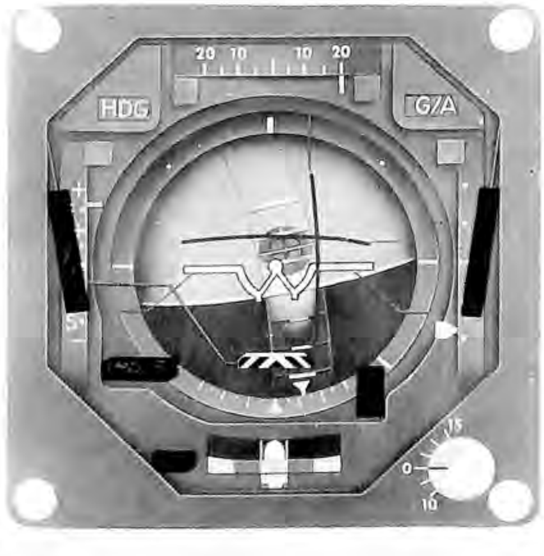
ATTITUDE DIRECTOR INDICATOR FOR C-5A

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

A new Attitude Director Indicator (ADI) with dual display capability has been designed for commercial and military aircraft. The ADI's initial application is on the USAF/Lockheed C-5A heavy logistics transport. The indicator provides a pilot with either a precise bull's-eye display in 3-dimensional form of an instrument landing system (ILS) approach gate or, alternatively, a conventional type of display during cruise mode. An integral component of a flight director system, the ADI utilizes the commands from a flight steering computer for control of the aircraft to a selected flight path for cross-country navigation or landing approach.





HEAD-UP DISPLAY SYSTEM

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

The Head-Up Display System (Specto System) takes essential flight information out of the cockpit and puts it on a transparent viewer right in front of the pilot in line with his vision through the windshield. The system thereby eliminates head motion and hurried eye refocusing from the instrument panel to the real world and reduces fatigue by allowing the pilot to view outside objects while reading essential flight data. The heart of the system is a cathode ray tube similar to a television set tube. It projects symbols representing flight and engine characteristics on a transparent display screen 2 feet in front of the pilot's eyes. The pilot pushes a button and gets all the data he needs to perform a particular function, such as landing, en route flying or tactical maneuvering. The system operates in wide application from executive, helicopter and fighter aircraft to large military and commercial supersonic transports. The Head-Up Display System consists of 4 units: 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. The basic system is comprised of a cockpit-mounted controller and a remotely located programmer; 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. Another system is being produced for the Army's AH-56A Cheyenne armed helicopter. This system was designed basically to enable the pilot or copilot/gunner to program the release of stores from 6 weapons stations and the release of rockets from 4 weapons stations. It has built-in test equipment and uses microelectronics circuitry.

AN/GSM-133 PROGRAMMER COMPARATOR

Prime Contractor: The Bendix Corporation, Navigation & Control Division

Remarks

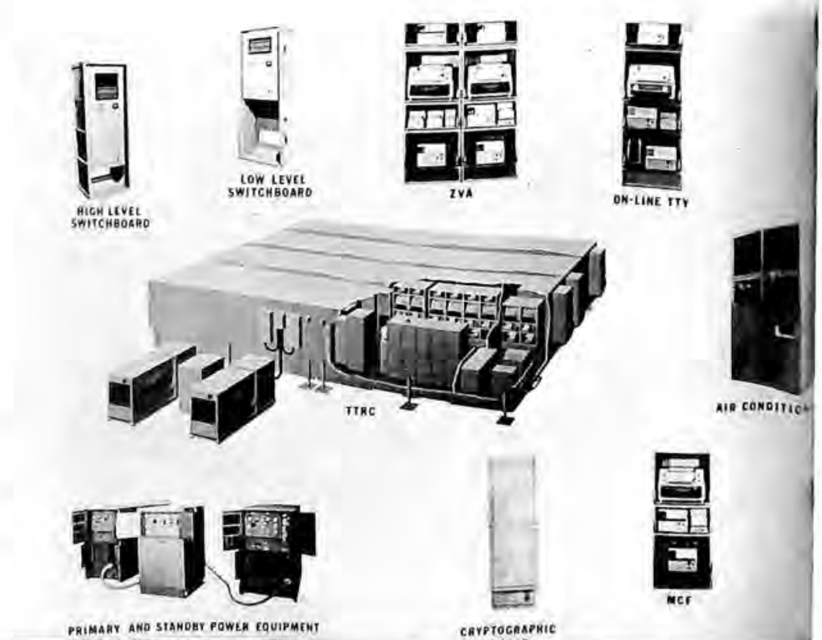
The AN/GSM-133 is an automatic, versatile, programmable testing system that will, for the first time, provide consistent automatic checking of avionic systems for aircraft, missiles and space vehicles at all levels from factory and depot to flight line and on-site maintenance. This second-generation programmer-comparator incorporates micrologic techniques that reduce its size by 30 percent and its weight by 50 percent over current models. It can be transported either by air or over land. The system performs serial-type evaluations on both analog and digital signals, utilizing integrated (micrologic) elements for all logic functions. It evaluates voltage levels and measures time, events, frequencies and resistances to high orders of accuracy; it is compatible with testing requirements anticipated through 1975. The wide interfacing capability of the set permits the direct coupling of alternate programming sources, manual controls, displays, recorders and measurement devices, 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/TGC-36 COMMUNICATIONS CENTRAL

Prime Contractor: The Bendix Corporation, Communications Division

Remarks

The AN/TGC-36 is a 20-line, full duplex, teletypewriter message relay central. Contained in 4 shelter enclosures of the prefabricated, quick assembly and disassembly type, it is transportable by land, sea or air to any location or environment. It provides torn tape relay equipment for 20 full duplex teletypewriter circuits, facility for installation of cryptographic equipment for these circuits, channel and technical control facilities and other associated facilities and equipment normally provided by a fixed communications relay center. The AN/TGC-36 is designed for low-level keying, and it complies with DCA Circular CIR 300-175-1 and NAG-5A/TSEC. Modular in concept, the central is engineered to provide a 20-line facility capable of subdivision into self-sustaining segments suitable for deployment as one 20-line facility consisting of 4 modules, 2 10-line facilities consisting of 2 modules each, or 4 5-line facilities consisting of one module each. All modules are identical and are electrically and mechanically compatible. Each 5-line facility is capable of being assembled into a 10-line or 20-line facility. Each prefabricated shelter contains (a) a message center (cross office termination), (b) torn tape relay (5 duplex line), (c) communications center ancillary equipment, (d) tape reproduction (ZVA-4 addressee), (e) on-line cryptographic (5 KW-26 positions), (f) channel and technical control (5 line), (g) air conditioning (2 units), (h) power generators (2 units; one operating, one backup) and (i) complete AGE. Also included is an emergency kit that contains sufficient supplies to provide 90 days' operation without external logistic support.



AN/FPS-85 SPACE TRACK RADAR SYSTEM

Prime Contractor: The Bendix Corporation, Communications Division

Remarks

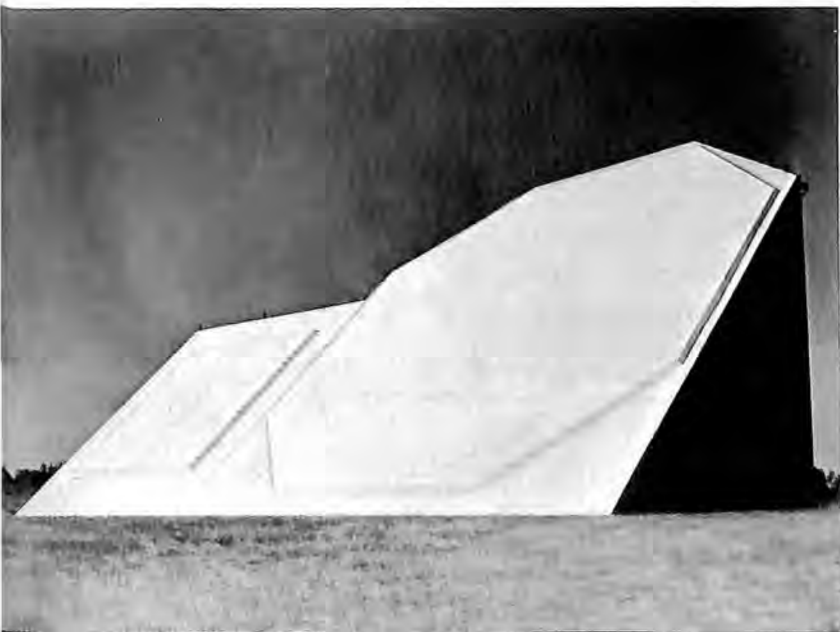
This new radar facility (original destroyed by fire January 1965), located at Eglin Air Force Base, Florida, is a major element of the United States' aerospace surveillance and warning system. The building housing the space track radar is 13 stories high and more than a city block long. The radar system 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 was under the sponsorship of the Electronic Systems Division, but the facility is operated by the Air Defense Command.

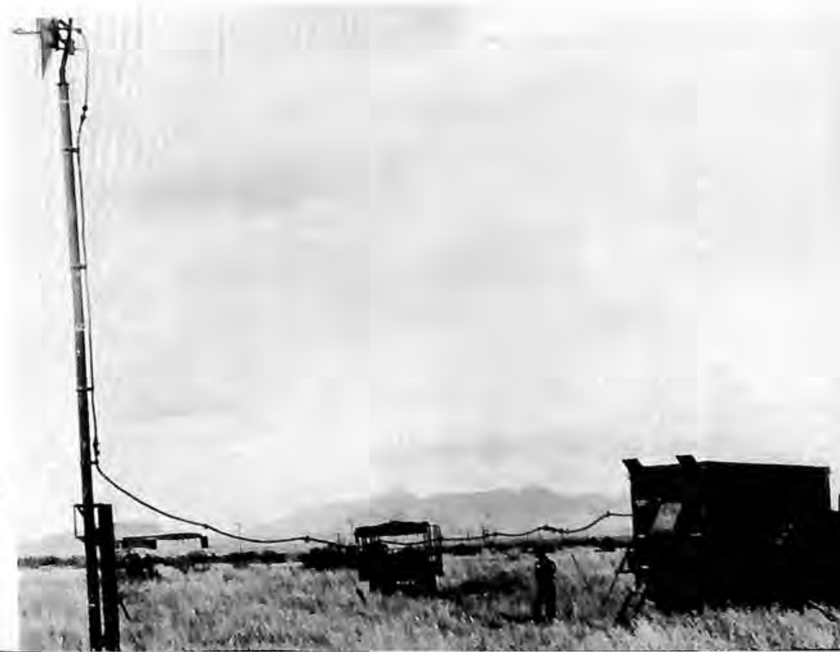
AN/TRC-111 RADIO REPEATER SET

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 spare radio or as 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

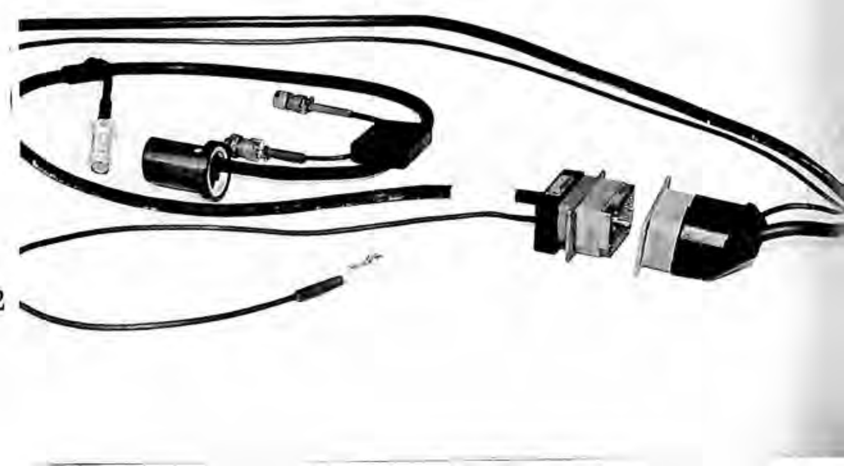
Combining the best features of previous radios, plus experience gained in Southeast Asia, the Bendix Communications Division has developed for the Air Force a light and very flexible manpack radio set available for forward air control in tactical situations. Conceived to bridge the interservice communications gap, this radio set, designated the AN/PRC-72, provides absolute operational flexibility. Combined in one compact, open frame rucksack are 4 self-contained, 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 has delivered developmental models to the Air Force.

SEA SPARROW INTERCONNECTING CABLE ASSEMBLY

Prime Contractor: Amphenol Space & Missile Systems, Amphenol Connector Division, The Bunker-Ramo Corporation

Remarks

This cable system was specially designed for the Navy's Sea Sparrow missile system. Sea Sparrow is basically a ship-carried adaptation of the proven Sparrow air-to-air missile. Its mission is short-range defense against aircraft and missiles. The missile is 12 feet long and 8 inches in diameter; it weighs 450 pounds. Its speed is 3 to 4 times the speed of sound, and its range is up to 8 miles. Missiles are mounted in 8-tube launchers. Under attack situations, shipboard radar picks up hostile aircraft or missiles 10 to 15 miles away. Two or more Sea Sparrows are fired in quick succession when the intruder is about 8 miles away. Amphenol Space & Missile Systems first became involved in the Sea Sparrow program by working with engineers at the Navy's Point Hueneme, California, facility on a connector problem. After evaluating the problem, Amphenol engineers suggested use of a modified missile staging connector. At Puget Sound Shipyard, Navy evaluation of the connector included extensive durability tests; for example, 6,000 mating cycles. The connector passed. There was still more to come for Amphenol SAMS; the facility was allowed to value engineer the entire Sea Sparrow cable assembly. The Navy furnished SAMS a launcher rail. Back came a redesigned cable assembly with greater reliability at a cost saving over the existing system.



AN/TPS-54

Prime Contractor: Electronics and Space Division, Emerson Electric Company

Remarks

AN/TPS-54 is a portable, lightweight, high-performance radar possessing very low operating power requirements. The system, operable in a worldwide environment and tailored specifically for tropical environments, was developed under contract to Rome Air Development Center. Utilizing a solid-state design, integrated circuits and lightweight structure, the only electron tubes are power amplifiers for the radar transmitter and a cathode ray tube for operator display. Optional dual transmitters and receivers operating in the frequency diversity mode improve low-altitude coverage by reducing antenna lobe structure. Single frequency surveillance radars produce a strong lobe structure in the vertical plane. Frequency diversity can minimize vertical lobing, improve low-angle detection and provide a spare transmitter/receiver for radar. AN/TPS-54 can be rapidly emplaced, erected to its 27-foot height and made operational by 4 persons. Capabilities of the system are particularly suited to combat area operations and include detection and tracking of enemy aircraft; air traffic control and guidance of friendly aircraft on sentry, supply, rescue or close-support attack missions; and approach control of aircraft during IFR (instrument flight rules).

Specifications

Range 100 nautical miles; altitude coverage 30,000 feet; weight 640 pounds.

MOVING TARGET FIRE CONTROL RADAR

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 configured 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 helicopter weapon 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 searched continually as the helicopter flies above the effective range of enemy small arms ground fire. Moving targets are detected at extended ranges and are displayed on the Indicator Unit. As the range to the target closes, the copilot expands the display and positions a cursor over the target indication to perform the gunlaying action.

XM-28 ARMAMENT SYSTEM

Prime Contractor: Electronics and Space Division, Emerson Electric Company

Remarks

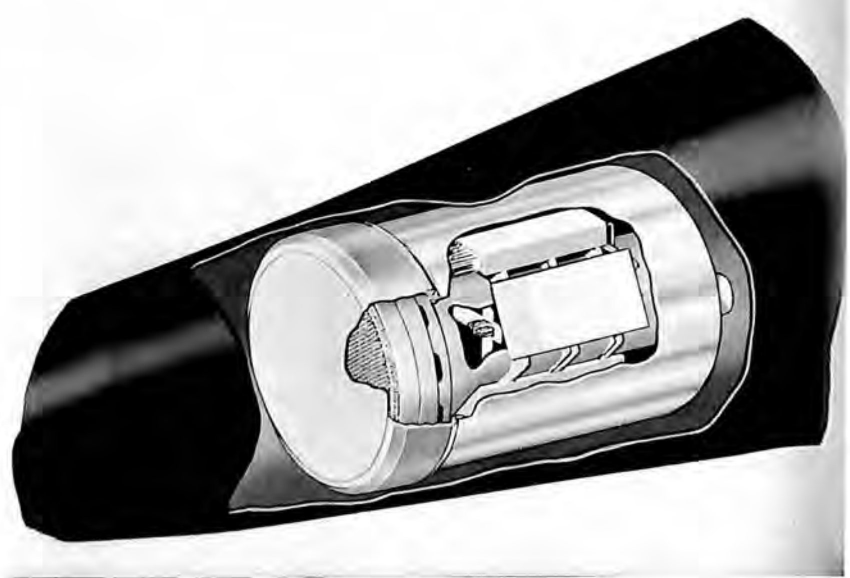
The XM-28 is an advanced flexible armament system scheduled for installation in the Bell AH-1G HueyCobra helicopter. The system consists of a power-operated turret, sighting station, fire control subsystem and ammunition storage and synchronized feed systems for 7.62-millimeter and 40-millimeter ammunition. Weapon interchangeability for combinations of 2 7.62-millimeter, high rate of fire, multibarrel GAU-2B/A machine guns, 2 XM129 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 multimode radar functions with one antenna on a time-shared, noninterference 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, backup surveillance after bomb attack on prime radars, counterinsurgency 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 7-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. Complete IFF/SIF is included to serve as a navigation aid. MTI circuits are incorporated to detect aircraft flying above heavy ground clutter.

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 setup 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 1 milliradian or less. Stable operation in a 40-knot wind has been demonstrated. Versions of the system are operational with F-104, F-105 and F-4 aircraft. The system is readily adaptable to other aircraft such as the A-7 and F-111.

REFRACTIVE INDEX SOUNDING SYSTEM (RISS)

Prime Contractor: Fairchild Hiller Corporation, Space & Electronics Systems Division

Remarks

The Refractive Index Sounding System (RISS) provides a new capability to determine accurately aerial photo mapping and charting operations. RISS obtains and processes high-resolution air temperature, humidity and pressure data to compute the index of refraction and thus increase the accuracy with which the actual location of the airborne optical sensor can be established. Fairchild Hiller will deliver 50 radiosondes and 2 ground stations for receiving and recording the radiosonde data. The ground station receives the radiosonde data and processes this information in a high-accuracy digital data processor. Accuracy in translating radiosonde pulse frequency data to digital data is in the order of .05 percent. The output of the data processor is recorded on magnetic tape for subsequent computerized data reduction. In addition, a digital printer monitors the data recorded on the magnetic tape.

AUXILIARY DATA ANNOTATION SYSTEM

Prime Contractor: Fairchild Hiller Corporation, Space & Electronics Systems Division

Remarks

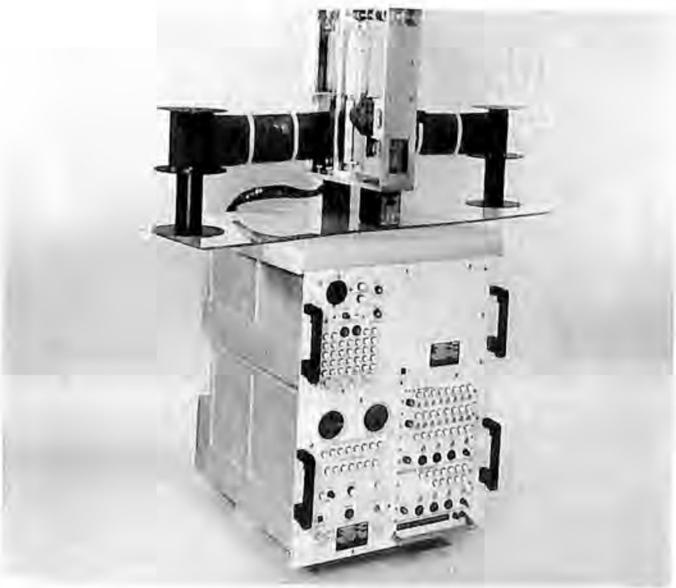
The Auxiliary Data Annotation System (ADAS) provides mission data annotation capability to airborne reconnaissance film recording systems. Flight information such as time, latitude, longitude, speed, barometric and radar altitude, heading, pitch, roll, drift, date, sortie number, detachment, radar mode, electronic data, sensor/station identification and taking unit identification can be marked automatically on the sensor film. Fairchild Hiller has produced the following ADAS equipment: AN/ASQ-90 for RF-4B/C, AN/ASQ-92 for the AN/USQ-28 in KC-135, AN/ASQ-94 for RF-101, MAS-1 for RF-104G and AN/AYA-5 (shown). Each of these sets has been designed for compliance with MIL-STD-782B and may provide an alternate mode of operation to record data in any one of the following forms: MIL-STD-782B, alphanumeric or alternating forms. Information is recorded on film by means of a cathode ray tube contained in each Recording Head Assembly. Fixed program data (date, sortie number, etc.) are inserted prior to flight. An earlier alphanumeric ADAS system was designed for the AN/USD-5 reconnaissance drone.

CODE MATRIX BLOCK READER

Prime Contractor: Fairchild Hiller Corporation, Space & Electronics Systems Division

Remarks

The advanced Code Matrix Block Reader developed by Fairchild Hiller is employed with the existing viewing equipment in a photo-interpretation facility to retrieve automatically any desired frame of photography bearing MIL-STD-782B annotation. The Tactical Intelligence Processing and Interpretation system (TIPI) utilizes this reader. The reader also permits conversion of code block data into alphanumeric form with provision of direct outputs for hard-copy printout, for on-line film titling or for on-line general-purpose computation. The reader uses a single line of photosensitive diodes to detect code block on the film. The MIL-STD-782 code blocks are read and 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 is re-identified 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. The reader handles film rates up to 40 inches per second or 8 code blocks per second in either direction of film travel.

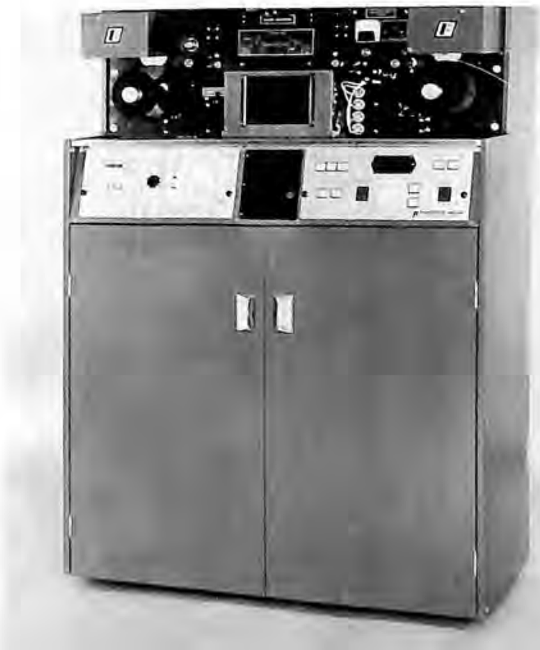


CONTINUOUS ENLARGER

Prime Contractor: Fairchild Hiller Corporation, Space & Electronics Systems Division

Remarks

Fairchild Hiller Model 702 Continuous Enlarger, military designation EN-95 (XA-2), combines versatility with high optical precision in handling continuous strips of photographic negatives for enlargement and printing. The unit has a paper transport rate of 60 feet per minute and an exposure rate of one print per second. A high-speed xenon flash lamp exposes the negative and the print material as they move past, insuring freedom from linear distortion and image smear. The 50/200-microsecond exposure time eliminates the need to match precisely both negative and print speeds. This innovation allows 3 modes of operation to be combined in a single instrument for the first time: continuous, panoramic and step and repeat. In the continuous mode, each frame is exposed by the xenon flash. Negative and print material move continuously, with the xenon flash triggered to expose each successive frame. The panoramic mode accommodates negatives too long for a single-frame exposure. The long negative is exposed in sections with adequate format overlap to establish the relationship of adjacent prints. In step-and-repeat mode, the print material moves continuously, while the desired negative frame remains stationary. Paper motion distance and the required number of prints are preset. The xenon flash is triggered until the preselected number of identical prints are exposed. The entire operation is continuous, with no need for the print material to be stopped for each exposure. Access for quick change of photographic paper is provided by large double doors in the front of the unit. All principal controls are sequentially illuminated to guide the operator.



SOLAR PANELS

Prime Contractor: Fairchild Hiller Corporation, Space & Electronics Systems Division

Remarks

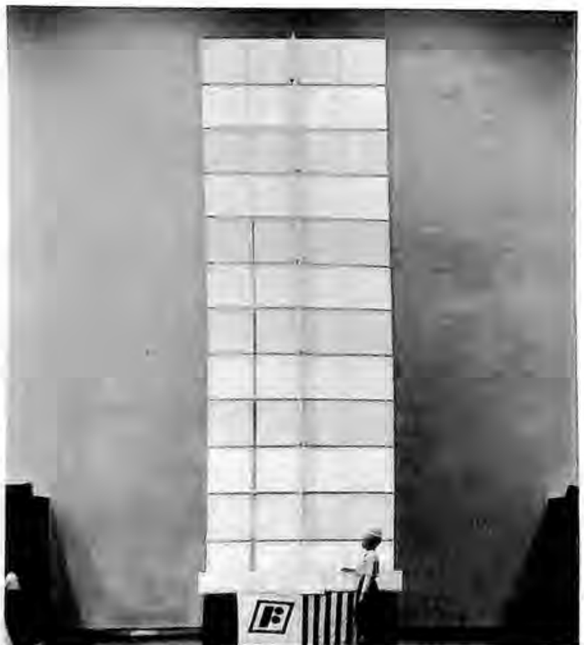
Fairchild Hiller has been actively engaged for a number of years in the development of large extendible solar arrays, the most recent of which is a full-scale working mock-up of panels for the S-IVB workshop program (photo). The design consists of 12 accordion-folded panels driven by a cross linkage. The extended length is 27 feet; width is 8 feet. This panel is one-eighth of the total array proposed for the workshop. The Radio Astronomy Explorer (RAE-1) satellite, launched July 4, 1968, carries solar arrays designed, developed and produced by Fairchild Hiller. During the last several years, Fairchild Hiller conducted development programs on flexible deployable solar arrays for NASA and the Jet Propulsion Laboratory. A notable accomplishment in this area was the successful completion of the 30-watt/pound, 270-square-foot solar array programs for JPL. Fairchild Hiller is also developing a 2-degree-of-freedom system on the Nimbus Advanced Solar Array. Through the acquisition of S. J. Industries, one of the few companies in the U.S. specializing in the installation of solar cells on array panels, Fairchild Hiller has become a leading designer and fabricator of solar panels.

TUBULAR EXTENDIBLE ELEMENTS (TEE)

Prime Contractor: Fairchild Hiller Corporation, Space & Electronics Systems Division

Remarks

Fairchild Hiller has developed and is producing Tubular Extendible Element (TEE) devices and systems for a wide range of applications. For the Radio Astronomy Explorer (RAE-1) satellite, launched July 4, 1968, Fairchild Hiller designed and produced the 750-foot-long extendible dipole antenna elements that form the 2 1,500-foot antennas, a dual extendible 315-foot libration boom and 2 60-foot nonmotorized antennas (photo shows TEE comparison with Empire State Building). The TEE devices have all been successfully deployed. Fairchild Hiller TEEs 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 to be stored in a small space. When unwound, they automatically reconstruct themselves into tubes. Motorized systems can extend the tubes in lengths ranging up to thousands of feet and then retract them back on spools in their original form. TEEs can operate reliably in any kind of environment and require no maintenance. In addition to diameter and material variations, hybrid TEEs can be manufactured with electrical insulative coatings, dielectric joints and in-line antenna termination networks. TEEs are also manufactured with open section seams (overlapped and underlapped) or with torque-resisting interlocked seams. Solar flux windows and thermal control coating can be provided. Currently under development are systems to increase the capability of the elements in torsion, bending and resistance to thermal deflection.



STORES MANAGEMENT SET (SMS) MARK II AVIONICS

Prime Contractor: Fairchild Hiller Corporation, Space & Electronics Systems Division

Remarks

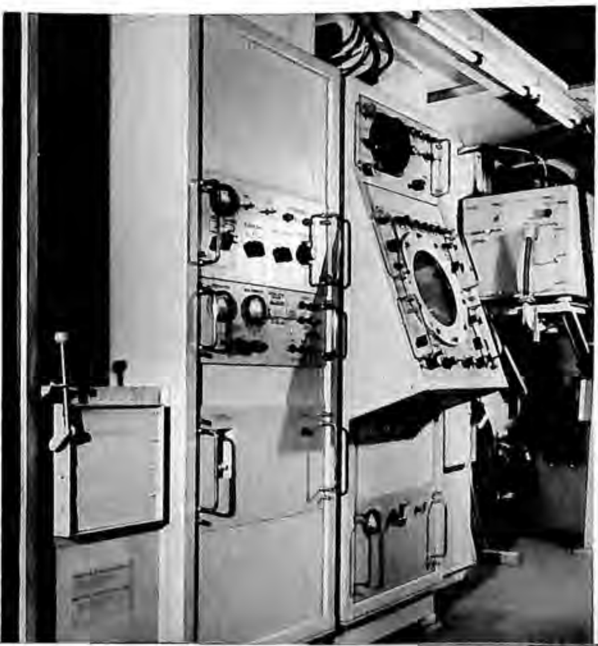
Under contract from the Autonetics Division of North American Rockwell Corporation, Fairchild Hiller designed and developed the MARK II Stores Management system for use in F-111D aircraft. The SMS will give F-111D pilots a centralized cockpit display by providing on command data about available stores for a given mission, available delivery modes and corresponding flight restrictions. The main system elements are 2 cockpit control panels and a solid-state micrologic computer unit. The major advantages of SMS are substantially increased pilot and crew efficiency during combat and increased flight safety. The centralized SMS cockpit display panels contain all weapon management controls, data displays indicating type and quantity of weapon loading at each station, applicable release modes, arming status and circuitry status. Data are continuously available on aircraft flight limitations (both airspeed and acceleration) for any stage of weapon carriage and release, from full loading to depletion of weapons. The most effective quantity of stores and ripple rate can be selected. All weapon management selections can be held indefinitely in the SMS memory for each weapon station, even during conditions of power interruption. Integral logic circuitry in the SMS prevents inadvertent selections of conflicting weapons, stations or release modes.

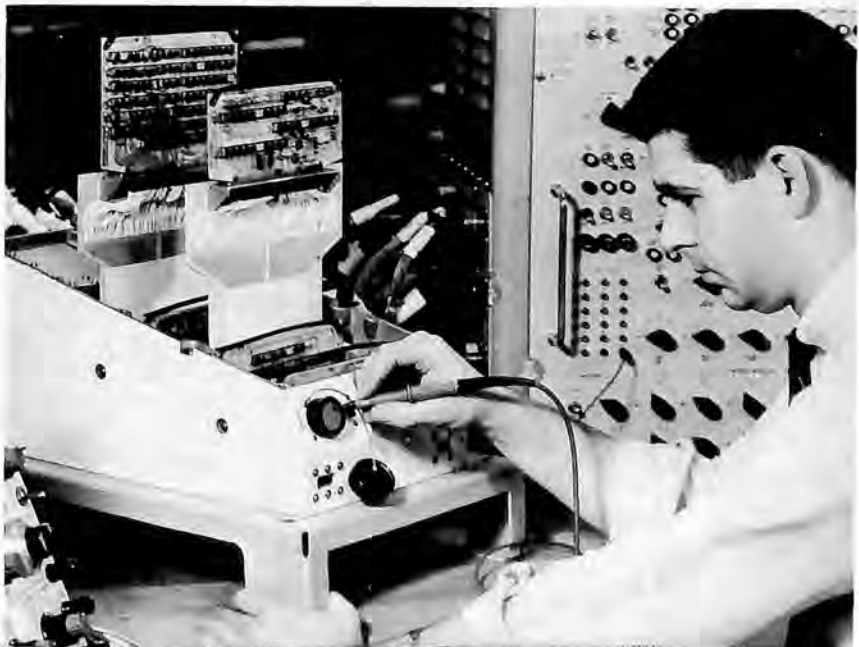
AN/TPS-41 MOBILE WEATHER RADAR

Prime Contractor: Fairchild Hiller Corporation, Space & Electronics Systems Division

Remarks

Fairchild Hiller has developed 2 successive generations of mobile weather radar for the U.S. Army. The initial development in 1965 resulted in a van-housed radar system, capable of being placed in operation in less than 20 minutes on a self-supporting basis. The latest development, the AN/TPS-41 (XE-2) is a highly flexible, lightweight system that can be transported by jeep or carried by one man. The major system features are ISO-Echo capability; RHI, PPI, A/R and Nixie displays; lightweight antenna pedestal (158 pounds); and 250-kilowatt peak power X-band transmitter and remote indicator operation. The Mobile Weather Radars provide a completely automatic processing, reduction and display system for rapid presentation of fresh meteorological data from a mobile position. Battle commanders can locate and measure precipitation and natural or nuclear clouds for tactical purposes at ranges up to 150 miles.





RECEIVER TEST BENCH SUBSYSTEM

Prime Contractor: Fairchild Hiller Corporation, Space & Electronics Systems Division

Remarks

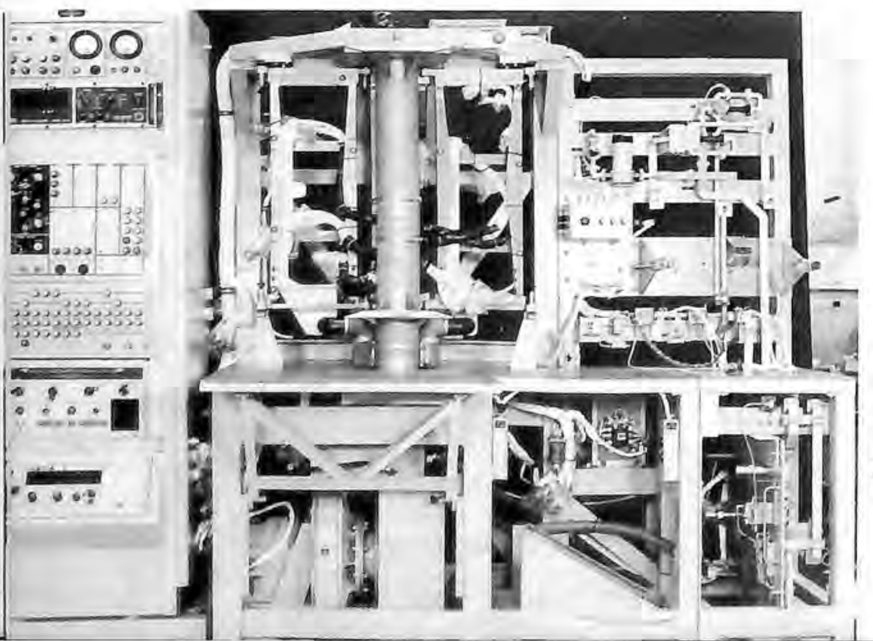
The AN/AWG-10 Receiver Test Bench Subsystem is a ground support equipment designed to provide for test and maintenance of the receiver section of the AN/APG-59 pulse-Doppler fire control radar. The AN/AWG-10 is a multimission weapons control system for the F-4B/J/K/M aircraft using the Sparrow missile system. It is built almost entirely from solid-state components. Under contract from Westinghouse Electric Corporation, Fairchild Hiller-SESD shared in the design and is the producer of the Receiver Test Bench Subsystem, consisting of a Receiver Bench Assembly and a Test and Control Rack Assembly. The bench assembly contains provisions for mounting and operating the radar receiver subsystem. It also provides work space, cooling air, interconnection to the Test and Control Rack, and the microwave calibration package. The Test and Control Rack is a single cabinet which contains the necessary controls for primary power system control, simulated test inputs and loads, system controls and test equipment. Built-in characteristics of the Receiver Test Bench include capability for calibrating receiver gain over the complete radar band. A self-calibration capability permits balance of 2 parallel paths to within .1 db. Insertion of radar components, such as the BIT Target generator, into one of the balanced paths permits calibration by a modified substitution method. Maximum height of the AN/AWG-10 Receiver Test Bench Subsystem is 76 inches. The subsystem is designed to be fastened to the deck and bulkhead of a ship or to the floor and wall of a shelter, with the rack shock-mounted. Floor space required for the subsystem is 29x96 inches.

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 4x5-inch film chips that hold up to 9,800 frames of technical data in a 99x99 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 and pushes a button, and the frame is automatically found and displayed on a screen. The film chips on which the hi-ratio reduction microphotographic 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 75x75-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

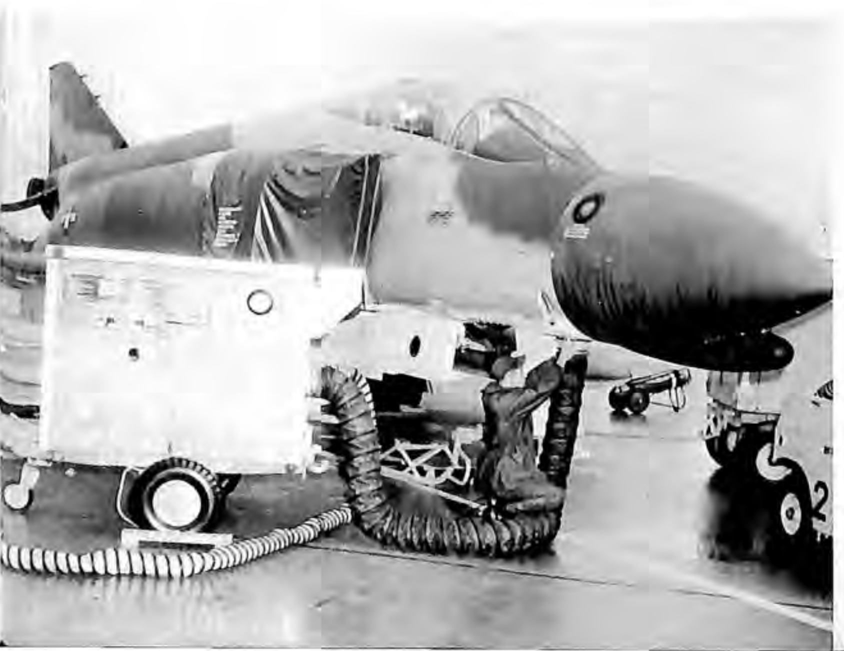
The Stratos Model GEA50-1 Ground Air Conditioner (A/M32C-10) is a mobile, compact unit that was designed to deliver cooling or heating air to personnel, cargo and electronic compartments in military aircraft during ground servicing and checkout. The conditioned air is delivered directly into the air-duct 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/M32A-60 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, back-pressure 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.

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 1 percent of its design point.



TOTAL ENVIRONMENT FACILITY (TEF)

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

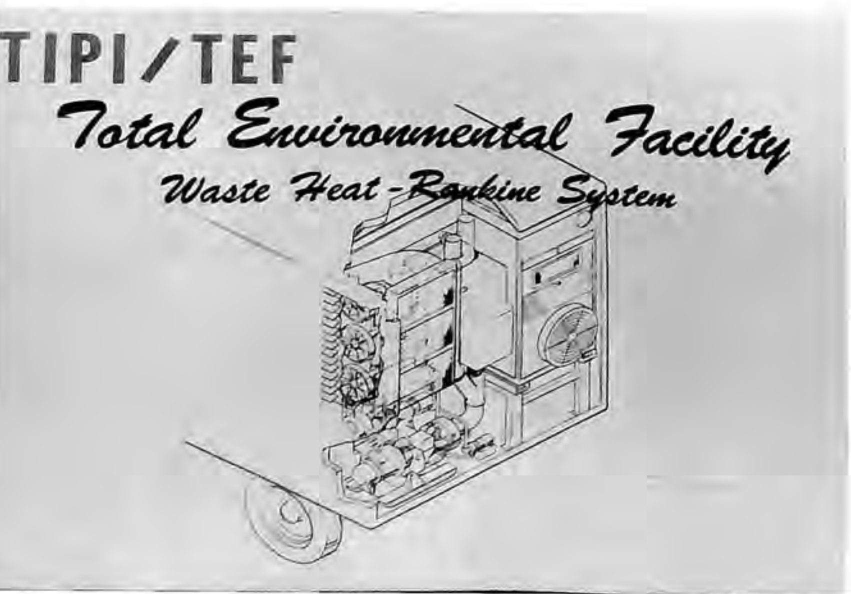
Under development, the Total Environment Facility (TEF) is a lightweight, highly mobile shelter that contains provisions for the installation of electronic and photographic equipment and will house personnel associated with the processing of reconnaissance data. The heart of the TEF is a utilities section 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 20x8x8-foot shelter, are a gas turbine-generator set with 50-kilowatt capacity and an environmental control system powered by utilizing the gas turbine exhaust gases 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 at which 50 kilowatts of usable refined electrical power are 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 saving (up to 60 percent), which represents a significant reduction in logistic support required. The TEF will be deployed as part of the TIPI (Tactical Information Processing and Interpretation System), a 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, 3 Beech and 3 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.

AIRCRAFT INTEGRATED DATA SYSTEM

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Division, Los Angeles

Remarks

The AiResearch Aircraft Integrated Data System (AIDS) is a comprehensive airborne monitoring and recording system designed to reduce aircraft maintenance costs and to improve operational procedures and flight safety. Three major international airlines, American, Alitalia and CP Air, are using versions of the AiResearch AIDS in daily operations. In addition, AiResearch, under USAF contract, is developing an advanced airborne AIDS for present and future manned bomber-type aircraft. Depending on individual airline requirements, the AIDS automatically monitors preselected engine and system parameters continuously or at specified intervals. This data is recorded in digital form for later analysis by ground-based computers. If preferred, the system may be linked directly to an on-board computer for real-time fault detection and isolation. The type and number of parameters monitored by the AIDS are dependent on aircraft use and airline preference. Generally, the recorded data falls into 3 categories: maintenance recording for quick assessment of aircraft systems conditions and long-term trend and predictive information; performance monitoring for developing, improving and verifying flight procedures; and flight data for improved flight safety and compliance with FAA regulations. Any or all of these types of recording may be integrated in the AiResearch AIDS.

CONTINUOUS NONEQUILIBRIUM MHD POWER GENERATOR

Prime Contractor: General Electric Company, Space Sciences Laboratory

Remarks

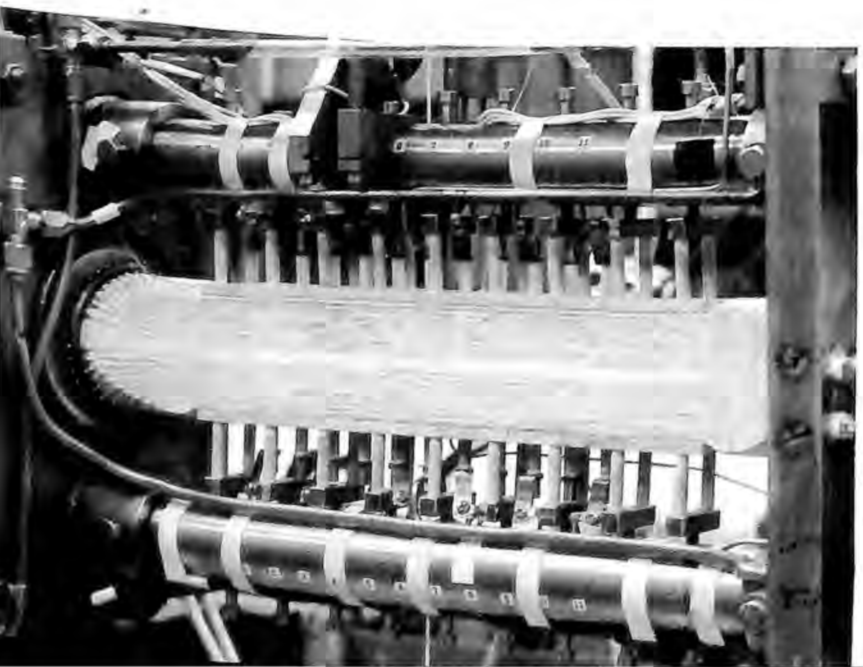
A magnetohydrodynamic generator was continuously operated without high heating, for the first time, in a series of basic experiments at the GE Space Sciences Laboratory. The Department of Defense and GE cosponsored the work under the Independent Research & Development Program. Steady electric power of several watts was continuously extracted at 93 percent of the theoretically attainable level of induced voltage. Running times, effectively limited only by the experimental gas supply, were typically about an hour. The success depended on raising the working plasma's level of ionization far above the equilibrium value for the relatively low temperature. (The transverse conductivity during power extraction was approximately 150 times the thermal equilibrium value at 1,500 degrees Kelvin.) The nonequilibrium MHD generator, perhaps as a topping device on a ground-based system, should be 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.

SNAP-27

Prime Contractor: General Electric Company, Missile and Space Division
Principal Subcontractors: 3M Company (thermopile); Solar Division of International Harvester Company (beryllium fabrication)

Remarks

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.



JET AIRCRAFT ENGINE IGNITION SYSTEMS

Prime Contractor: General Laboratory Associates, Inc.

Remarks

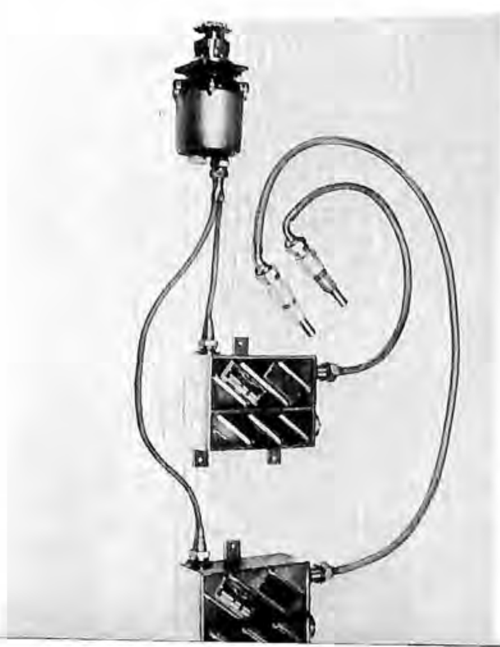
GLA has supplied capacitor discharge ignition devices for both military and commercial jet aircraft engines. A typical example of a system employing several products manufactured by GLA is pictured. This TF30-P-12 Engine Ignition System, which is used on the F-111 aircraft program, features an engine-driven alternator, low-voltage interconnecting leads, ignition exciters, high-voltage leads and, not shown, an instrumentation harness which connects to the alternator. Customized designs for similar equipment on the VSX and UTT aircraft programs are under active development. Commercial programs utilizing GLA ignition devices include the Boeing 707/720, Douglas DC-8/DC-9, Convair 880/990 and Lockheed Electra II aircraft. Military programs include Lockheed C-130/141, Boeing B-52/KC-197 and Sikorsky Skycrane.

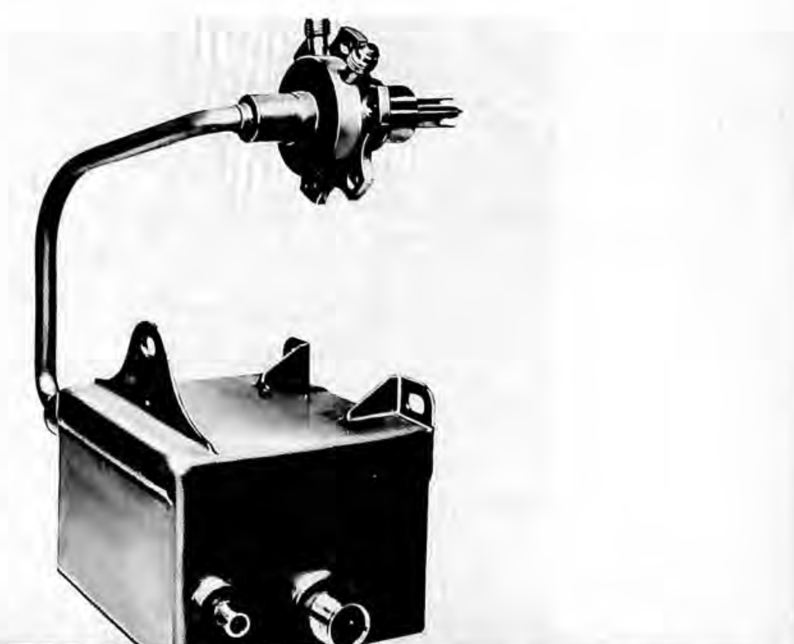
ROCKET ENGINE IGNITION SYSTEMS

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 RL10 LOX hydrogen engine. Successful RL10 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.





JET ENGINE TEMPERATURE SENSING SYSTEMS

Prime Contractor: General Laboratory Associates, Inc.

Remarks

The illustrated system is a typical GLA application of the thermocouple principle to current jet engine temperature sensing requirements. The system has been designed specifically to pick up temperature in a number of places in the tailpipe area of the jet engine. The output is an electrical signal representing the average gas temperature in the searched area. This system incorporates provisions for engine mounting and easy installation or replacement of system components, and it contains features which permit ground checking of engine functions as well as a check-out of the temperature sensing system itself. The system weighs approximately 5 pounds and has a life expectancy in excess of 15,000 hours.

LIGHTWEIGHT PNEUMATIC DE-ICING SYSTEM, ELECTRICAL PROPELLER DE-ICING SYSTEM

Prime Contractor: B. F. Goodrich Aerospace and Defense Products

Remarks

The B. F. Goodrich Lightweight Pneumatic De-Icing System gives inflight protection from the hazards of ice formation on wing and empennage leading edges. It can be put into operation instantly 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 lightweight, 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 Lightweight 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.

SATELLITE NAVIGATION SYSTEM

Prime Contractor: Honeywell Inc.

Remarks

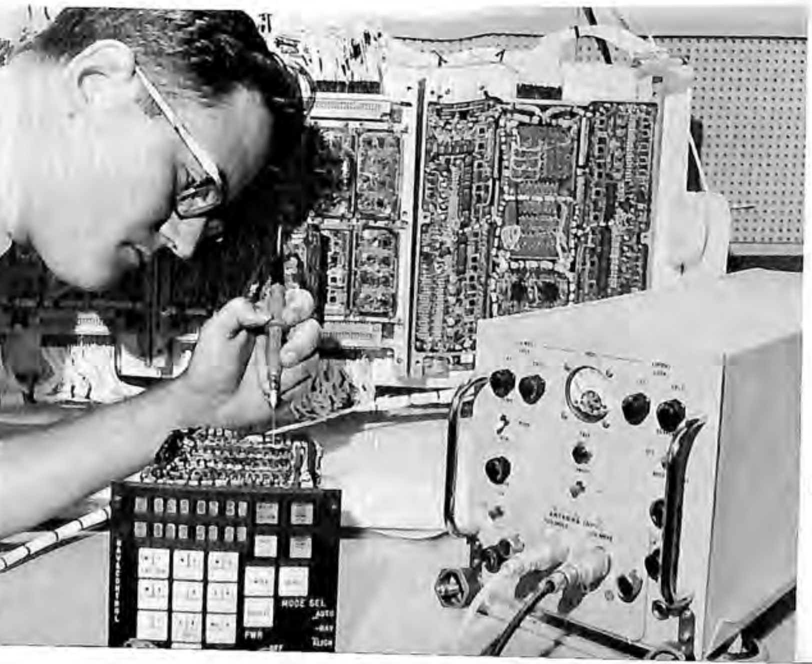
The satellite navigation receiver system is designed to furnish extremely accurate position information for aircraft and ships. The system consists of a specially designed satellite Doppler signal receiver, a digital computer to automatically calculate vehicle position, a display unit and power supply for both the computer and the receiver (in photo, control display unit is in foreground, power supply at right and computer circuitry in background). In airborne applications, the computer receives velocity information from an inertial navigator or a Doppler navigator. Altitude information is furnished by the aircraft's air data system. Position fixes are gained through receipt of signals from one of 4 Navy satellites now in operation. The proposed commercial version of the system is called Update Geo Navigator. Essentially, the system updates position information obtained by the primary inertial or Doppler navigation system by feeding signals from the appropriate satellite into the computer. Continuously accurate position information will result when a sufficient number of navigation satellites are in orbit. The company says the global position-fixing technique has broad application to tactical and strategic aircraft needs, general marine use and geophysical survey work.

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 electrooptical positioning concept eliminates restrictive mechanical linkages between helmet and cockpit. Once determined by computer, the helmet's position is fed by electronic signals to command gun or camera direction.



FINE SUN SENSOR

Prime Contractor: Honeywell Inc.

Remarks

A fine sun sensor developed by the Honeywell Radiation Center, Lexington, Massachusetts, for the Apollo Telescope Mount (ATM) is designed to enable U.S. astronaut-scientists to conduct solar experiments from a space laboratory orbiting the earth in the 1970s. The sensor, part of the pointing and control system of the modified Apollo spacecraft, is said to be the most precise electrooptical instrument of its type ever developed. Under normal operating conditions, the device can hold an accuracy of 1.7 arc-seconds. For up to an hour, it can measure to within .1 arc-second. The company was building 5 of the instruments for NASA's Marshall Space Flight Center, Huntsville, Alabama, under a $1,500,000 contract. Since it provides the high-accuracy attitude information necessary in a pointing or scanning mode, the sensor can be used for navigation, guidance or control of a space vehicle as well as for experiments.

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.

MISSILE MENTOR FIRE COORDINATION SYSTEM

Prime Contractor: Hughes Aircraft Company

Remarks

The Hughes Missile Mentor (AN/TSQ-51) Army air defense fire coordination system provides coordinated management of dispersed surface-to-air missile (SAM) batteries, such as Nike Hercules and Hawk. The system is being operated by the U.S. Army at a number of sites throughout the United States. A basic Missile Mentor system is comprised of 2 military vans that operate as a single "command post." Data display and processing equipment in the vans provides surveillance, tracking, threat evaluation, battery status monitoring, weapons assignment and damage assessment data among other information. The system uses a general-purpose computer, the first time such a device has been used for coordination and control of Army air defense units. The system, in operation, consists of 2 standard military vans, or trailers, which are parked together to form an Army Air Defense Command Post (AADCP). In some defenses, one or more single, van-mounted Remote Radar Integration Stations (RRIS) are being used to greatly enlarge the area of defense radar coverage. The system's physical mobility allows tactical flexibility, and its modular design makes it easily adaptable to both large and small system requirements.

SATELLITE COMMUNICATIONS EARTH STATIONS

Prime Contractor: Hughes Aircraft Company

Remarks

Satellite communications earth stations, built by Hughes and operated by the U.S. military services, are providing global voice and teletype communications through random-orbiting Department of Defense satellites. The company has built and delivered 2 types of military earth terminals. They are the land-based Mark 1B (AN/MSC-46) terminals, the world's largest air-transportable systems of their kind, and the smaller, lightweight, shipboard satellite communications terminals (AN/SSC-3), designed to link Navy ships with each other and with shore installations. The Mark 1B terminals are the first designed specifically for operational military communications. Their 40-foot-diameter antennas rotate in elevation and in azimuth to remain "fixed" on the moving satellite. Each Mark 1B system consists of the pedestal-mounted antenna housed in a protective radome, communications and support equipment including 3 30-foot mobile vans, and 3 diesel generators to provide power. Fourteen of the giant terminals were delivered to the U.S. Army Satellite Communications (SATCOM) Agency, which serves as Army project manager for the triservice Defense Satellite Communications Program (DSCP). The antennas of the smaller, shipboard satellite communications terminals are designed to be mounted on the masts of ships for an unobstructed view in all directions. They feature a new 3-axis, lightweight pedestal, developed to eliminate the effect of a ship's roll and pitch. The terminal's 6-foot-diameter antenna and its electronics system are mounted on the pedestal. In photo, a Mark 1B AN/MSC-46 terminal.

AIR DEFENSE GROUND ENVIRONMENT SYSTEMS

Prime Contractor: Hughes Aircraft Company

Remarks

Advanced Air Defense Ground Environment (ADGE) systems, designed by Hughes, are installed now in a number of free world countries. The modular systems, which can be tailored to the requirements of the individual countries and are designed to provide an electronic "umbrella" of protection against attack from the air, are installed in Japan, West Germany, the Netherlands, and Belgium. A similar Hughes system is being installed in Switzerland, and Hughes is one of 6 international firms incorporated to design and build the $300,000,000 NATO Air Defense Ground Environment (NADGE) system in Europe. The ADGE systems are composed of state-of-the-art, general-purpose computers, electronic data display units, data-processing equipment and communications equipment that, when combined with long-range modern radars, provide a modernized quick-reacting capability for rapid detection, identification and tracking of potential enemy air threats and to-the-target control of supersonic air defense missiles and fighter interceptors. ADGE systems are designed to meet specific air defense needs of today but have the capability of growth to meet new air defense challenges of tomorrow. In photo, artist's concept of ADGE underground bunker.

AUTOMATIC COMPUTER-CONTROLLED FILM READER/RECORDER SYSTEM

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

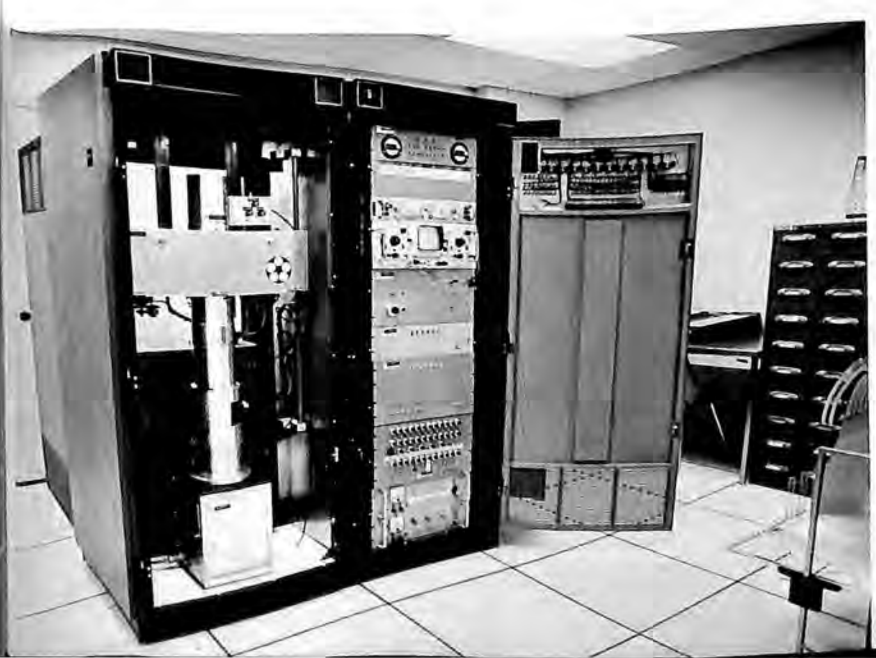
An automatic, computer-controlled Film Reader/Recorder has been developed by IBM Federal Systems Division for data handling, data compaction and other applications involving large volumes of photographic information. The system utilizes a cathode ray tube scanner controlled directly by a digital computer. 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 4,096x4,096 positions and can encode 64 gray levels. This permits the program to look for changes in relative gray levels as significant events rather than rely on a "black-white" decision imposed by a clipping level. Because of these features, the reader can digitize and re-create 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 of counting anything that is highly repetitive and requires accuracy. A great deal of imagery falls into this class.

TWO-SPEED DIGITAL MODEM

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

A digital modem that operates on C1/C2-grade telephone lines at 4,800 and 7,200 bits a second, without expensive automatic equalization, has been developed by International Business Machines Corporation's Federal Systems Division. Both speeds are available in one unit equipped with a speed selector switch. The modem (modulator/ demodulator) can be equalized quickly with built-in fixed and manual controls. Equalization compensates for delay distortion in the telephone lines, which occurs when all parts of a signal do not arrive at the receiver at the same time. C1/C2 lines are conditioned especially for digital transmission. The digital modem avoids errors with a new modulation technique that reduces signal band width and eliminates the dc component, or zero reference line. Data is encoded into dipulses with equal positive and negative amplitudes. The resulting waveform is filtered and shifted to the center of the telephone band with single sideband modulation. The dc component can be eliminated because the average value of the dipulse positive and negative amplitudes is zero. Therefore, a zero reference line is not necessary. The dc component tends to shift slightly above and below zero. Eliminating it means fewer errors at the receiver.



SATURN INSTRUMENT UNIT

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

The Instrument Unit (IU)—the 3-foot-high "nerve center" stage of Saturn—was designed at NASA's Marshall Space Flight Center and is assembled at Huntsville, Alabama, by IBM Federal Systems Division. Each Saturn IB and Saturn V has one of these aluminum rings 21.7 feet in diameter. More than 60 electrical and electronic units are integrated within each IU to provide the vehicle with guidance, navigation, control and data-handling systems. IBM has system integration responsibility for the Saturn IUs including fabrication, assembly, checkout and launch support. IBM also builds the onboard computer and the data adapter. During a mission, the IU's sensitive instruments process millions of bits of data every few minutes, and its guidance system measures acceleration and vehicle attitude 25 times a second. It determines velocity and position every second, then calculates and issues steering commands to keep Saturn on course. The IU samples 200 sensors that measure environment and systems performance, tests sound levels, temperatures, pressures and vibration levels more than 7,000 times a minute, and records and relays flight information to ground stations. Before launch, the IU aids in countdown check-out. Under blockhouse control, the on-board IBM computer checks itself and the Saturn vehicle. It tests switch selectors in each stage and orders first-stage engines to gimbal for visual observation. Once in earth orbit, the IU commands engine re-ignition to put Apollo on a correct lunar trajectory. When on course, it stabilizes the stage for the turnaround and docking maneuver.

DACOR 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 that promises to greatly advance means of controlling errors in digital data transmissions. The device applies advanced polynomial 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 which becomes garbled during transmission from a data source does not have to be retransmitted. The equipment has broad communications applications. While other methods of error control—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 only a fixed, fraction-of-a-second decoding delay. The Dacor system has in its receiver a special decoding capability, 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 is 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.

FAST FOURIER ANALYZER

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

IBM's Fast Fourier Analyzer quickly and efficiently performs signal processing operations, fast Fourier transform, and complex multiplication. The most important feature of the Fast Fourier Analyzer is the fast Fourier transform, a new computational algorithm that reduces computation time for signal processing functions such as spectrum analysis and digital filtering. Many signal processing problems can be solved faster and more economically than before. The fast Fourier transform is a computationally efficient method for obtaining the discrete Fourier transform of a series of data samples. The basic system consists of a Fast Fourier Analyzer connected to an IBM System/360 central processor by the IBM 2701 Parallel Data Adapter unit. Signal processing involves repetitive mathematical operations performed on large amounts of data. Using normal computer instructions, the processing is costly and time consuming. The Fast Fourier Analyzer provides a cost effective solution to signal processing. Once a channel command has been initiated, the Fast Fourier Analyzer operates independently of the central processing unit. Main storage cycle stealing is minimized because the analyzer contains sufficient storage for its own internal processing. Once a block of data is transferred from main storage to the analyzer, it is processed independently of the central processing unit and then transferred back to main storage. This releases the central processing unit memory and channel for other processing.

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 $\frac{4}{10}$ 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. Other applications include the Navy's EA-6B electronic warfare aircraft, in an electronic system to process and correlate enemy radar data; the Navy's Target Identification and Acquisition System, an airborne system used with Standard ARM antiradiation missile; the Navy's A-6A attack aircraft; the Air Force's Manned Orbiting Laboratory; and both Navy and Air Force versions of the A-7 fighter-bomber. System/4 Pi makes the first use of read-only storage for computer logic control in aerospace systems. There are 3 System/4 Pi models: Model TC (tactical computer) for satellites, tactical missiles, helicopters and other applications requiring a very small, lightweight computer; Model CP (customized processor) for real-time computing applications; and Model EP (extended performance) for applications that require real-time calculation of very large amounts of data.

AN/ARN-90 AIRBORNE TACAN BEACON SYSTEM

Prime Contractor: ITT Avionics, a division of International Telephone and Telegraph Corporation

Remarks

The original TACAN AN/ARN-52(V) was designed for use by military aircraft in conjunction with a mobile or fixed beacon. The TACAN AN/ARN-90 is an airborne system which adds the TACAN air-to-air bearing capability to the already existing TACAN air-to-air distance capability of the AN/ARN-52(V) (TACAN navigation equipment). The combined distance and bearing facility of an AN/ARN-90-equipped aircraft may then provide TACAN navigational service to user aircraft. The AN/ARN-90 equipment complement consists of a Bearing Data Unit, a rotating Antenna (new designs), and a Receiver-Transmitter (modified AN/ARN-52). This new system offers a wide choice of potential air-to-air applications including refueling, rendezvous and station keeping. It is compatible with the TACAN System.

TACAN MINIBEACON BN1-107

Prime Contractor: ITT Avionics, a division of International Telephone and Telegraph Corporation

Remarks

The DME/TACAN Minibeacon (BN1-107) solves the important tactical problem of locating and supporting ground or airborne forces. Operated as a fixed surface, mobile surface or airborne beacon, the unit provides distance information to any aircraft carrying standard DME or TACAN equipment. This TACAN Minibeacon is capable of supplying both DME and DME plus bearing information to suitably equipped aircraft. Only a stub antenna (such as ITT type 1052189) is required for DME service; the newly developed rotating antenna, YN1-107, plus a special video card, is required when both DME and bearing service is desired. Obviously, any aircraft equipped with an inverse mode TACAN capability can obtain both DME and bearing information from this transponder when it is configured for DME service only. Several of these Minibeacons have been built and successfully tested by both the U.S. Air Force and the Army.

SATELLITE COMMUNICATION EARTH TERMINAL

Prime Contractor: ITT Defense Communications, a division of International Telephone and Telegraph Corporation

Remarks

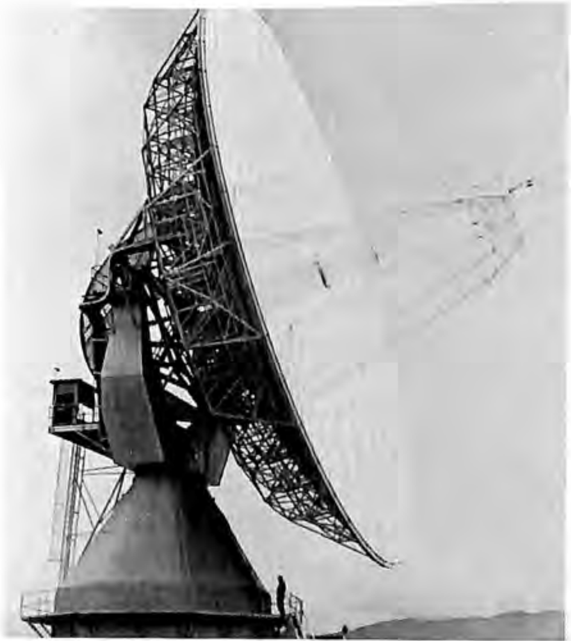
This satellite communication earth terminal is situated in Buitrago, Spain, 50 miles north of Madrid, and was built by ITT Defense Communications Division for Compania Telefonica Nacional de Espana, the national telephone company of Spain. The terminal provides Spain with a communication gateway to North and South America via the Intelsat series of commercial communication satellites. The terminal permits simultaneous transmission over 10 message links and a television circuit.

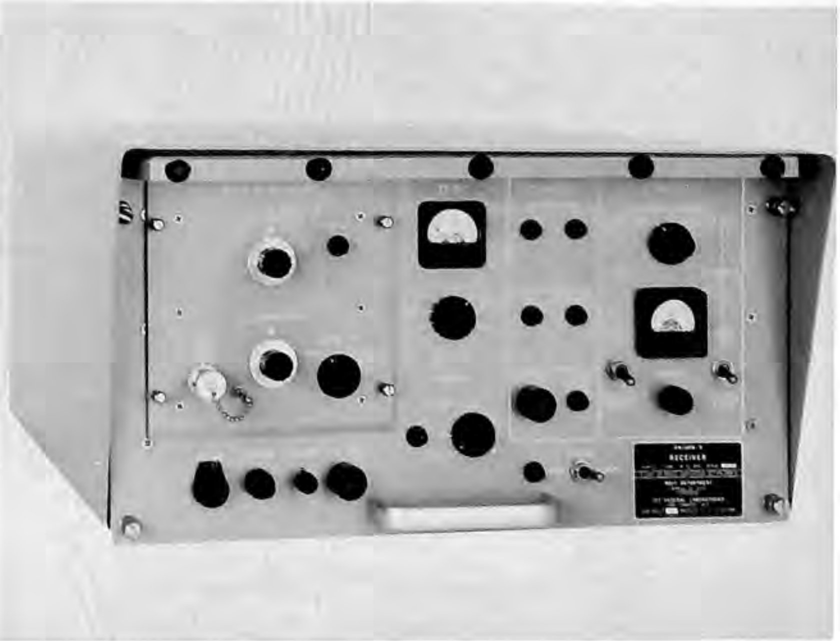
SATELLITE NAVIGATION SHIPBOARD RECEIVING EQUIPMENT

Prime Contractor: ITTFL-Aerospace, San Fernando, a division of International Telephone and Telegraph Corporation

Remarks

The AN/SRN-9 Radio Navigation Set was developed and produced by ITTFL-Aerospace for shipboard use by the U.S. Navy in obtaining precise position fixes from the Navy Navigation Satellite System (formerly designated TRANSIT). The dual-channel, phase lock receiver, with its unique conical helix antenna, acquires from the satellite's signals the orbital parameters of the satellite, its Doppler shift and refraction index, and formats these to enable a digital computer to provide a position fix in direct readout of latitude and longitude, with an accuracy better than .1 nautical mile. The equipment operates reliably in all weather conditions, worldwide, with an accuracy unaffected by seasonal or diurnal ionospheric shifts. The system has been in operational Navy use since 1964. Its declassification in 1967 has opened up its use in commercial and scientific oceanographic applications with the Model 4007AB commercial version of the equipment. Both the naval and commercial versions are being produced in quantity and have been proven in operational use.





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 electrooptical 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 STADAN antenna facilitates calibration of antenna pointing angles. Manual control is exercised during target acquisition; after the target has been acquired, the system tracks automatically.

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 developed by ITT Gilfillan specifically 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

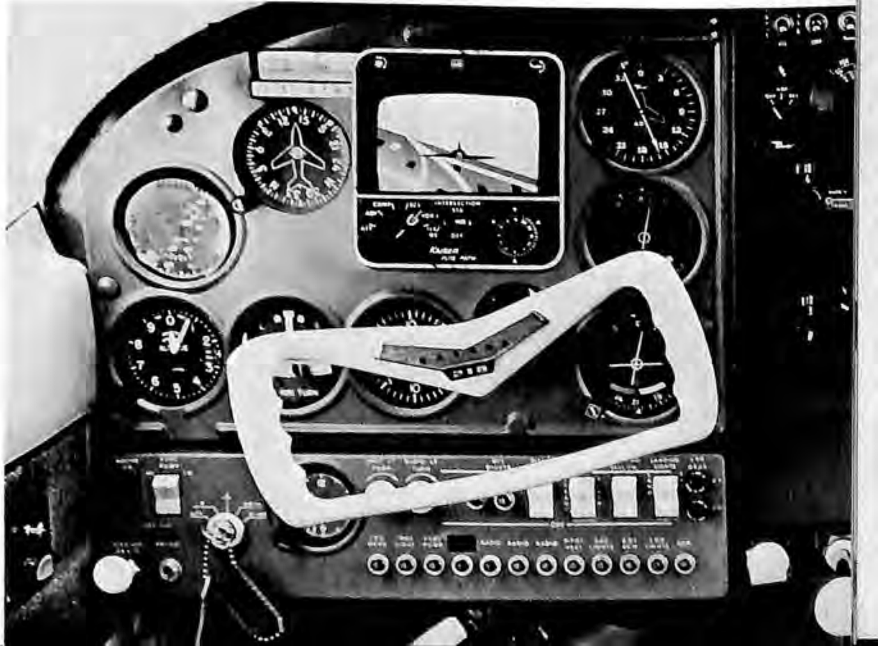
The Quadradar is a complete, 4-in-1 ground control approach radar which provides precision approach, surveillance, height finding and taxi radar coverage for air traffic control. On final approach the ITT Gilfillan Quadradar presents to the operator the range, bearing and altitude of all aircraft within 40 miles. The data is used to keep the pilots on optimum courseline and glidepath to touchdown. The Quadradar provides 360-degree surveillance coverage to the 40-mile range, permitting the operator to control terminal traffic while establishing final approach patterns. Accurate altitude information on any aircraft up to 50,000 feet makes the Quadradar's height-finding system a valuable aid to complete air traffic control. The Quadradar's taxi coverage provides surface surveillance permitting an expanded view of aircraft or other objects on the runway.

FLITE-PATH DISPLAY

Prime Contractor: Kaiser Aerospace & Electronics Corporation

Remarks

Kaiser Aerospace & Electronics Corporation has developed a revolutionary new aircraft instrumentation system for light aircraft, 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 that 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, a gyro compass and an altitude sensor.



AN/USQ-28 AERIAL SURVEYING AND MAPPING SYSTEM

Prime Contractor: Kollsman Instrument Corporation

Remarks

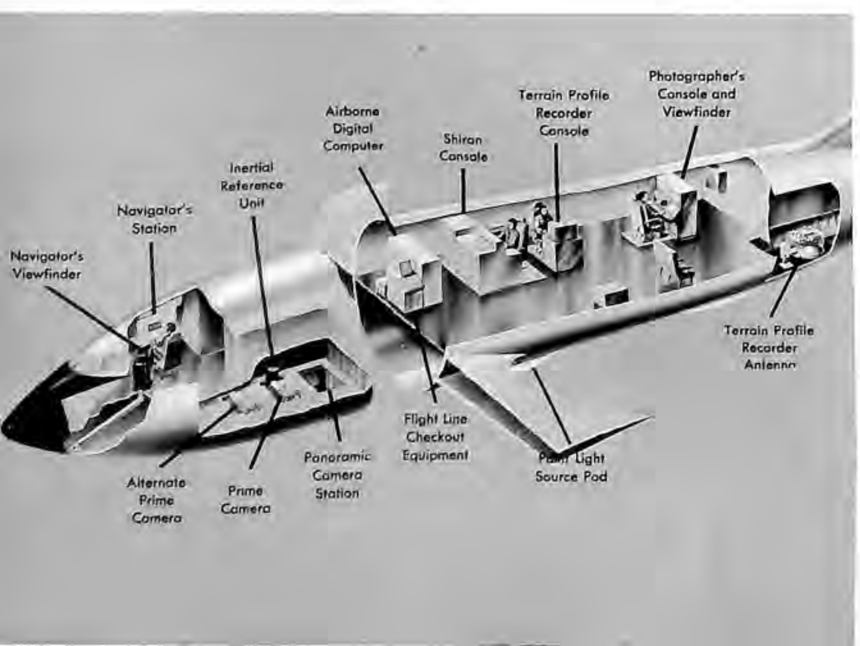
The AN/USQ-28 is the first of a new class of advanced airborne electronic photography systems that completely integrates aerial surveying and photomapping techniques with computer control. The system includes mapping cameras of advanced design which, with their support equipment, are located in a pressurized 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 amidship 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. Kollsman has delivered a prototype system and 3 production models for installation in Boeing RC-135A aircraft operating at Forbes AFB, Kansas, home of the 1370th Photo Mapping Wing.

CENTRAL AIR DATA COMPUTER SYSTEM

Prime Contractor: Kollsman Instrument Corporation

Remarks

The Air Data Computer, in production for the Boeing 737, stretched DC-8 and executive jets, was developed to meet requirements of commercial jet transports for an accurate, modular computing system. It operates with proven electromechanical and pneumatic computing elements. Design of the system is completely modular in construction to provide maximum configuration flexibility. Design of the basic computer is not affected by the configuration selected to meet 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. 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.



R-228

APOLLO OPTICAL UNIT ASSEMBLY AND LUNAR MODULE ALIGNMENT TELESCOPE

Prime Contractor: Kollsman Instrument Corporation

Remarks

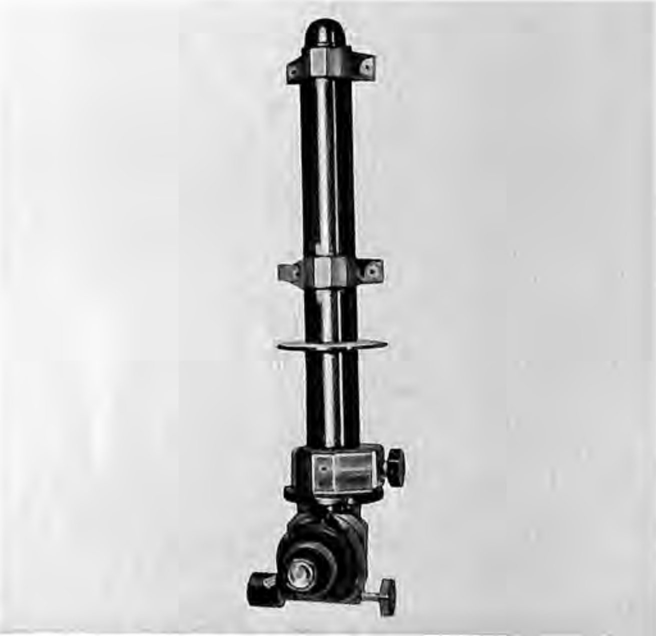
The Optical Unit Assembly (photo) is the primary component of the Apollo Guidance and Navigation optical subsystem. The assembly consists of a scanning telescope and a sextant, which are used in conjunction with the inertial guidance system and onboard computer to periodically establish an inertial reference for measurements and computation, to align the inertial reference by precise optical sightings and to compute the position and velocity of the spacecraft by optical navigation and inertial guidance. Different optical measurements are made at different phases of the Apollo flight. During orbital and midcourse flight phases, optical measurements are used to provide information for determining the position of the vehicle. The OUA Sextant is comprised of a telescope and sextant head. The telescope is a 28-power instrument with a 1.8-degree field of view. Field-of-view accuracy is 10 seconds of arc. The Scanning Telescope is a single line of sight, unity power, 60-degree field of view instrument. It is used primarily for target acquisition and known landmark bearing measurements. The Alignment Optical Telescope is carried aboard the Lunar Module and mounted on a common base with the Inertial Measurement Unit. It is used in conjunction with the guidance computer to align this stable inertial reference before and during descent to, and prior to launch from, the lunar surface. The AOT is a periscopic instrument which provides an instantaneous 60-degree field of view fixed in elevation, by means of an objective prism, at an angle of 45 degrees above the horizontal.

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

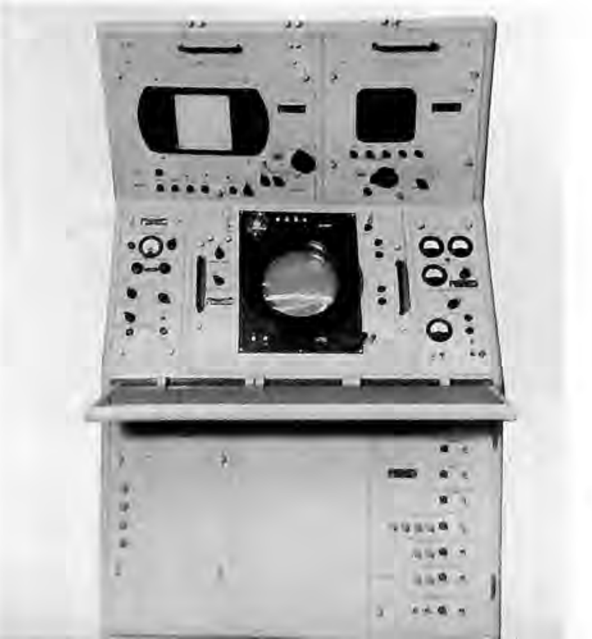
The purpose of the Radar Meteorological Set is to display and record the vertical and horizontal cross section of weather phenomena, such as storms, fronts and precipitation. Accomplishment of this is based on the principle that RF energy radiated into space by the radar set is reflected by weather phenomena 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; it contains the 3 main displays and provides all the necessary operating voltages. The upper part of the console houses the RHI and A/R scopes; the center portion houses the amplifier-detector, the PPI scope and the reference signal generator. More than 100 Radar Meteorological Sets have been delivered to the U.S. Air Force to be used as an integral part of the 433L Weather Observation and Forecasting System.

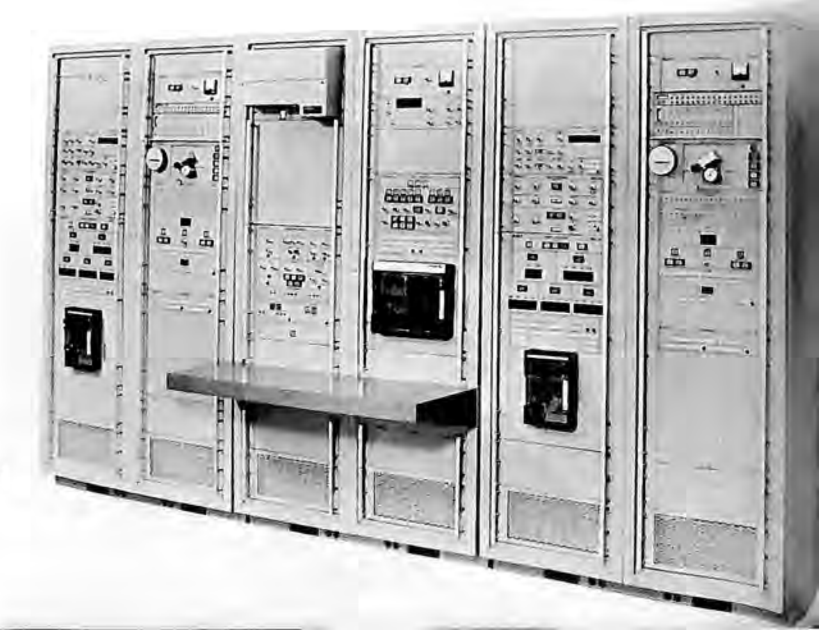
TELEMETRY STATION

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 bar graphs, 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 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.





AUTOMATIC FLIGHT CONTROL SYSTEM

Prime Contractor: Lear Siegler, Inc., Astronics Division

Remarks

The AN/ASW-26 Automatic Flight Control System (AFCS) used in the LTV Aerospace Corporation A-7A Corsair II is a solid-state, high-gain stick steering system that uses series hydraulic actuators. Dual channels (each having a dual actuator) are used for each of the 3 axes. Provisions are included to disconnect both channels automatically if the dual actuator fails to track within a prescribed percentage. The LSI-produced electronics for the 3 axes are packaged in 3 separate containers, one for each dual-channel axis, and they are housed in the same shock-mounted rack. A common elapsed-time indicator, mounted on the rack, records the operating time and presents this information in digital form. Plug-in modules are used throughout the system. A test connector, mounted on the front panel of each computer (control amplifier), provides a quick means of conducting troubleshooting tests without disturbing the installation. It is possible to monitor the position of each of the 3 dual actuators and to display this information on visual indicators in the cockpit. System control switches and channel monitor lights are also mounted in the cockpit. The system incorporates a self-test capacity which allows preflight tests to be performed in the cockpit. Self-test rate gyros and normal accelerometers form a part of this system. The self-test system also checks the monitor system for normal operation. Components of the system (shown clockwise from top) are dual yaw, pitch and roll computers; dual stick force sensor; mode selector; and trim indicators.

DC STATIC CONTROL PANEL

Prime Contractor: Lear Siegler, Inc., Power Equipment Division

Remarks

This DC Static Control Panel makes unusual use of integrated circuits and incorporates all features possible for a 28-volt DC system 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 electromechanical 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 (VSCF) SYSTEM

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. Use of integrated circuits results in smaller and lighter components. Frequent inspections are not required and a lower skill level is required for maintenance because of the simplicity of the electrical design. By the nature of the components, VSCF also demonstrates flexibility in packaging of equipment.

AN/TPQ-11 CLOUD HEIGHT RADAR

Prime Contractor: Lear Siegler, Inc., Data and Controls Division

Remarks

The AN/TPQ-11 Cloud Height Radar has been designed specifically to measure the profile of cloud density directly overhead between 500 and 60,000 feet, and to provide a paper tape recording with graphic indication of cloud density, altitude and time. The equipment components may be deployed with considerable flexibility, the transmitter, antennas and receiver being located as outdoor equipment up to 600 feet from the control console. Two major outputs are available: a modified "A" scope presentation in the control console and a facsimile chart recording generated by a recorder that may be mounted either atop the console or up to 50 feet away. The system operates in the Ka Band (34,500 to 35,600 megacycles); .5 microsecond pulses, at the rate of 100 pulses per second, are directed upward by the transmitting antenna. The radar echoes, which result because of scattering of the transmitted pulses, are intercepted by a second antenna and the radar receiver. The results are viewed on a cathode ray tube display on the console, which presents the echoes and range. In addition, the radar signals are processed so that a facsimile recording of cloud density is produced. The profile of cloud density directly overhead, between 500 and 60,000 feet, is thus measured and recorded on paper tape. Over 50 Cloud Height Radar 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 DECOMMUTATION AND DISPLAY SYSTEM

Prime Contractor: Lear Siegler, Inc., Electronic Instrumentation Division

Remarks

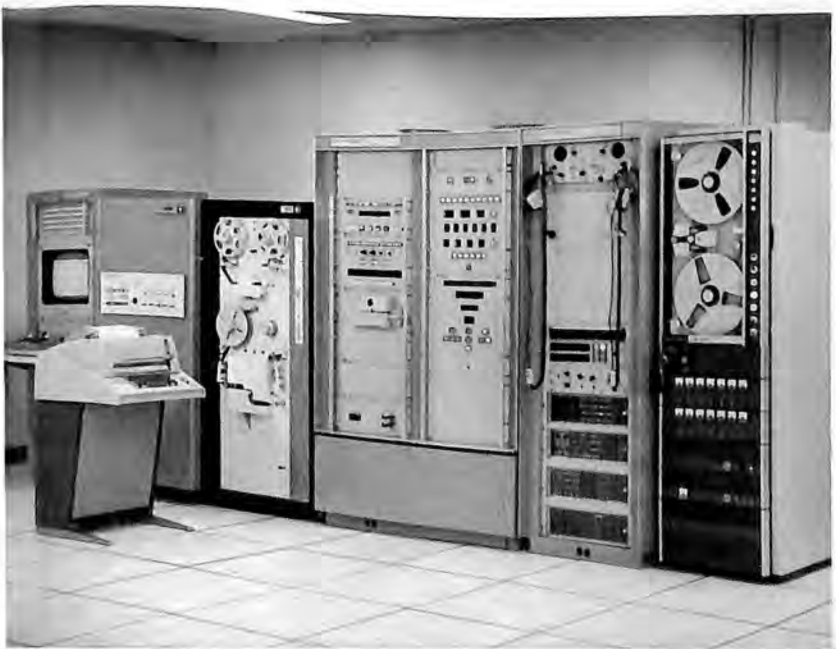
The LSI Model 680 TDDS is capable of accepting and decommutating 4 simultaneous data links at a bit rate of 1,024,000 bits per second per link. Additional arithmetic computations are performed and messages formatted for output to the displays, the line printers and the typewriters. The system consists of 4 Telemetry Processing Subsystems in conjunction with one Central Control Console and various standard computer peripheral equipments and analog quick-look equipment. The TDDS contains all the necessary equipments to accept information that is pulse code modulated (PCM), pulse amplitude modulated (PAM) and pulse duration modulated (PDM). Under the control of the instructions in the executive program, the 680 presents selected digitized data to displays, data transmission equipment, digital-to-analog converters, and IBM compatible magnetic tape recorders. The system can accommodate any of the presently operational telemetry formats, and it is designed to provide total flexibility and anti-obsolescence for anticipated future requirements by the use of stored program equipment and program controlled peripherals throughout the system. The system utilizes 4 general-purpose digital computers, 4 special-purpose telemetry processors with the associated signal conditioning and synchronizing equipment, 12 state-of-the-art CRT display/keyboard stations, 240 10-bit digital-to-analog converters, 4 high-speed (150 ips) digital magnetic tape units, 2 medium-speed (600-line-per-minute) line printers, one digital modem buffer and 4 paper tape and teletype stations together with a complement of card processing equipment.

ASTRONAUT MANEUVERING UNIT

Prime Contractor: LTV Aerospace Corporation, a subsidiary of Ling-Temco-Vought, Inc.

Remarks

The Astronaut Maneuvering Unit is a backpack device designed to permit an astronaut to leave his orbiting capsule and perform useful tasks in space, looking toward the day when man will assemble and service spacecraft in orbit, transfer from vehicle to vehicle and move equipment. The AMU equips the pressure-suited astronaut with a complete propulsion system for maneuvering, an automatic stabilization system and 2-way communications, plus oxygen, pressure and temperature systems. The 160-pound pack has sufficient oxygen for nearly 2 hours of operation outside the parent spacecraft. The astronaut maneuvers and travels by operating controls located on 2 arms extending forward of the pack. The pack has 12 hydrogen peroxide reaction jets, 4 firing forward, 4 rearward, 2 up and 2 down.



MANEUVERING WORK PLATFORM AND SPACE TAXI

Prime Contractor: LTV Aerospace Corporation, a subsidiary of Ling-Temco-Vought, Inc.

Remarks

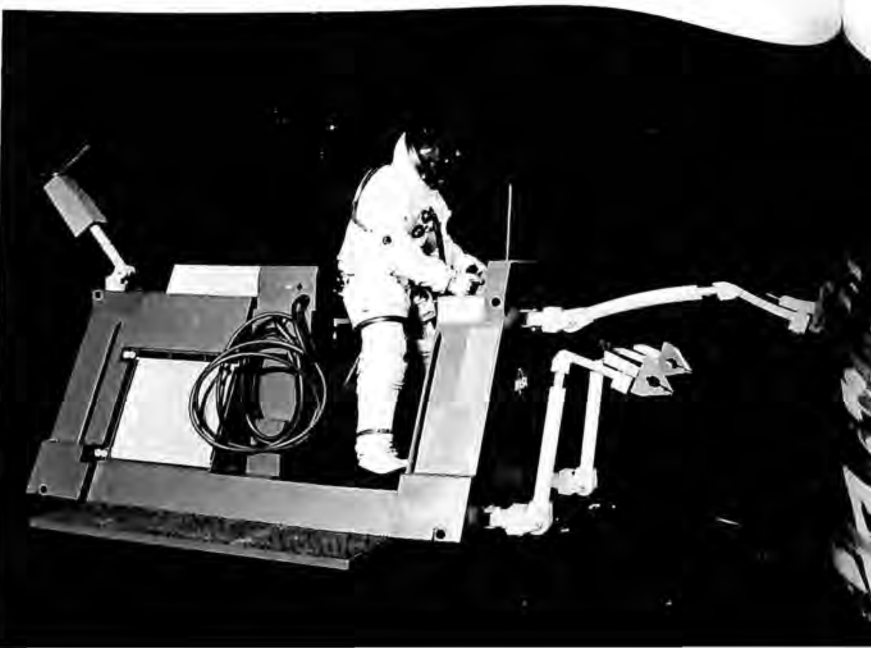
Two advanced extravehicular units, which could operate from a spacecraft to perform construction, maintenance and servicing tasks at orbital work-sites, have been designed by LTV Aerospace Corporation's Missiles and Space Division. The company performed conceptual design work and constructed full-scale mock-ups under contract to NASA's Marshall Space Flight Center. The Maneuvering Work Platform (shown), 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 extendible docking and anchoring grapplers. The Space Taxi is completely enclosed, permitting "shirt-sleeve" 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 on board, plus an external supply of expendables weighing up to 200 pounds. However, by using modules such as a tanker section or a "truck bed," it could accommodate far greater loads. The Space Taxi could carry nearly 400 pounds of such equipment on board, plus some 800 pounds of expendables mounted externally. Each would be propelled and maneuvered by 25 hydrazine-powered jets. The work platform can be extended to accept a variety of modules, including a variable-geometry cargo frame which can be assembled in space, without tools, from interchangeable aluminum tubing sections.

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 temperatures as low as minus 320 degrees Fahrenheit. Twenty xenon-mercury high-pressure lamps of 2,500 watts each permit solar simulation temperatures.



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 can operate from a standard power cart, using its own antennas. The van is completely self-contained and is mounted on retractable wheels. It is equipped with a visual situation display and has complete communications links in HF, UHF and VHF, with 14 operating stations (photo), each provided with a hinged writing surface and a pedestal console equipped for fingertip selection of any of 4 transceivers in the 20-transceiver bank.

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 DATA ACQUISITION SYSTEM

Prime Contractor: Lockheed Aircraft Service Company

Remarks

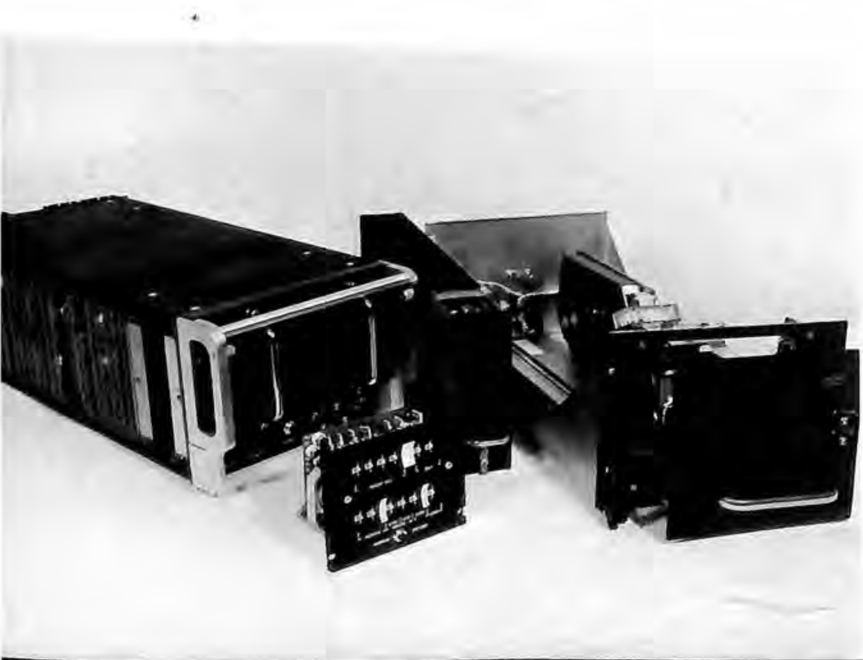
The aerospace industry's first automatic airborne data acquisition system (ADAS) was developed and manufactured by Lockheed Aircraft Service Company. First units were delivered to Trans World Airlines for its fleet of DC-9 jet transports. The DC-9 installation, monitoring 50 separate parameters of engine information, marked the first fleetwide application of automatic airborne data collection to provide a daily "health report" on aircraft engines and systems. ADAS is designed to reduce DC-9 cockpit paper work by automatically recording data reflecting the state of performance of all monitored components. Recorded on punched paper tape, data is transmitted by teletype to the airline's overhaul base at Kansas City, Missouri, where rapid computer analysis and printout permit 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.



MULTIFUNCTION HELICOPTER ROTOR-BLADE RADAR SYSTEM

Prime Contractor: Lockheed Electronics Company, Military Systems Division

Remarks

Lockheed Electronics Company has designed, developed and flight tested a Multifunction Helicopter Rotor-Blade Radar System. Unique features of the system are the rotor-blade antenna, providing 360-degree radar visibility for ground mapping, and an orthogonally placed vertical antenna giving the third spatial dimension—elevation. The combined use of the rotor-blade and vertical antennas is called the cross-beam system. This approach extends the rotor blade radar beyond the mapping mode to a true multifunctional radar. The cross-beam system, proved in flight tests, adds terminal navigation/landing, terrain clearance/avoidance, weapons/munitions delivery and air-to-ground signaling capabilities to the helicopter's versatility. Major advantages of the rotor blade antenna are large antenna aperture for narrow azimuth beam-width and high mapping resolution, unimpeded radar vision (360 degrees, map mode), increased azimuth data rate in forward sector scan (multiblade use), inherent azimuth scanning at rotor blade speed, undisturbed aircraft aerodynamics and performance, and savings in vital aircraft space and weight. The Lockheed Electronics Company multifunction helicopter rotor-blade radar is a highly compatible system because its modular design and an "around-the-mast" RF rotary joint, in addition to the in-line rotary joint, make the radar adaptable to both hollow and solid drive shaft helicopters. In photo, flight test of the system aboard Enstrom F-28 test-bed.

RADAR SET AN/VPS-2

Prime Contractor: Lockheed Electronics Company, Military Systems Division

Remarks

Radar set AN/VPS-2 was designed and is being produced by Lockheed Electronics Company as an integral part of the U.S. Army's forward area Vulcan Air Defense System. The radar automatically provides accurate range and range rate inputs to the fire control system. Since the radar set operates in a high clutter environment, it has been designed to acquire and track a moving target which is buried below a signal return from ground clutter 10,000 times as large as the target. The Doppler principle is used to discriminate between stationary targets and moving targets. The equipment is a coherent Doppler, moving target indicator (MTI), X-band radar. When there are no targets in the radar line of sight, the radar automatically searches in range and a target within its range will be acquired automatically. After lock-on, the radar continuously transmits the range and range rate values to the gun sight as analog voltages. To prevent the radar from losing targets that may move into a fade area, an automatic coast feature is provided. This feature enables the radar to continue to track, for a short time, a faded target so that it may be reacquired when it comes out of the fade, without interrupting the fire control solution. Modular design is used to facilitate maintenance and to enhance accessibility of units for replacement. Equipment is housed in small units so that it will fit within the limited vehicle space available. Radar circuitry is completely solid state, except for the klystron RF power amplifier. Microcircuit units are used in all digital elements of the equipment. Provisions are included for rapid boresighting of the antenna and for checking the operation of the equipment in the field. A neon lamp monitors the RF energy transmitted while a power meter may be used to check transmitter tuning.

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 tricolored beam of amber, green and red, the pilot can tell his relative angle of approach to the airstrip by straight-line sight. Amber means he is too high, red too low; the green light is the safety zone for a smooth and safe landing.

Specifications

Weight 35 pounds; unit size 21x21 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 kilowatt 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 Division

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.

SNAP-9A RADIOISOTOPE THERMOELECTRIC GENERATOR

Prime Contractor: Martin Marietta Corporation, Baltimore Division

Remarks

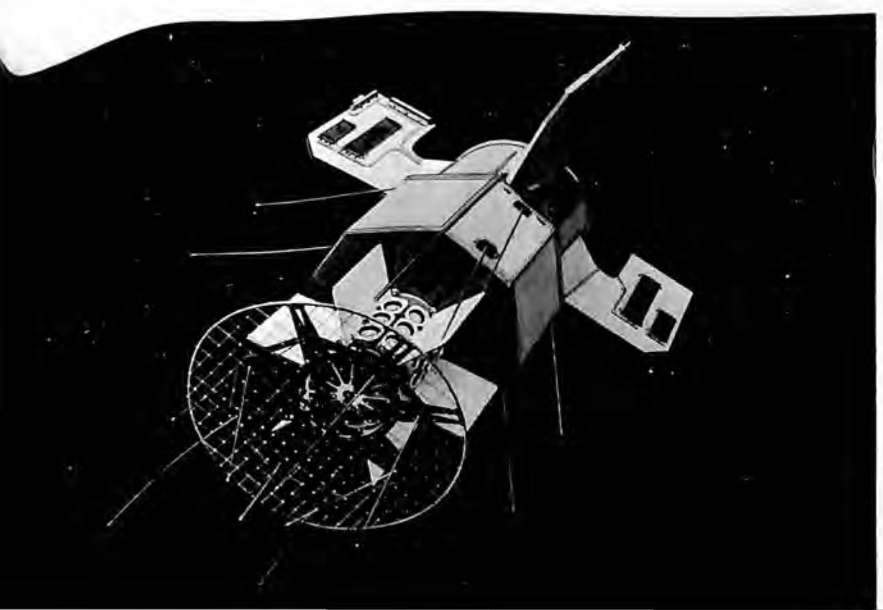
Two SNAP-9A radioisotope thermoelectric generators are in orbit aboard Navy navigation satellites (in photo, SNAP-9A is finned cylinder). The one launched in September 1963 was the first all-nuclear power system to be used on a satellite. The second is part of a 3-satellite navigational system for fleet 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. 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 Division

Remarks

BIRDiE is an electronic, semiautomatic air defense coordination and fire distribution system which makes optimum use of electronics, with human supervision imposed at critical points. BIRDiE provides effective air defense by automatic acceptance, generation, processing and distribution of pertinent target data for guided missiles. It can also monitor and/or direct fire unit activity and can even operate autonomously if higher command inputs are interrupted. One of its features is that all functions of surveillance, entry, tracking, monitoring and friendly protection are combined into a single situation display console. BIRDiE is transistorized and transportable. The system can be tailored to meet the size of the defense battery requirements.

MINESWEEPER LIQUID SPRINGS

Prime Contractor: Menasco Manufacturing Company

Remarks

A new concept in naval minesweeping has resulted in the application of blast protection techniques for both ship command and control personnel and vital systems equipment. A system has been designed which locates these personnel and this equipment within a modular pilot house. The module is in turn isolated from the ship structure by an interreacting system of 8 liquid springs. This system affords isolation from the effects of very severe displacements and accelerations transmitted through the hull in the event of any hostile weapons detonations. Liquid springs were chosen as the shock and blast mitigators of this integrated system because of their outstanding reliability and minimal maintenance requirements, their inherent characteristics of widely variable static load and input dynamics, and thousands-of-cycles repeatability. Similar units have been in service for years without indications of leakage or wear and have required no maintenance whatever. All materials utilized in these units are of the high-strength type, selected for maximum resistance to salt spray corrosion and galvanic reactions.

Specifications

Envelope: diameter 8 inches, length 49 inches; mitigating stroke plus or minus 7.5 inches; nominal precharge pressure 16,000 pounds per square inch.

Performance

The system mitigates the shock input to a 55,000-pound module at a ratio of approximately 7 to 1.

P-3 ORION LANDING GEAR SYSTEM

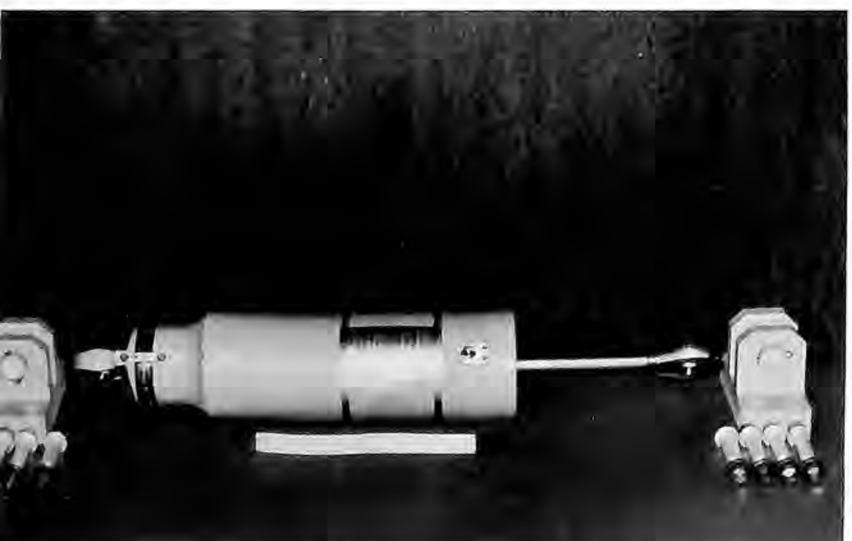
Prime Contractor: Menasco Manufacturing Company

Remarks

The P-3 Orion Landing Gear System is made up of 2 dual-wheel retractable main landing gears and a dual-wheel retractable nose gear. The nose gear is supplied with a sealed rack and pinion hydraulic steering motor and control valve. Both the main gear and the 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.



MINUTEMAN II AND III GUIDANCE AND CONTROL SYSTEM

Prime Contractor: Autonetics Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

Microelectronics is the key to major technical improvements incorporated into the Air Force's Minuteman II and III ICBMs. New equipment being furnished by the Autonetics Division, associate contractor for guidance, flight control and ground check-out equipment, includes an inertial guidance platform featuring use of pendulous integrating gyro accelerometers and a new gyrocompass azimuth assembly that provides backup to the primary optical reference; microelectronic airborne digital computer with expanded memory capacity, functional capability, greater reliability and reduced size and weight; and liquid injection for more efficient Stage II rocket motor flight control. Most of the flight control electronics have been incorporated into the "upstage" portion of the system, housed in the lightweight magnesium/cork guidance body section. The "downstage" portion includes an angular accelerometer unit similar to that in Minuteman I, Stage I and III nozzle control units, 2 Stage II electrohydraulic control units, and all-electrical cabling. Key element in the missile's N17 guidance system is the microelectronic computer that accepts information from sensing instruments mounted on the inertial platform and compares it with previously stored information. When course and speed deviations are noted, the computer signals the flight control equipment, which then directs rocket engine thrust toward the proper trajectory. In preflight operational deployment, the computer performs regular checks and reports on missile flight readiness.

POLARIS-POSEIDON SHIP'S INERTIAL NAVIGATION SYSTEMS (SINS)

Prime Contractor: Autonetics Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

Ship's Inertial Navigation Systems (SINS) enable Navy Polaris and Poseidon submarines to navigate submerged for long periods of time and to fix precisely their missile-launching positions. This self-contained system consists basically of a digital computer, velocity meters and an inertial platform stabilized by gyroscopes. Automatically and accurately, SINS sense a ship's accelerations, measure them and provide results in the form of continuously available position information, heading and velocity. Autonetics' first production-model SINS were installed in 1959 aboard the *George Washington*, the nation's first Polaris submarine. Under subsequent contracts, Autonetics became SINS supplier for the balance of the Navy's 41-ship Fleet Ballistic Missile force and those being built in the United Kingdom for the Royal Navy. Autonetics is now modifying and updating SINS aboard 31 of these submarines for the advanced Poseidon missile. This model includes an additional gyro that monitors and corrects the drift rates of other gyros to increase overall system accuracy. Other versions of the Autonetics' SINS are operational aboard U.S. Navy attack submarines, 3 attack carriers (USS *Enterprise*, USS *Independence* 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.

F-111 ADVANCED AVIONICS

Prime Contractor: Autonetics Division, Aerospace & Systems Group, North American Rockwell Corporation

Remarks

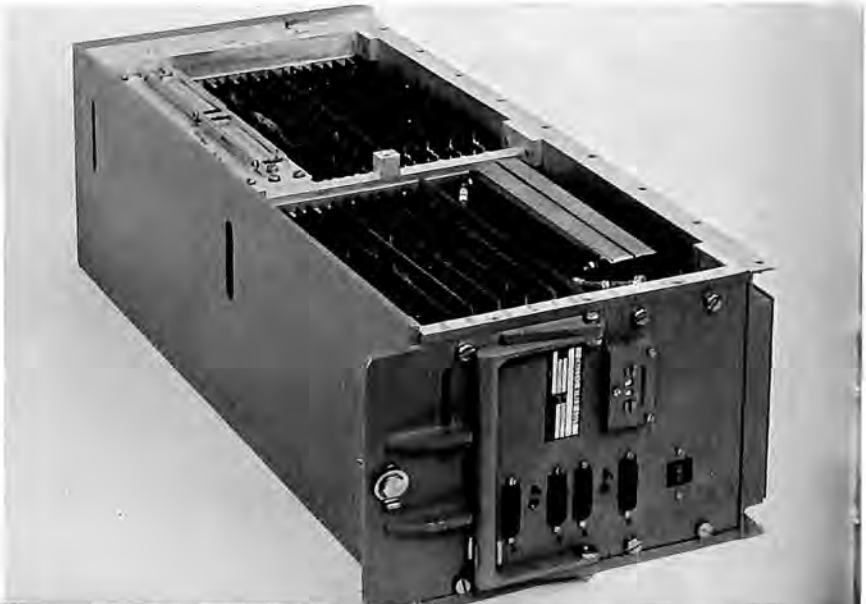
F-111D and FB-111 avionics, initially designated Mark II and Mark IIB, are second-generation systems designed to give the Air Force's swing-wing F-111D tactical fighter and FB-111 strategic bomber pinpoint navigation and weapons delivery accuracy through an integrated, computer-controlled blend of navigators, radars, displays and other major subsystems. FB-111 avionics will be in all FB-111 aircraft. Flight tests began in 1968. F-111D avionics, which will be used in all D versions of the F-111 tactical fighter aircraft, are scheduled to become operational within a few years. F-111D and FB-111 avionics are the nation's most advanced airborne systems. F-111D avionics is an integrated armament control system containing an attack radar, inertial navigation system, central digital computer complex, cockpit display system, 2 head-up displays, a multisensor display and vertical and horizontal situation displays. F-111D avionics enables the aircraft to penetrate more safely and to find and destroy targets more easily. FB-111 avionics is an integrated armament control system containing an inertial navigation system, central digital computer complex and related equipment. Autonetics is producing the N-16H inertial navigation set with a 12-bit 4,096-word D26J-41 microelectronic inertial measuring computer and a battery power supply; AN/APQ130 multimode radar; navigation and weapons delivery computers; head-up displays and display set; horizontal situation display; signal converter; display panels for stores control, flight data, navigation data, navigation control, test and maintenance; AN/APN189 Doppler radar and stores management. In photo, the D26J-41 computer.

F-105/R14A MULTIMODE, MONOPULSE RADAR

Prime Contractor: Autonetics Division, Aerospace & 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, 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.



INTEGRATED COMMAND DISPLAY SYSTEMS

Prime Contractor: Northrop Corporation

Remarks

Integrated display systems built by Northrop Corporation gather far-flung operational information and convert the data to multicolored dynamic projections which help command and control personnel in their decision-making tasks. Such multicolor displays now handle the demands of military commanders for clear and timely information in over 20 field locations. Three types of projection equipment, called Vigicon, generate the large-screen display, virtually in real time. In addition, the collection of hardware in the integrated command display system includes a computer, tracing table and teletype equipment for manual inputs. The Northrop Nortronics systems now in use provide a variety of display tasks: satellite tracking, missile launch simulation, training, military air and ground displays, weapons control and fleet operation.

TEST EVALUATION AND MONITORING SYSTEM

Prime Contractor: Northrop Corporation

Remarks

The Navy's new Knox-class destroyer escorts have the fleet's fastest troubleshooter—an automatic check-out system that 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 check-out 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 3 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 DIGITAL COMPUTERS

Prime Contractor: Northrop Corporation

Remarks

With orders for more than 250 airborne computers, Northrop is today one of the largest producers of such equipment in the United States. Northrop's diversified family of low-cost computers can be tailored to meet specific demands. Accomplishments of Northrop's Nortronics Division in the specialized computer field include: (1) a contract for airborne computers for the C-5 inertial-Doppler navigation system, (2) a contract for the computers for the C-5 Malfunction Analysis and Recording (MADAR) system, (3) completion of USAF acceptance tests on the NDC-1050A and its integration into an Air Force navigation system for flight tests and (4) introduction of the NDC-1051, 1060, and NDC-1070 series of general-purpose airborne digital computers for aerospace uses. All are solid-state microelectronic devices for which an extensive library of checked-out routines, subroutines, tests and other software packages is available. In photo, the 56 integrated circuit assemblies in the Nortronics NDC-1051 conductively cooled logic section.

C-5 INERTIAL NAVIGATION SYSTEM

Prime Contractor: Northrop Corporation

Remarks

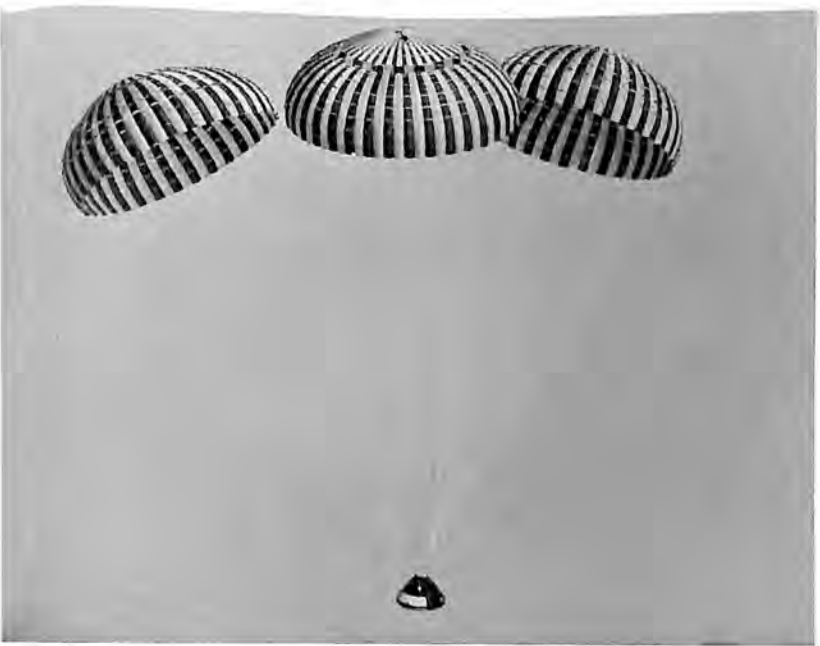
The U.S. Air Force C-5, the world's largest aircraft, will be the first cargo plane to use both inertial and Doppler navigation systems. Northrop Corporation's Nortronics Division is producing the inertial-Doppler system under a contract awarded by Lockheed-Georgia, a division of Lockheed Aircraft Corporation. Accuracy of the system will be better than 1 nautical mile per hour. Without 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.

APOLLO EARTH LANDING SYSTEM

Prime Contractor: Northrop Corporation

Remarks

The Apollo Earth Landing System qualification test program was completed in 1968. Certain system components were 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 16.5-foot-diameter drogue parachutes, 3 7.2-foot-diameter ringslot pilot chutes, and 3 ringsail-type main parachutes each having a canopy diameter of 83.5 feet. Major improvements to the system were the utilization of larger drogues and a 2-step reefing method for the main parachutes. System operation begins at an altitude of 25,000 feet, where a barometric pressure switch initiates a pyrotechnic device which jettisons the forward heat shield, exposing the parachute compartment. Two seconds later, the drogue parachutes are mortar-deployed for stabilization and deceleration. At about 10,000 feet, the 3 pilot chutes are deployed, also by mortar, and each subsequently extracts its respective main parachute. Landing speed is approximately 31 feet per second with 3 parachutes functioning; 38 feet per second, with 2.



XM129 GRENADE LAUNCHER

Prime Contractor: Aeronutronic Division, Philco-Ford Corporation

Remarks

The XM129 is a lightweight, externally powered grenade launcher which fires 40-millimeter, high-velocity M384/M385 ammunition. A gear train rotates a drum cam which is mounted concentric to the bore. The cam reciprocates the barrel one full cycle per revolution of the drum cam. The functions of feeding and firing are also governed by cams. The XM129 can be powered by a motor or hand crank at rates up to 440 shots per minute. It can be assembled to feed from either side; and, because the center of gravity coincides almost exactly with the centerline of the bore, mounting problems are greatly reduced. The XM129 is the area target weapon for the Army's AH-56A Cheyenne helicopter. In addition to helicopter applications, the XM129 is a candidate for use on riverboats and ground vehicles. The XM129 is in quantity production at Aeronutronic for Army Weapons Command.

Specifications

Weight 43 pounds; length 23.5 inches; width 8.9 inches; height 9.2 inches; rate of fire up to 440 shots per minute; range 2,200 meters; muzzle velocity 790 feet per second; method of feed, belt.

XM140 AUTOMATIC GUN

Prime Contractor: Aeronutronic Division, Philco-Ford Corporation

Remarks

The XM140 is an electrically powered, single-barreled automatic gun which fires the XM552 HE-DP 30-millimeter dual-purpose ammunition. It is a lightweight, compact combination area and point target, aircraft-type weapon, with recoil force characteristics compatible with helicopter and light aircraft structural limits. Half of the entire gun mass is dynamically soft-mounted within the gun cradle so that peak recoil and counter recoil forces are minimized. An electric motor drives the reciprocating barrel for chambering of the ammunition and to drive the feeder. Nominal fire rate is 425 shots per minute. The weapon can be assembled to feed from either side. Replacement of the entire gun in a turret can be accomplished in less than 5 minutes. The XM140 is the primary armament on the Army's AH-56A Cheyenne helicopter. In addition, potential applications exist for the XM140 on ground and water vehicles. The XM140 is in final development by Aeronutronic for Army Weapons Command.

Specifications

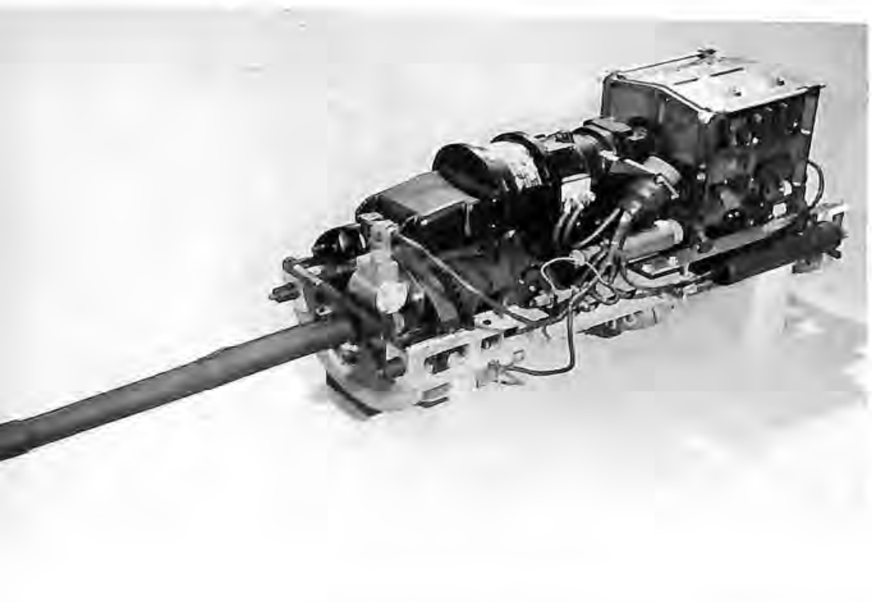
Weight 150 pounds; length (barrel forward) 54.5 inches; length (barrel rearward) 47 inches; width 12.2 inches; height 14.4 inches; rate of fire 425 shots per minute; range 3,000 meters; muzzle velocity 2,200 feet per second; method of feed, disintegrating link belt.

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 being installed and used in U.S. Air Force C-130 aircraft. 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 signals from the nose and forward main landing gear sensors, is applied to the center of gravity computing network. The resulting center of gravity computation is displayed by the computer as a percent of the mean aerodynamic chord. 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. Availability of accurate weight information during loading permits better performance with attendant reduction in fuel consumption. Turnaround time is greatly reduced by quick determination of weight and balance. The STOW system is accurate to within 1 percent under all normal operating conditions.



SATURN GROUND COMPUTER SYSTEM

Prime Contractor: RCA, Defense Electronic Products, Electromagnetic and Aviation Systems Division

Remarks

The Saturn Ground Computer System is an on-line, real-time computer system utilized to perform automatic check-out and launch control functions for the Saturn IB and Saturn V launch vehicles. The input/output capabilities are tailored to NASA needs on the Apollo program. The RCA 110A SGCS is very well-suited to meet NASA requirements for increased automatic control, flexibility, check-out capacity, accuracy, speed and reliability. This computer system is the first process control machine to offer a general-purpose organization featuring core memory and an automatic priority interrupt system for efficient multiprogramming. Unit consists of 19 to 20 cabinets including the following systems or subsystems: data link, discrete, interface to digital data acquisition system and analog system. The RCA system is used for check-outs in static captive firings, unit tests and actual launch procedures. Twenty-four systems will be placed in use for testing of individual instrumentation units or booster units and 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 through 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.

TRANSPORTABLE COUNTERMEASURE SYSTEM

Prime Contractor: RCA, Defense Electronic Products, Electromagnetic and Aviation Systems Division

Remarks

The Transportable Countermeasure System is in production in RCA's Electromagnetic and Aviation Systems Division. The first system was delivered on schedule 13 weeks after contract award and was operationally tested immediately after delivery. The division, located in Van Nuys, California, is a major supplier of electronic warfare systems to the Navy. It also has contracts in this area with the Air Force and with the Army. Other work being performed by the division includes investigation of threats to ground-based, shipborne, airborne and orbital military vehicles. EASD has performed work on all major electronic countermeasure techniques such as barrage, spot-noise jammers, inverse gain, control, conical scan repeaters, range gate pull-off, Doppler deception, LORO defeat, electronic countermeasure synthesis and intercept receiver techniques. Some of the other contractual work that the division has or is engaged in includes development or manufacture of automatic airborne electronic countermeasure systems, automatic airborne spot-noise jammer systems, radio frequency amplifiers, radio frequency oscillators, electronic countermeasure techniques for use in high-altitude orbital flight, universal radio frequency oscillators and line-of-sight electronic countermeasure systems.

VIDEO DATA DISPLAY TERMINALS

Prime Contractor: RCA, Defense Electronic Products, Electromagnetic and Aviation Systems Division

Remarks

RCA's Electromagnetic and Aviation Systems Division has developed a series of flexible video data display terminals. Several unique features characterize RCA video terminals: high quality of displayed characters; simplified, reliable electronics system contained in 6 logic boards; flexible interface contained on 2 of the 6 logic boards, simplifying interface to various computers. The total system is contained in a single desk-top unit. One thousand units are in use, and the production rate exceeds 100 per month. Operational characteristics: the operator may compose and edit a message in an off-line mode; single character, line, and screen erase, as well as data insertion, is simply accomplished through the keyboard for off-line editing ease; upon completion of message composition, a keyboard switch transmits the message, holding costly computer time to a minimum; after transmission, the display terminal will await a return response, return to the write mode or redisplay the message to provide a check for transmission errors. Optional features include single gun, multicolor displays, graphic presentations, special function keyboards, hard-copy printout and large-screen group displays. Alternate page formats in excess of 5,000 characters, having 80 or 110 characters per line, are available. Qualified military designs for airborne, shipboard, or tactical ground systems where severe environments are encountered are operational.

LUNAR MODULE SYSTEMS

Prime Contractor: RCA, Defense Electronic Products, Aerospace Systems Division and Defense Communications Systems Division

Remarks

RCA has multiple systems responsibilities in connection with NASA's Lunar Module, shown descending to the moon after separation from the Apollo spacecraft. RCA provides the DECA (Descent Engine Control Assembly) which regulates the engine thrust over a wide range from a maximum of 10,500 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: RCA, Defense Electronic Products, Missile & Surface Radar Division

Remarks

The Real-Time Telemetry Data System is an electronic system capable of unprecedented speed, accuracy and simplicity in processing and distributing scientific information transmitted to earth from missiles and space vehicles. The central station of the RCA-built system is at Telemetry Station 4 of the Air Force Eastern Test Range, with other stations on 4 downrange island installations and still others installed aboard tracking ships. The system allows mission directors to program in advance of the flight the data desired from a spacecraft or missile. The information is then transmitted from the downrange stations to the central station in real time in uniform digital form that can be stored, retransmitted and modified by computer. This eliminates the need to station at these remote areas medical, engineering and other specialists to monitor and interpret incoming data from space vehicles. It also speeds and simplifies postflight analysis of the performance of missiles and space vehicles.

AN/FPQ-6 PRECISION INSTRUMENTATION RADAR

Prime Contractor: RCA, Defense Electronic Products, Missile & Surface Radar Division

Remarks

The AN/FPQ-6 Instrumentation Radar and its transportable version, the AN/TPQ-8, are the newest generation of precision trackers for observation of the flight characteristics of missiles and space vehicles. Either can skin-track a target of 1 square meter in cross section to a range of about 600 nautical miles and is equipped for transponder tracking to 32,000 miles. Both have 29-foot Cassegrain antennas with 5-horn feed, 3 megawatt transmitters and low-noise (8 decibels) receivers. Both have angle tracking precision of .05 mil and systematic errors of plus/minus 2 yards in range. The installation pictured, developed for the Air Force Western Test Range and stationed at Point Pillar, California, uses integrated circuits for all circuitry in its digital range machine, computer and video integrator and receiver to reduce system space, power and air-conditioning requirements. RCA also produced the AN/FPS-16 radar, part of the national space tracking network, standardized for use by the military services and NASA. The AN/FPS-16 and its air-transportable counterpart, AN/MPS-25, are C-band radars that can acquire and automatically track passive or active targets with velocities up to 10,000 yards per second. More than 60 of these stations are in use.

HAND-HELD TACTICAL RADAR

Prime Contractor: RCA, Defense Electronic Products, Missile & Surface Radar Division

Remarks

Several years ago RCA decided to leapfrog existing lightweight tactical radar technology by developing the first all-solid-state hand-held tactical radars. The first model (photo) weighed 2.2 pounds exclusive of battery and headphones; it was designed for use as a weapons sight, especially on the M-79 grenade launcher. Three new models have been developed for use in surveillance, perimeter defense, airfield security and ambush operations. These instruments weigh, with self-contained battery and scanner, about 10 pounds, and they can detect man-sized targets at ranges up to 1,500 meters. They are being produced for all of the military services. Additional development, now taking place, will adapt the radar's circuitry and packaging for use in radar altimeters, collision avoidance instruments, small boat navigation and medical electronics.

CAPRI

Prime Contractor: RCA, 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. 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. The first group of CAPRI radars will be trailer-mounted for mobile use on White Sands Missile Range. In photo, CAPRI antenna.

LASER TRACKING AND RANGING SYSTEM

Prime Contractor: RCA, Defense Electronic Products, Astro-Electronics Division

Remarks

The laser tracker shown is a prototype of a new system that could be used on the moon to track exploring astronauts and to help survey the lunar surface. The prototype was built to prove the feasibility of using a laser to automatically follow and determine the position of an astronaut or roving vehicle on the moon. A Gallium Arsenide (GaAs) injection laser produces light pulses, invisible to the human eye, which are returned by a specially designed reflector consisting of a cluster of corner cubes. The reflector, mounted on a staff carried by the exploring astronaut or roving vehicle, will transmit a pulse back to the tracker regardless of which way the staff is turned. The tracker can compute the range or distance to the exploring astronaut by measuring the time difference between transmitted and reflected pulses. The laser automatically locks on to the reflector. Range of the prototype is half a mile, but the system is capable of a 5-mile range with accuracy of less than 3 feet.

AN/TRC-97 TROPOSPHERIC SCATTER RADIO RELAY EQUIPMENT

Prime Contractor: RCA, Defense Electronic Products, Defense Communications Systems Division

Remarks

The AN/TRC-97 is a solid-state radio relay terminal providing tunable microwave, diffraction or tropospheric scatter communications in the military band of 4,400 to 5,000 megacycles. With power equipment and antenna in a standard trailer, the entire AN/TRC-97, designed for quick reaction tactical use, is readily transportable by ¾-ton truck or suitable aircraft; it can be set up and in operation within an hour after arrival at site. The antenna system consists of 2 8-foot parabolic antennas, which can be set up and aligned in less than 40 minutes. 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 COMMUNICATIONS SATELLITE TERMINALS

Prime Contractor: RCA, Defense Electronic Products, Defense Communications Systems Division

Remarks

The SHF TACCOMSAT 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 TACCOMSAT Terminals will offer significant reliability improvement. Five configurations are to be supplied: airborne, manpack, teampack, jeep-mounted and 1¼-ton truck shelter terminals. Multifold size and weight reduction and high performance will be achieved through state-of-the-art techniques such as differential PSK modulation, parametric amplifiers and ultrastable frequency control components. Except for the manpack, which is a receive-only unit, each system contains a low-noise uncooled receiver, exciter, power amplifier, beacon receiver and associated terminal equipment such as teletype, vocoders and digital modems. Doppler correction is integral to the airborne system. The tactical stations will be tested with an experimental earth-synchronous satellite by all 3 military services.

LAND COMBAT SUPPORT SYSTEM

Prime Contractor: RCA, 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 electro-optical 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 electro-optics. 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.

VARIABLE INSTRUCTION COMPUTER (VIC)

Prime Contractor: RCA, Defense Electronic Products, Aerospace Systems Division

Remarks

The Variable Instruction Computer is a joint RCA/USAF development which makes available to the aerospace computer user a high degree of flexibility, modularity and reliability. For example, this digital computer can, in effect, alter its internal logic to fulfill a wide variety of aerospace applications such as command and control, automatic test systems and avionics and weapons control. A specific application provides compatibility with a ground-based 7090 command and control computer via the JOVIAL J2 Compiler. Making extensive use of integrated circuits and modular construction, this general-purpose 36-bit parallel word machine has redundant 400 Hz power supplies and completely independent 4,096-word main memory modules for reliable operation. The expanded configuration of this system is 4.4 cubic feet; it weighs 175 pounds and has a 32,768-word capacity. VIC's 3-microsecond main memory and .6-microsecond high-speed memories enable it to interface with a wide range of high-speed data processing and communications equipment for future airborne command posts. The system's unique variable instruction technique provides a powerful tool for compatibility and commonality with ground-based C^2 computers.

AIR TRAFFIC CONTROL CENTRAL AN/TSW-7

Prime Contractor: RCA, Defense Electronic Products, Aerospace Systems Division

Remarks

The AN/TSW-7 Mobile Control Tower is a lightweight, air-transportable, self-contained unit capable of providing the communication and navigation aid facilities necessary to control aircraft on or within the terminal area of an airfield. Basically a second-generation system to the RCA-developed AN/TSW-6, the AN/TSW-7 configuration takes advantage of the latest advances in the development of new techniques and hardware design, such as highly reliable solid-state UHF and VHF radios, DF digital displays, solid-state power supplies, a new antenna coupling scheme and a unique UHF/VHF antenna design. Adaptable as well as versatile, the AN/TSW-7 allows operation in arctic or tropical areas against the full range of hostile environments including temperatures from −40 to +125 degrees Fahrenheit. Within these environmental extremes, the system has the flexibility of autonomous operation, or it can be efficiently interfaced with all ATC systems, including civil and military, foreign and domestic installations.

MULTISENSOR DISPLAY

Prime Contractor: RCA, Defense Electronic Products, Aerospace Systems Division

Remarks

RCA has developed, under company sponsorship, a scan converter cathode ray tube display prototype to be used in conjunction with RCA's Weather Radars AVQ-20/30 and closed-circuit television. The need for TV displays on the new superjets, such as the Boeing 747, prompted this development. The new system, using small television cameras at strategic locations throughout the plane, will enable pilots to view these points on the same 5-inch radar screen that is used to display information on what kind of weather lies hundreds of miles ahead. When the radar is not required for weather observation, the crew can flip a switch to convert the screen for pictures beamed from cameras mounted on the aircraft. Among other data, this will give a pilot a complete view of the landing gear and its relation to lines and markers while taxiing to and from runways and loading ramps. This is particularly important with the new superjets, whose sheer size makes ground maneuvering difficult. RCA has also recently completed a Scan Converter Display (SCD) to interface with the AN/APQ-116 Radar on the A-7 aircraft. It is designed as a direct replacement for the IP-799/APQ-116 Storage Tube Indicator (DST). The SCD model has dimensions which exactly match the present indicator; it provides TV presentations of Walleye video, and all the modes of the radar. The design is completely compatible with the Sweep Generator of the APQ-116 Radar.

SABRELINER THRUST REVERSER

Prime Contractor: Rohr Corporation

Remarks

Rohr Corporation has entered the field of design and production of thrust reversers for the growing number of business jets, with the Sabreliner an example of advances in this area. Sabreliner models NA 265-40 and NA 265-60, utilizing Pratt & Whitney Aircraft JT12A-6A (3,000 pounds thrust) or JT12A-8A (3,300 pounds thrust) engines, have been equipped with Rohr-designed target-type thrust reversers. The unique design of this system is characterized by the reverser doors' forming an ejector barrel around the tailpipe when the doors are stowed. Deployment of the doors is effected by rotating each door about a single pivot point in such a way that the trailing edges of the door meet at the center of the jet, causing the jet to divide and exit with an equal reverse component for each half-jet. The development of these doors resulted in a circumferential slot cut in each door. The slots serve several purposes: hot gas impingement on the fuselage was lessened, reducing skin temperatures as much as 200 degrees Fahrenheit; take-off thrust was improved by 2 percent because of improved ejector efficiency; back pressuring of the engine in reverse thrust was reduced to within tolerable limits. Incremental weight of the system is 64 pounds. Operationally, the reverser system augments the airplane's wheel brakes on landing ground roll and rejected take-off. The reverser efficiency, 35 percent for the -6A engine and 41 percent for the -8A, has been demonstrated to be adequate to bring the aircraft almost to a complete stop, without brakes, without incurring reingestion of the exhaust gases.

COMMUNICATIONS SATELLITE ANTENNA

Prime Contractor: Rohr Corporation, Antenna Division

Remarks

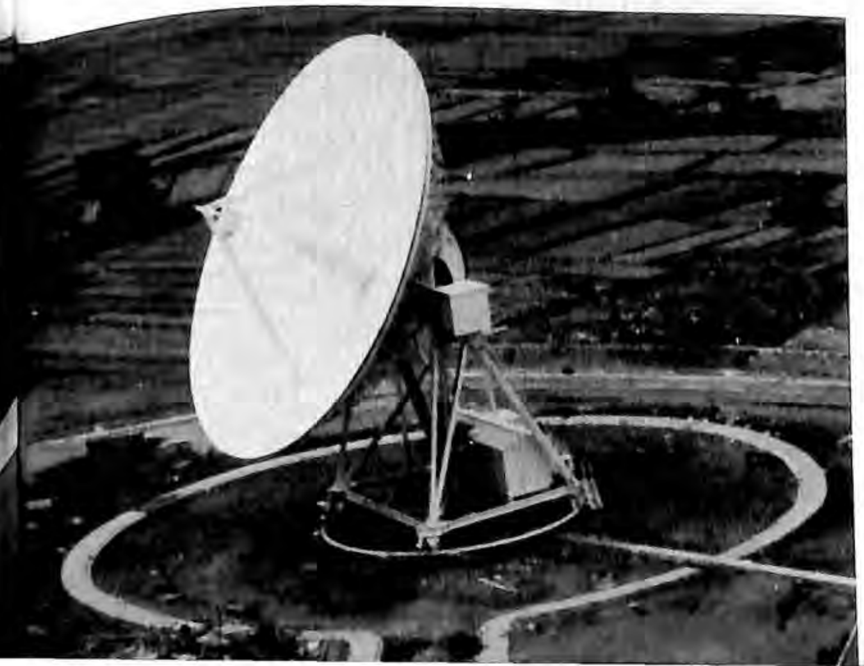
This 97-foot-diameter tracking antenna, located in Thailand, has been in operation since mid-1968. It is a key earth-station link in the worldwide communications satellite network. Erected under a subcontract to Sylvania Electric Products, a subsidiary of General Telephone & Electronics International, the precise antenna structure is a space frame design, which rotates in azimuth on a wheel and track drive system, a concept which permitted erection of structural and mechanical hardwares within 7 weeks. The instrument's reflector is fabricated of solid-surface precision aluminum panels. The manufacturing accuracy is .051 inch RMS. The antenna's elevation motion is provided by 2 20-horsepower electric motor gear drive systems. The azimuth motion is a friction drive utilizing 2 20-horsepower electric motors driving single bogies on a 60-foot-diameter rail. Tracking rate is 1 degree per second. Operating modes are manual position and automatic tracking. Total weight of the antenna is 400,000 pounds. Axis alignments and orthogonality of .003 degree or better were 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 120 miles per hour in stow. The specially designed foundation for this antenna was constructed of a 60-foot-diameter, 11-foot-deep concrete ring with a wall thickness of 24 inches. A 12x37-foot equipment building is located on the azimuth platform and rotates about the azimuth axis.

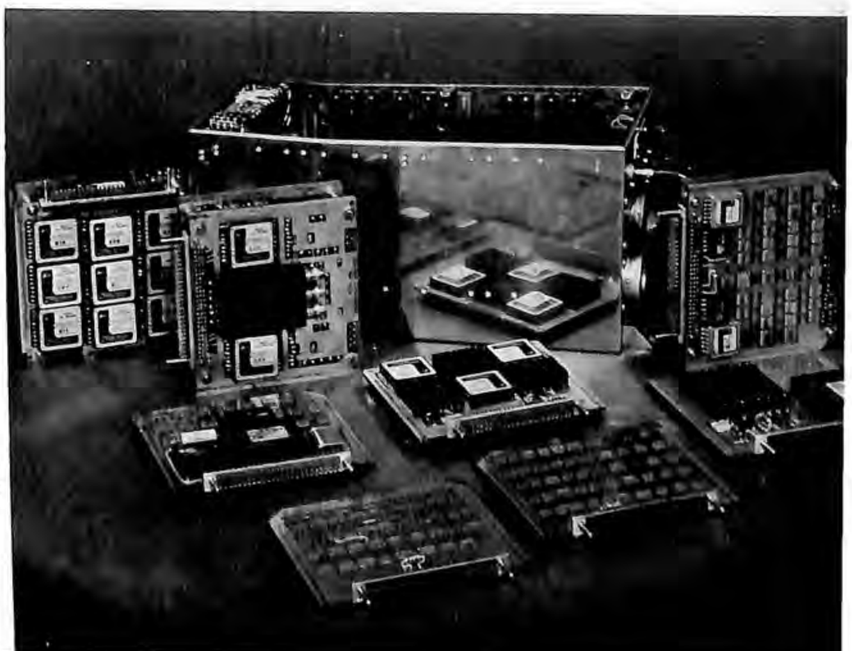
ANALOG AND DIGITAL CONVERTER (AN/ASN 58)

Prime Contractor: Kearfott Products Division, Kearfott Group, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

The Kearfott AN/ASN 58 analog-digital converter is a small, lightweight, high-density converter. It is part of the Phoenix aircraft missile control system. The converter interfaces with the system's digital computer and performs both synchro-to-digital and linear analog-to-digital conversion. Its 6 analog input channels are continuously sampled by a sequential sampling multiplexer network for inputs from 2 dual-speed (27X) and 2 single-speed (1X) synchros, and 2 ac signals varying linearly with an ac reference voltage. Analog input signals are converted to a digital output number, which is stored in an output register. Stored output can be interrogated at any time by one of 6 interrogate signals to a multiplexer, gating the registers to 16 output lines to provide random access to the outputs. Among its more important features are the following: extensive use of microelectronic devices; self-test, continuous malfunction tests; multiplexed, non-ambiguous readout; extensive flight testing in the F-111.





INERTIAL MEASUREMENT SET (IMS)

Prime Contractor: Kearfott Systems Division, Kearfott Group, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

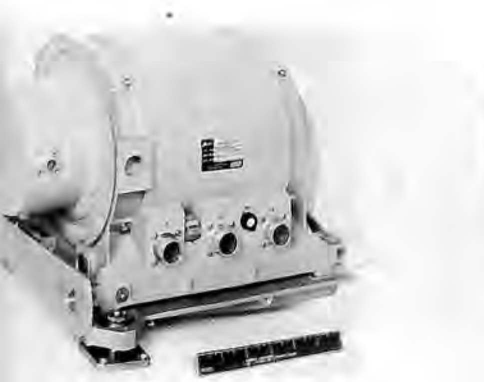
Kearfott's Inertial Measurement Set for A-7D and A-7E aircraft provides heading, attitude and velocity information in conjunction with the aircraft's Doppler navigation and digital navigation weapon delivery computer equipment. This equipment exhibits 6 major advantages: fast reaction, zero time required before take-off; instantaneous accurate velocity for weapons delivery; accurate heading for precise navigation; long-term accuracy, uses extremely stable inertial components; pure Schuler capability should Doppler signal become unavailable; computer self-check capability, BITE included. Consisting of an Inertial Measurement Unit (IMU), an adapter/power supply, a controller and an IMU adjustable mount, all line replaceable, the system weighs 56 pounds. The Inertial Measurement Unit, with associated electronics, contains 2 2-axis Kearfott-developed GYROFLEX® gyros, one Kearfott 2-axis accelerometer and a Kearfott single-axis (vertical) accelerometer. It interfaces directly with the aircraft's digital Navigation/Weapons Delivery computer. The Adapter section contains an electromechanical servomechanism for repeating IMU true heading, damping of raw magnetic heading information, and magnetic deviation correction. Solid-state repeaters are provided for pitch and roll information, and a sequencer switches the IMS through its various submodes. A Controller permits input of magnetic variation (normal modes) or latitude (used in grid backup mode), mode control, and grid slew capability.

AN/ASN-24(G) AIRBORNE/AEROSPACE COMPUTER SET

Prime Contractor: Kearfott Products Division, Kearfott Group, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

The AN/ASN-24(G) general-purpose digital computer set is the follow-on to the AN/ASN-24(V), which logged more than 30,000 hours of flight operating time aboard the Air Force C-141 aircraft. The AN/ASN-24(V) has been updated, improved and value-engineered to result in this new configuration. AN/ASN-24(G) represents a major improvement in performance while retaining commonality with existing AN/ASN-24(V) inventory. The major changes are a 50 percent increase in memory capacity and clock rate, providing the expanded capability to meet the demands of airborne navigation, flight management and airborne data processing. The new system was designed to fit the same mounting racks and to use the same test equipment, handbooks, maintenance procedures and production assembly lines and equipment as the AN/ASN-24(V). The AN/ASN-24(G) computer set consists of the GPK-50 general-purpose digital computer, console-mounted control and display units, input-output equipment, signal conditioners and power supplies. In operation, the AN/ASN-24(G) accepts multiple, varied inputs and processes the data logically, systematically and almost instantaneously. The resulting computed data is simple and straightforward, whether as signals to automatic controls or as data the operator can easily interpret and use. The 50 percent improvement in capacity and speed of the AN/ASN-24(G) is obtained by increasing the density of the binary digits packed upon the surface of the rotating memory drum. The new memory drum will be physically interchangeable with the AN/ASN-24(V) drum, but the bits will be spaced 50 percent closer together.



SD-510 INERTIAL GUIDANCE SYSTEM (SUBROC)

Prime Contractor: Kearfott Systems Division, Kearfott Group, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

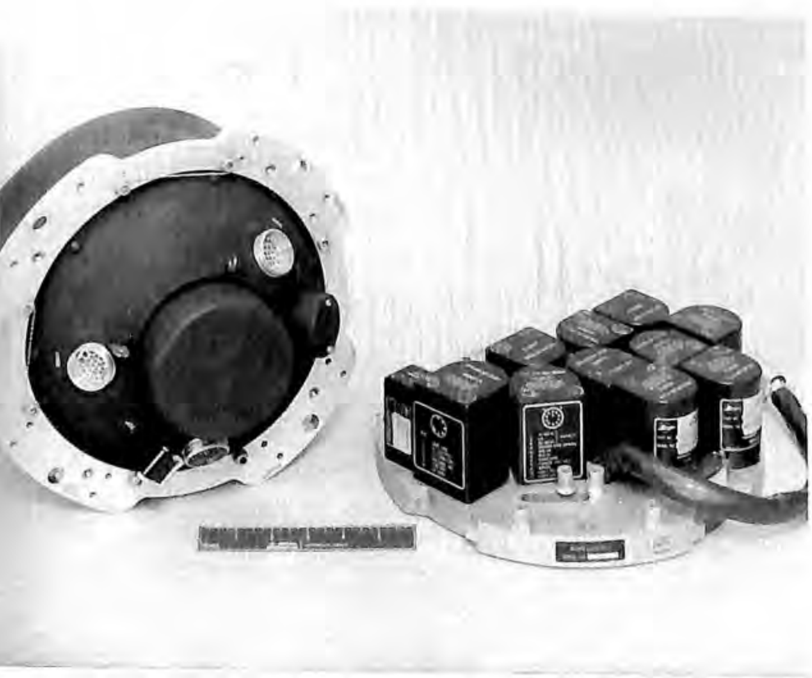
The SD-510 inertial guidance system for Subroc provides information needed for orientation of the missile during its prescribed underwater-to-air-to-underwater path. The system has been subjected to extensive qualification and sled tests. Designed for ballistic missiles, SD-510 is a 3-gimbal configuration for high g and vibration environments. For other applications a mirror assembly can be used for optical 3-axis alignment; 4 gimbals for all-attitude capabilities; or other inertial components for less stringent applications. SD-510 employs 3 floated gyros (C70 2519 Type) and 3 force-balance accelerometers (C70 2401 Type). The electronics package contains printed circuits and potted modules.

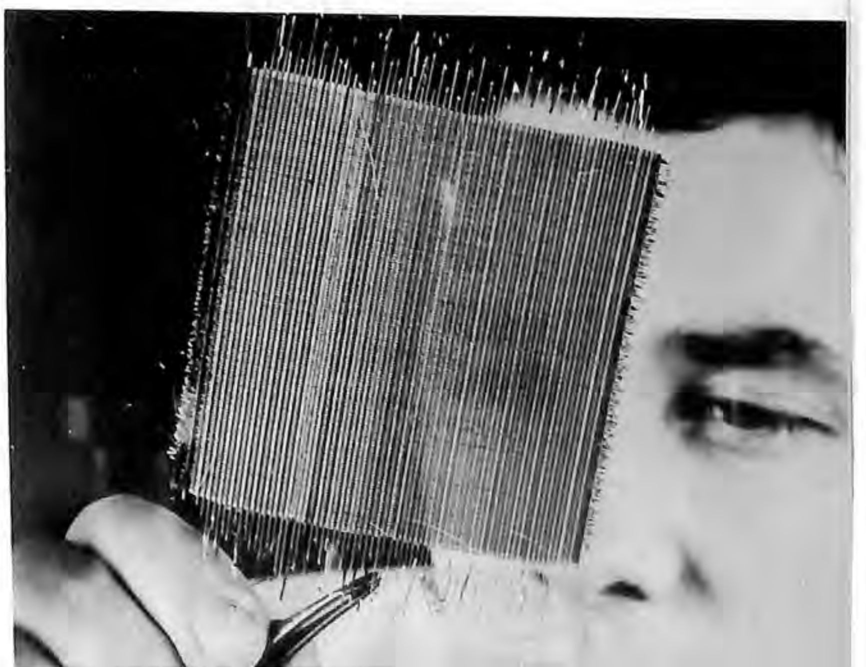
WOVEN PLATED WIRE MEMORY

Prime Contractor: Librascope Group, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

Librascope Woven Plated Wire Memory is a new-generation magnetic memory for aerospace computer, telemetry and other applications. It is woven automatically 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 4 functional organizations: (1) linear select; (2) coincident select; (3) read-only, electrically alterable; (4) read-only, permanently woven.





AUTOMATED MICROFILM APERTURE CARD UPDATING SYSTEM

Prime Contractor: Link Group, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

Link developed the Automated Microfilm Aperture Card Updating System (AMACUS) under contract with the 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. 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 control keyboard and teletypewriter. 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. The new aperture card is processed automatically and is available for use immediately.

APD-5000 MICROFILM PLOTTER

Prime Contractor: Link Group, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

The new APD-5000 Microfilm Plotter introduces a marked improvement in both resolution and cost to the plotter industry. The Link Plotter has a number of significant advancements in resolution, speed, system design, service and software. One of the most important advancements offered by the Link Plotter is its high resolution. Each film frame is divided into 4,096x4,096 raster elements. This means that the user is provided with the necessary resolution to produce intricate and detailed drawings on 35-millimeter film that can be enlarged to D size without losing any detail. In ordinary use the film aperture produced on this system is divided into 4,096 horizontal and 2,731 vertical raster elements. This has been done to provide maximum use of the film area and to achieve frame butting when needed. The square raster of 4,096x4,096 is also available. The Link Plotter has the ability to draw 4 different line widths. Each line width is programmable and can be made up of any number of raster elements. Each of the line widths can have a varied intensity level, if desired. This variable line width feature eliminates the necessity of retracing to produce wider lines. It will plot at the speed of 100,000 points/second when operating on-line. The Link Plotter will operate at the same high speed when connected to an optional off-line special magnetic tape unit. Included in the purchase price of the APD-5000 is a complete software package. This third-generation software package is of superior design, providing a more effective utilization of computer time costs.

VARIABLE ANAMORPHIC MOTION PICTURE (VAMP) VISUAL SYSTEM

Prime Contractor: Link Group, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

Link has made a major contribution to the simulation of visual approaches and landings with the development of the VAMP visual system. The VAMP provides a means for improving pilot skills in landing aircraft under Normal, Category II and Category III restricted visibility conditions. The visual system provides a display covering the forward cockpit windscreens of an aircraft simulator such as the Boeing 707 and 727 and the Douglas DC-8 and DC-9. A wide variety of approach and landing situations for any visibility condition can be provided. Pilots and copilots can be exposed to combinations of approach and visibility conditions, day or night, at any area of the world, without leaving the simulator cockpit. The new approach used in the VAMP visual system employs 70-millimeter Todd-AO color motion picture films taken during actual aircraft take-offs, approaches and landings. The VAMP optically modifies the perspective of the original scene in synchronism with the pilot's control movements to provide an image as seen from the position and attitude of the simulated aircraft. The VAMP system is built as a complete entity which can be fully integrated with the simulator without expansion of the basic computer.

FLIGHT SUIT PRESSURE REGULATOR

Prime Contractor: Vāp-Air Division, Vapor Corporation, Singer-General Precision, Inc., a subsidiary of The Singer Company

Remarks

Vāp-Air has developed a pressure regulator controlling low-pressure bleed air to pilots' and copilots' flight suits 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 pound 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, Singer-General Precision, Inc., a subsidiary of The Singer Company

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 and 3.75 inches wide; it weighs 2.54 pounds.

TERRIER MISSILE FIRE CONTROL SYSTEM MODERNIZATION

Prime Contractor: Sperry Rand Corporation, Sperry Gyroscope Division

Remarks

Mark 76 fire control systems for the Terrier surface-to-air missile, used in fleet air defense role, are being modernized on DLG-class ships. The program is designed for rapid equipment turnaround to keep ship out-of-commission time to a minimum. Sperry constructed full-scale working replicas of the ship's 7 fire control compartments within its Great Neck, New York, plant. Engineers, working with actual equipment and ship interior designs, were able to precisely plan electrical cable runs and connector locations, to check equipment installation areas and to correct problems found before actual installation of equipment aboard ship, where delays can be costly. Currently, 7 ships are programmed. Each Mark 76 system consists of 2 Sperry AN/SPG-55B tracking radars, 2 Mk 119 fire control computers, and control and ancillary equipment. The new systems will be capable of handling the new Standard missile as well as the Terrier.

LORAN-D RADIO NAVIGATION SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Gyroscope Division

Remarks

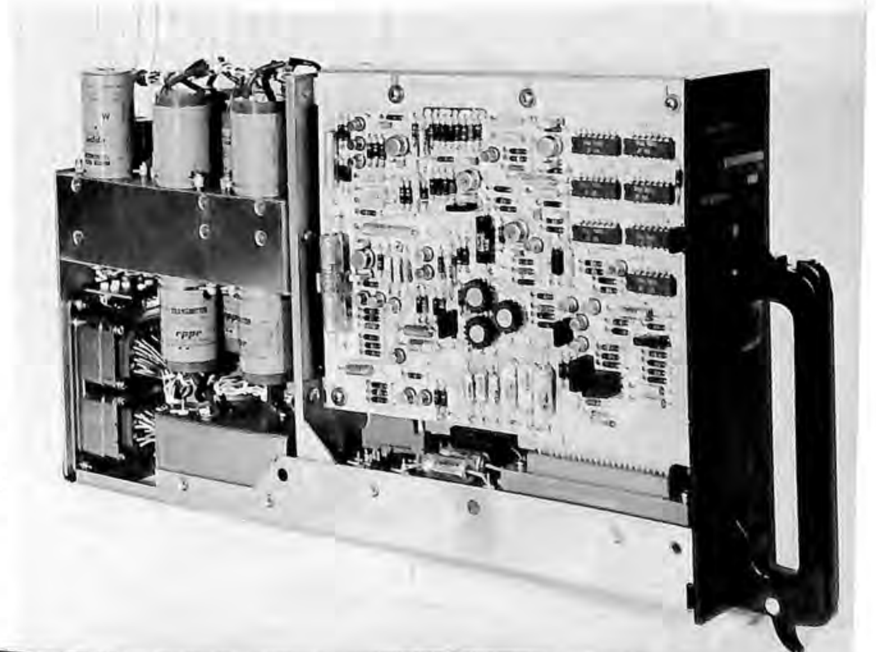
The Loran-D portable radio navigation system consists of navigation receivers for both ground and air vehicles plus transportable ground stations which broadcast position signals. It will enable these forces to operate from the same, exact position information, particularly important in a limited-warfare 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. In photo, air-transportable transmitter hut.

MAGNETIC HEADING REFERENCE SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Flight Systems Division

Remarks

Magnetic heading information for use by aircraft equipped with an inertial navigation system or a directional gyroscope compass system is provided by the Sperry Magnetic Heading Reference System. The compass coupler illustrated is one of the 4 components which comprise the system. Others are a pre-indexed flux valve, a magnetic compensator and a pilot's controller. Basic function of the complete system is to sense the earth's magnetic field and provide stable magnetic heading outputs for instrument and autopilot use. The compass coupler processes the long-term, compensated magnetic signal with the short-term, stable heading signal provided by an inertial navigation system or a directional gyroscope to produce accurate, stable magnetic heading outputs. The system is designed so that it may be used initially with a directional gyro, then used later with an inertial platform if the aircraft operator makes this change in his equipment installation. In-line failure monitoring of system power, gyro and magnetic heading inputs and heading follow-up loop is provided.



FLIGHT INSTRUMENT SYSTEMS

Prime Contractor: Sperry Rand Corporation, Sperry Flight Systems Division

Remarks

Flight instrument indicator systems for the latest generation of jet transport aircraft have been developed by Sperry Flight Systems Division. Two such systems are an attitude director indicator (HZ-6F) and a horizontal situation indicator (RD-350), each incorporating the latest available techniques in indicator construction and display methods. The attitude director indicator displays aircraft attitude and flight path information as well as flight director commands. Among its features are use of DC torquer motors instead of AC servos to drive the attitude sphere. This method eliminates the gear train used in other, similar indicators to move the attitude sphere, increasing instrument reliability and decreasing the production of heat within the indicator case. The companion horizontal situation indicator displays compass heading, radio facility bearing and distance information, and instrument landing system information. A new feature of this indicator is presentation of distance measuring equipment readouts through use of gas plasma segmented digital displays instead of counter drum displays as formerly used. Each indicator has all associated amplifiers built into the indicator case rather than located remotely in the aircraft electronics rack, simplifying installation and maintenance and decreasing weight.

AUTOMATIC LANDING AUTOPILOT SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Flight Systems Division

Remarks

A 3-axis autopilot system certified for making automatic landings at approved airports, now in regular passenger service aboard certain Boeing 727 jetliners, is produced by Sperry Flight Systems Division. The system is a basic 727 autopilot plus additional components to provide full dual pitch channels, an independent roll monitor, a flare coupler and 2 normal accelerometers. Provision is made for automatic disengagement of the autopilot in case of a disagreement between the dual pitch channels, or between the roll channel and the roll monitor. In case of a failure of one pitch channel, the pilot may select the valid channel to make an automatic approach, then resume manual control for touchdown. In addition to automatic monitoring of pitch and roll channel performance, the system also provides cross-check monitoring of the 2 localizer receivers, 2 compass systems and 2 vertical gyros, as well as monitoring of several stages of signal processing and amplifier circuits. An autothrottle is an optional part of the system.

INTEGRATED AUTOPILOT/FLIGHT DIRECTOR SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Flight Systems Division

Remarks

Integration of autopilot and flight director computer channels is a key feature of the system being produced by Sperry Flight Systems Division for the Boeing 747. The illustrated pilots' controller serves both the autopilot and the flight director systems. Other components include pitch and roll computers, automatic stabilizer trim unit, and monitor and logic unit, plus a small additional pilots' controller used for making autopilot pitch and roll adjustments. The system uses triplex pitch and roll computer channels with provision in the design for growth to full triplex fail-operational configuration. Integration of autopilot and flight director computers simplifies pilots' procedures, reduces amount of electronics equipment needed and allows closer tracking of the autopilot by the flight director. The system makes extensive use of high-density embedded modules for saving space and weight, and of DC computation techniques which make possible wide use of standardized microcircuits. The DC computation also allows close electrical tolerances to be held without external adjustment. Sophisticated built-in test equipment, with "go-no go" indicators, is an integral part of the system.

FLY-BY-WIRE STUDY SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Flight Systems Division

Remarks

A breadboard fly-by-wire system for studying concepts and defining problems involved in practical hardware situations has been designed and built by Sperry Flight Systems Division for the Flight Dynamics Laboratory at Wright-Patterson Air Force Base. It provides complete simulation of a full fly-by-wire system in which pilot's control movements are transmitted to actuators by electrical wires instead of mechanical linkages, with feedback employed to assure that vehicle motion is the controlled parameter. Four electronics channels are used for each of the 3 control axes. The 4 channels assure the system's operation without degradation after 2 failures in any axis. These 4 channels are comprised of 3 active channels and an electronic model. Mid-value logic is used to determine the value of the output signal which is transmitted to the actuators. All 4 channels are monitored to detect failures and annunciate these to the pilot. The actuator, a triplex force-summed configuration, also is monitored electronically and will continue to operate after 2 failures. The system also includes a complete self-test feature which checks for any latent failure in the logic and monitoring circuitry.

UHF RANGING BEACON SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Flight Systems Division

Remarks

The Sperry Remote Area Terminal System is a combination communication, ranging and letdown system operating in the military UHF communications band. It consists of a ground unit, which includes a beacon transponder and a voice transceiver, and of a set of airborne units, which includes an interrogator, a pilot's controller and a cockpit indicator. These airborne units provide for a pilot information on range and bearing to the ground beacon. This information, plus manual setting of ground barometric pressure into the airborne unit, makes possible descent of the aircraft toward the beacon from any direction and along a pilot-selected glide path angle. The airborne equipment may be linked to standard cockpit instrument landing system indicators. The unit is designed for use in rotary- or fixed-wing aircraft for such missions as logistic support, tactical approach and letdown, medical evacuation and station keeping.

UNIVAC CP-890 COMPUTER

Prime Contractor: Sperry Rand Corporation, UNIVAC Division

Remarks

The UNIVAC CP-890 Computer, utilizing microelectronic circuitry and wire-wrapped connections, is equipped with a 1.8-microsecond memory of 32K 30-bit words and 12 I/O channels expandable to 16. The cabinet measures 65 inches high, 22 inches wide, and 18 inches deep with 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.

R-264

UNIVAC CP-642B MILITARY COMPUTER

Prime Contractor: Sperry Rand Corporation, UNIVAC Division

Remarks

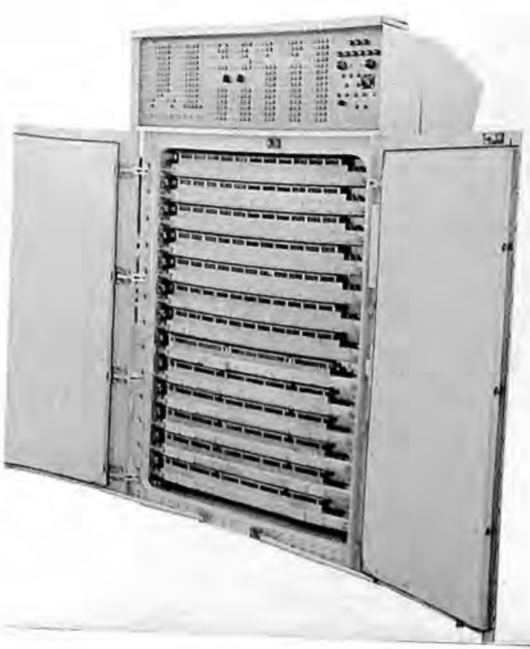
The UNIVAC CP-642B Military Computer was developed as the next-generation NTDS (Naval Tactical Data System) computer, incorporating thin-film memory and UNIFLUXOR NDRO memory. Utilizing advances in computer technology, the CP-642B was designed to be compatible with the CP-642A, but with internal processing speeds twice as fast, and 16 I/O channels with transfer speeds 4 times as fast. The thin-film memory is used as 64 words of control and index register storage at 667-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.

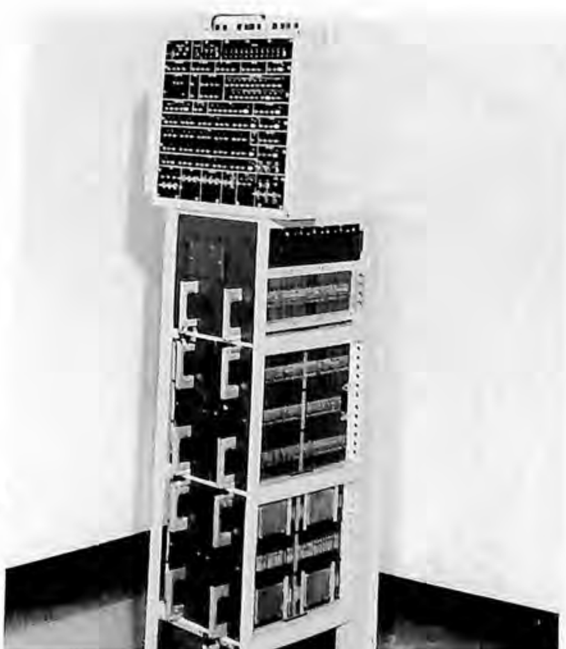
UNIVAC 1830A AVIONICS COMPUTER

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/O on each of 16 channels, occupying only 3 cubic feet of space. This computer was designed to MIL-E-5400 in a basic aerospace configuration, adapted to general, limited-space utilization. The UNIVAC 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

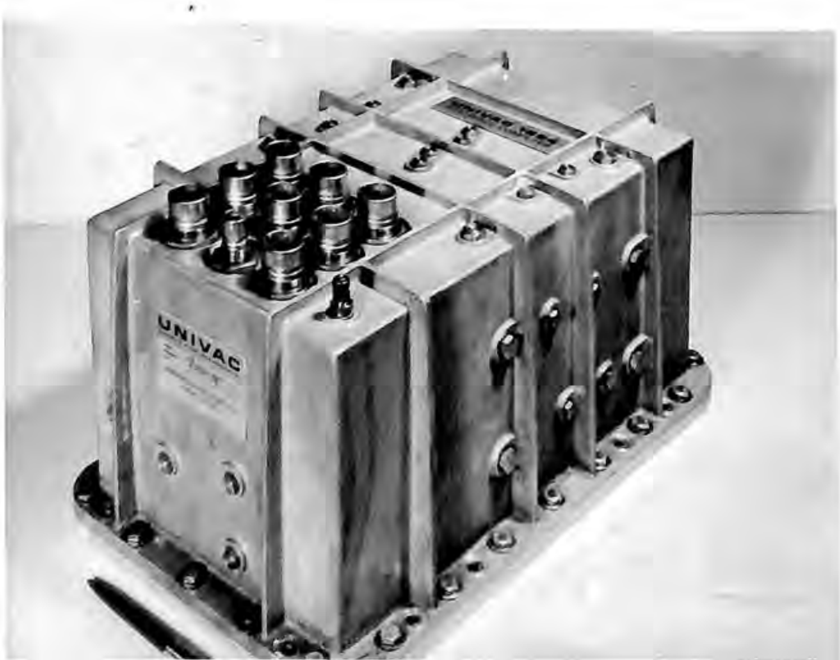
The UNIVAC 1824 Aerospace Computer is a general-purpose, ruggedized machine designed for use where high reliability and high environmental tolerance are required and where very small size, weight and power consumption are premium considerations. The computer utilizes an advanced method of construction, 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 check-out and self-check on the Titan III launch vehicle.

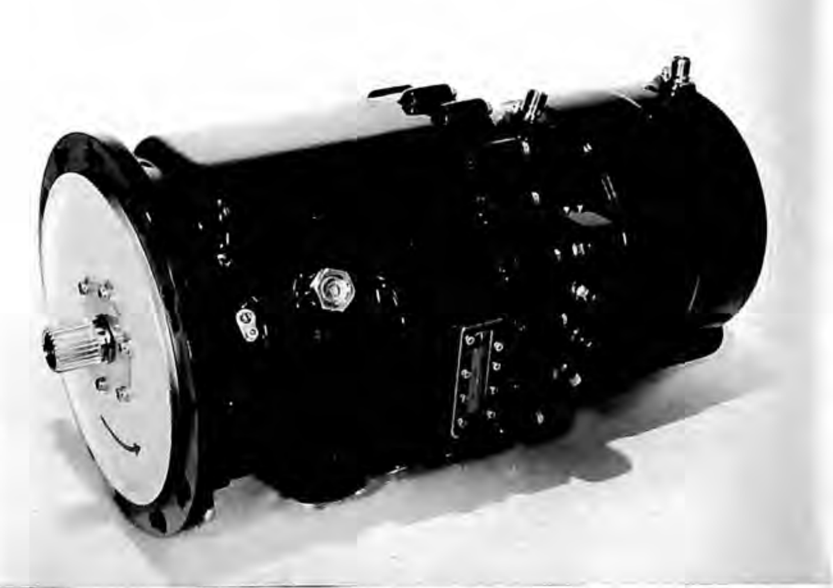
INTEGRATED DRIVE GENERATOR

Prime Contractor: Sundstrand Aviation, a division of Sundstrand Corporation

Remarks

Sundstrand's integrated drive generator (IDG) package consists of an axial gear differential (AGD) and a constant-speed generator compactly joined within adjacent housings. The IDG package provides constant-frequency ac power to aircraft systems by converting varying engine shaft speeds to constant output speeds. The IDG was designed as an alternative to the use of separate drives and generators. This combined package concept results in lower weight and higher reliability than can be achieved with separate units. The generator heat transfer capability is the most significant feature of the IDG system. Oil flow from drive to generator combines conduction and direct oil spray impingement cooling. This novel cooling method eliminates hot spots, prolongs generator bearing life and lowers operating temperatures within the generator, thus increasing reliability.





ACCESSORY DRIVE SYSTEMS

Prime Contractor: Sundstrand Aviation, a division of Sundstrand Corporation

Remarks

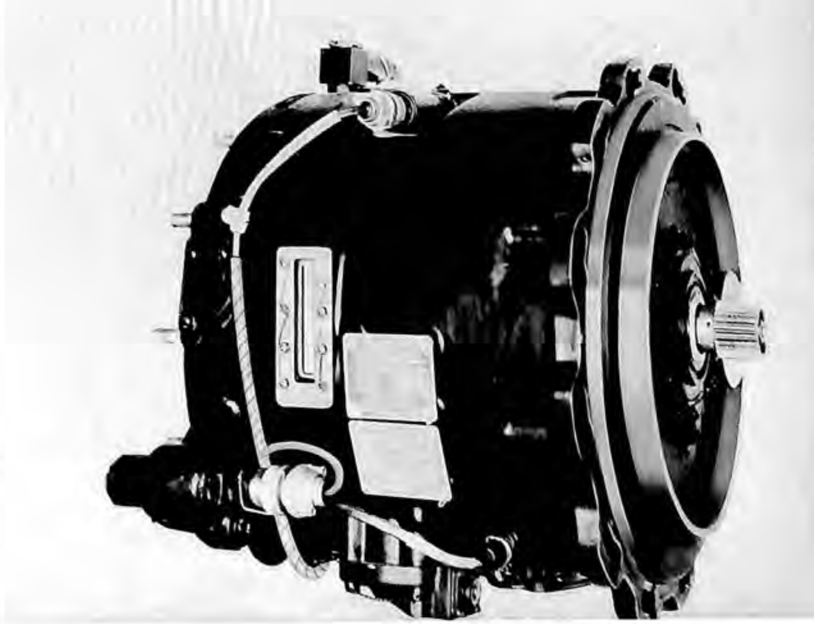
Accessory drive systems (ADS) are comprised of gearboxes mounted to drive constant-speed drives (CSD), generators, hydraulic pumps, fuel pumps, starters and other aircraft accessory equipment. Sundstrand designs have included units with partially integrated pneumatic starters, coolers, fans and decoupler/recoupler provisions. With these added provisions, ground power can be provided through pneumatic motoring. Single-piece cast housings provide maximum reliability, long life and light weight. In addition to magnesium housings, accessory drive systems utilizing fabricated steel or titanium have been developed and produced for special applications. 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.

AXIAL GEAR DIFFERENTIAL-CONSTANT SPEED DRIVE (AGD-CSD)

Prime Contractor: Sundstrand Aviation, a division of Sundstrand Corporation

Remarks

The axial gear differential-constant speed drive (AGD-CSD) is a completely redesigned version of the original Sundstrand CSD. Its function is to convert varying engine shaft speeds to a constant output speed for driving electrical generators to furnish constant-frequency ac power for aircraft electrical systems. In the AGD, most of the output power is mechanically transferred directly from the input by a simple gear train. Small hydrostatically balanced hydraulic units maintain constant output speed by trimming through the differential unit. Since the hydraulic units act in a trimming capacity, they carry only a small portion of the transmitted power and are small in size. These units are independently mounted; bearings required are small and are sized for very long life. All high hertz stress elements are eliminated as all thrust loads are carried hydrostatically at the porting and slipper surfaces. AGD drives, similar to the C-5A model shown here, have demonstrated remarkable reliability with mean time between failures (MTBF) of over 20,000 hours.



HYDRAULIC PUMPS

Prime Contractor: Sundstrand Aviation, a division of Sundstrand Corporation

Remarks

Sundstrand has developed, tested and proved the capabilities of the latest advance in pumping mechanisms—the half head pump design for aerospace application. The half head design is an articulated piston unit that exploits conservative hydraulic parameters, such as modest piston velocity and block rubbing speed, to obtain a hydraulic unit with input speed capability. The high input speed, coupled with the pump's excellent efficiency, results in a high-density hydraulic power package. These hydraulic pumps are adaptable for operation in several types of applications: engine-driven pumps, ac motor pumps, hydraulic starter motor/pumps, air-turbine-driven pumps and hydraulic transfer units. A main feature of these units is their high speed capability which results in a high horsepower-to-weight ratio. The pumps provide maximum flow with minimum size and weight and temperature capabilities necessary for use in Type II rated systems. In addition, half head pumps have been built and tested for Type III system use on supersonic aircraft. Missile applications include turbine-driven pumps for ballistic missile thrust vector control systems.

6425 25-MILLIMETER CANNON SYSTEM

Prime Contractor: TRW Equipment Group, 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 link-belt 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 one-man operated, designed for standard 34-40-inch hull openings. TRW 6425 is lighter (150 pounds) than any other 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.

BOEING 747 ENVIRONMENTAL CONTROL SYSTEM

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

The Boeing 747 environmental control system supplies the cooling, heating, ventilation and pressurization requirements of the 380-passenger superjet. Its 72-ton cooling capacity can condition 8,000 cubic feet of air per minute, completely changing the air inside the passenger compartment every 3½ minutes. The system's 3 air-conditioning packages process air bled from the 747's engines during flight or supplied on the ground by an auxiliary power unit. Two packs can handle cooling requirements if one becomes inoperative. The cooling task is performed by each pack's "simple bootstrap" air-cycle machine developed by Hamilton Standard. The 3-wheel design places the air circulation fan on the same shaft as the compressor wheel and cooling turbine instead of a separate mounting as in other types of refrigeration units. Power produced by the turbine drives the fan, eliminating the need for a separate power source. This simpler arrangement increases cooling efficiency and reduces the unit's weight, electrical power requirements and maintenance costs. At 30,000 feet, where the air is cooler, the 747 system's heat exchangers, one per air-conditioning package, take over the cooling function. Before entering the passenger compartment, processed air is mixed with warm engine bleed air. A 4-zone temperature control subsystem automatically maintains cabin temperatures between 70 and 80 degrees Fahrenheit. Each control zone is designed to operate independently from the others. The automatic cabin pressurization control maintains pressure at an equivalent 8,000-foot altitude. The 747 heat exchanger combines the primary and secondary heat exchangers in one unit.

U.S. NAVY PLAINVIEW HYDROFOIL AUTOPILOT

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

An integral part of the U.S. Navy *Plainview* ship's hydrofoil system, the autopilot controls and stabilizes the experimental craft during all foilborne conditions in calm and rough seas. It senses pitch, roll and yaw motions and feeds the electronic information to a computer. Hydraulic actuators adjust the foils to maintain the *Plainview's* attitude and height above the water. Automatic control sensitivity allows the foilborne 212-foot ship to cut through waves in low and moderate seas or to ride wave contours in heavy seas. Its design based on helicopter automatic stabilization systems, the autopilot also controls the 300-ton craft when it makes coordinated turns on its hydrofoils. Three sonic height sensors, 2 forward and one aft, maintain the hull several feet above the waves. Electromagnetic sensors measure both hullborne and foilborne speeds. Major system components include computer, pitch, roll and acceleration sensor package, height sensors and transducers, attitude and foil-angle indicators, self-test and control panels, alarm lights and static inverter power supply.

AH-56A PUSHER PROPELLER

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

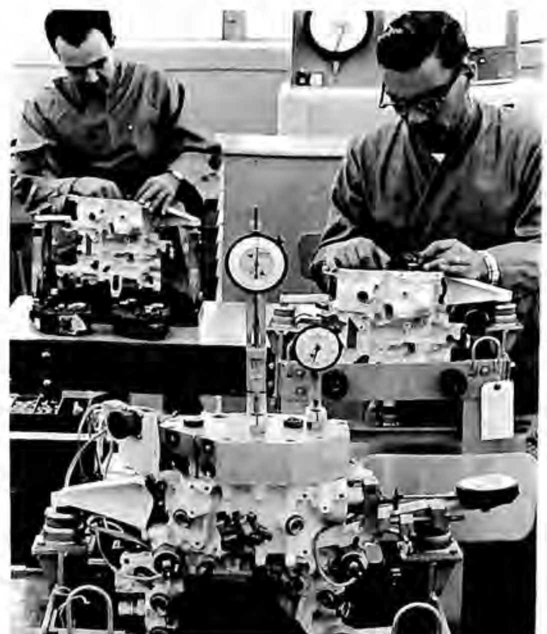
The Lockheed AH-56A armed helicopter's more than 200-knot top speed is provided by the additional thrust of the tail-mounted pusher propeller. The rear-facing propeller also increases the U.S. Army helicopter's maneuverability. By changing propeller blade angle independently from engine power setting, the pilot can accelerate the AH-56A from hover to 200 knots in 38 seconds. He can slow down the compound helicopter from 200 to 60 knots in 13 seconds. The 10-foot propeller has 3 blades fabricated out of a fiberglass-reinforced plastic shell with a tubular steel core and foam fill inside. With these lightweight blades and an integral gearbox, it is 40 percent lighter than a propeller of the same size using aluminum blades and a separate gearbox. The AH-56A propeller is the first Hamilton Standard-developed lightweight, high-thrust propeller to enter production. A similar fiberglass blade-integral gearbox design was used in the propellers fabricated for XC-142A and X-22A V/STOL experimental aircraft. The AH-56A propeller embodies several features that allow maintenance and parts replacement in the field without propeller removal, reducing servicing time from several hours to a few minutes. A quick-disconnect retention mechanism, for example, permits the quick and easy removal of a damaged blade from the hub. The helicopter's gas turbine engine, which powers the main rotor, drives the pusher propeller through a connecting shaft. The propeller reduction gearbox drives the tail rotor used for directional control. Its spinner is made of fiberglass-reinforced plastic. An axial flow fan attached to the spinner aft section supplies cooling air to the propeller hub and gearbox.

F-111 AIR INLET CONTROL

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

The air inlet control for the U.S. Air Force/General Dynamics F-111 fighter-bomber matches the variable-geometry inlet to engine operation to assure proper airflow to the twin engines during all supersonic and subsonic flight conditions. The hydromechanical system automatically adjusts the inlet spikes, which slow down and compress the airflow, and maintain the normal shock in the proper position in the ducts by expanding or contracting the spike's cone section. Pneumatic signals from probes and taps on the air inlet are transmitted to 3 pressure ratio sensors, on the main control, which respond to minute pressures. The signals are translated into hydraulic pressure for activating the spike and cone servo actuators. The system is designed to respond to pressures as small as one-thousandth of a pound per square inch, yet accurately position the spike within 1.5 percent of total travel against multi-ton loads. Its main components include main control, spike actuator, cone angle actuator and feedback transmission. In event of hydraulic failure, the pilot activates an emergency shuttle valve to supply pneumatic pressure which fully extends the spike and contracts the cone for flight safety.



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 84 pounds, it supplies oxygen and pressurization and controls the temperature, relative humidity, carbon dioxide and other contaminants of the ventilating gases in the suit. The PLSS also recirculates and recools the water that flows through the tubing of the liquid-cooling garment worn under the Apollo space suit. This water removes the astronaut's body heat. The life-support pack permits 4-hour extravehicular expeditions. Its expendables 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 for relay to earth. An oxygen purge system on top of the PLSS holds a 30-minute supply of oxygen for emergency and backup use. Connected separately to the suit, it also can be used independently as a life-support chest pack during extravehicular transfer of astronauts between the Lunar Module and the Command Module. Hamilton Standard developed the PLSS for NASA's Manned Spacecraft Center.

C-5A MULTIMODE RADAR SYSTEM

Prime Contractor: Norden Division of United Aircraft Corporation

Remarks

The C-5A multimode 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, beacon, weather mapping, terrain following, and radar approach to landing are included in the modes of operation. The system features 2 essentially independent radars, X-band and Ku-band, and 3 indicators, 2 for the pilots and one for the navigator. Each radar has identical mode capabilities, utilizing different frequencies to emphasize certain features. Ku-band provides higher resolution 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.

VERTICAL SITUATION DISPLAY

Prime Contractor: Norden Division of United Aircraft Corporation

Remarks

Norden's vertical situation display for the Integrated Helicopter Avionics System (IHAS) for the Marine Corps' CH-53A helicopter is designed to present to the pilot all necessary flight cues to enable him to fly a complete mission from take-off to landing, in adverse weather, night or day. This is accomplished by taking inputs from peripheral sensor and digital computational equipments (radar, navigational computer, etc.) to present integrated comprehensive displays of flight information using electronically generated symbology. The vertical display indicator (VDI) displays its flight cues in a raster scan (TV) format. The equipment consists of 2 vertical display indicators and a vertical display generator. The 2 vertical situation displays can operate in the same or in dissimilar modes. In the contact analog mode, the display presents status and command information to the pilot in the form of qualitative and quantitative symbology. The horizontal elements of the ground texture are used to show speed error at ground speeds of 30 knots or greater. At less than 30 knots, the vertical and horizontal motion of the lines represents actual hovering ground speed. In the terrain following and avoidance mode, the display presents a shaded gray terrain presentation for terrain avoidance or terrain following maneuvers. This presentation consists of a maximum of 7 discrete shades of gray for 5 contour lines, varying from dark gray for the closest range to light gray at the farthest range. Horizon line, velocity vector and command velocity vector appear superimposed on the radar display. In the E-scan mode, the display presents light gray terrain contrasted by a dark gray sky background and terrain elevation angle versus slant range relative to the velocity vector.

AIRLINE PASSENGER SEATS

Prime Contractor: UOP Aerotherm Division, Universal Oil Products Company

Remarks

Two new airplane passenger seat concepts were introduced by the UOP Aerotherm Division in 1968. The first was an entirely new system of seat structure called the Olympian. In this design, the main lateral structural member runs along the floor instead of in the upper sitting area, permitting support legs to be placed in a position providing each occupant with the greatest space possible under the seat. It also provides a built-in stowage area for life jackets and meets all FAA regulations for underseat baggage restraint. The basic structure restrains underseat baggage from sliding forward, aft or sideward without interfering with the occupant's legs or feet. The second concept, called "Glide-Away Recline," employs a new recline geometry that raises comfort levels to an all-time high. As the occupant reclines the seat back, the seat bottom moves in the aft direction in a gliding motion with the rear of the seat bottom area lowering at the same time. This cradles the occupant and provides improved sitting posture conditions. Notable is the elimination of the need for the occupant to readjust his personal sitting position to achieve a comfortable attitude of posture. Both designs have been combined into an entirely new type of seat which will be introduced into service in 1969 and 1970 on the B-747 and DC-10. Designs have also been drawn for the L-1011 and other commercial jets.

AIRCRAFT CARGO PALLET

Prime Contractor: UOP Aerotherm Division, Universal Oil Products Company

Remarks

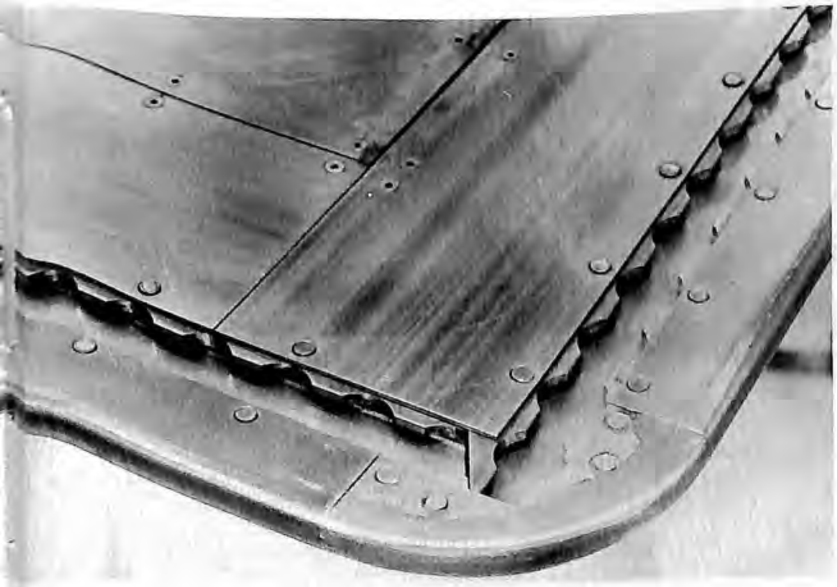
An entirely new concept in cargo pallets has been introduced by the UOP Aerotherm Division. The pallet is all extruded aluminum construction and meets the 3g and 9g specifications as one unit. It is also designed as an 88x125-inch pallet, and the addition of one piece of floor track permits it to be used as an 88x108-inch size when an aisle is required in the aircraft. The standard pallet fits all Boeing 707, 720, 727 and 737s and Douglas DC-8-60 series aircraft. Other sizes to fit the B-747, DC-10 and L-1011 are under test for certification. Outstanding advantages of the all-aluminum pallet include lighter weight, longer life, delamination proof, and easy repair with ordinary on-line maintenance equipment.

FLEXIBLE DUCTING

Prime Contractor: Calumet & Hecla Corporation, division of Universal Oil Products Company

Remarks

At high speeds, high altitudes, high pressures and extremes in temperatures, flexible ducting becomes important. Often it must expand and contract, take motion in any direction, be lightweight, carry high pressures and be manufactured in unusual shapes and sizes. Special Flexonics ducting components made a first appearance on early World War II aircraft. Since then, the ducting demands of supersonic aircraft and the most advanced aerospace vehicles have been and are being met by Flexonics. Typical applications for flexible ducting include cabin air conditioning, engine exhaust, anti-icing, rain removal and boundary layer control. Metal hose applications include hydraulic brakes, fuel lines, oil lines, oxygen breathing, vibration absorbing connections and exhaust connections, to mention a few.



M-71 MINIATURE PRESSURE SWITCH

Prime Contractor: Instruments Division, Universal Oil Products Company

Remarks

Weighing only 2.5 ounces and occupying less than 2 cubic inches of volume, this miniature switch is available with settings from 1 to 3,000 pounds per square inch. The all-metal sensing element provides a reliable leak-proof design and is available in stainless steel for corrosive pressure media. Contained within the stainless steel housing is a double-throw, snap-acting switch that provides chatter-free performance during 50g shock and 15g vibration. The instrument has been qualified in accordance with the environmental requirements of MIL-E-5272C, including Procedure IV Explosion Proof. The M-71 switch has found application on military fighter aircraft, VTOL and STOL aircraft and commercial transports.

LIQUID COOLANT FLOW SWITCH

Prime Contractor: Instruments Division, Universal Oil Products Company

Remarks

Developed to protect electronic equipment against low coolant flow or excessive operating temperature, the B-232 is available with flow settings to 4 gallons per minute with a maximum pressure drop of 10 pounds per square inch. Higher settings can be achieved by increasing the allowable pressure drop. The flow switch maintains an accuracy of plus or minus 2 percent of set point over a wide range of operating temperatures. The self-contained thermostat de-energizes the circuit when coolant temperature exceeds 190 degrees Fahrenheit. The double-pole, double-throw contacts are rated at 10 amperes. This versatile switch is available in a broad selection of temperature and flow settings for a variety of processes and fluids.

FREEZER/OVEN

Prime Contractor: REF Dynamics Division, Universal Oil Products Company

Remarks

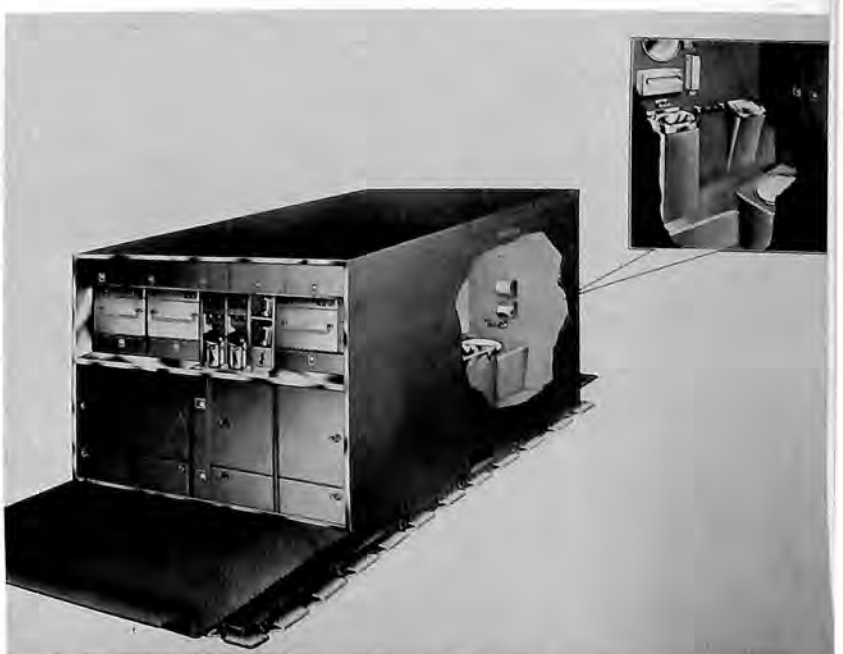
A combination freezer/oven has been designed by the REF Dynamics Division for greater utilization of space in an aircraft galley and to provide numerous distinct advantages over conventional separate units. For instance, cost savings can be achieved because one unit handles all phases of food service: freezing, refrigeration storage and the reconstituting of the food for serving to passengers. The combination unit eliminates separate units; therefore, no dual handling of food is required. It also saves time in loading and/or transfer of units. Liquid nitrogen (LN_2), used for the coolant system, offers the flexibility of storing a main nitrogen source below deck or incorporating cylinders into individual modular units. The freezer can be operated at −10 degrees Fahrenheit or as a refrigerator at 40 degrees Fahrenheit. The oven system is forced warm air capable of holding, warming and reconstituting from 140 to 500 degrees Fahrenheit. Solid-state controls may be mounted with the units, or an added feature permits them to be located on the upper deck with the oven/freezer placed in the lower lobe. Demonstration units proved the concept, and production was to be started in 1969.

BUFFET/LAVATORY UNIT

Prime Contractor: REF Dynamics Division, Universal Oil Products Company

Remarks

The buffet/lavatory unit is designed to meet all the requirements of MIL-B-38157 (B) USAF and is in service on the USAF's Lockheed C-141. The basic unit is bonded construction utilizing end grain balsa to aluminum skins. The unit was designed to have sufficient capacity for the food, drink and hygienic requirements to sustain 132 people with 2 meals in a flight duration of 18 hours, without re-servicing the unit. The unit is pallet-mounted and designed for compatibility with the A/B-37 S-1 loading system, therefore negating costly time for loading and tie down with the aircraft. Forklift entries were designed into the structure to facilitate handling. The buffet complex contains coffee brewers, makes hot water for tea and has a cold-water unit for drinking purposes. "Whirlwind" ovens contain a variable thermostat providing the versatility of either holding meals at a desired temperature or reconstituting them from a frozen state. Interchangeability, reliability, maintenance and durability were prime design considerations.

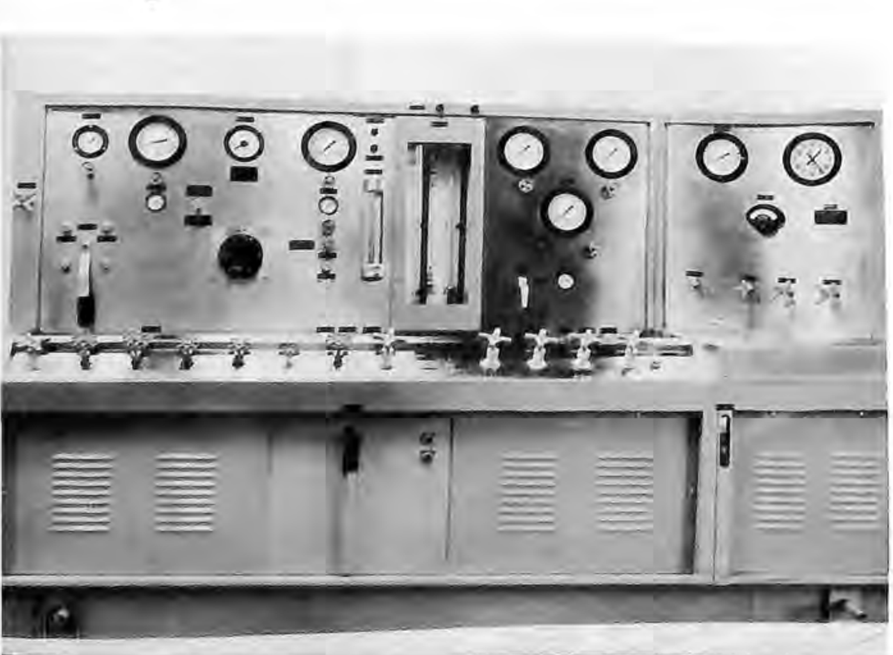


HYDRAULIC COMPONENTS TEST STAND

Prime Contractor: REF Dynamics Division, Universal Oil Products Company

Remarks

The Model JHCT-1 is designed to test rapidly and accurately the performance and operating characteristics of jet aircraft hydraulic systems components, such as pumps, motors, valves and other system accessories, both rotating and nonrotating. The JHCT-1 is capable of providing cylinder or impulse testing and reverse flow in a positive and highly accurate manner. To prevent drive speed surges with sudden load changes, a flow circuit is provided through a variable-speed drive. Complete data is provided for converting torque to pressure readings on the JHCT-1. A static test circuit produces pressures up to 10,000 psi, and a temperature control circuit is incorporated into the test stand system. The unit can be furnished for connection to either 220-, 380- or 440-volt, 3-phase electric power supplies of either 50 or 60 cycles. Circuitry can be modified to suit specific customer requirements. The compact unit is of rugged steel structure with components arranged for ease of servicing. All circuits are relief valve protected.

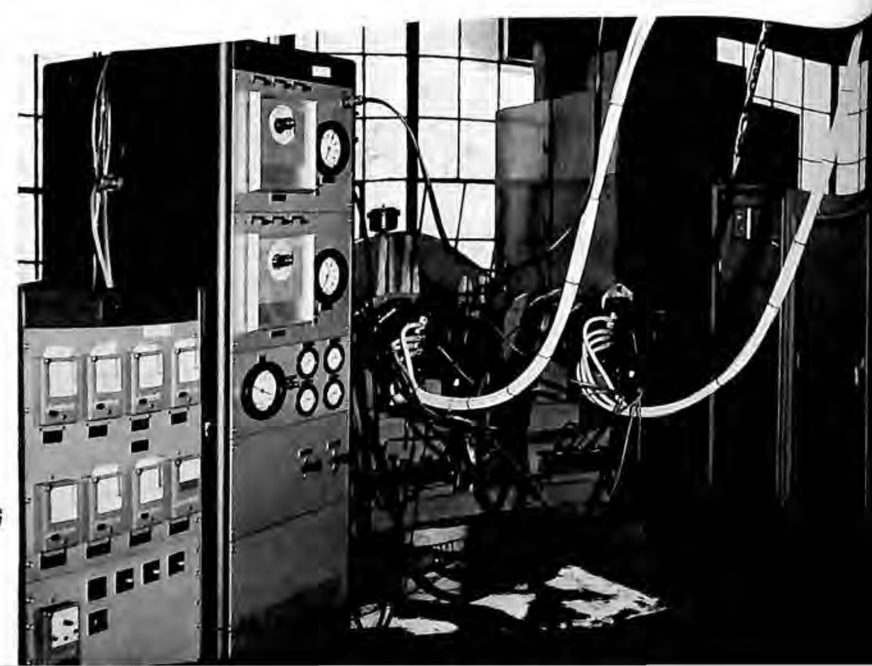


ELECTRIC POWER GENERATING SYSTEM

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 a 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 was 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.

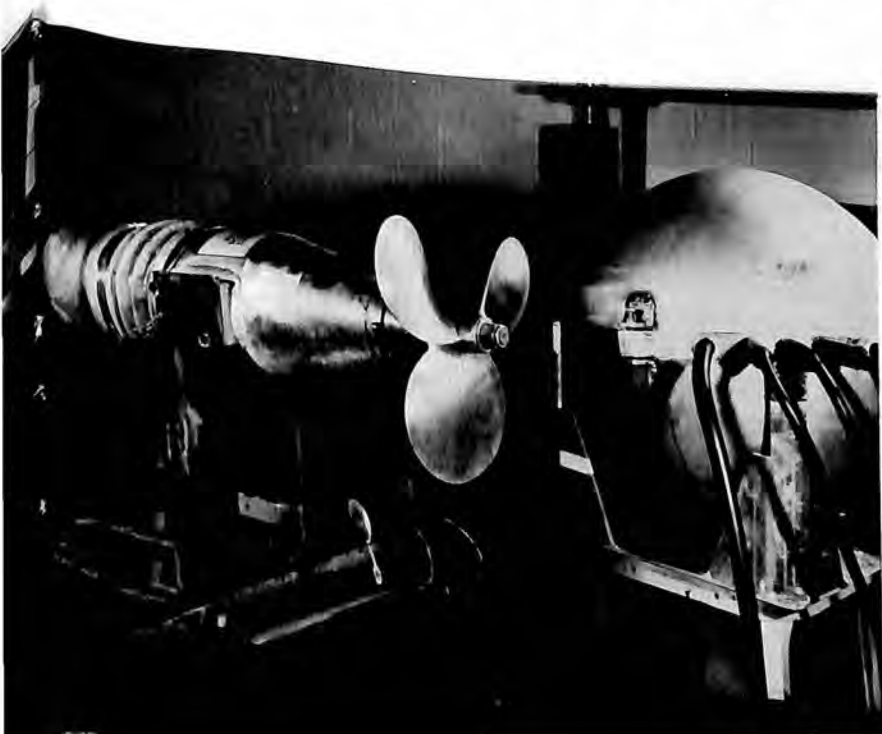


DEEP SUBMERGENCE PROPULSION SYSTEM

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.



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 thermoelectric 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.

AN/APQ-120 ADVANCED WEAPONS CONTROL SYSTEMS

Prime Contractor: Westinghouse Electric Corporation, Defense and Space Center

Remarks

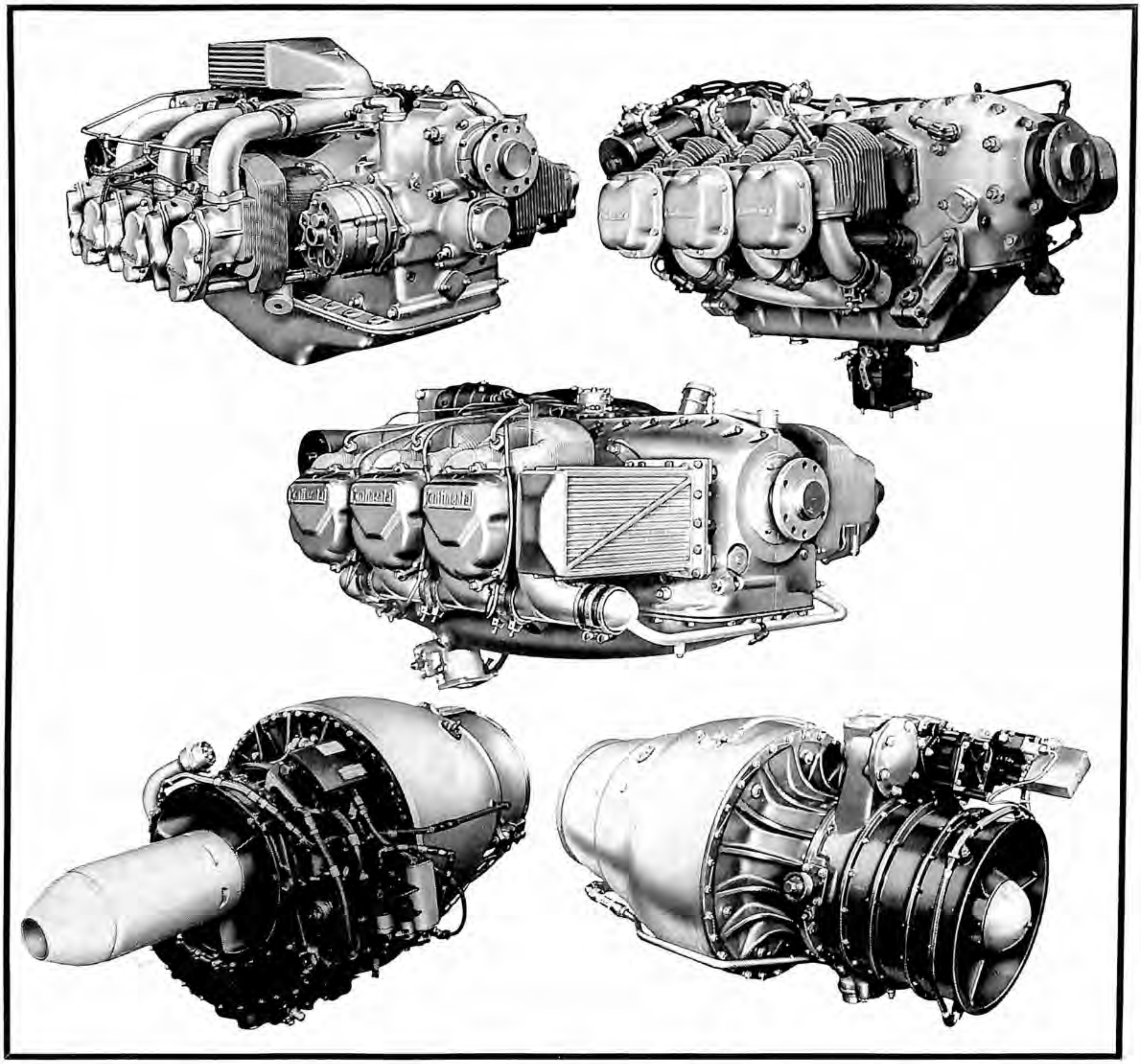
The AN/APQ-120 is a highly reliable, pulse airborne radar fire control system produced by the Westinghouse Aerospace Division for use by the USAF in the F-4E aircraft. It is the latest of a generation of radar systems which have evolved from the AN/APQ-72 in the F-4B through the AN/APQ-100 and 109 in the F-4C and F-4D aircraft. Extensive use of solid-state components, printed circuits, molded units and modular design provides reliability, improved maintainability, reduced component weight and volume and the increased ruggedness essential for operation in the vibration environment associated with the operation of the adjacent 20-millimeter gun installed in the nose compartment. The improved capabilities incorporated in the AN/APQ-120, coupled with associated compatible aircraft equipment, provide maximum weapons delivery effectiveness permitting full utilization of the F-4E's air-to-air and air-to-ground performance capabilities.

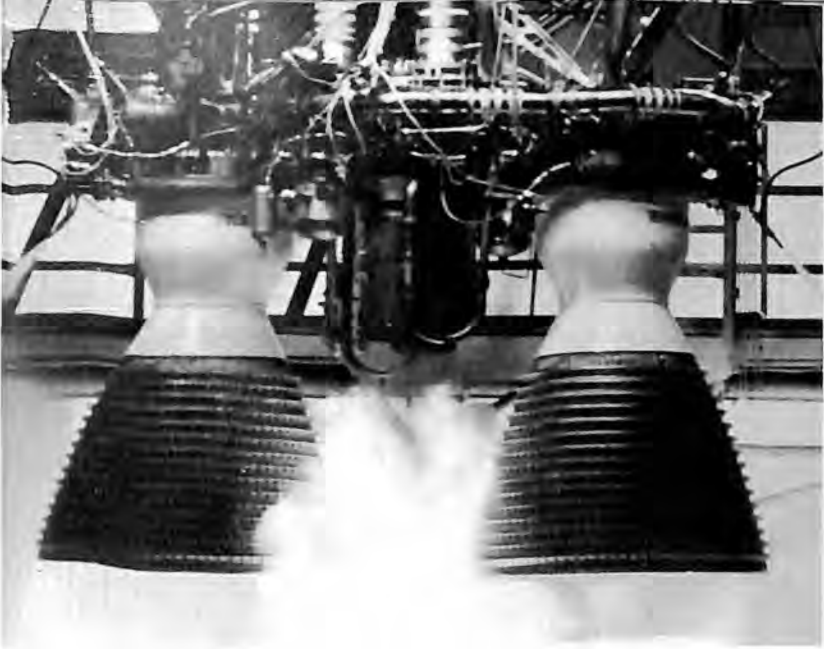
AWG-10 RADAR FOR F-4J AIRCRAFT

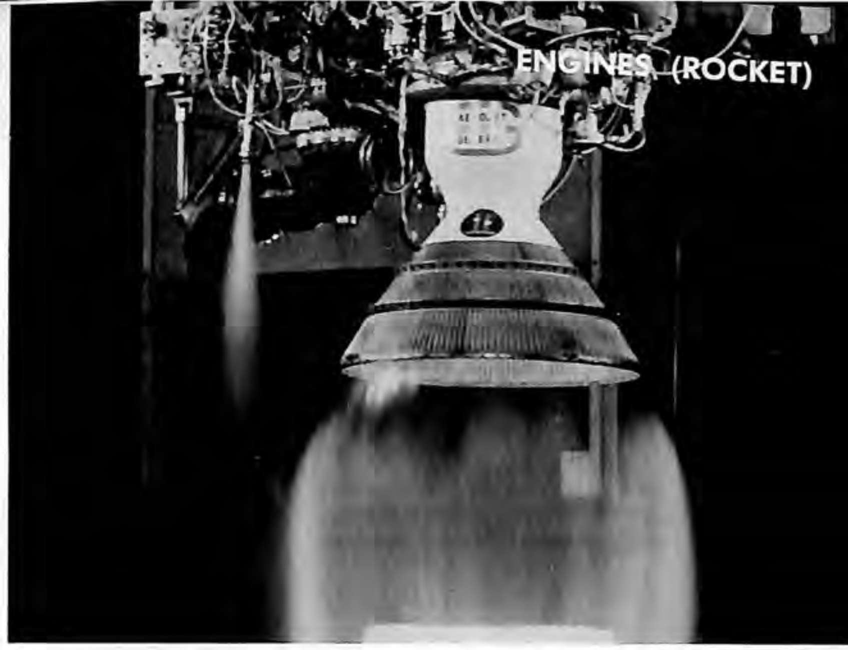
Prime Contractor: Westinghouse Electric Corporation, Defense and Space Center

Remarks

The Navy F-4J utilizes the AN/AWG-10 multimission interceptor weapons control system which has followed the highly successful Westinghouse AN/APQ-72, presently operational on the F-4B aircraft, and the fire control radars, APQ-100 and APQ-109, which are produced for USAF's F-4C and F-4D aircraft. The AN/AWG-10 missile control system resulted from a Westinghouse contract for design, development, fabrication, integration and testing for the Naval Air Systems Command. The Westinghouse AWG-10 radar has built-in self-test with the ability to detect and isolate systems faults automatically and to repair them on a quick change basis. This enhances field maintenance, a key element in all common complex electronic equipment. Thus, rigid maintenance goals have been successfully achieved as the entire weapon control system slides out from inside the aircraft nose. Individual subassemblies can be rotated out to gain access to separate plug-in solid-state component modules and microcircuits.







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, 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 it is capable of altitude ignition when used in conjunction with solid-propellant, zero-stage boosters. This twin-barrel engine is pump fed and regeneratively cooled as is the Aerojet second-stage engine. A feature of Aerojet's propulsion system for Titan II and III launch vehicles is storable propellants. The fuel is a blend of hydrazine and unsymmetrical dimethyl hydrazine (UDMH) with nitrogen tetroxide (N_2O_4) as oxidizer. These hypergolic propellants require no ignition system since they ignite on contact. They are the key to the quick reaction time of the Titan launch vehicle and the simplicity of its engine system.

Performance

Thrust 430,000 pounds at sea-level ignition, 470,000 pounds at altitude ignition.

TITAN II AND III SECOND-STAGE ENGINE

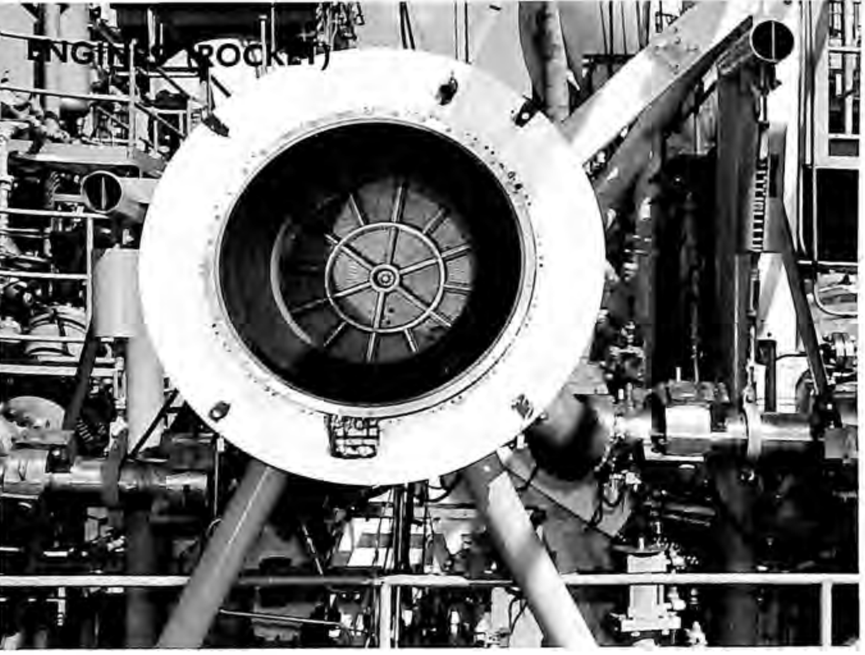
Prime Contractor: Aerojet-General Corporation

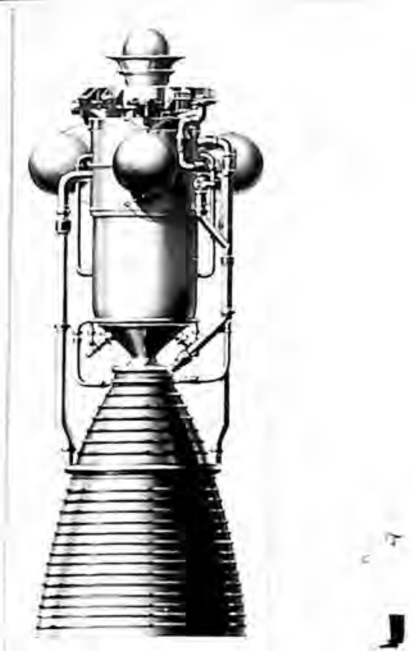
Remarks

The second-stage Titan II and III liquid rocket engine, working with its first-stage mate, successfully placed 20 Gemini astronauts directly into orbit, and it is a vital stage in the space operations of the Titan III launch vehicle. Like the first-stage engine, the Aerojet single-barrel, second-stage propulsion system burns hypergolic propellants UDMH and nitrogen tetroxide which are pump fed. Operating at high altitudes, this engine has added to its thrust chamber an ablative skirt which increases the expansion ratio from 13:1 to 49.2:1.

Performance

Thrust 100,000 pounds at altitude.





ADVANCED HIGH-THRUST HYDROGEN ROCKET PROGRAM

Prime Contractor: Aerojet-General Corporation

Remarks

A NASA program to advance the state of the art in high-thrust hydrogen/oxygen engine systems is being conducted at Aerojet's Sacramento facility under the direction of NASA's Lewis Research Center. A fluorine ignition system has been developed, along with pumps and a thrust chamber, for engine systems of 1,500,000 pounds thrust and above. Test firings are continuing with systems producing the vacuum equivalent of 1,500,000 pounds. Photo shows "breakthrough" injector. This "first-cut" injector has demonstrated excellent performance, mechanical integrity and good stability.

NERVA (NUCLEAR ENGINE FOR ROCKET VEHICLE APPLICATION)

Prime Contractor: Aerojet-General Corporation
Principal Subcontractor: Westinghouse Electric Corporation, Astronuclear Laboratory
Program Direction: Atomic Energy Commission and National Aeronautics and Space Administration

Remarks

NERVA is America's first nuclear rocket-propulsion system. It is under development by Aerojet-General Corporation, with Westinghouse Electric Corporation, as principal subcontractor, providing the nuclear reactor. The NERVA engine development is based on the solid core, heat exchanger reactor concept. Liquid hydrogen (−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. A series of "cold flow" tests of an experimental nuclear rocket engine—the first down-firing engine—was completed successfully at the Nevada test site in April 1968. Nuclear stages employing NERVA offer dramatic advantages over chemical stages now in use since they are capable of much higher specific impulses, promising far greater payloads to the moon, Mars and Venus, and for deep space probes.

MINUTEMAN II SECOND-STAGE ENGINE

Prime Contractor: Aerojet-General Corporation

Remarks

The second-stage, solid-propellant rocket motor for the Air Force Minuteman II ICBM is 50 percent more powerful than its predecessor, increasing the missile range from Minuteman I's 6,300 to 7,000 miles. The advanced motor is equipped with a large single nozzle instead of the 4 smaller nozzles that move in pairs on the 2 other stages to guide the vehicle during flight. The motor uses an advanced thrust vector control system that injects cold liquid freon into the fast-moving hot gas stream in the nozzle exit area to create a shock which turns the missile to the desired heading.

APOLLO SERVICE PROPULSION SYSTEM

Prime Contractor: Aerojet-General Corporation

Remarks

The Apollo Service Propulsion System engine is America's largest and most powerful spacecraft rocket engine. Producing 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; it uses a bipropellant feed system which makes possible a step-thrust capability from 70 percent to full thrust. Using hypergolic storable propellants aerozine 50 and nitrogen tetroxide, the SPS engine is a simple propulsion unit with ablative thrust chamber and large titanium/columbium extension skirt with an expansion ratio of 62.5:1—largest expansion ratio of any U.S. rocket engine. It has a design life of 750 seconds. Missions of the Aerojet SPS engine include (1) midcourse 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. The engine is capable of any other large maneuvers required by the Apollo Command/Service Modules.

PHOEBUS-2 NUCLEAR ROCKET NOZZLE

Prime Contractor: Aerojet-General Corporation

Remarks

America's nuclear rocket program moved closer to its ultimate goal with the completion of successful qualification tests of the Phoebus-2 nozzle, world's largest nuclear rocket nozzle, in August 1967 at Aerojet-General Corporation's Propulsion Division, Sacramento, California. The chemical simulation testing demonstrated development of a 250,000-pound-thrust oxygen/hydrogen thrust chamber assembly with performance approaching 100 percent of theoretical. Electrical discharge machining (EDM) of the Hastelloy X nozzle represented major advances in state-of-the-art technology. Aerojet developed the system for the joint AEC-NASA Space Nuclear Propulsion Office.

MINUTEMAN III STAGE III MOTOR

Prime Contractor: Aerojet-General Corporation

Remarks

Increased performance of the Minuteman III ICBM over its predecessors is the major factor of this new third-stage, solid rocket motor produced for the Air Force by Aerojet's Propulsion Division. This newest member of the Air Force's deterrent force underwent a very successful initial flight on August 16, 1968, from Cape Kennedy, Florida. The motor has the same diameter as the second stage of the missile. Previous third-stage motors had a smaller diameter.

POLARIS MOTORS

Prime Contractor: Aerojet-General Corporation

Remarks

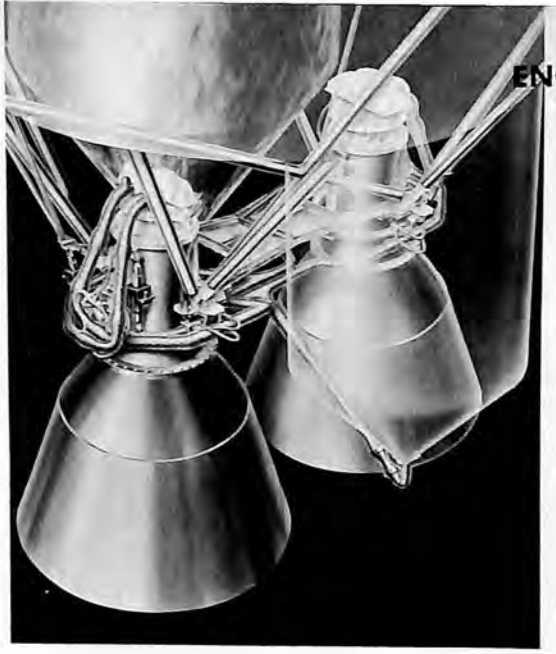
Aerojet-General has produced more than 2,000 solid-propellant rocket motors for the Navy's Polaris fleet ballistic missile. While details of the power plant are classified, the engine shown is designed for use in the Polaris A3, the 2,500-nautical-mile-range model and the latest to go into service. Aerojet-General 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 A1 version and the first-stage units for the 1,500-mile A2, and it is now producing the first-stage engine for the A3.

SVM-2 APOGEE KICK ROCKET

Prime Contractor: Aerojet-General Corporation

Remarks

Aerojet-General's Propellant Division produced the SVM-2 apogee motor for the TRW Systems Group, contractor to the Communications Satellite Corporation for the Intelsat III satellite. The motor is 22.25 inches in diameter; 35.1 inches long; weighs 350 pounds, loaded; produces 3,140 pounds of thrust, average, over its 27.6-second firing duration. The motor fires in space to place the satellite in synchronous earth orbit.



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 aerozine 50 and nitrogen tetroxide. Its record-setting 4 restarts on the same space flight in which it placed payloads in 4 different orbits have caused it to be labeled a space "switch" engine.

Performance

Thrust 8,000 pounds each engine, total 16,000 pounds.

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 in which rapid provision of desired thrust levels is necessary for midcourse correction, rendezvous maneuvers, orbit insertion and landing deceleration. The engine is built for the Naval Air Systems Command.

ALGOL

Prime Contractor: Aerojet-General Corporation

Remarks

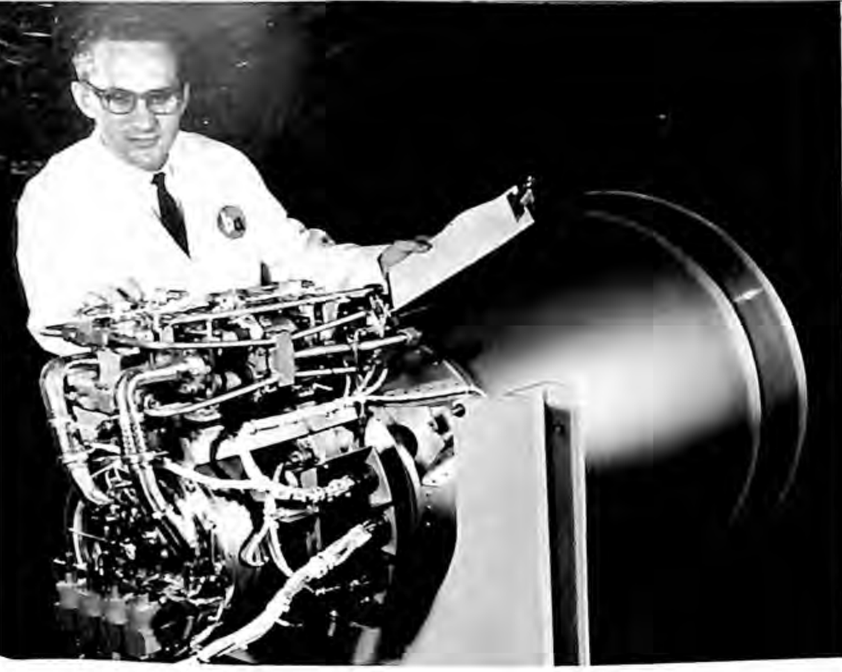
Algol is used as the first stage of the NASA Scout launch vehicle. Originally designed and developed by Aerojet-General Corporation's Solid Rocket Operations as a static test motor, and the forerunner of such solid rockets as Polaris and Minuteman, Algol is approximately 30 feet long and 40 inches in diameter and contains nearly 10 tons of propellant. It produces more than 100,000 pounds of thrust. Algol serves also as the first stage for the Air Force Blue Scout, and it was used in clusters during the NASA Little Joe program.

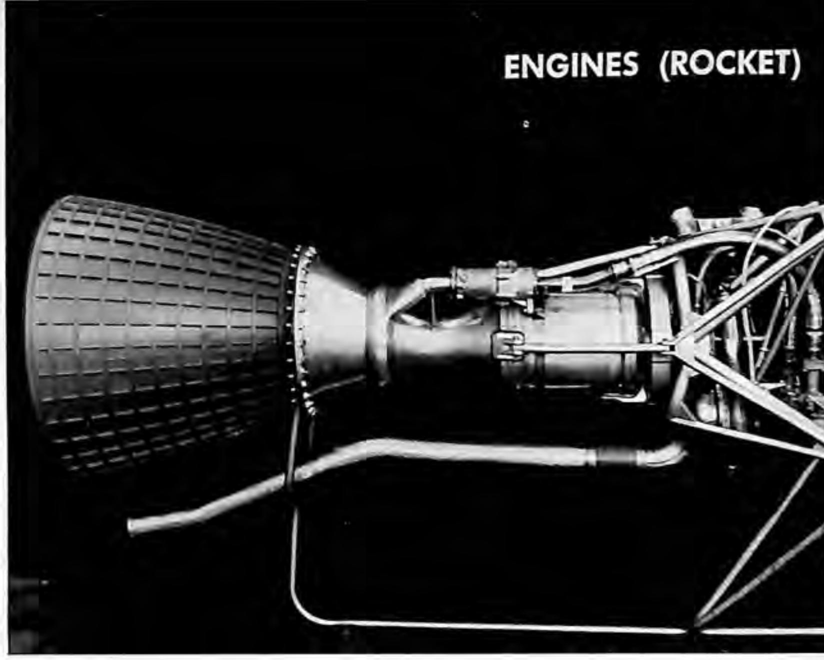
ALCOR

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 10,000 pounds of thrust.





LUNAR MODULE ASCENT ENGINE

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The ascent rocket engine propels the ascent stage of the Apollo Lunar Module from the lunar surface into lunar orbit, where it makes rendezvous with the orbiting Command and Service Modules. Orbit adjustments may be made by restarting the engine. The basic engine completed qualification in 1968. First sent into orbit in January 1968, the engine was fired and restarted successfully while in orbit.

Specifications

Propellants nitrogen tetroxide, 50/50 blend of hydrazine and UDMH; ablative thrust chamber and nozzle; hypergolic ignition; pressure-fed engine with series-parallel redundant valving with a valve-out capability.

Performance

Average thrust 3,500 pounds.

AGENA ENGINE

Prime Contractor: Textron's Bell Aerosystems 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 has placed approximately 60 percent of the free world's functional unmanned payloads in space. Fired in space hundreds of times, the Agena engine has a reliability record exceeding 99 percent.

Specifications

Length 7 feet; width 3 feet; weight 300 pounds; propellants UDMH and inhibited red fuming nitric acid.

Performance

Thrust 16,000 pounds average; specific impulse approximately 300 seconds; chamber pressure approximately 500 pounds per square inch.

HERCULES SOLID ROCKET SERIES

Prime Contractor: Hercules Incorporated

Remarks

Hercules Incorporated builds solid-propellant rocket motors for the following missile systems: Honest John, Little John, Minuteman, Polaris A2, Polaris A3, Nike Ajax (booster), Poseidon, Sprint, Hibex, Nike Hercules (booster), Talos (booster), Terrier I, Terrier II, Bullpup and Sparrow. In addition, the company manufactures these motors:

X248 ALTAIR (photo)

Incorporated into Thor, Delta, Scout, Argo and other programs, the Altair was the first rocket to feature a glass fiber filament-wound case structure.

Specifications

Length 58 inches; diameter 18 inches; weight 500 pounds.

Performance

Thrust 3,100 pounds; time 38 seconds.

ANTARES

A scale-up of the X248 Altair built specifically for Scout, Antares is also used in several other space vehicles. It has a mass fraction of .93.

Specifications

Length 113 inches; diameter 30 inches; weight 2,285 pounds.

Performance

Thrust 14,000 pounds; time 36 seconds.

RANGER RETRO (photo)

Originally designed for the Ranger lunar impacter, this motor 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 single-stage Hydac vehicle at top of stand, a Javelin III in the lower front and a Javelin II sled rocket motor in the lower rear of the stand.

Specifications

Hydac: length 146 inches, diameter 9 inches, weight 557 pounds. Javelin II: length 101 inches, diameter 8.7 inches, weight 341 pounds. Javelin III: length 103 inches, diameter 9 inches, weight 363 pounds. Sirocco: length 112 inches, diameter 5.5 inches, weight 144 pounds.

Performance

Hydac: 10,200 pounds thrust for 9.4 seconds duration. Javelin II: 31,560 pounds for 1.76 seconds. Javelin III: 10,710 pounds for 4.8 seconds. Sirocco: 3,340 pounds for 5.5 seconds.

APOLLO LAUNCH ESCAPE MOTOR

Prime Contractor: Lockheed Propulsion Company

Remarks

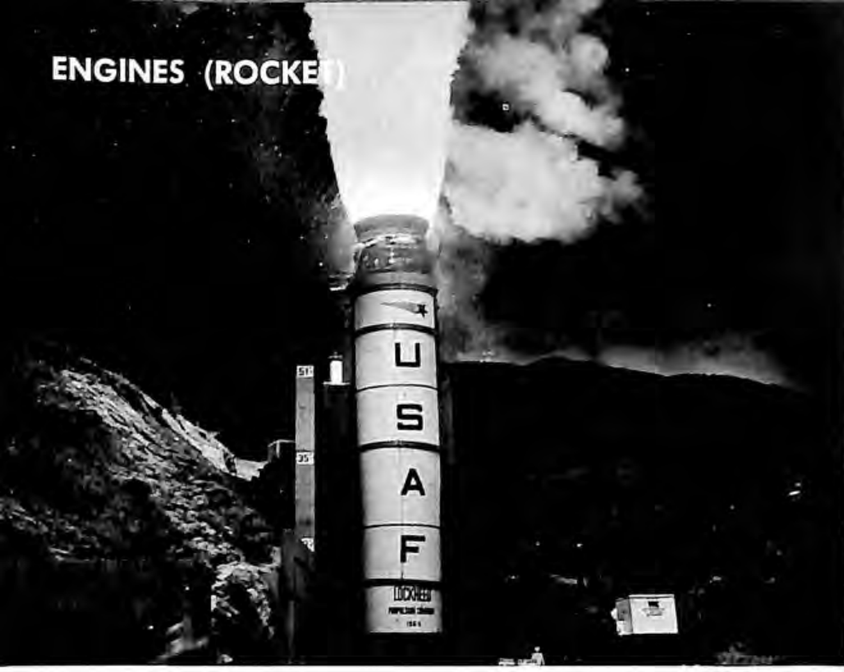
The Apollo Launch Escape Motor subsystem consists of 2 solid-propellant rocket motors designed to pull the Apollo Command Module away from the Saturn booster in the event of malfunction during launch. A solid-fuel motor (1) supplies the main impulse. The escaping spacecraft is put into an arching trajectory by a smaller, pitch control motor (2) mounted in the forward section of the assembly. Photo shows Launch Escape Motor being integrated into the Launch Escape System (LES) at Cape Kennedy.

Specifications

Length (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

Under an Air Force feasibility demonstration program, Lockheed's 156-inch-diameter solid rocket motors have developed thrusts up to 3,000,000 pounds for durations up to approximately 120 seconds. Segmented and monolithic maraged steel cases have been employed in the tests, which have also demonstrated liquid injection, jet tab, and hot gas valve thrust vector control systems.

SRAM PULSE MOTOR

Prime Contractor: Lockheed Propulsion Company

Remarks

Lockheed is developing the solid rocket pulse motor for the Air Force's new SRAM (Short-Range Attack Missile), or AGM-69A missile, slated to be carried aboard FB-111 and B-52 aircraft. Lockheed Propulsion has test fired solid rocket motors containing nearly 250 pulses during the 4 years it has been engaged in pulse motor work.

VIP ROCKET MOTORS

Prime Contractor: Lockheed Propulsion Company

Remarks

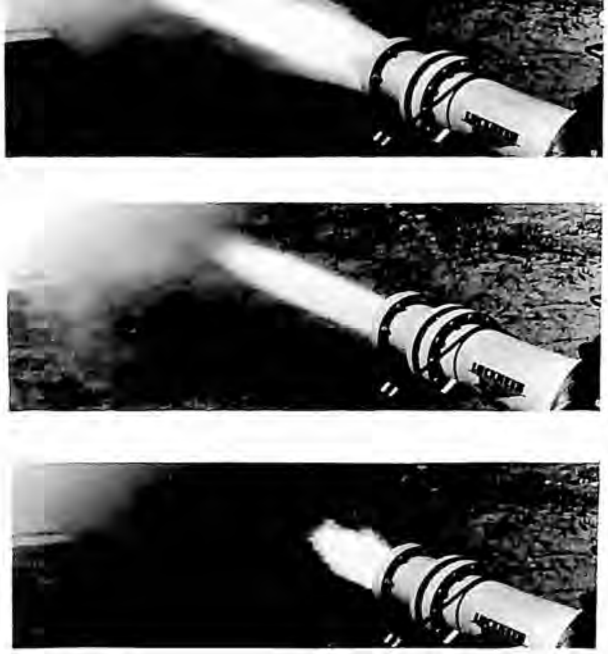
Lockheed has production contracts for over 20 versions of its small VIP (Velocity Increment Producing) rockets being produced for several missile programs including the Air Force Minuteman. Actually 2 rocket motors within a single case, the VIP units are capable of imparting both spin and axial thrust in varying amounts that can be tailored with exact precision. In photo, Lockheed official points to one of 3 small spin rocket motor nozzles in the aft end of a typical rocket motor.

GUN-LAUNCHED ROCKETS

Prime Contractor: Lockheed Propulsion Company

Remarks

Lockheed Propulsion Company is conducting a series of research, development and demonstration programs, some sponsored by the military services, of launching high mass fraction rocket vehicles from guns using normal powder charges to blast the vehicles from their muzzles. The work is based on 2 recently received Lockheed patents which cover the firm's liquid suspension method of launching. The new technique offers velocity double that of a standard shell and significant increases in range. One stage to orbit vehicles and low-cost sounding rockets are also under study using this technique. Photo shows technicians loading rocket vehicle into a 155-millimeter field gun at firm's Potrero test range.



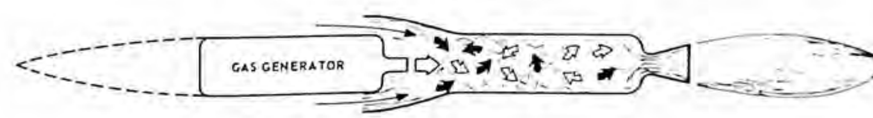
LOCKHEED RSVP ROCKET MOTORS

Prime Contractor: Lockheed Propulsion Company

Remarks

Lockheed is conducting a series of development programs of controllable rocket motors among which the RSVP (Restartable, Solid, Variable Pulse) rockets are prominent. Designed for use in upper-stage applications, RSVP systems have an inherent capability of unlimited starting and stopping and variation of thrust over a wide range. Hundreds of RSVP motors have been fired by the firm, with the longest being a 7½-minute test. RSVP rockets, which come in solid-solid and liquid-solid versions, are based on the mass augmentation principle developed at Lockheed. Photo shows a liquid-solid engine of heavy-weight design undergoing 19:1 throttling test, with full thrust depicted at top, intermediate thrust in the center and low thrust at bottom.

AIR AUGMENTED HYBRID ROCKET MOTOR



LOCKHEED AIR AUGMENTED HYBRID ROCKET

Prime Contractor: Lockheed Propulsion Company

Remarks

Under development at Lockheed for the Air Force is an advanced air augmented rocket engine designed to combine air scooped up during flight with fuel-rich exhaust products of a hybrid rocket gas generator. Secondary combustion, taking place in an afterburner, results in an increase in specific impulse. Photo shows sketch of how rocket works.

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 served also as the velocity control rocket for NASA's Lunar Orbiter spacecraft, and it is used on 2 other classified vehicles. The Model R-4D provides high pulsing and steady state performance in combination with reliable, long-life operation. Fully qualified and in production, the engine has successfully demonstrated flight reliability on Apollo-Saturn flights as well as on 5 Lunar Orbiter missions.

Specifications

Length 13.4 inches; diameter 5.6 inches; weight 4.9 pounds; propellants (oxidizer) nitrogen tetroxide and (fuel) 50-50 blend of hydrazine and unsymmetrical dimethyl hydrazine or monomethyl hydrazine; radiation-cooled chamber.

Performance

Thrust 100 pounds nominal vacuum.

R-5B

Prime Contractor: The Marquardt Corporation

Remarks

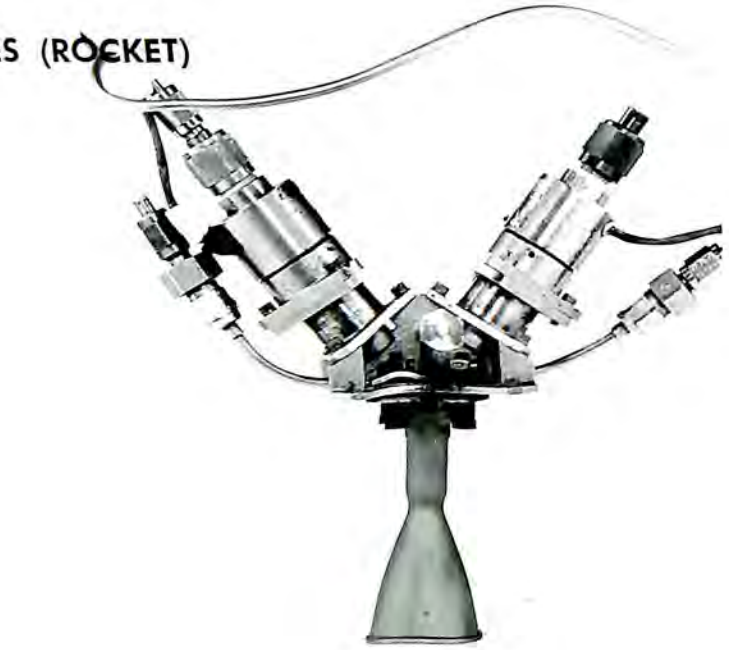
The Model R-5B liquid hypergolic bipropellant rocket engine was developed for NASA as an ullage and Delta V rocket, originally for application on the Saturn S-IVB stage.

Specifications

Length 38.7 inches; diameter 17 inches maximum; weight 70 pounds; propellant (oxidizer) nitrogen tetroxide and (fuel) 50-50 blend of nitrogen tetroxide and unsymmetrical dimethyl hydrazine; ablative chamber.

Performance

Thrust 1,750 pounds nominal vacuum.



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 furthur 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. It is now used on a classified vehicle. Engine is developed for high pulsing and steady state performance in combination with reliable, long-life operational characteristics.

Specifications

Length 10.1 inches; diameter 6 inches; weight 3.5 pounds; propellants (oxidizer) nitrogen tetroxide and (fuel) monomethyl hydrazine or blend of hydrazine and unsymmetrical dimethyl hydrazine; radiation-cooled chamber.

Performance

Thrust 22 pounds nominal vacuum.

DEMAND MODE INTEGRAL ROCKET RAMJET

Prime Contractor: The Marquardt Corporation

Remarks

The Demand Mode Integral Rocket Ramjet (DMIRR) is intended as the propulsion system for advanced volume-limited air-launched tactical missile systems. The system combines liquid-fueled rocket and ramjet engine technology to provide potential mission flexibility. DMIRR is in exploratory development under U.S. Navy sponsorship.

R-13C

Prime Contractor: The Marquardt Corporation

Remarks

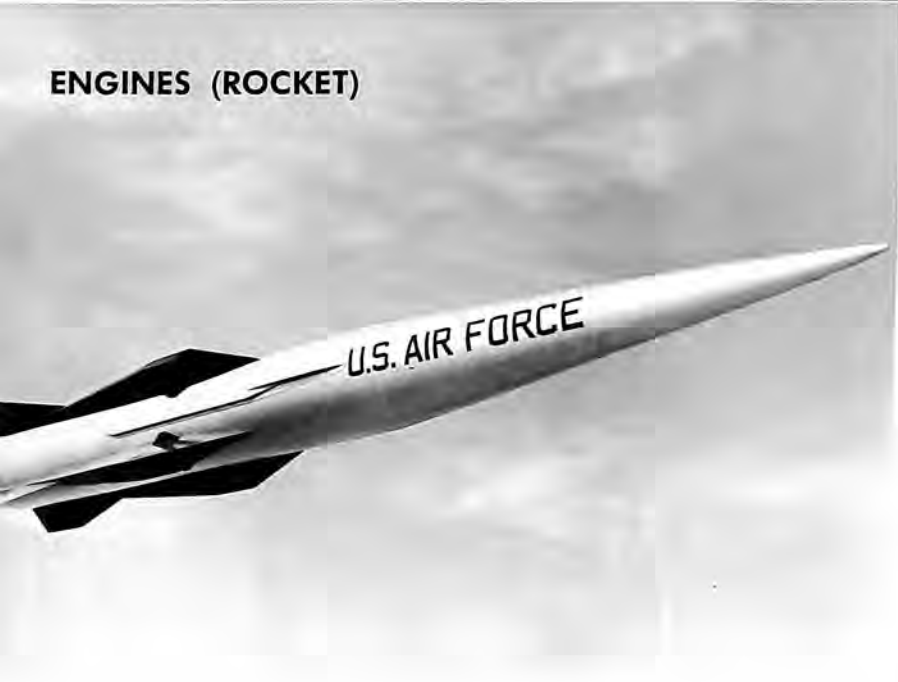
The Model R-13C is a monopropellant hydrazine rocket engine developed as a spin rate control, station-keeping and plane change engine for spacecraft. The engine has been developed for high-performance reliability and long life in both the steady state mode and the pulsing mode.

Specifications

Length 6.65 inches; diameter 2.09 inches; weight 1.47 pounds, lightweight version .936 pound; fuel hydrazine.

Performance

Thrust 5 pounds nominal vacuum.



SCP/LASRM INTEGRAL RAMJET ROCKET

Prime Contractor: The Marquardt Corporation

Remarks

Developed for the Air Force, the Supersonic Chemical Propulsion for Low-Altitude Short-Range Missiles (SCP/LASRM) combines the high acceleration capability of the solid rocket and the high speed cruise capability of the ramjet in a single propulsion package. This is an advanced development program including both ground and flight testing to demonstrate the feasibility of combining the 2 propulsion modes. The integral ramjet rocket has particular application to that class of airborne missile requiring low-volume, high-payload capability.

RL10 ROCKET ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

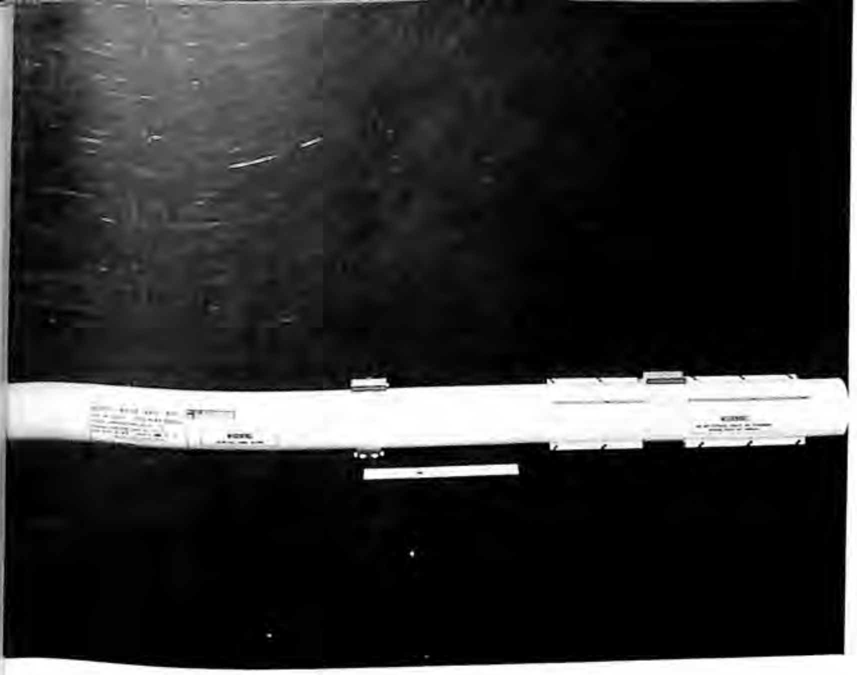
The RL10A-3-1 was the world's first operational liquid-hydrogen rocket engine. It was developed for NASA as power plant for the Centaur and for the Douglas S-IV stage of Saturn I. The latter, a developmental stage leading to larger hydrogen-powered space vehicles, was phased out after 6 successful flights. Centaur was designed to carry unmanned scientific payloads to the moon, Mars and other planets. An advanced model of the RL10, the 10A-3-3, has been flown successfully on the more recent Centaur flights.

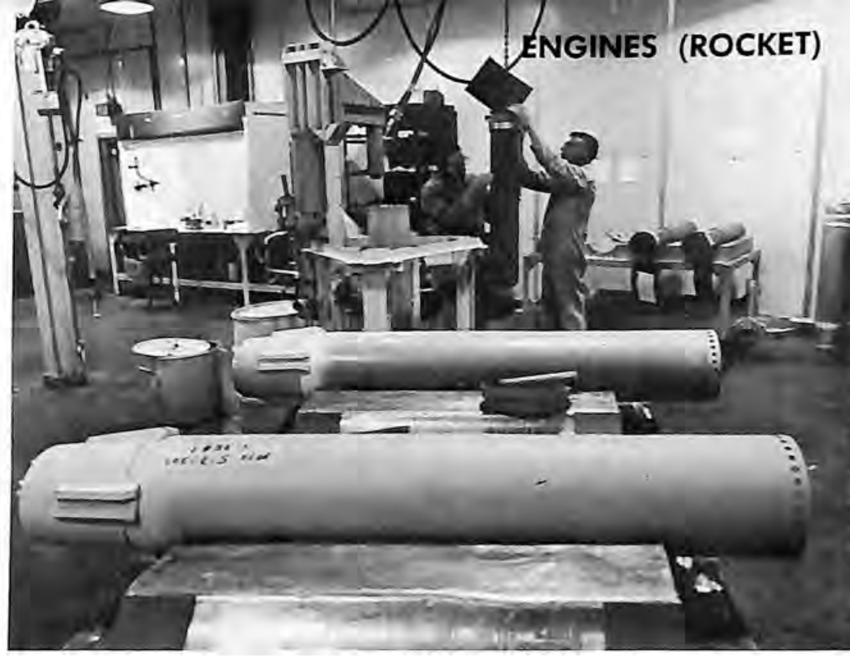
Specifications

Length 69 inches; diameter at exhaust nozzle 40 inches; weight (approximate) 292 pounds; expansion ratio (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 is 72 inches long and 5 inches in diameter and contains 60 pounds of Flexadyne propellant. Loaded with propellant, the motor was subjected to extensive vibration, shock, drop tests simulating extremes of operational use, and temperature extremes ranging from subzero 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 subzero to over 300 degrees Fahrenheit, survived several days of continuous vibration, and passed drop tests from heights up to 40 feet and special shock tests simulating aircraft carrier catapult and arrested landing conditions. The Sparrow III motor is the first to combine a unique free-standing propellant charge (grain) with Flexadyne, a solid propellant which increases performance and operating temperature range and resists cracking or tearing at extremely low temperatures.

SHRIKE ROCKET MOTOR (AGM-45A)

Prime Contractor: Rocketdyne Division of North American Rockwell Corporation

Remarks

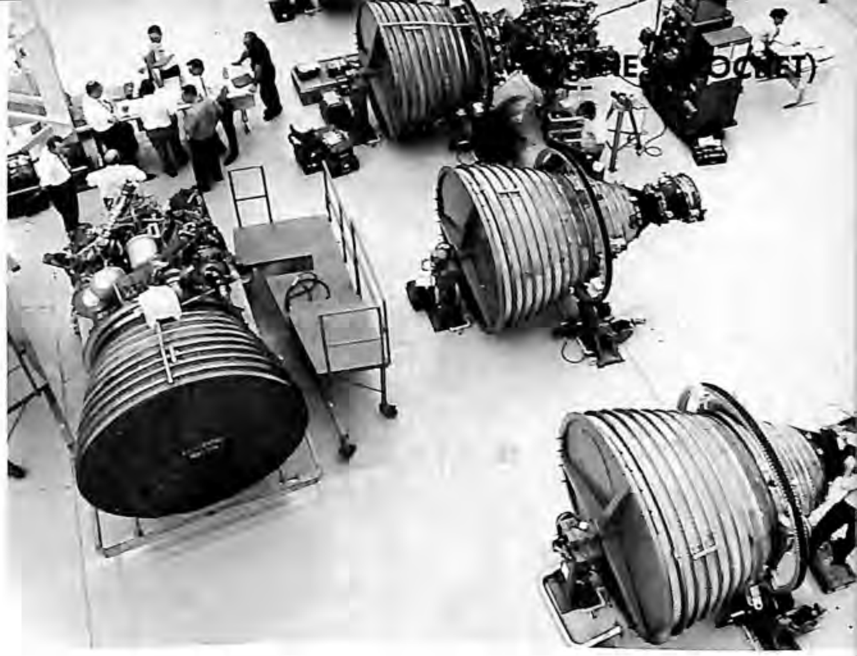
First in a new generation of tactical weapons, the Navy's Shrike air-to-ground missile is powered by a solid-propellant rocket motor similar in design and performance to the propulsion system of Sparrow III 6-b. Both motors combine a unique, free-standing propellant charge (grain) with Flexadyne, a solid 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 SOLID MOTORS

Prime Contractor: Rocketdyne Division of North American Rockwell Corporation

Remarks

Rocketdyne's Solid Rocket Division, McGregor, Texas, produces a number of motors for specialized applications. Among them are the ullage motors (photo) 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 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.



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 8 units, has been uprated to first-stage thrust of 1,640,000 pounds for later flights of the Saturn IB vehicles. Regeneratively cooled, it burns a combination of RP-1 fuel and liquid oxygen oxidizer. Engines are tested singly at Rocketdyne's Santa Susana Field Laboratory in California prior to delivery to NASA's Marshall Space Flight Center and the Chrysler assembly plant at Michoud, Louisiana.

Specifications

Maximum envelope length 102 inches; maximum diameter 66 inches.

Performance

Thrust 205,000 pounds.

J-2 ENGINE

Prime Contractor: Rocketdyne Division of North American Rockwell Corporation

Remarks

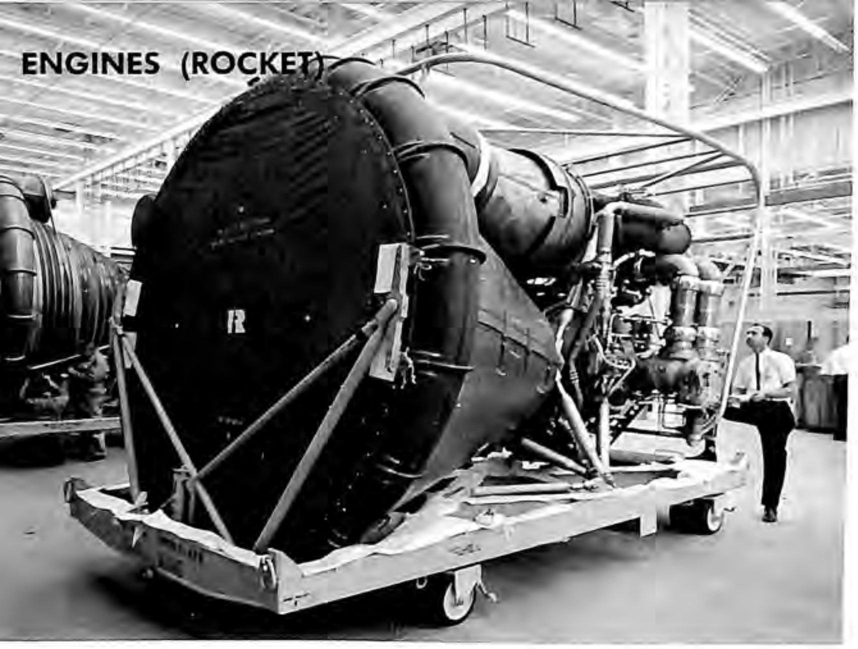
One of the major engines in NASA's manned space flight program is the J-2, which burns liquid hydrogen fuel with a liquid oxygen oxidizer; it is the largest hydrogen-burning engine to reach qualification and production status (in photo, J-2 production line at Rocketdyne's Canoga Park, California, plant). The regeneratively cooled, 225,000-pound-thrust engine plays an important role in the nation's 2 largest launch vehicles: in Saturn IB, it is used singly, as the propulsion unit for the S-IVB stage, second stage of the vehicle; in Saturn V, it is employed in a 1,000,000-pound-thrust cluster of 5 as the second stage and in the S-IVB as the third stage, which sends Apollo astronauts into a lunar trajectory. J-2 was developed under the technical direction of NASA's Marshall Space Flight Center.

Specifications

Maximum envelope length 133 inches; maximum envelope diameter 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. 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.

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

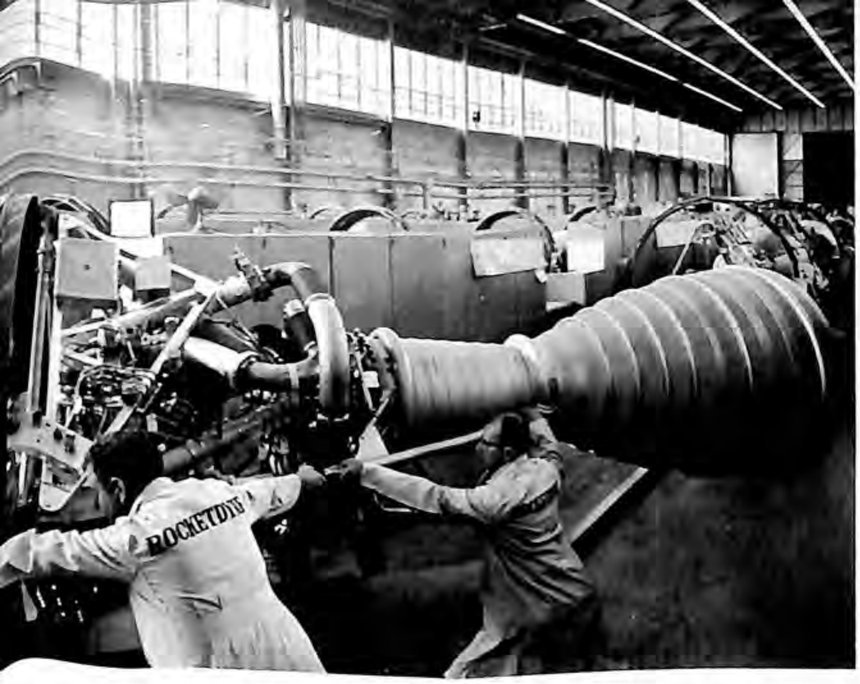
The MA-5 system is the propulsion package for the SLV-3 launch vehicle. Generating 388,300 pounds of thrust, it was used for all Mercury Atlas astronaut launchings. In long-range missile tests, the engine hurled the Atlas as far as 9,000 miles from the launching pad at Cape Kennedy. The primary engine 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

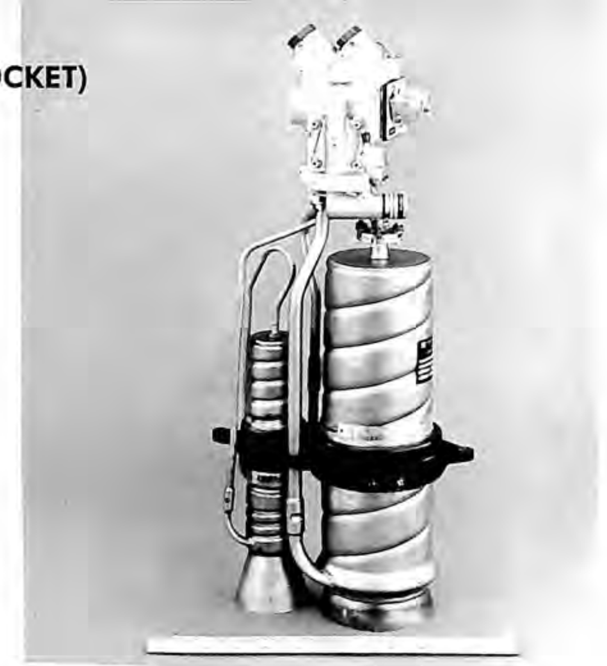
A supplemental propulsion unit for manned aircraft, the AR2-3 provides extra thrust for the Lockheed NF-104A Starfighter to augment its turbojet engines and enable it to attain altitudes up to 130,000 feet for aerospace training missions. The liquid-propellant rocket engines boost thrust by more than 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

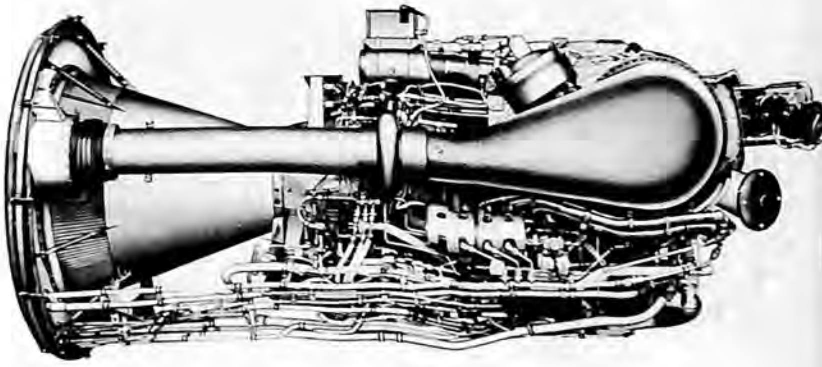
Thrust (sustainer) 106 pounds at 70,000 feet, (booster) 550 pounds at 25,000 feet.

GEMINI, APOLLO ATTITUDE CONTROL THRUSTERS

Prime Contractor: Rocketdyne Division of North American Rockwell Corporation

Remarks

The Gemini and Apollo attitude control thrusters are small, liquid-propellant rockets which burn a combination of monomethyl hydrazine fuel and nitrogen tetroxide oxidizer. They are employed for corrections of spacecraft attitude in orbit, in lunar trajectory and during reentry. The units are employed in multiples. The Gemini system has 8 thrusters of 25 pounds thrust each. The Apollo system (individual units shown in photo) has 2 sets of 6 engines each, one set redundant, all engines 93 pounds thrust.



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 has completed an extensive qualification program at Rocketdyne. All work on the propulsion system is being done at Rocketdyne's Solid Rocket Division, McGregor, Texas. First powered flight test of the Phoenix missile, designated AIM-54A, came in April 1966, just 2 months after completion of the propulsion development program. The Phoenix motor utilizes Flexadyne, a proven solid propellant developed by Rocketdyne to provide tactical missiles with performance increases throughout an extended environmental operating temperature range. Flexadyne propellant is particularly adaptable to the Phoenix missile requirements of high volumetric loading, high total impulse and long burning time, thus providing the long-range operational capability required by the Navy.

YLR99-RM-1 TURBOROCKET

Prime Contractor: Thiokol Chemical Corporation

Remarks

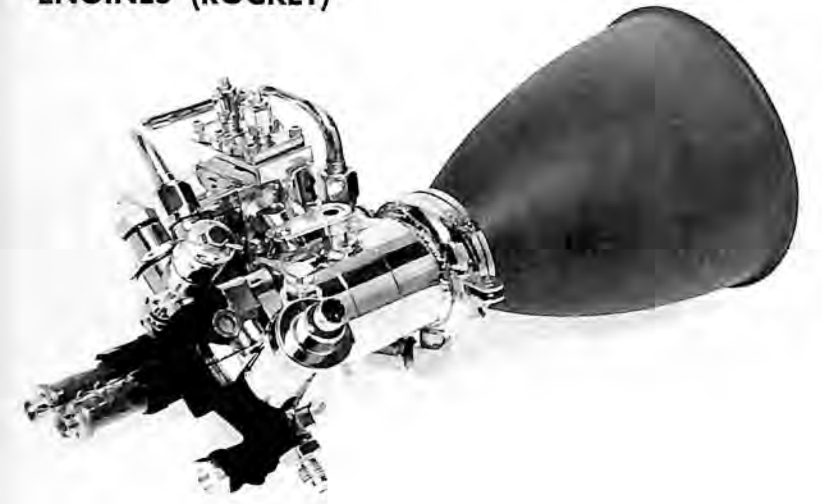
The YLR99-RM-1 throttleable turborocket engine was developed by Thiokol's Reaction Motors Division to provide propulsion for the X-15 hypersonic manned research aircraft. The engine fulfills the manned safety requirements of MIL-E-5149 and incorporates extensive malfunction self-monitoring and safety 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 flow rate 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 monomethyl hydrazine 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.

AF 156-8 LARGE SOLID BOOSTER MOTOR

Prime Contractor: Thiokol Chemical Corporation

Remarks

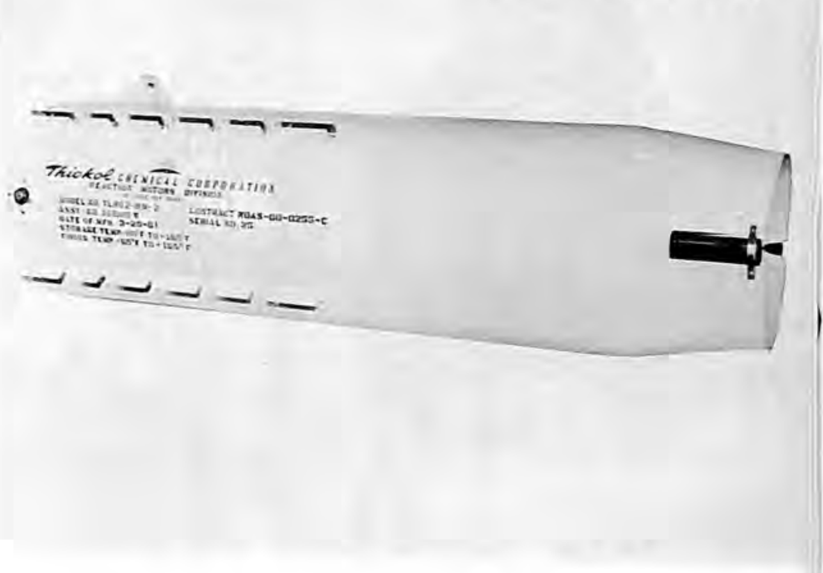
The AF 156-8 motor, incorporating the world's largest segmented fiberglass reinforced case, was test fired at the Wasatch Division of Thiokol Chemical Corporation near Brigham City, Utah, on June 25, 1968. Developed under a manufacturing technology program funded by the Air Force Materials Laboratory, Wright-Patterson AFB, the segmented fiberglass case weighed approximately 26,000 pounds. It was designed by Thiokol and fabricated under subcontract by the Aerospace and Defense Products Division of the B. F. Goodrich Company, Akron, Ohio. The nonhydroclaved ablative nozzle was developed in a separate program by TRW Systems, Cleveland, Ohio. The segmented case was hydroproof tested prior to loading with approximately 500,000 pounds of propellant, then hydrostatically burst following the static firing. The motor developed approximately 1,000,000 pounds of thrust during the 120-second firing, and all test objectives were met.

Specifications

Overall length of assembled case 606.87 inches; outside diameter 156 inches; loaded weight 519,800 pounds; nozzle throat diameter 32.9 inches.

Performance

Operating time 123.8 seconds; total impulse 118,000,000 pounds.



C-1 RADIAMIC ENGINE

Prime Contractor: Thiokol Chemical Corporation

Remarks

The C-1 Radiamic Engine is a 100-pound, fixed-thrust liquid rocket engine developed for NASA's George C. Marshall Space Flight Center to meet space vehicle maneuvering and velocity control requirements of typical missions. The engine is a high-performance unit having unlimited restart capability for operation in steady state modes of 2 seconds to 2,000 seconds' duration. The C-1 engine was qualified with radiation-type nozzle extensions. However, the basic chamber is designed to accept interchangeable ablative extensions. Operating propellants are helium saturated nitrogen tetroxide oxidizer and monomethyl hydrazine fuel. The engines can be equipped with quadredundant valves incorporating series-parallel propellant controls which offer valve redundancy features, or with mechanically linked bipropellant valves. The C-1 qualification design has a reliability of 99 percent to a 50 percent confidence level for the mission duty cycle demonstrated. The engine's design maturity is reflected in a test history which encompasses 750,000 engine starts and nearly 100 hours of hot firing time.

Specifications

Thrust 100 pounds (vacuum); chamber pressure 96 pounds per square inch; specific impulse 292 seconds; wet weight, with bipropellant valve 6.95 pounds, with quadredundant valve 16.25 pounds.

LR62-RM-2/4 ROCKET ENGINE

Prime Contractor: Thiokol Chemical Corporation

Remarks

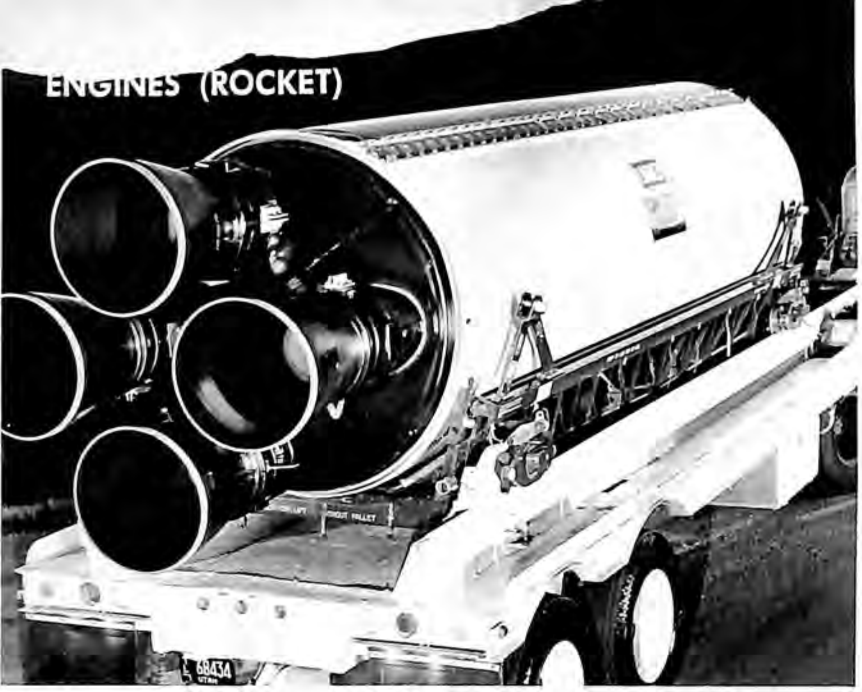
The LR62 packaged, liquid-propellant rocket engines provide power for Navy and Air Force Bullpup B (AGM-12C) air-to-surface guided missile. The engine, a larger version of Thiokol's LR58 engine which was developed for Bullpup, utilizes factory-loaded propellants of inhibited red fuming nitric acid (IRFNA) and a mixed amine fuel (MAF-1). Arrangement of internal components and operation are 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 61.2 inches; diameter 17.32 inches; weight 536 pounds (loaded).

Performance

Storage life 5 years; reliability 99.84 percent.



M55A1 MINUTEMAN STAGE I MOTOR

Prime Contractor: Thiokol Chemical Corporation

Remarks

The first full-scale Stage I Minuteman motor was successfully static tested in April 1959. Subsequent static tests demonstrated a successful motor design that was subjected to preliminary flight rating tests (PFRT) beginning in October 1960. The first Minuteman flight test followed in February 1961 and was completely successful. Following this initial flight success, the PFRT configuration motor was optimized into the Wing I motor configuration for qualification and delivery to the first operational wing at Malmstrom AFB, Montana. Wing I motor production was initiated in November 1961. Production of Wing II configuration motors was initiated in December 1962. In early 1966, production of the Reliability Improvement Program Wing VI motor configuration was started.

Specifications

Overall length, including nozzles (4), 294.9 inches; diameter, including insulation and welds, 65.9 inches; case material D6AC steel; nozzle type, swivel, hydraulically actuated.

Performance

Thrust level (approximate) 180,000 pounds; operational time 60 seconds.

AIR-2A GENIE MOTOR

Prime Contractor: Thiokol Chemical Corporation

Remarks

The AIR-2A Genie is an unguided air-to-air missile, weighing 800 pounds, which is operational on the F-101B, F-106 and F-4 aircraft. Packing a nuclear warhead and having a 6-nautical-mile range, the single-nozzle missile uses free flight supersonic guidance and has proximity fuzing. The TU-289 rocket motor, which powers the AIR-2A Genie, is produced by the Wasatch Division of Thiokol Chemical Corporation. The solid-propellant motor weighs 482 pounds loaded. It has been qualified for operation over a temperature range from −75 to +175 degrees Fahrenheit and over the full range of environments specified by the MIL-R25532 series. Motor shelf life is in excess of 4 years.

Specifications

Length 67 inches; diameter 15 inches; case material AISI 4130 steel; propellant weight 320 pounds.

SPARM

Prime Contractor: Thiokol Chemical Corporation

Remarks

Air-augmented propulsion can provide a severalfold increase in performance over conventional chemical rockets. This has been amply demonstrated in many subscale and full-scale direct tests, as well as in free flight jet and flight tests. Thiokol, under direction of Eglin AFB, conducted an Air Force program called SPARM, for Solid-Propellant Augmented Rocket Motor. Using a modified AQM-37A target drone as the test vehicle, 2 vehicles were launched from an F-4B aircraft at the Naval Missile Test Center, Point Mugu, California, to complete the program. SPARM incorporated a unique feature using the secondary combustion chamber as the chamber for a conventional booster motor. After boost, the head end dome and the booster nozzle were jettisoned, resulting in a minimum-weight 2-stage system. Through contracted and company-funded programs, significant improvements over SPARM performance have been demonstrated; gas generators employing both solid and liquid/slurry propellants generate fuel-rich gases which are mixed with air for subsonic combustion in a secondary combustion chamber. In addition, supersonic combustion has been demonstrated in a realistic hardware configuration with fuel-rich solid propellants.

TE-M-364 SURVEYOR MAIN RETRO MOTOR

Prime Contractor: Thiokol Chemical Corporation

Remarks

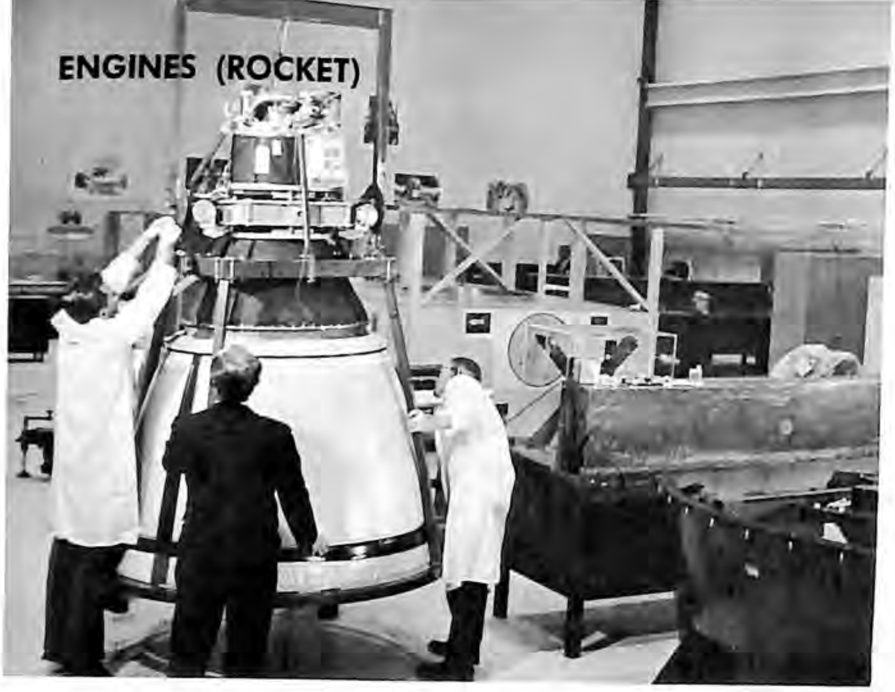
The TE-M-364 Surveyor Main Retro motor was developed to provide the major portion of deceleration during the descent of the Surveyor spacecraft to the lunar surface. The motor was ignited at a slant range of about 60 miles from the lunar surface approximately 3 minutes before touchdown. The Surveyor Main Retro motor is a spherical, solid-propellant unit equipped with a semisubmerged nozzle to minimize overall length. An ingenious cutting method permits each grain, although cast to the same propellant weight, to be tailored to mate with a specific spacecraft. The case is of D6AC steel with a minimum membrane thickness of .037 inch. The unique composite nozzle structure incorporates a glass cloth-phenolic structural member running the length of the nozzle. The nominal expansion ratio is 53:1. The pyrogen igniter system is equipped with a safe-and-arm device. A versatile motor, the Surveyor has appeared in 2 other applications: Burner II and Delta. The mounting structure was modified to adapt the motor to propulsion of the Burner II second stage and Delta third stage.

Specifications

Length 37 inches in diameter, 55 inches overall; propellant weight 1,400 pounds; burnout weight 145 pounds.

Performance

Burn time 40 seconds, decelerating spacecraft from 8,700 to 400 feet per second.



LUNAR MODULE DESCENT ENGINE (LMDE)

Prime Contractor: TRW Systems Group, 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 midcourse, retro and orbit adjust maneuvers and, therefore, operate 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 storable bipropellants at a mixture ratio of 1.6. The engine has an ablative chamber with a lightweight titanium nozzle extension.

URSA 100 R

Prime Contractor: TRW Systems Group, TRW Inc.

Remarks

This storable bipropellant engine being developed by TRW completed its PERT 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 Group, TRW Inc.

Remarks

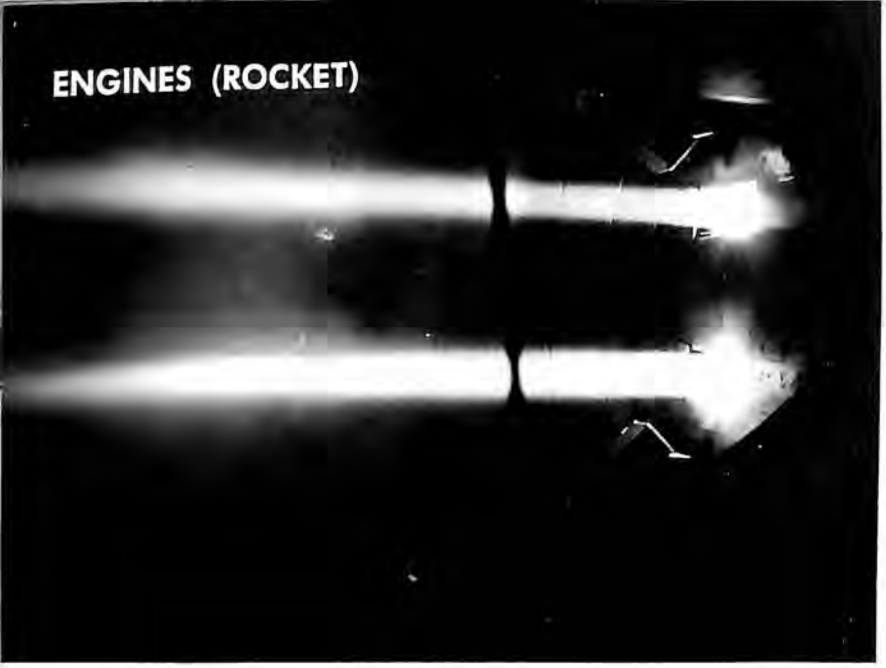
The Position and Orientation Propulsion System for Intelsat III was developed by TRW Systems. This is a monopropellant hydrazine propulsion system which uses Shell 405 spontaneous catalyst to decompose the propellant. A series redundant valve on each thruster is designed for 50,000 cycles. The POPS is designed for 5 years in space operation. The system operates over a blow down range of 4 pounds thrust to 1.2 pounds thrust and has 2 sets of 2 thrusters each (redundant). The system loaded weighs 63 pounds and each thruster valve assembly weighs .53 pound.

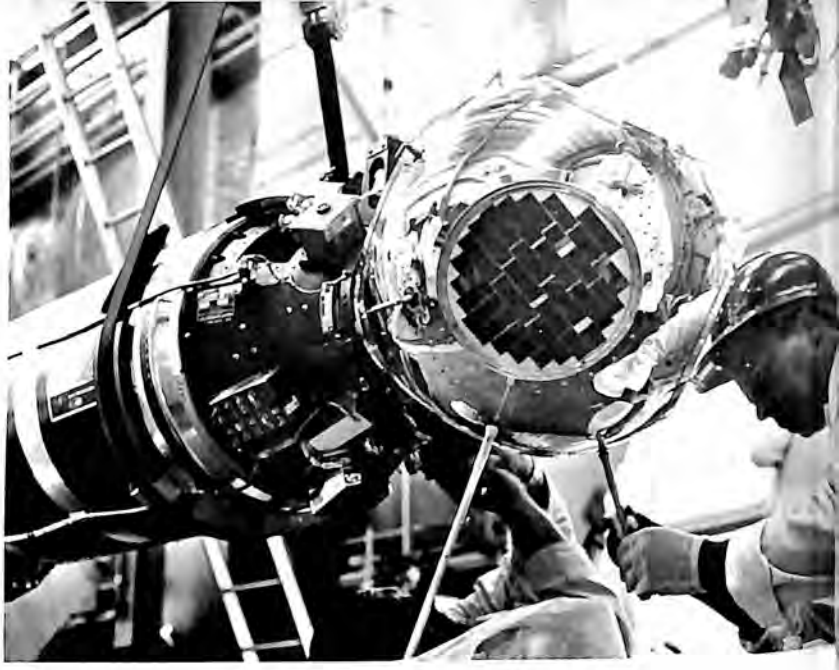
MARINER '69 PROPULSION SYSTEM

Prime Contractor: TRW Systems Group, TRW Inc.

Remarks

This system has been 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 quadredundant squib valve and jet vanes for thrust vector control.





TRW ION ENGINE
Prime Contractor: TRW Systems Group, TRW Inc.

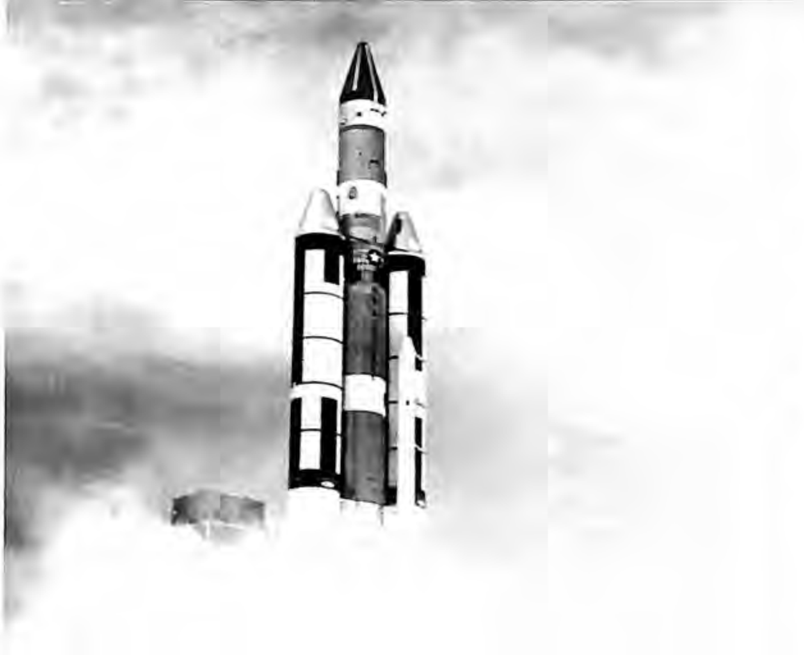
Remarks
One major effort of TRW Systems in its extensive research and development in the field of electric propulsion is a working ion engine, a cesium contact thrust device. The engine operates by feeding cesium to a hot tungsten plate where it ionizes; the positive ions leave the hot plate and pass through a charged electric grid. Accelerating the ions, the grid causes them to exit through the nozzle at velocities of about 30 miles per second.

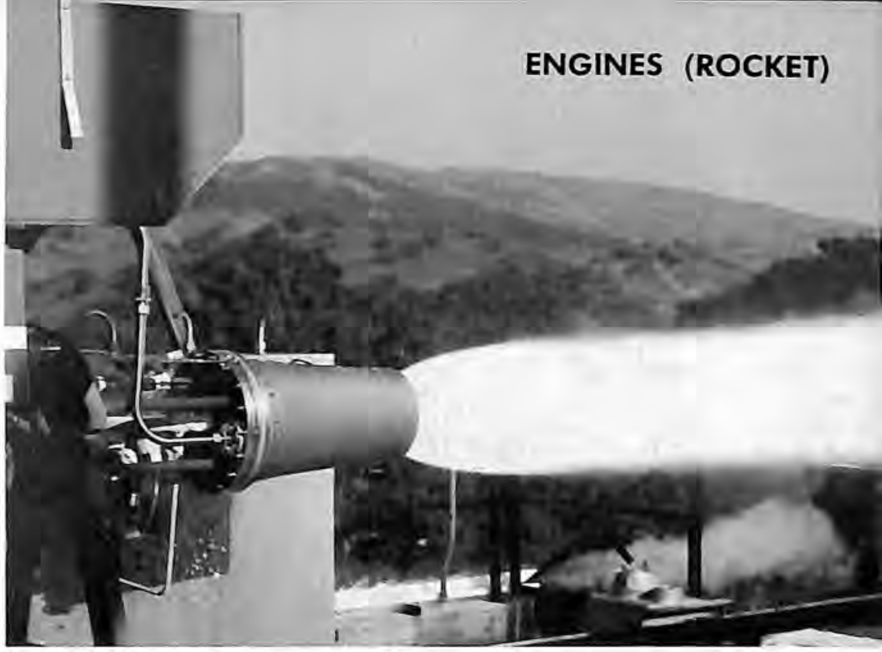
FW-4 UPPER-STAGE ROCKET
Prime Contractor: United Technology Center

Remarks
The FW-4 solid-propellant upper-stage rocket motor is designed for use on boost vehicles with orbital, probe or reentry missions, as well as for retrorocket propulsion for space vehicles and as 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 a 6,000-pound-thrust USAF version used as improved Scout fourth stage.

Specifications
Length 58.43 inches; diameter 19.6 inches; weight 660.5 pounds; propellant PBAN with aluminum additives and ammonium perchlorate oxidizer; nozzle composite structure of aluminum, graphite and silica; ignition redundant squib pyrogen.

Performance
Thrust 5,400 pounds.





TITAN III-C BOOSTER ROCKETS

Prime Contractor: United Technology Center

Remarks

The Titan III-C is a versatile space launch vehicle designed to boost military payloads ranging from more than 25,000 pounds in low earth orbit to 5,000 pounds in deep space. Its UTC booster stage has operated flawlessly in all launches since its initial flight in 1965. This stage includes 2 120-inch-diameter, 1,000,000-pound-thrust rockets operating in tandem, each with its own thrust termination and destruct systems, and a secondary liquid injection system for steering. UTC has been awarded a 3½-year contract to produce this booster stage for the Titan III-C/D. Also, UTC is developing a more powerful version of this booster stage for use on the Titan III-M. Each of the giant booster rockets for this vehicle will provide 1,600,000 pounds of thrust.

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 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 liquid-propellant engines that can remain in space with stop-start 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 dimethyl hydrogen and nitrogen tetroxide; nozzle composite structure with fiberglass shell and silica-phenolic liner; ignition hypergolic.

Performance

Thrust, smallest 2,000 pounds, largest 50,000 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

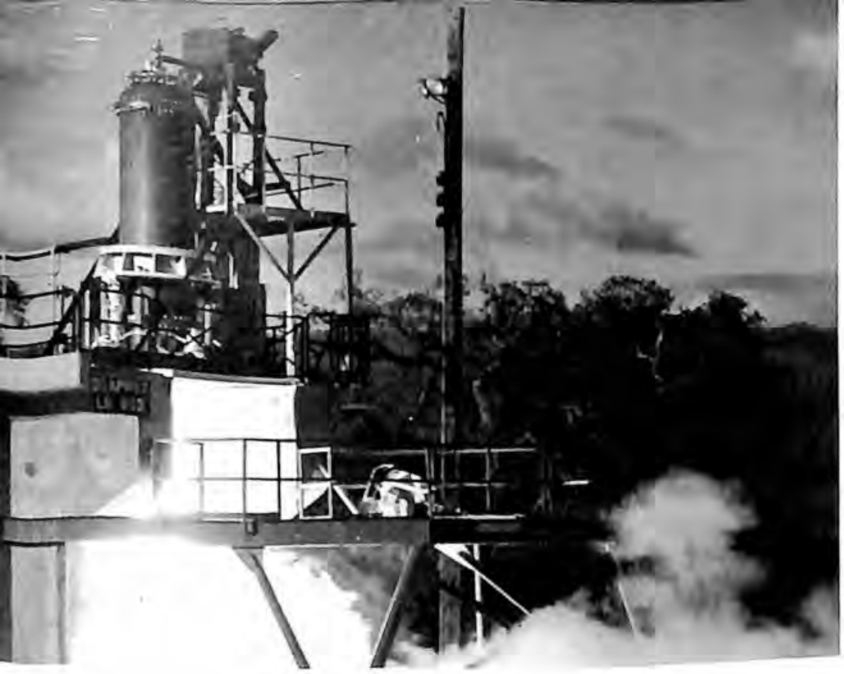
UTC's solid-propellant translation rockets were developed in 1963 for use in separation of the Titan II intercontinental ballistic missile's stages. The company designed, produced and test fired the first translation rocket in 122 days. In mass production at UTC, the aluminum-encased rocket is also used 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.

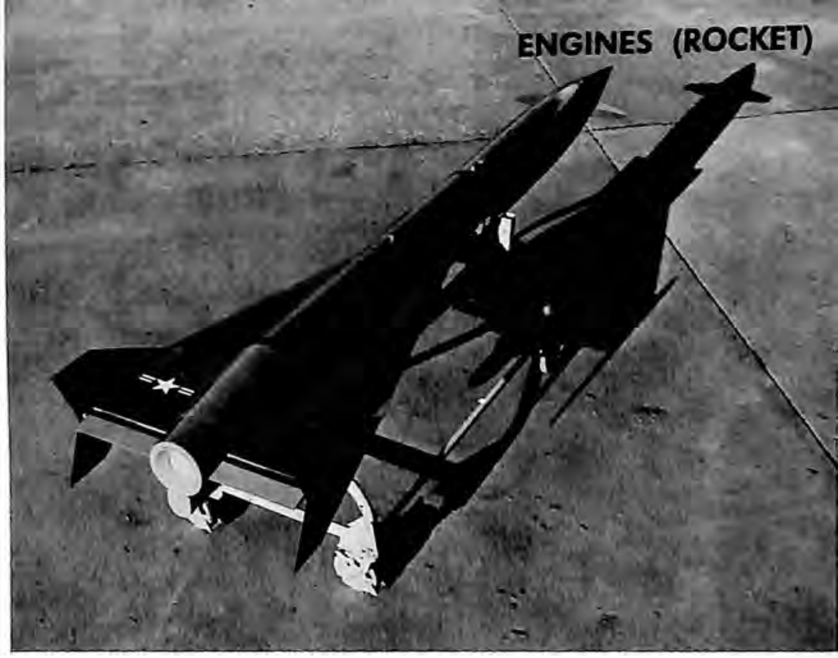
Specifications

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; diameter 38 inches; 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 subsonic and supersonic speeds. Its propulsion system will be the nation's first operational hybrid rocket and will use a solid fuel and liquid oxidizer. It will also have, for the first time in any rocket engine, a wide-range flight pattern which can be predetermined by the simple twist of a mechanical dial. This system is known as "dial-a-thrust." Airframe for the vehicle is a modified AQM-37A target missile produced by Beech Aircraft.

Specifications

Sandpiper will be 175 inches long and 10 inches in diameter and will weigh 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.

O-235 SERIES RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

The O-235 series engine has been in the Lycoming line for many years. A popular flat opposed engine, it is being used in the new American Aviation Yankee and Champion and in some export aircraft.

Specifications

Length 30.7 inches; width 32 inches; height 22.4 inches; weight 242 pounds; bore 4.375 inches; stroke 3.875 inches; displacement 235 cubic inches; compression ratio 6.75:1.

Performance

Take-off 115 horsepower, continuous 108 horsepower.

IO-320 FUEL INJECTED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

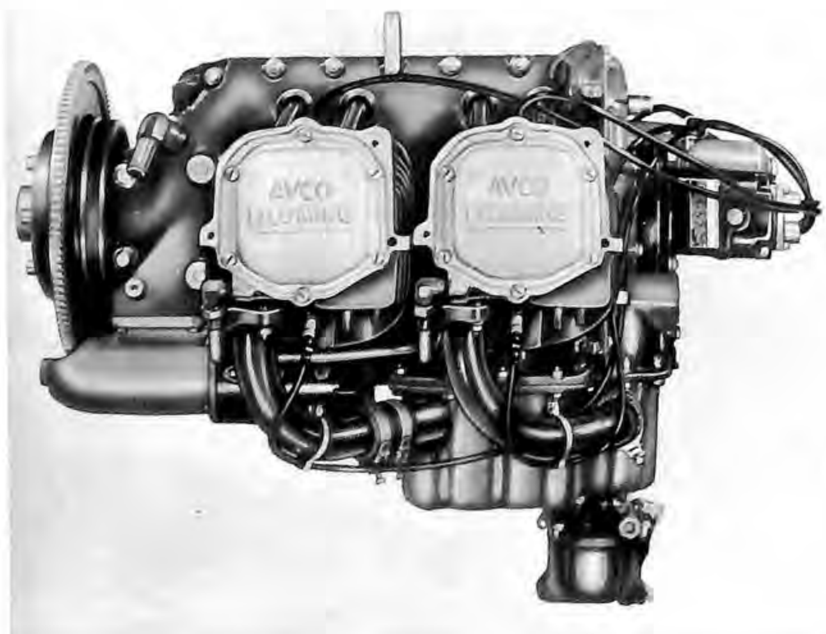
The IO-320 engine is a high compression, fuel injected version of the original famous Lycoming 150-horsepower, flat opposed engine that is so well known in the general aviation industry. The engine is being used by Piper in the Twin Comanche and by Wing Aircraft in the Derringer. The engine is supplied with an automotive type starter and generator/alternator and uses 100/130 octane fuel.

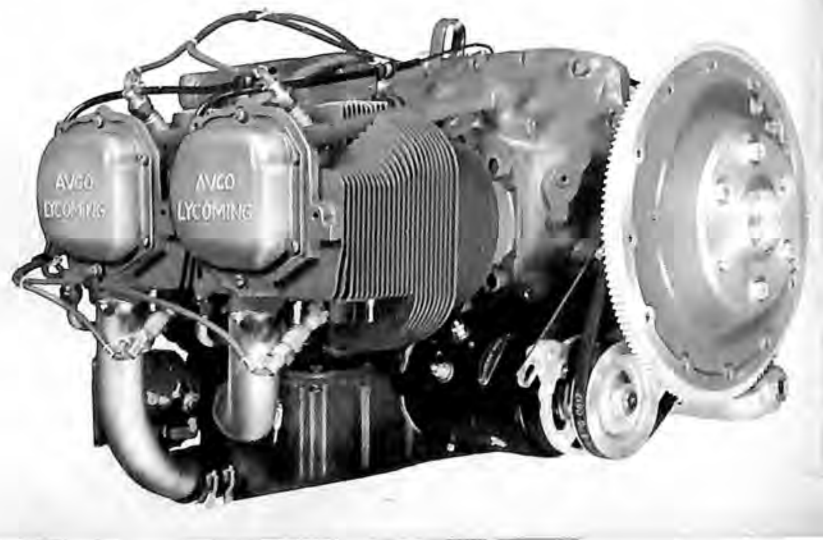
Specifications

Length 33.59 inches; width 32.24 inches; height 19.22 inches; weight 287 pounds; bore 5.125 inches; stroke 3.875 inches; displacement 320 cubic inches; compression ratio 8.5:1.

Performance

160 horsepower continuous.





AIO-360 FUEL INJECTED AEROBATIC ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

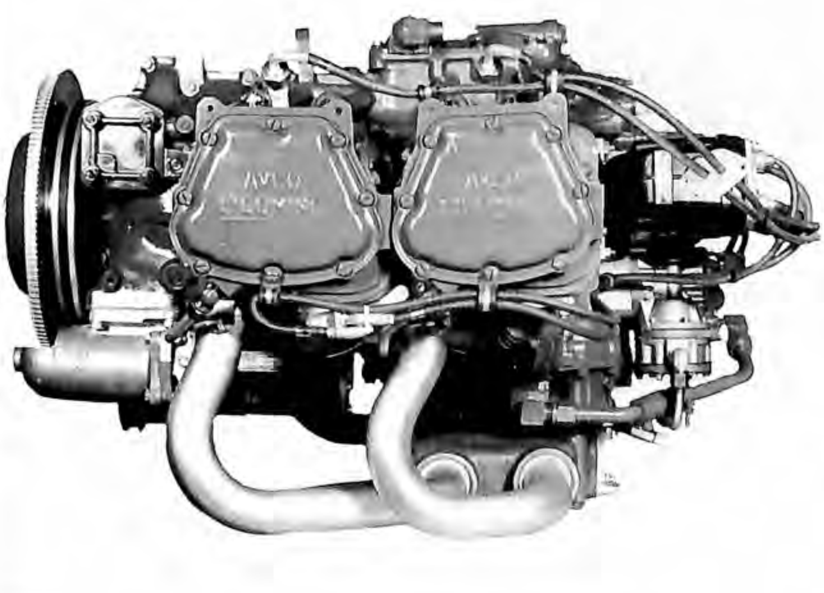
Avco Lycoming was the first engine manufacturer to receive a production certificate for an aerobatic engine. This engine is equipped with a continuous fuel flow injection system and has a small oil sump on top of the engine which is designed in such a manner that the engine will receive proper lubrication when the aircraft is being flown inverted. Avco Lycoming designed this engine because of the many requests received from aerobatic pilots both in the United States and in foreign countries.

Specifications

Length 30.08 inches; width 34.25 inches; height 20.76 inches; weight 331 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 360 cubic inches; compression ratio 8.7:1.

Performance

200 horsepower continuous.



TIO-360 FUEL INJECTED TURBOCHARGED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

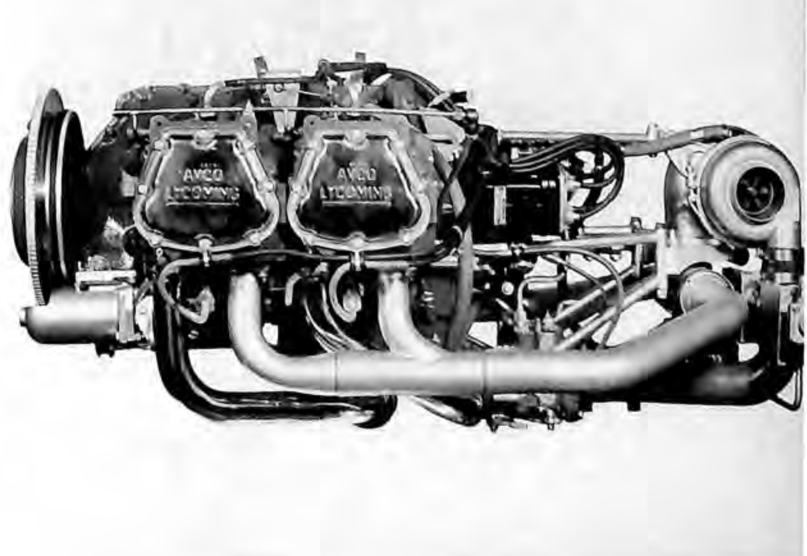
This is the first 4-cylinder, flat opposed engine to come from the manufacturer equipped with turbocharging. There are several prototype aircraft flying in the United States equipped with this model engine. Siai-Marchetti, an Italian manufacturer, has taken delivery of this model engine.

Specifications

Length 45.41 inches; width 34.25 inches; height 19.92 inches; weight 386 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 360 cubic inches; compression ratio 7.3:1.

Performance

200 horsepower continuous.



TVO-435 TURBOCHARGED HELICOPTER ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

This is the turbocharged version of the basic VO-435 helicopter engine that Avco Lycoming has produced for the Bell Helicopter Company for many years. It is an updated version which incorporates all of the refinements that Avco Lycoming has been designing into its flat opposed engines for fixed-wing aircraft. The engine incorporates the latest in design, heavy cylinders, piston-cooling oil jets and the AiResearch turbocharger which is used for ground boost as well as altitude performance.

Specifications

Length 39.46 inches; width 34.11 inches; height 34.32 inches; weight 487 pounds; bore 4.875 inches; stroke 3.875 inches; displacement 435 cubic inches; compression ratio 7.3:1.

Performance

Take-off horsepower 280, continuous horsepower 250.

IGSO-480 FUEL INJECTED, GEARED, SUPERCHARGED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

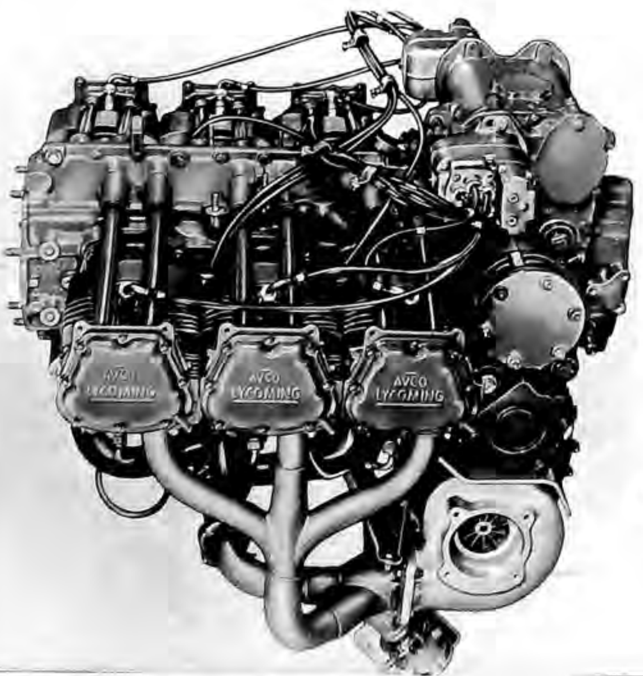
This engine is the latest refined version of the basic geared, supercharged 480 series engine used by Beech, Aero Commander, Helio Courier and others for many years. The present model is used to power the Beech Queen Air 65 aircraft. Side-mounted accessories provide ease of maintenance. The military has been getting a high number of hours between overhaul on the IGSO-480 engine.

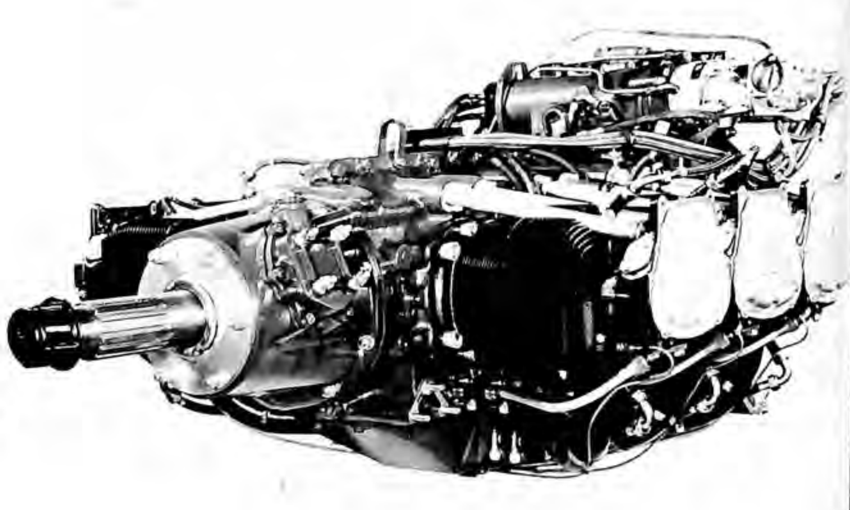
Specifications

Length 47.27 inches; width 33.12 inches; height 31.05 inches; weight 515 pounds; bore 5.125 inches; stroke 3.875 inches; displacement 480 cubic inches; compression ratio 7.3:1.

Performance

Take-off horsepower 340, continuous horsepower 320.





O-540-B SERIES RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

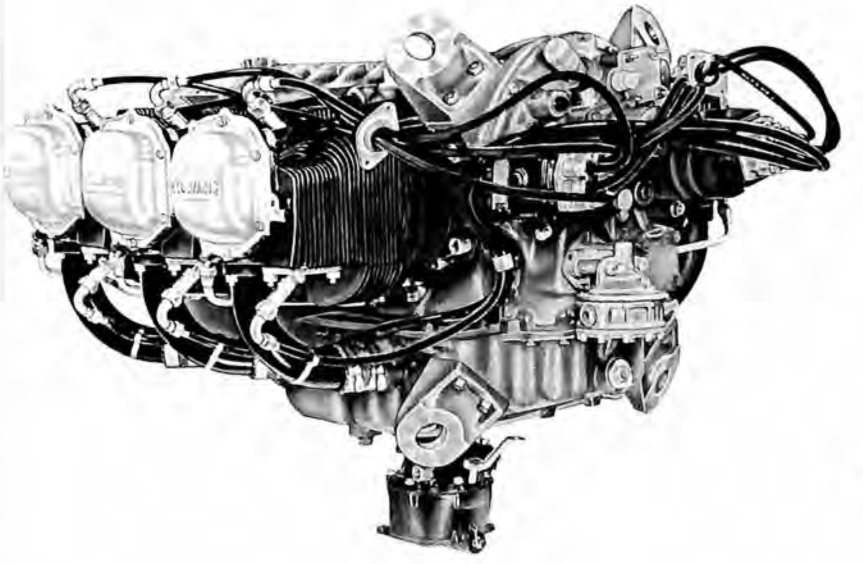
This is a low-compression version of the long-standing Avco Lycoming 6-cylinder 540 series engine. It is being used by Piper Aircraft in its 235 Cherokee and Pawnee agricultural aircraft. The engine uses 80/87 octane fuel and has a reputation in the industry for long maintenance-free life.

Specifications

Length 37.22 inches; width 33.37 inches; height 24.56 inches; weight 395 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 540 cubic inches; compression ratio 7.2:1.

Performance

235 horsepower continuous.



IO-720 SERIES FUEL INJECTED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

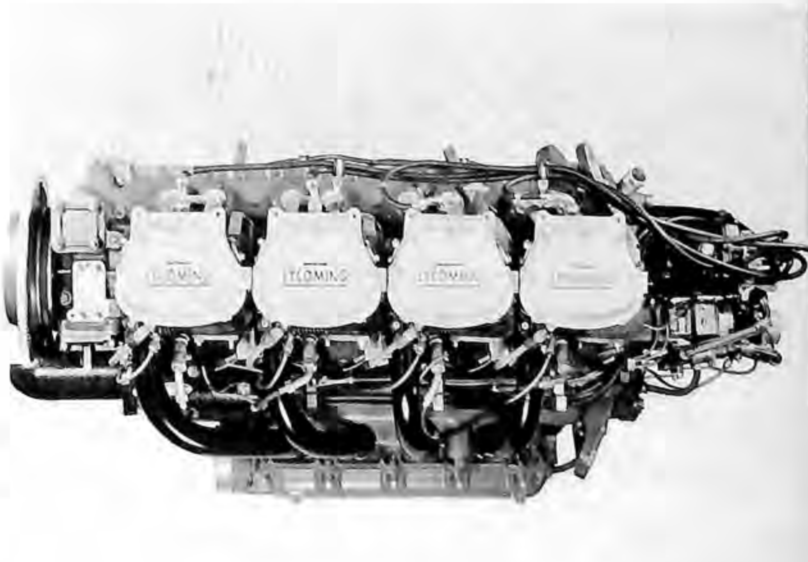
This 400-horsepower, direct-drive engine powers the single-engine Piper Comanche 400. The same basic model engine is used to power the Riley Dove, Imco Model B1 agricultural sprayer and the Swearingen conversion of the Beech Queen Air 65. Like many of its sister engines in this family, the IO-720 incorporates piston-cooling oil jets and a continuous flow fuel injection system. 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; bore 5.125 inches; stroke 4.375 inches; displacement 722 cubic inches; compression ratio 8.7:1.

Performance

400 horsepower continuous.



IO-540-K FUEL INJECTED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

This fuel injected, flat opposed, direct-drive piston engine powers the Piper Cherokee 300, a 6-place single-engine utility aircraft. The engine incorporates piston-cooling oil jets, a tuned induction system, a continuous flow fuel injection system, and, like all Avco Lycoming direct-drive engines, it is supplied with an automotive-type starter and generator or alternator. This engine has a continuous rating of 2,700 revolutions per minute and uses 100/130 octane fuel.

Specifications

Length 39.34 inches; width 34.25 inches; height 19.6 inches; weight 470 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 541.5 cubic inches; compression ratio 8.7:1.

Performance

300 horsepower continuous.

IO-360-A1A FUEL INJECTED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

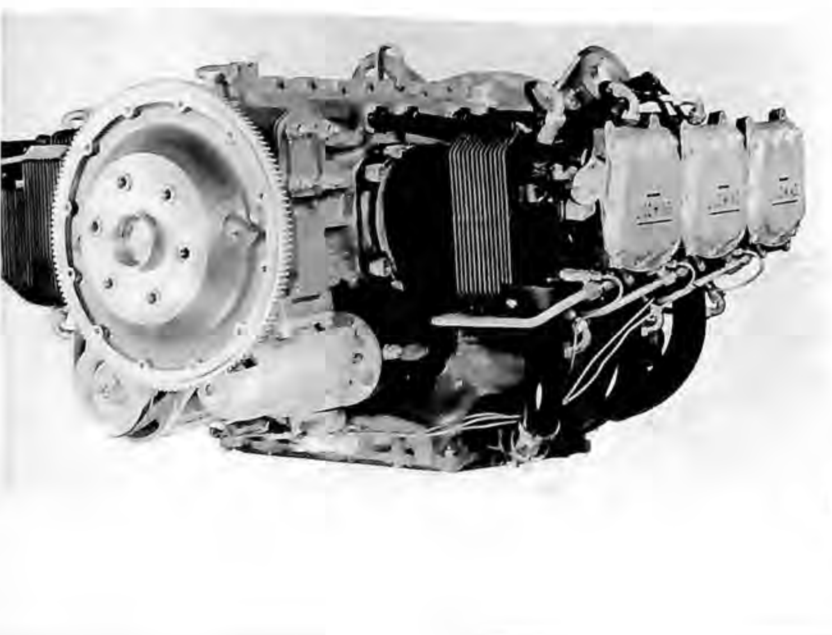
First installed in the Mooney Super 21, this 200-horsepower, 4-cylinder, flat opposed, direct-drive engine also powers the new Mooney Executive model aircraft. Producing 50 horsepower per cylinder, the IO-360-A1A has an excellent horsepower-to-weight ratio while maintaining the simplicity of design associated with the direct-drive-type piston engine. A tuned induction system and a continuous flow fuel injection system are incorporated in this series.

Specifications

Length 29.81 inches; width 34.25 inches; height 19.35 inches; bore 5.125 inches; stroke 4.375 inches; weight 323 pounds; displacement 361 cubic inches; compression ratio 8.7:1.

Performance

200 horsepower continuous.



TIO-540-A1A TURBOCHARGED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

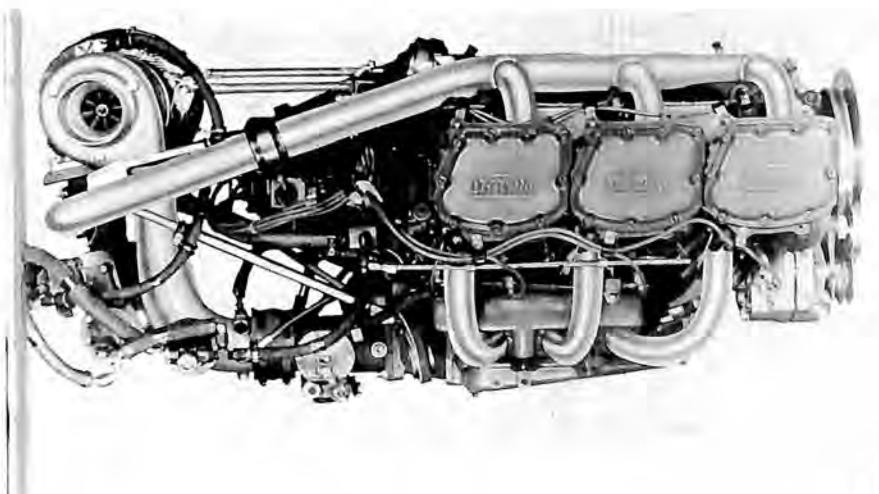
This turbocharged fuel injected engine powers the new Piper Navajo Twin to weather-topping altitudes beyond the capability of normally aspirated engines. The TIO-540-A1A, like all other Avco Lycoming engines supplied with a turbocharger, incorporates automatic controls. Also, all turbocharged engines built by Avco Lycoming feature shell moulded cylinder heads, 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; bore 5.125 inches; stroke 4.375 inches; displacement 541.5 cubic inches; compression ratio 7.3:1.

Performance

310 horsepower continuous to 15,000 feet and 230 horsepower to 25,000 feet.



TIO-541 TURBOCHARGED PISTON ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

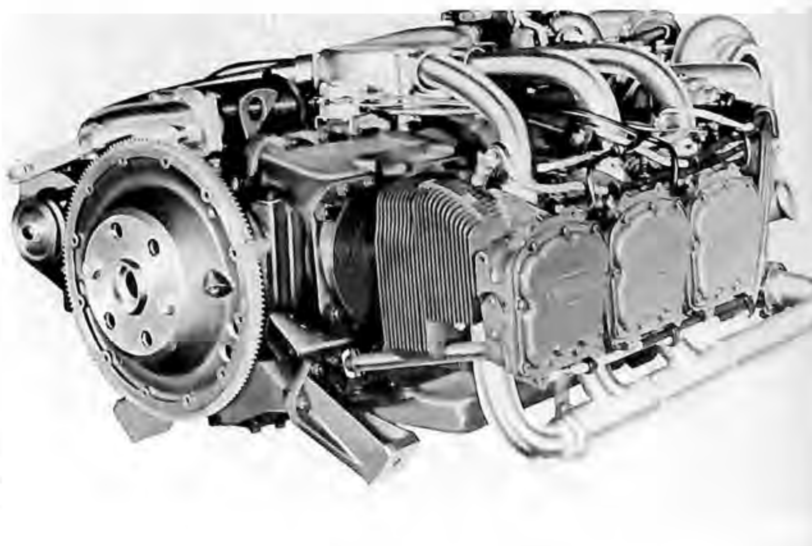
The first in Avco Lycoming's new series of engines is the TIO-541, which powers the Mooney M22. The basic engine is available with a 380-horsepower rating; it powers the Beech Turbo Baron 56TC and Beech Duke. This new design concept for Avco Lycoming in the piston engine field incorporates all of the engineering improvements learned in 25 years of manufacturing air-cooled aircraft engines. Equipped with side-mounted accessories for ease of maintenance, the TIO-541 also incorporates an integral oil cooler and a turbocharger with provision for cabin pressurization and a drive for a Freon compressor for air conditioning.

Specifications

Length 49.09 inches; width 34.25 inches; height 21.38 inches; weight 579 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 541 cubic inches; compression ratio 7.3:1.

Performance

TIO-541-A1A: 310 brake horsepower continuous.
TIO-541-E: 380 brake horsepower continuous.



TIGO-541 SERIES TURBOCHARGED PISTON ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

The second in the newest family of piston engines to come from Avco Lycoming 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 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; bore 5.125 inches; stroke 4.375 inches; displacement 541 cubic inches; compression ratio 7.3:1.

Performance

400 brake horsepower continuous.

IGSO-540 SERIES SUPERCHARGED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

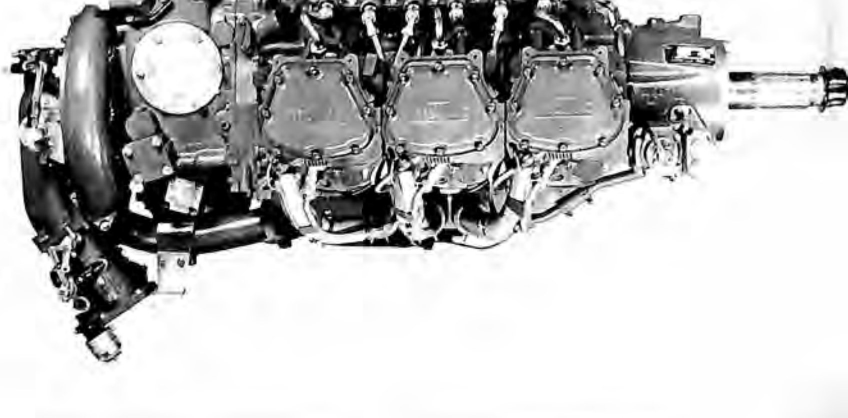
This series of engines powers the 680 series of aircraft manufactured by Aero Commander and the Queen Air 80 model aircraft manufactured by Beech. A mechanically supercharged, fuel injected engine, this model has accumulated many hours of flight time and compiled an envious record of safety and low maintenance costs. Side-mounted accessories provide ease of maintenance, and the engine is built with either updraft or downdraft exhaust cylinders. Basically used by Aero and Beech, many smaller companies are using the IGSO-540 as a conversion power plant to increase the performance of other aircraft.

Specifications

Length 48.15 inches; width 34.25 inches; height 28.44 inches; weight 530 pounds; bore 5.125 inches; stroke 4.375 inches; displacement 541.5 cubic inches; compression ratio 7.3:1.

Performance

380 brake horsepower 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 23.18 inches, width 31.56 inches; dry weight with accessories 217.87 pounds; cylinders 4; bore 4.06 inches; stroke 3.88 inches; displacement 201 cubic inches; compression ratio 7:1.

Performance

Rated power, sea level, 100 horsepower; 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.

MODELS O-300-A, -B, -C, -D

Prime Contractor: Continental Motors Corporation

Remarks

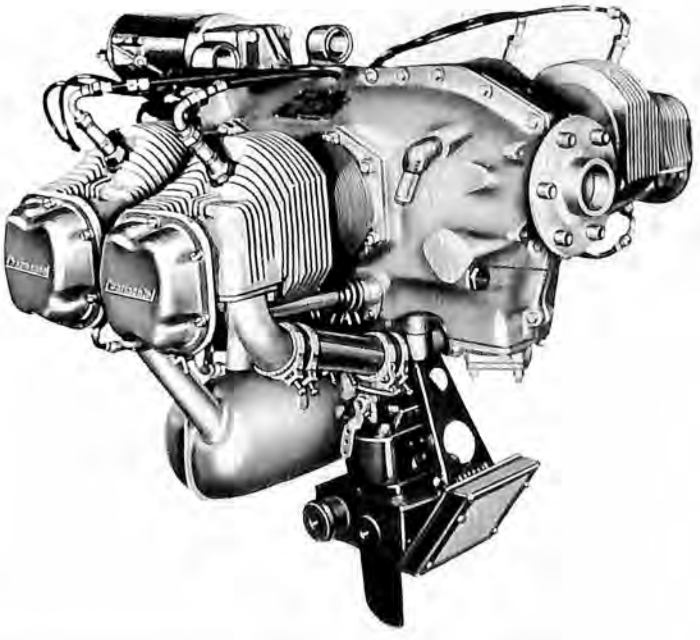
The O-300 engine powers the Cessna 170, the Cessna 172, the Cessna T-41A (military) and the Maule Bee Dee M-4.

Specifications

Dimensions with standard equipment installed: length 35.53 inches (-D 36 inches), height 26.91 inches (-D 27 inches), width 31½ inches; dry weight with carburetor 268 pounds; cylinders 6; bore 4½₆ inches; stroke 3⅞ inches; displacement 301 cubic inches; compression ratio 7:1.

Performance

Sea-level rating 145 horsepower; sea-level take-off power 145 horsepower; cruise 109 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-346

Prime Contractor: Continental Motors Corporation

Remarks

The IO-346 engine is the power plant in the Beechcraft Musketeer.

Specifications

Dimensions with standard equipment installed: length 30 inches, height 22.48 inches, width 33.38 inches; dry weight with accessories 296.5 pounds; cylinders 4; bore 5.25 inches; stroke 4 inches; displacement 346 cubic inches; compression ratio 7.5:1.

Performance

Sea-level rating 165 horsepower; 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.

MODELS IO-360-C, -D

Prime Contractor: Continental Motors Corporation

Remarks

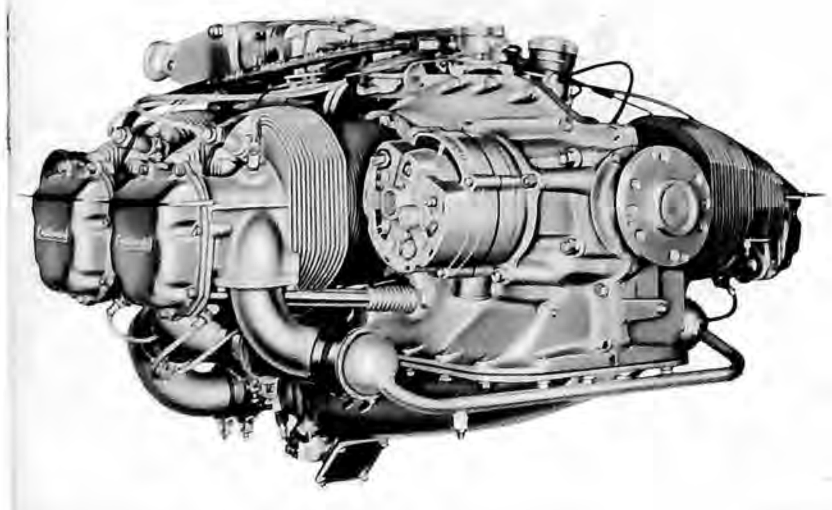
The IO-360 engine is the power plant for the Cessna 337, Cessna T-41B, O-2A and O-2B.

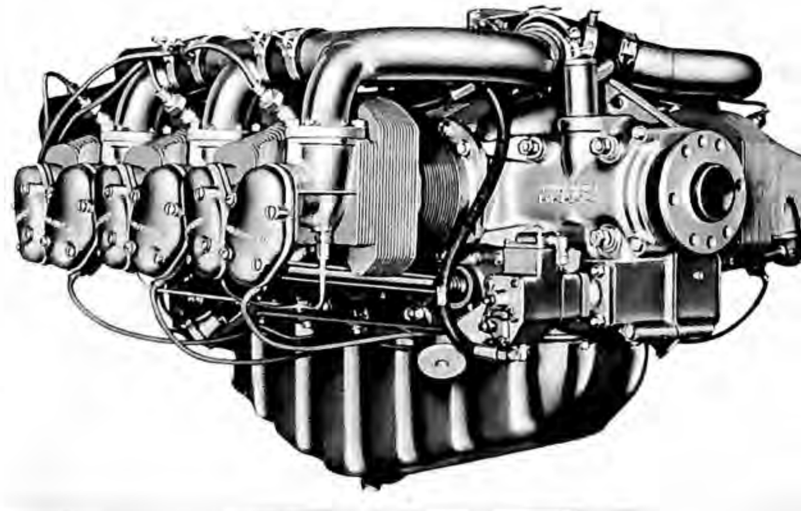
Specifications

Dimensions with standard equipment installed: length 35.34 inches, height 23.74 inches, width 31.4 inches; dry weight with accessories 298.25 pounds; cylinders 6; bore 4.438 inches; stroke 3.875 inches; displacement 360 cubic inches; compression ratio 8.5:1.

Performance

Sea-level rating 210 horsepower; 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.





MODELS TSIO-360-A, -B

Prime Contractor: Continental Motors Corporation

Remarks

The TSIO-360-A and -B engines are the power plants in the Cessna T337 Super Skymaster.

Specifications

Dimensions with standard equipment installed: length (-A) 35.34 inches, (-B) 33.84 inches, height (-A) 23.64 inches, (-B) 30.74 inches, width 33.11 inches; dry weight with accessories (-A) 300.25 pounds, (-B) 296.25 pounds; cylinders 6; bore 4.438 inches; stroke 3.875 inches; displacement 360 cubic inches; compression ratio 7.5:1.

Performance

Sea-level rating 210 horsepower; 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 2,700; cruising revolutions per minute 2,600.

Note: The difference between the -A and -B models is that -A has vacuum pump drive on the rear of the starter adapter.

MODEL O-470-R

Prime Contractor: Continental Motors Corporation

Remarks

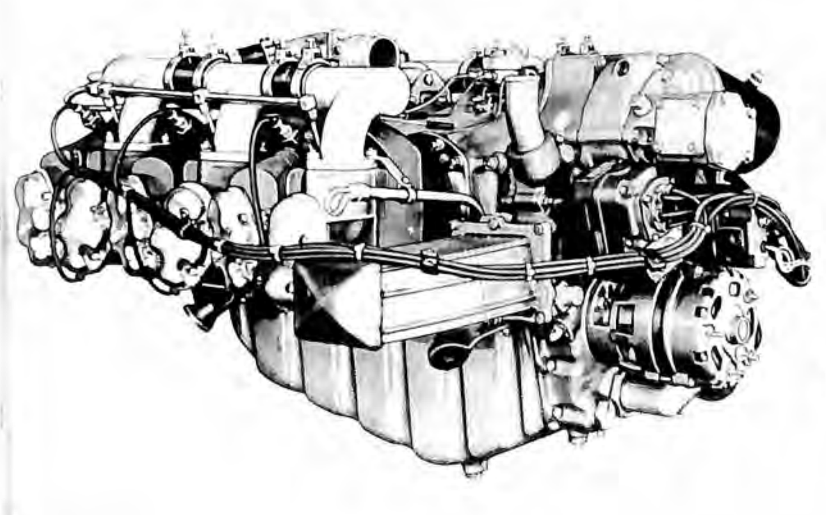
The O-470-R engine powers the Cessna 180, 182 and 188 and the Wren 460.

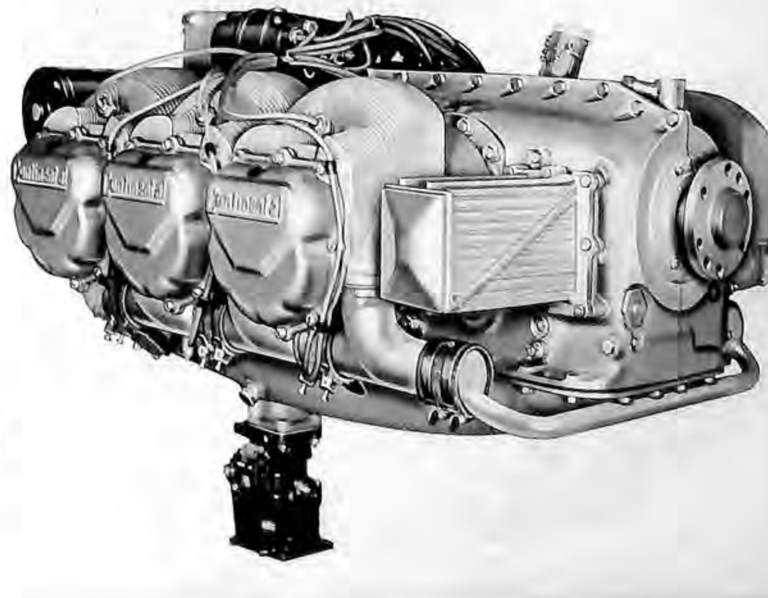
Specifications

Dimensions with standard equipment installed: length 36.03 inches, height 28.42 inches, width 33.56 inches; dry weight with accessories 438.35 pounds; cylinders 6; bore 5 inches; stroke 4 inches; displacement 471 cubic inches; compression ratio 7:1.

Performance

Sea-level rating 230 horsepower; sea-level 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 IO-470-K, -L

Prime Contractor: Continental Motors Corporation

Remarks

The IO-470-K is the power plant in the Beechcraft Debonair B33; the -L is used in the Beechcraft Baron B55.

Specifications (-K)

Dimensions with standard equipment installed: length 38.14 inches, height 26.81 inches, width 33.39 inches; dry weight with accessories 413 pounds; cylinders 6; bore 5 inches; stroke 4 inches; displacement 471 cubic inches; compression ratio 7:1.

Performance (-K)

Sea-level rating 225 horsepower; take-off rating, sea level, 225 horsepower; cruise rating 169 horsepower; revolutions per minute at rated power 2,600; revolutions per minute at take-off power 2,600; cruising revolutions per minute 2,450.

Specifications (-L)

Dimensions with standard equipment installed: length 43.17 inches, height 19.75 inches, width 33.56 inches; dry weight with accessories 469.35 pounds; cylinders 6; bore 5 inches; stroke 4 inches; displacement 471 cubic inches; compression ratio 8.6:1.

Performance (-L)

Sea-level rating 260 horsepower; take-off rating, sea level, 260 horsepower; cruise rating 195 horsepower; revolutions per minute at rated power 2,625; revolutions per minute at take-off power 2,625; cruising revolutions per minute 2,450.

MODEL IO-470-V

Prime Contractor: Continental Motors Corporation

Remarks

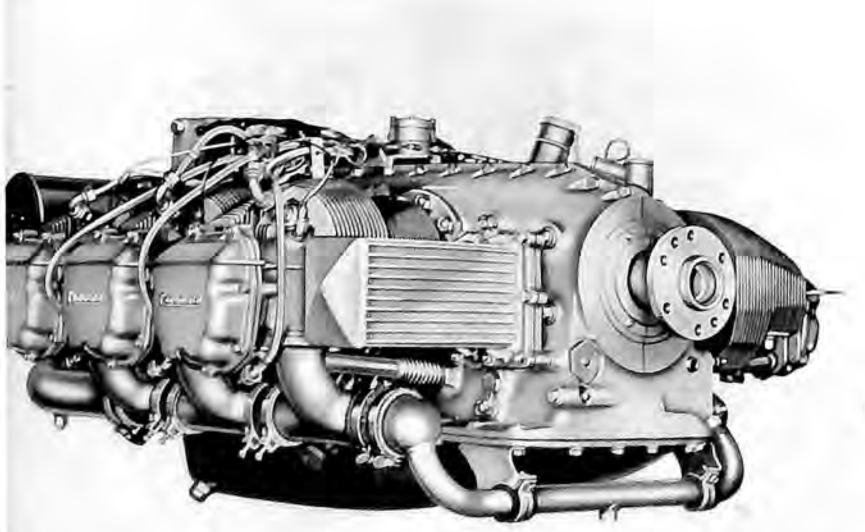
The IO-470-V is the power plant in the Cessna 310K and Cessna 310L.

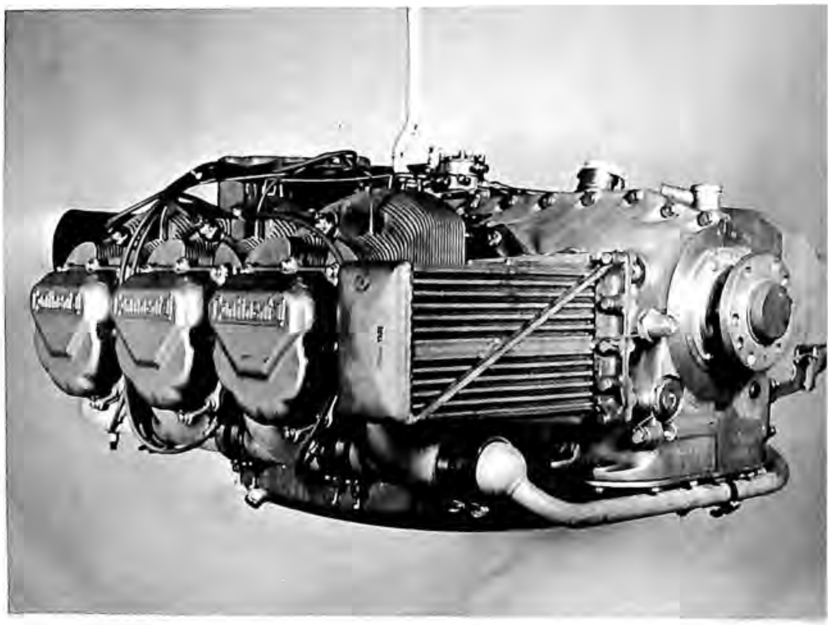
Specifications

Dimensions with standard equipment installed: length 43.19 inches, height 19.75 inches, width 33.56 inches; dry weight with accessories 423.47 pounds; cylinders 6; bore 5 inches; stroke 4 inches; displacement 471 cubic inches; compression ratio 8.6:1.

Performance

Sea-level rating 260 horsepower; take-off rating, sea level, 260 horsepower; cruise rating 195 horsepower; revolutions per minute at rated power 2,625; revolutions per minute at take-off power 2,625; cruising revolutions per minute 2,450.





MODELS IO-520-A, -D, -E, -F, -J

Prime Contractor: Continental Motors Corporation

Remarks

The IO-520 series engines are employed as follows: IO-520-A in the Cessna 210 and 206, Aero Commander 200D; IO-520-D, Cessna 185 Skywagon and 188 Agwagon, Bellanca Viking; IO-520-E, Aero Commander 500A; IO-520-F, Cessna U206; IO-520-J, Cessna 210.

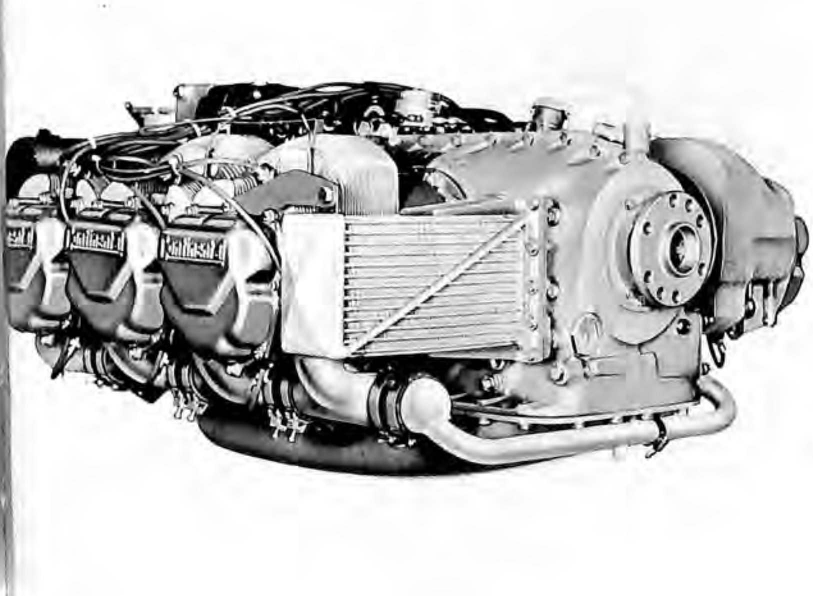
Specifications (-A)

Dimensions with standard equipment installed: length 40.91 inches, height 19.75 inches, width 33.56 inches; dry weight with accessories 471.28 pounds; cylinders 6; bore 5.25 inches; displacement 520 cubic inches; compression ratio 8.5:1.

Performance (-A)

Sea-level rating 285 horsepower; 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 deviations from -A specifications and performance are: (-D) length 36.86 inches, height 23.79 inches, dry weight 455.56 pounds, take-off rating 300 horsepower, take-off revolutions per minute 2,850, cruising revolutions per minute 2,550; (-E) length 47.26 inches, width 35.56 inches, take-off rating 300 horsepower at 2,850 revolutions per minute, cruise rating 213 horsepower at 2,500 revolutions per minute; (-F) take-off rating 300 horsepower at 2,850 revolutions per minute, cruise rating 215 horsepower at 2,550 revolutions per minute.



MODEL IO-520-B

Prime Contractor: Continental Motors Corporation

Remarks

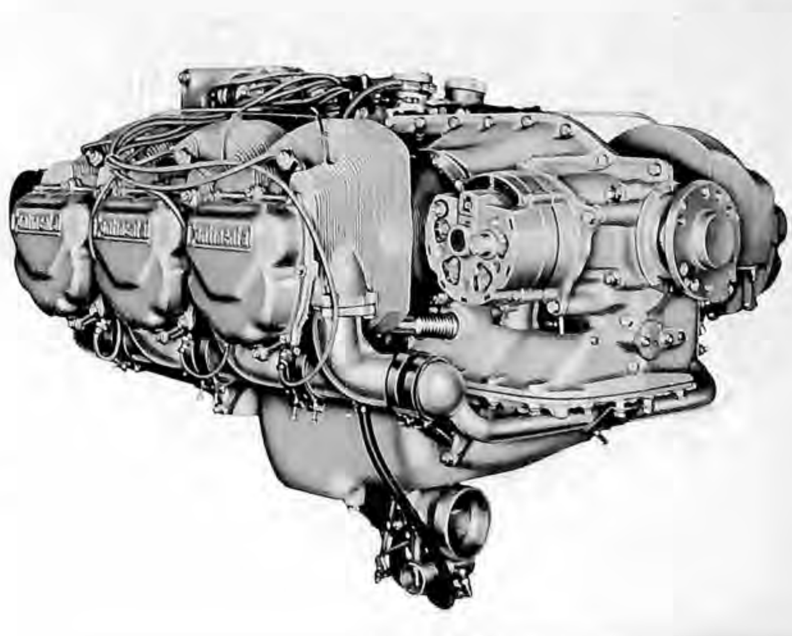
The IO-520-B is the power plant in the Beechcraft Bonanza S35, Beechcraft Debonair B33A and the Navion.

Specifications

Dimensions with standard equipment installed: length 38.47 inches, height 26.71 inches, width 33.58 inches; dry weight with accessories 457.65 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 8.5:1.

Performance

Sea-level rating 285 horsepower; 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.

MODELS TSIO-520-B, -E

Prime Contractor: Continental Motors Corporation

Remarks

The TSIO-520-B is the power plant in the Cessna 320D Skynight.

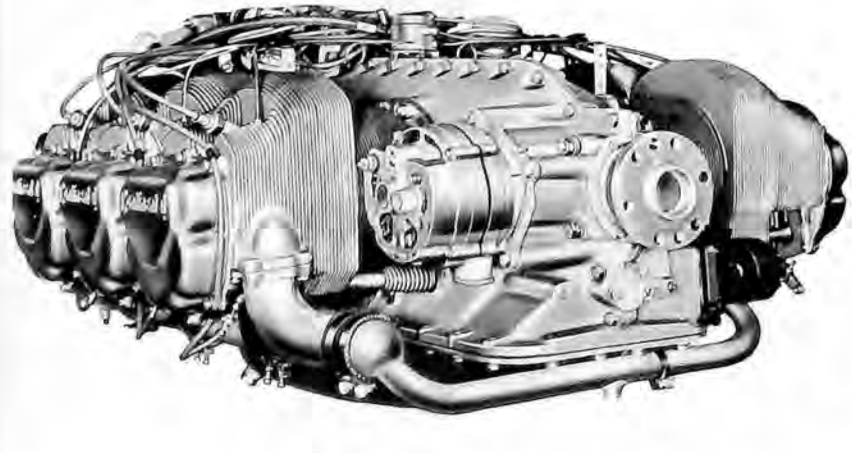
Specifications

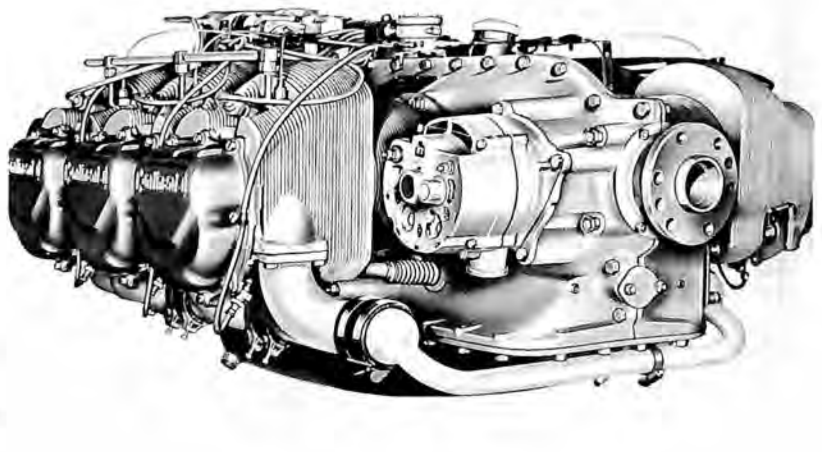
Dimensions with standard equipment installed: length 39.25 inches, height 20.47 inches, width 33.56 inches, length with turbo 57.73 inches; dry weight with accessories 475 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 7.5:1.

Performance

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.





MODELS TSIO-520-C, -H

Prime Contractor: Continental Motors Corporation

Remarks

The TSIO-520-C and -H engines are used in the Cessna T210.

Specifications

Dimensions with standard equipment installed: length 40.91 inches, height 20.04 inches, width 33.56 inches; dry weight with accessories 458.01 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 7.5:1.

Performance

Sea-level rating 285 horsepower; 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 2,700; cruising revolutions per minute 2,500.

MODEL TSIO-520-D

Prime Contractor: Continental Motors Corporation

Remarks

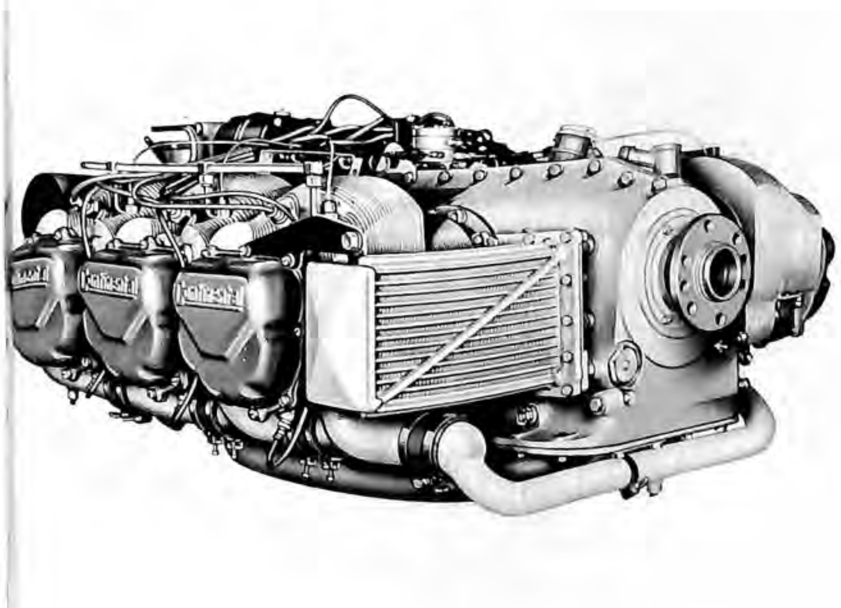
The TSIO-520-D engine is the power plant in the Beechcraft Turbo Bonanza.

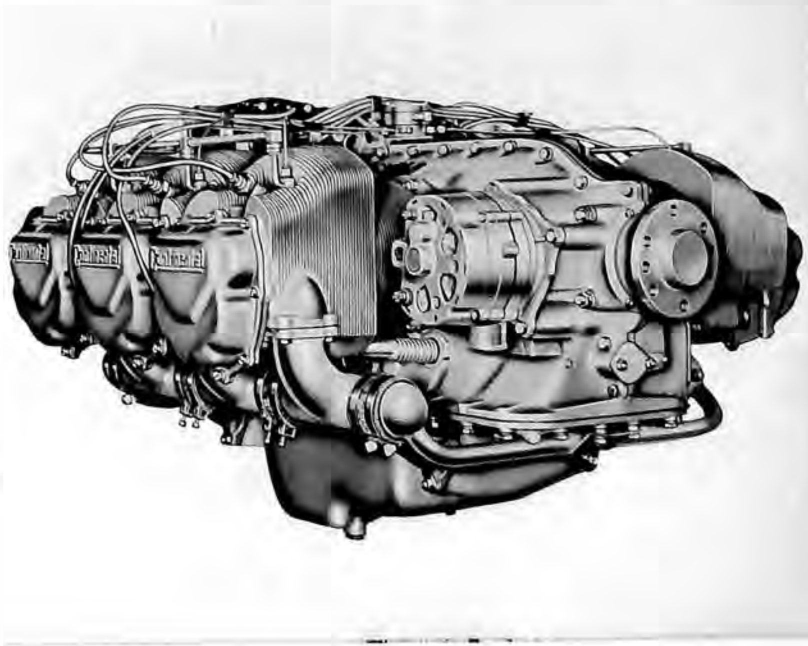
Specifications

Dimensions with standard equipment installed: length (turbo not included) 42.58 inches, height 29.4 inches, width 33.56 inches; dry weight with accessories 484.5 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 7.5:1.

Performance

Sea-level rating 285 horsepower; 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.





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.

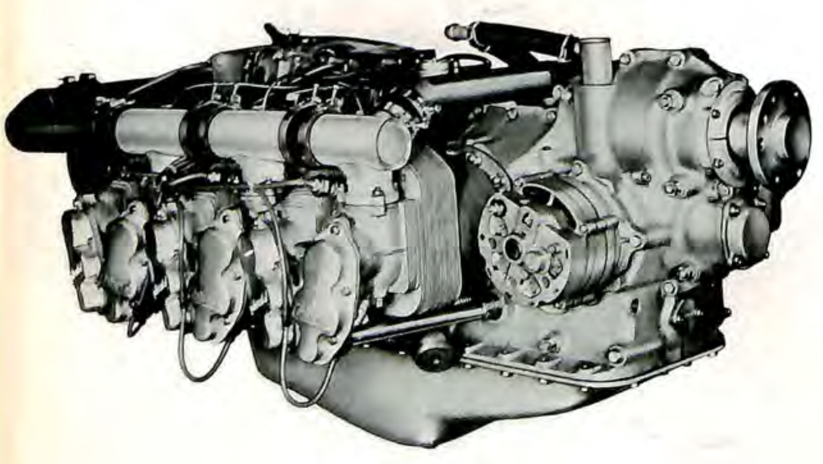
MODEL GTSIO-520-D

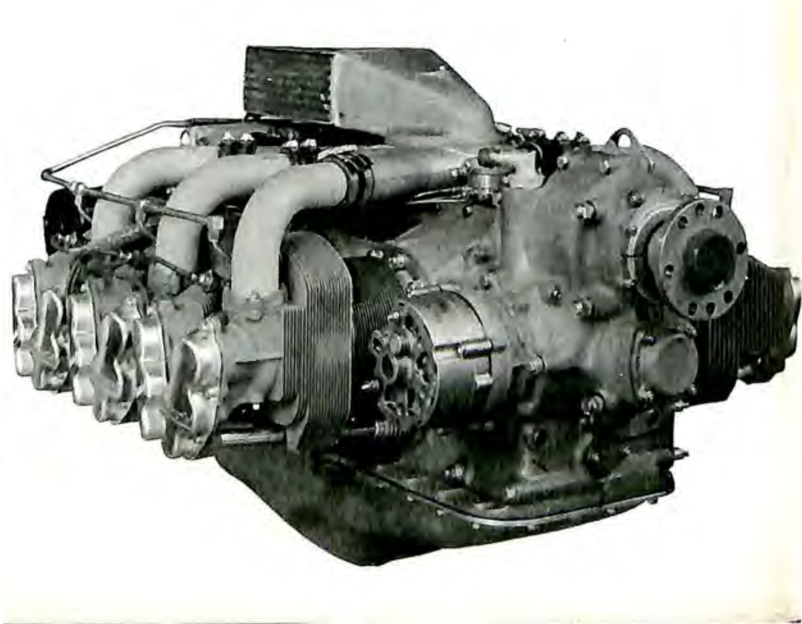
Prime Contractor: Continental Motors Corporation

Remarks
The GTSIO-520-D engine is the power plant in the Cessna 421.

Specifications
Dimensions with standard equipment installed: length 42.56 inches, height 26.78 inches, width 34.03 inches; dry weight with accessories 578 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 7.5:1.

Performance
Sea-level rating 375 horsepower; 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.





R1300 ENGINE (C7BA)

Prime Contractor: Curtiss-Wright Corporation

Remarks

Among applications of the R1300 Cyclone 7 series engines are the North American T-28A trainer, the Sikorsky H-19 helicopter and the Goodyear ZPG and ZS2G airships.

Specifications

Dry weights 1,065-1,092 pounds; length 48.12 inches; diameter 50.45 inches; fuel grade 91/96.

Performance

Take-off power at sea level 800 brake horsepower.

R1820-82A ENGINE (C9)

Prime Contractor: Curtiss-Wright Corporation

Remarks

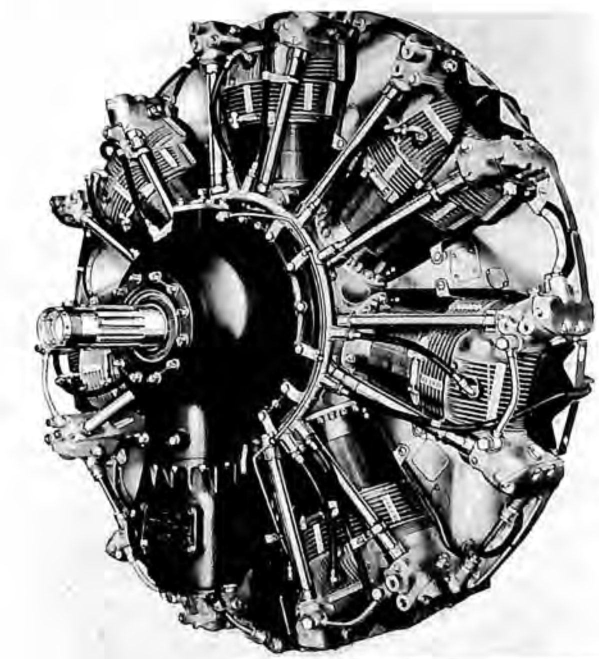
A 9-cylinder, single-row radial reciprocating engine, the C9 is manufactured for the Grumman S-2D, S-2E and E-1B series aircraft.

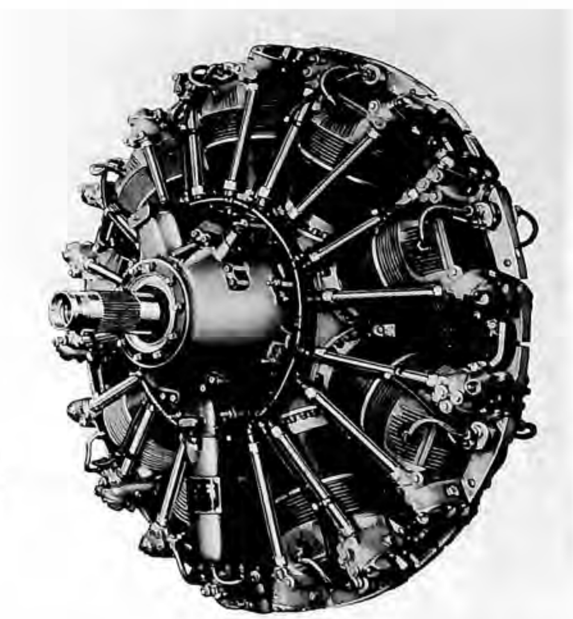
Specifications

Dry weight 1,479 pounds; length 50.1 inches; diameter 55.74 inches; fuel grade 115/145.

Performance

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 turbocompound reciprocating engine used by the military services in P-2 and P-5 series aircraft.

Specifications

Dry weight 3,560 pounds; length 91.8 inches; diameter 56.59 inches; fuel grade 115/145.

Performance

Take-off power at sea level 3,700 brake horsepower.

R3350-26WD ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

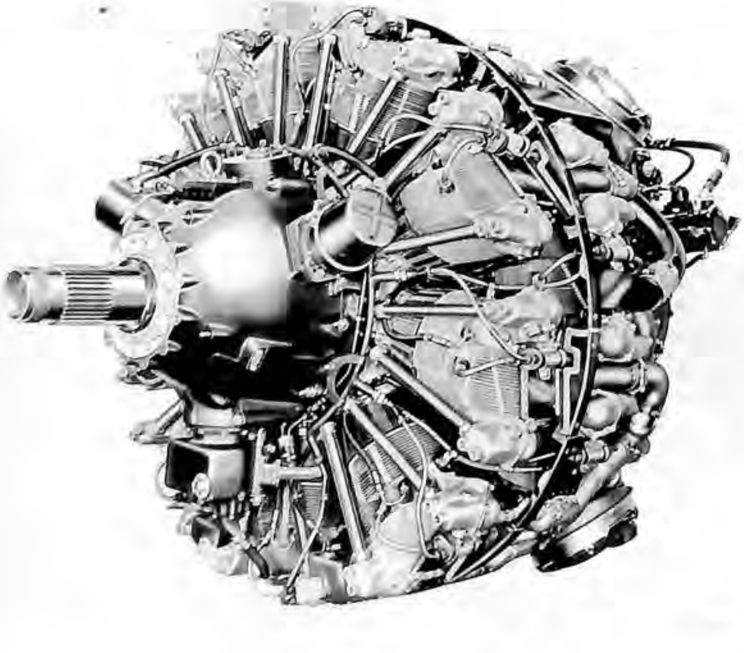
An 18-cylinder, double-row radial reciprocating engine, the R3350-26WD is manufactured for the Douglas AD series and Lockheed P-2 series aircraft.

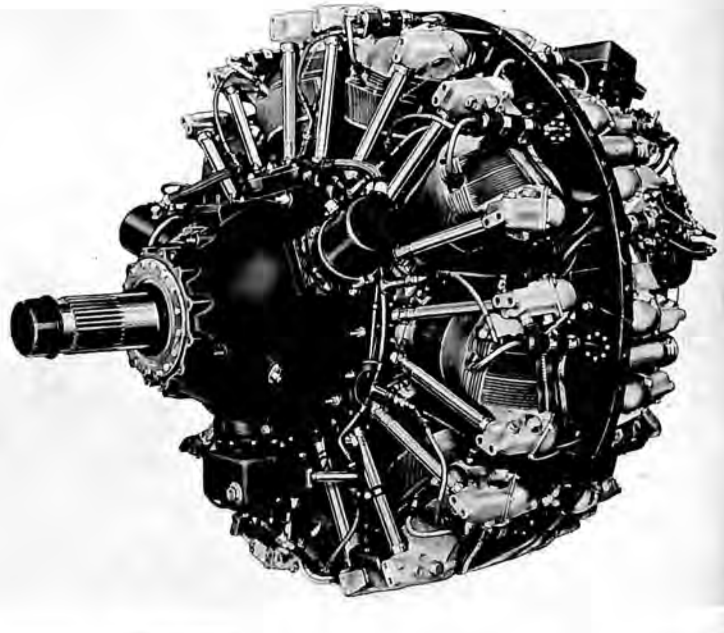
Specifications

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.





YRC-180-2 ROTATING COMBUSTION ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

The Rotating Combustion Engine is a new internal combustion engine which operates on the familiar Otto cycle but incorporates a unique and simplified geometry which provides a very high ratio of power to displacement. Designed for Navy aircraft applications, the YRC-180-2 is an advanced version of the RC2-90, the initial Rotating Combustion Aircraft Engine developed by Curtiss-Wright. It is an air-cooled, twin-rotor engine incorporating JP fuel injection with coordinated spark ignition. The engine is naturally aspirated and has its own cooling air blower. Torque, air and fuel consumption characteristics are comparable to conventional reciprocating engines; size, weight and smoothness of operation approach that of turbine engines.

Specifications

Length 32.4 inches; height 18 inches; width 20.7 inches; weight 278 pounds.

Performance

Take-off rating 310 brake horsepower at 6,000 revolutions per minute.

H-63 ENGINES

Prime Contractor: Nelson Aircraft Corporation

Remarks

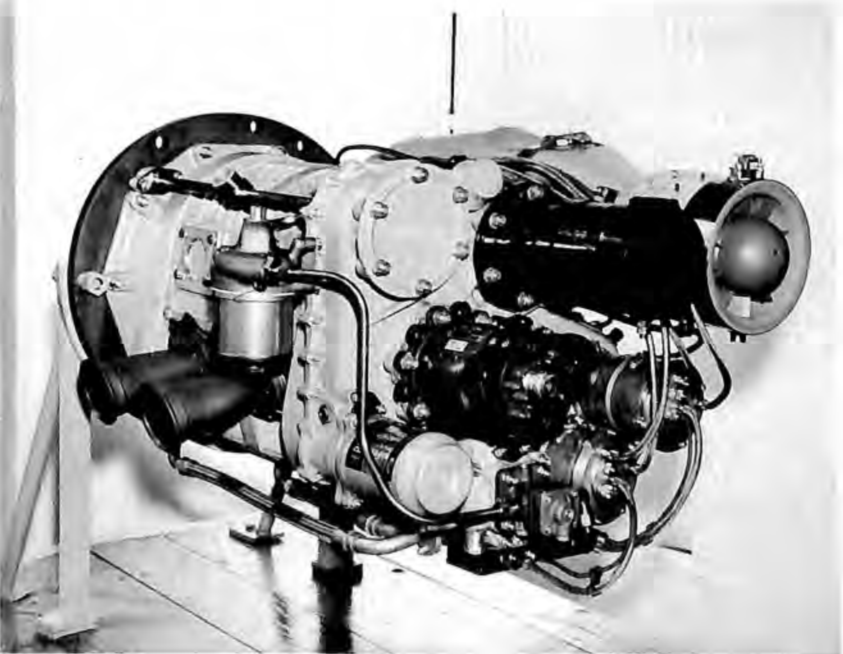
Nelson Aircraft Corporation produces to order the H-63, a 4-cylinder, 2-cycle air-cooled engine certified by the Federal Aviation Administration as a power plant for single-seat helicopters and also available for propeller-driven aircraft. Model H-63-C (photo) is the basic helicopter unit for vertical installation. Model H-63-CP is the same basic engine but without clutch, fan and shroud, intended for installation in a horizontal position with direct drive to the propeller.

Specifications

H-63-C: Weight 76 pounds; displacement 63 cubic inches; compression ratio 8:1; fuel grade 80/87. H-63-CP: Weight 68 pounds; displacement 63 cubic inches; compression ratio 8:1; fuel grade 80/87.

Performance

H-63-C: Take-off rating 43 horsepower at 4,000 revolutions per minute, continuous same. H-63-CP: Take-off rating 48 horsepower at 4,400 revolutions per minute, continuous 45 horsepower at 4,000 revolutions per minute.



R1830 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

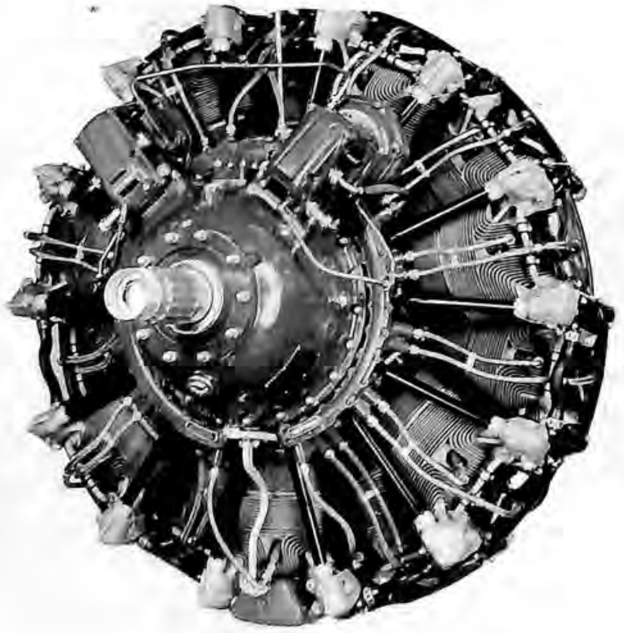
First installed in the famous Pan American Airways Martin China Clipper in the early 1930s, the R1830 Twin Wasp is a 14-cylinder, radial, air-cooled piston engine, now out of production but still in service. A 1,000-horsepower engine was installed in the Douglas DC-3 and the 1,200-horsepower version eventually powered most of the DC-3s. This engine, also the power plant for the Lockheed Lodestar and other aircraft, was manufactured in greater numbers than any other Pratt & Whitney model between 1932 and 1947.

Specifications (Model S1C3-G)

Length 61.16 inches; diameter 48.19 inches; bore 5.5 inches; stroke 5.5 inches; displacement 1,830 cubic inches; compression ratio 6.7:1; dry weight 1,467 pounds.

Performance

Rating 1,200 brake horsepower at 2,700 revolutions per minute.



R1340 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

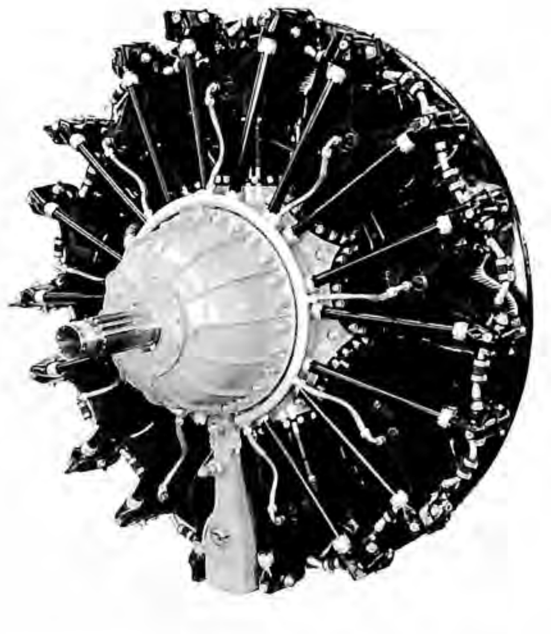
Still in use, the R1340 Wasp was produced in numerous configurations for 35 years—longer than any other Pratt & Whitney engine. It powered many military and commercial airplanes in aviation's pioneering days. Among the planes still flying with R1340 engines are the de Havilland Otter, the Grumman Mallard and various helicopters.

Specifications (Model S1H1-G)

Length 47.8 inches; diameter 51.81 inches; dry weight 930 pounds.

Performance

Rating 600 brake horsepower at 2,250 revolutions per minute.



R2000 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

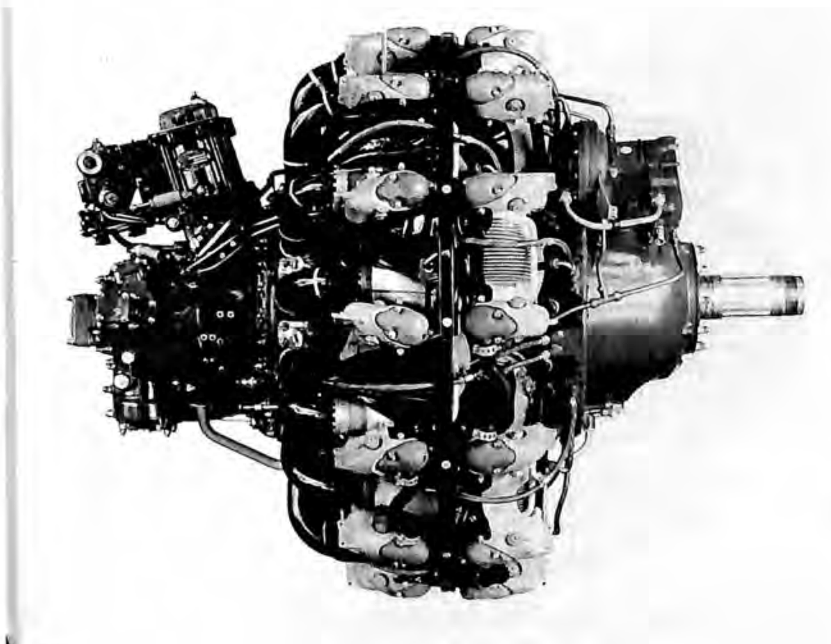
Out of production but still in use, the R2000 Twin Wasp is a 14-cylinder, radial, air-cooled piston engine. It powered the Douglas C-54 Skymaster, workhorse of World War II, the Berlin Airlift and the transpacific airlift supporting the Korean campaign. Presently in Vietnam, it powers the Army's CX-2B or de Havilland DHC-4 Caribou.

Specifications (Model 2SD13-G)

Length 59.66 inches; diameter 49.1 inches; bore 5.75 inches; stroke 5.5 inches; displacement 2,004 cubic inches; compression ratio 6.5:1; dry weight 1,605 pounds.

Performance

Rating 1,450 brake horsepower at 2,700 revolutions per minute.



R2180 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

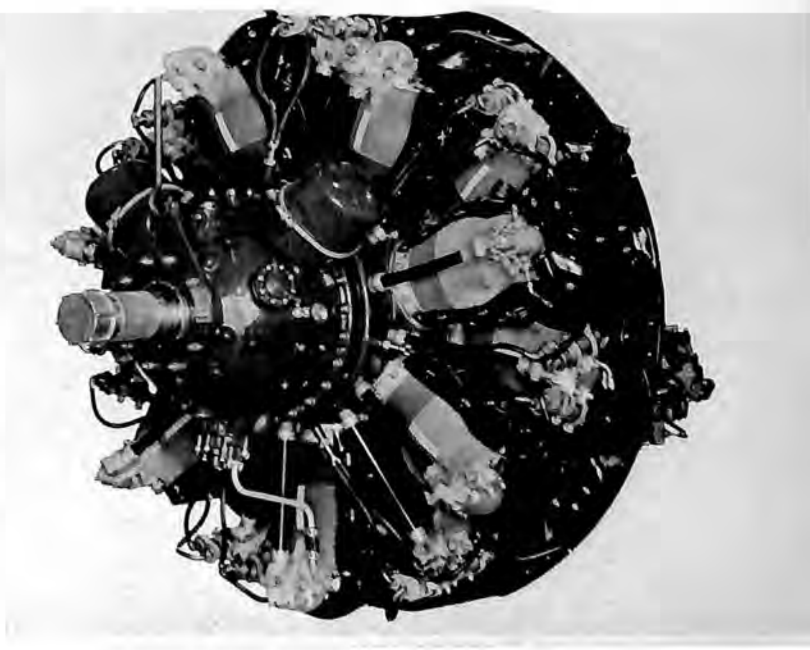
The R2180 Twin Wasp, a 14-cylinder, radial, air-cooled piston engine, was developed after World War II but had a short production life. It is used in the SAAB Scandia transport.

Specifications (Model E1)

Length 76.2 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 (with water injection) at 2,800 revolutions per minute.



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 (Model CB16)

Length 81.4 inches; diameter 52.8 inches; bore 5.75 inches; stroke 6 inches; displacement 2,804 cubic inches; compression ratio 6.76:1; dry weight 2,350 pounds.

Performance

Rating 2,400 brake horsepower (with water injection) at 2,700 revolutions per minute.

R4360 MILITARY-COMMERCIAL RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

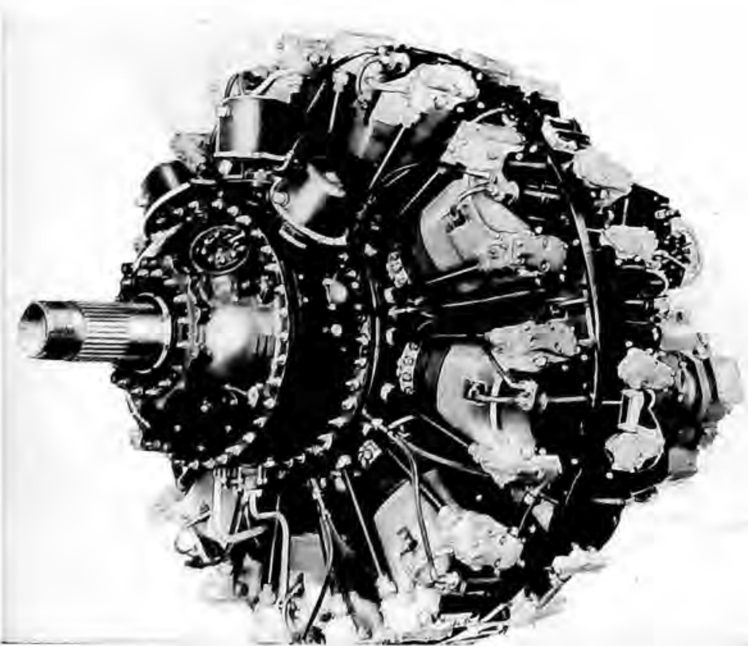
A 28-cylinder, radial, air-cooled piston engine, the R4360 was the most powerful engine of its type produced. It was developed during World War II and still powers the Boeing C-97, Fairchild C-119 and Douglas C-124 Globemaster transports and the Boeing 377 Stratoliner.

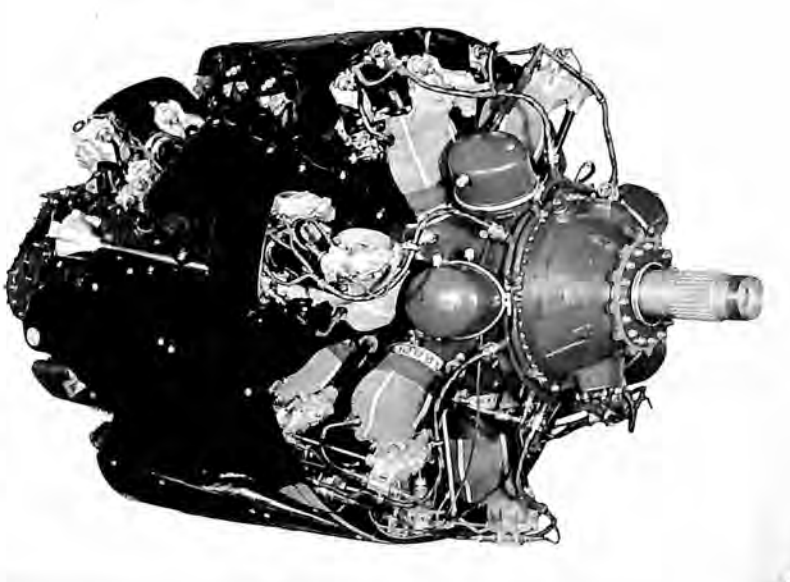
Specifications (Model B6)

Length 96.5 inches; diameter 55 inches; bore 5.75 inches; stroke 6 inches; displacement 4,363 cubic inches; compression ratio 6.7:1; dry weight 3,584 pounds.

Performance

Rating 3,500 brake horsepower (with water injection) at 2,700 revolutions per minute.





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

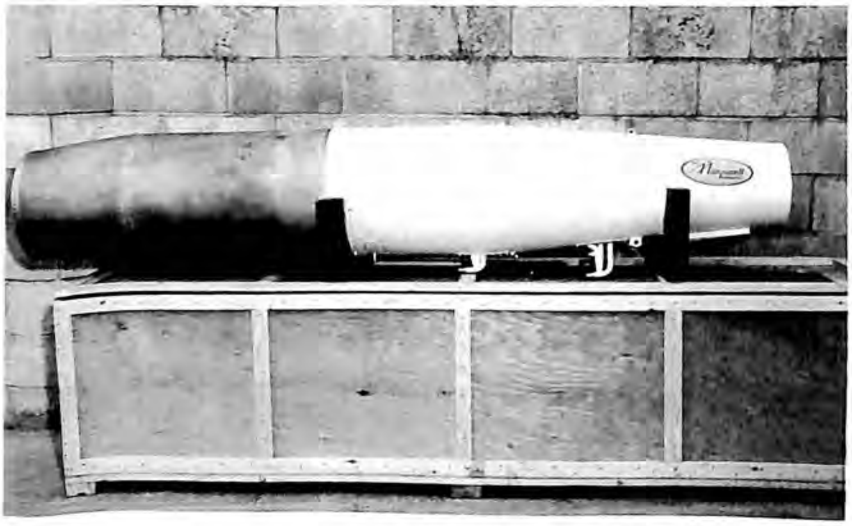
The RJ-43-MA-11, produced for the Air Force, is a complete nacelle-type supersonic ramjet engine with a high compression inlet spike. This engine (2 units) provides the cruise propulsion source for the Boeing Bomarc B interceptor missile.

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 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

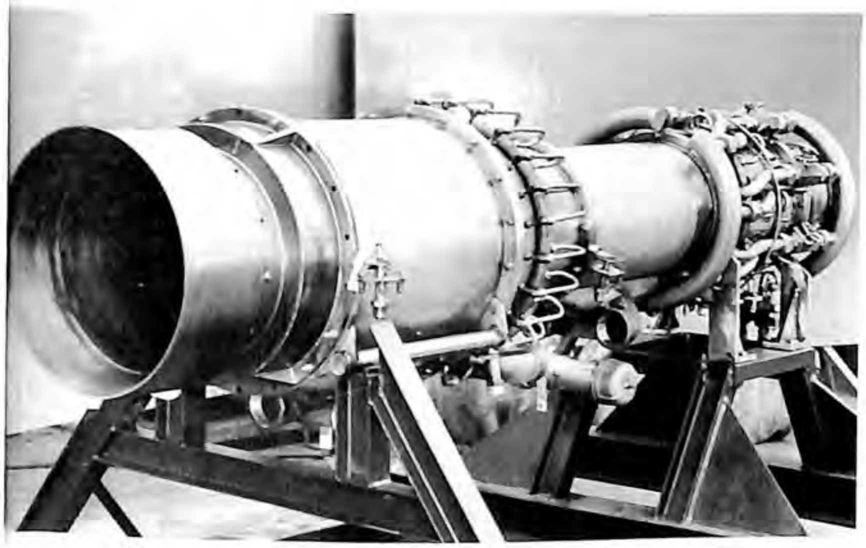
The MA150-XAA is a nacelle-type subsonic and supersonic ramjet engine with normal shock inlet. It provides the cruise propulsion for the Army's North American Rockwell Advanced Roadrunner target missile system for high- and low-altitude application.

Specifications

Length 104.5 inches; diameter 19 inches; weight 165 pounds; fuel JP-4; convergent sonic exit.

Performance

Thrust 2,300 pounds net jet at low altitude; 575 pounds net jet at high altitude.

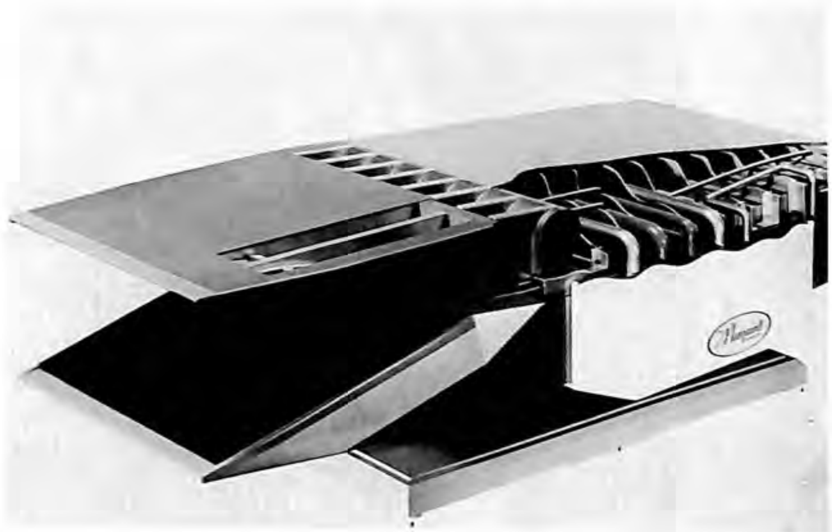


EJECTOR RAMJET

Prime Contractor: The Marquardt 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 a simple, lightweight acceleration-and-cruise propulsion system which provides vehicle performance (1) superior to separate rockets and ramjets because of commonality of structure plus rocket thrust augmentation and (2) competitive with complex turbomachinery at hypersonic flight speeds.

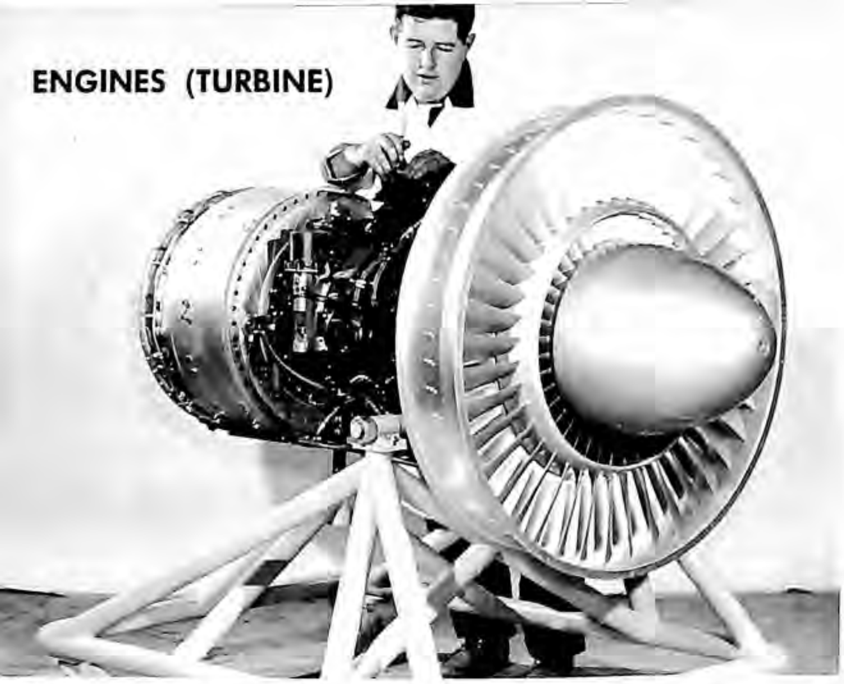


SCRAMJET

Prime Contractor: The Marquardt 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. The 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-11: 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 pound per pound of thrust per hour. PLFIC-2: 6,700 pounds thrust; specific fuel consumption .36 pound per pound of thrust per hour.

T53 TURBOPROP GAS TURBINE ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

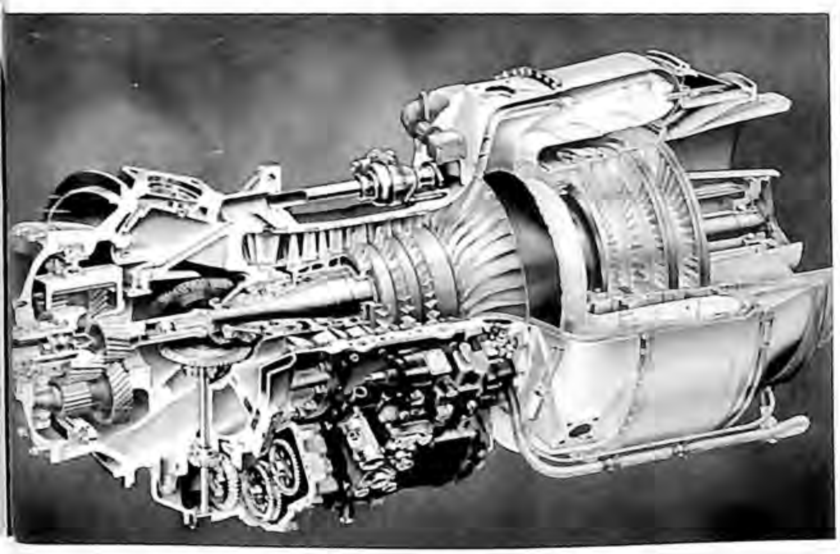
The turboprop version of the T53, designated L-7, powers the Army's Grumman OV-1 Mohawk STOL surveillance aircraft and the Swiss C3504 training and tow target aircraft. This engine is basically the same as the shaft version except for the front-end gearing which mates the engine to a conventional propeller. The 1,203 equivalent shaft horsepower T53-L-15 is the latest production configuration and will be installed on advanced Mohawks.

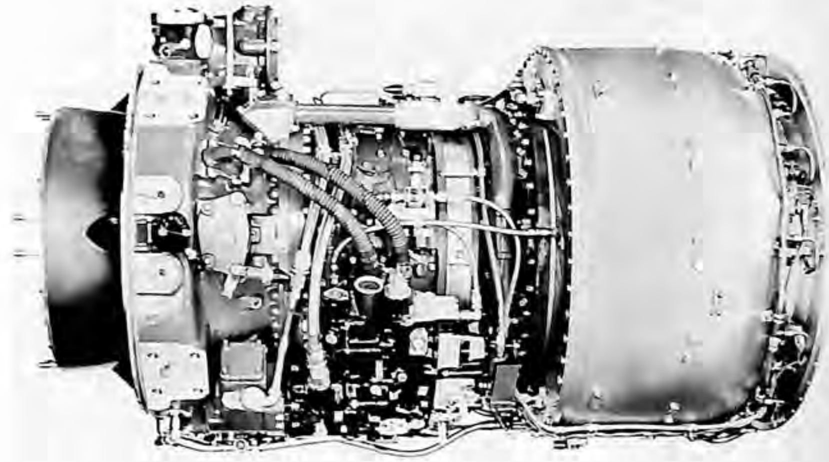
Specifications

Length 59 inches; diameter 23 inches; weight 605 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: 1,203 equivalent shaft horsepower (1,400 thermodynamic); specific fuel consumption .62 pound per shaft horsepower per hour. T53-L-7 (photo): 1,100 shaft horsepower; specific fuel consumption .69 pound per shaft horsepower per hour.





T53 TURBOSHAFT GAS TURBINE ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

With multimillion-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 (1 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 pound per shaft horsepower per hour. T53-L-11: 1,100 shaft horsepower; specific fuel consumption .68 pound per horsepower per hour.

T55 TURBOSHAFT GAS TURBINE ENGINE

Prime Contractor: Avco Corporation, Avco Lycoming Division

Remarks

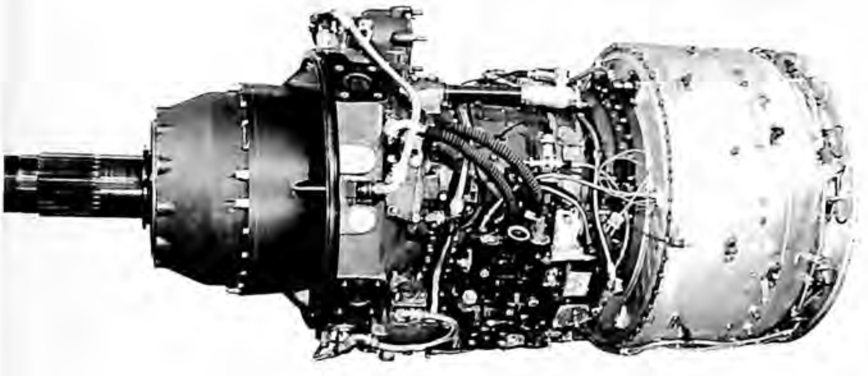
Maintaining the proven T53 design philosophy, the T55 is the more powerful of Avco Lycoming's 2 families of gas turbine engines. Twin 2,850 shaft horsepower T55-L-7Cs power the Army's battle-tested Boeing Vertol CH-47 Chinook medium transport helicopter. Uprated 3,750 shaft horsepower T55-L-11s power 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.

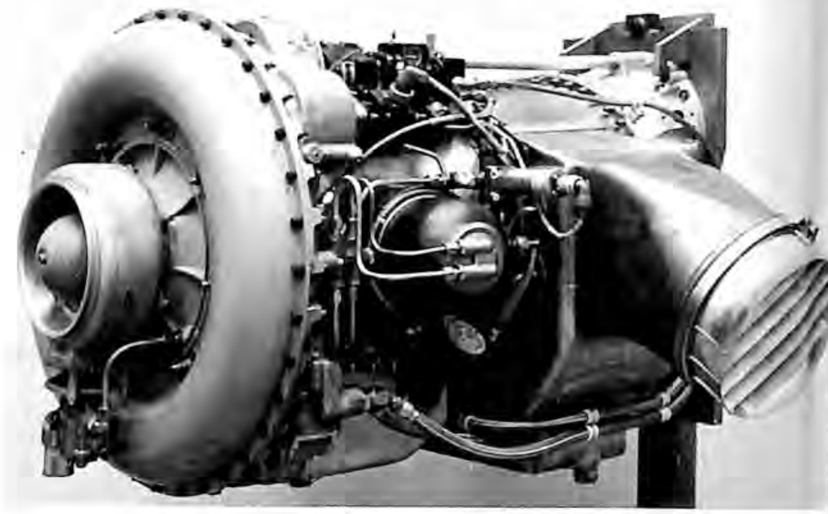
Specifications

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 670 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 .6 pound per shaft horsepower per hour. T55-L-11: 3,750 shaft horsepower; specific fuel consumption .52 pound 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 power plant 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 pound per horsepower per hour. LTC4R-1: 3,690 shaft horsepower; specific fuel consumption .54 pound per horsepower per hour.

T50 MILITARY TURBOSHAFT

Prime Contractor: The Boeing Company

Remarks

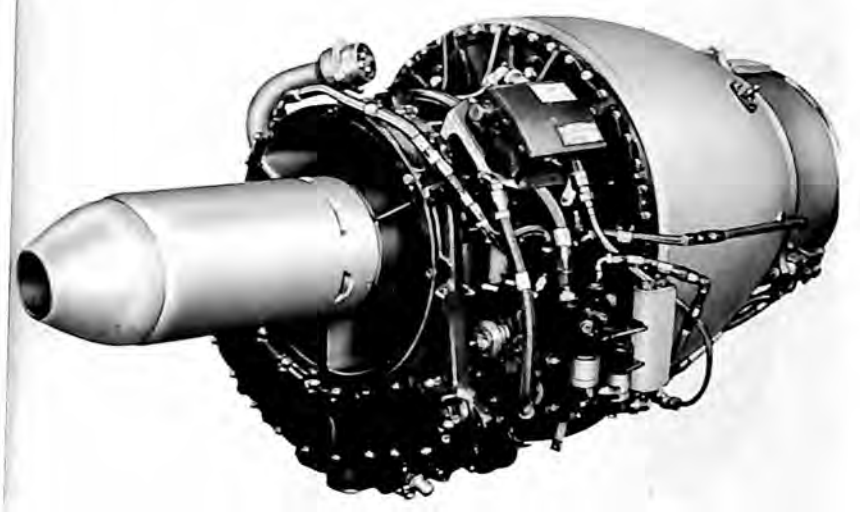
Configurations of the T50 military turboshaft engine power the Navy/Gyrodyne QH-50 series drone antisubmarine helicopters. Production of the engine ended in May 1968.

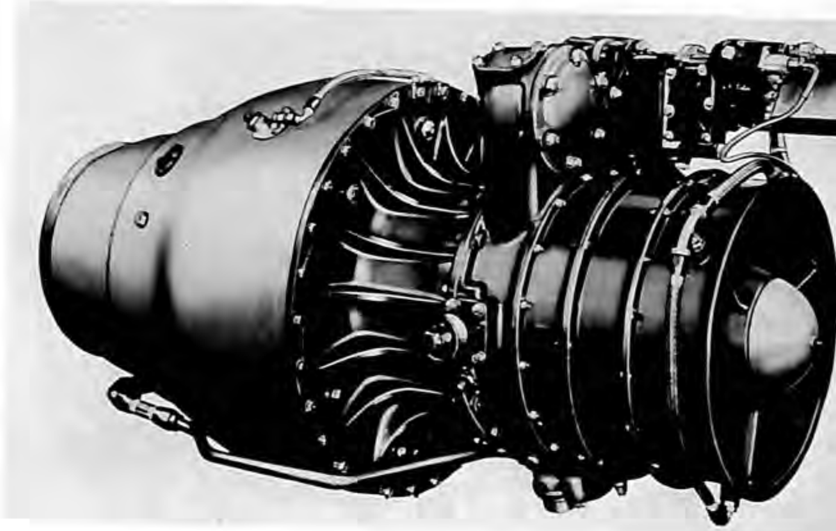
Specifications (T50-BO-12)

Length 37.5 inches; diameter 24 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 .5 pound per hour.

J69-T-29 TURBOJET

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

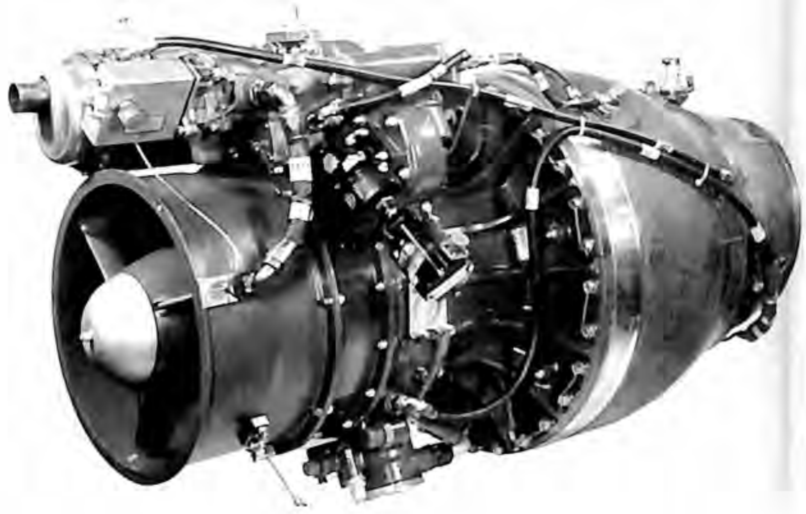
Current production installation is Ryan BQM-34A Firebee.

Specifications

Length 44.8 inches; diameter 22.3 inches; compression ratio 5.3:1; compression stages 2; turbine stages 1; weight 340 pounds.

Performance

1,700 pounds thrust maximum; 1,375 pounds thrust normal rated; 1.1 specific fuel consumption; oil consumption 1 pound per hour.



J69-T-6 TURBOJET

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

Current production installation is the BQM-34E drone.

Specifications

Weight 360 pounds; compression ratio 5.5:1.

Performance

Thrust 1,840 pounds; airflow 30.5 pounds per second; specific fuel consumption 1.1.

J69-T-41A TURBOJET

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

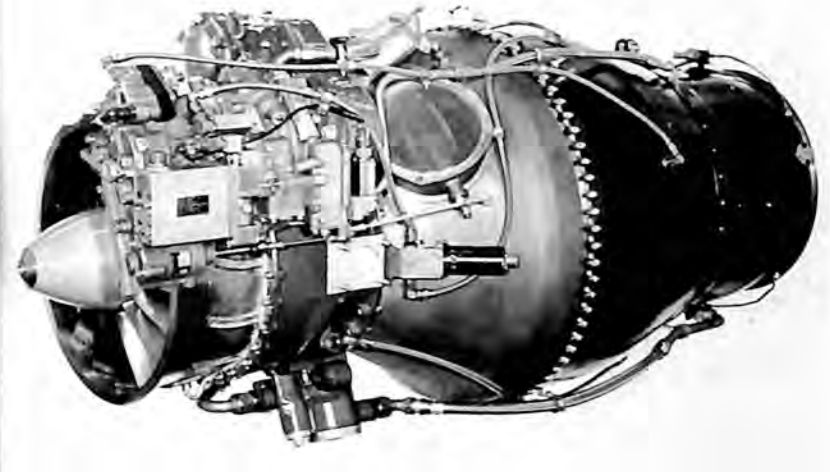
Advanced drone application.

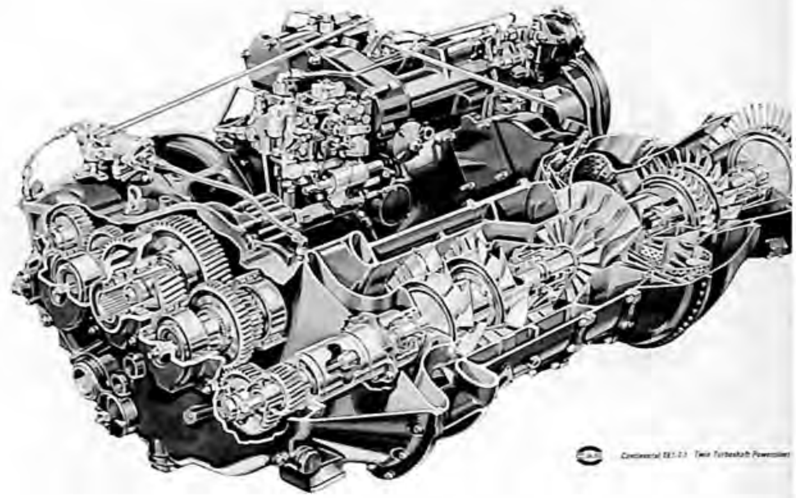
Specifications

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; 1.1 specific fuel consumption.





J100-CA-100 TURBOJET

Prime Contractor: Continental Aviation and Engineering Corporation

Specifications

Weight 405 pounds; compression ratio 6.3:1.

Performance

Thrust 2,700 pounds; airflow 44.5 pounds per second; specific fuel consumption 1.1.

T67-T-1 TWIN TURBOSHAFT

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

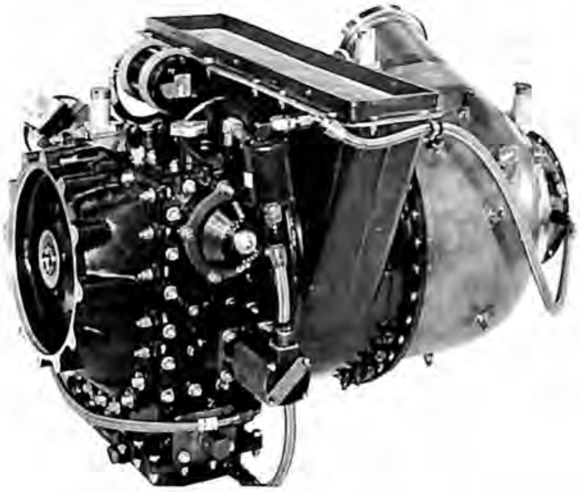
Featuring 2 independent engines combined with automatic power sharing system, the T67-T-1 has been flight tested in a UH-1D helicopter.

Specifications

Length 52 inches; 21 inches high by 38 inches wide; compression ratio 7.5:1; compression stages 3 per engine; turbine stages 2 gas generator plus 1 power turbine per engine; weight 540 pounds.

Performance

1,700 shaft horsepower maximum, 1,540 continuous; .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 .67 specific fuel consumption.

TS120-G6 TURBOSHAFT

Prime Contractor: Continental Aviation and Engineering Corporation

Remarks

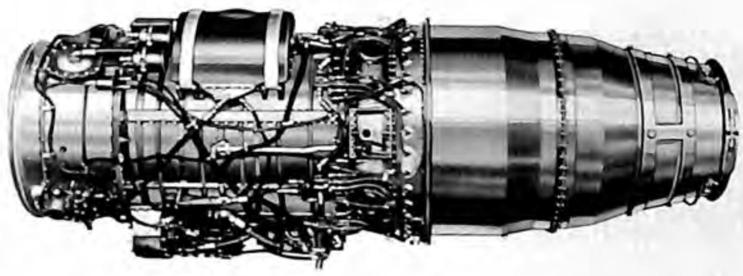
Model TS120 industrial gas turbine engine is being developed under contract to U.S. Army Mobility Equipment Research & Development Center.

Specifications

Length 29.2 inches; 29.8 inches wide by 21.6 inches high; compression ratio 5.6:1; compression stages 2; turbine stages 1; weight 215 pounds.

Performance

180 shaft horsepower at .65 specific fuel consumption.



J65-W-7 ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

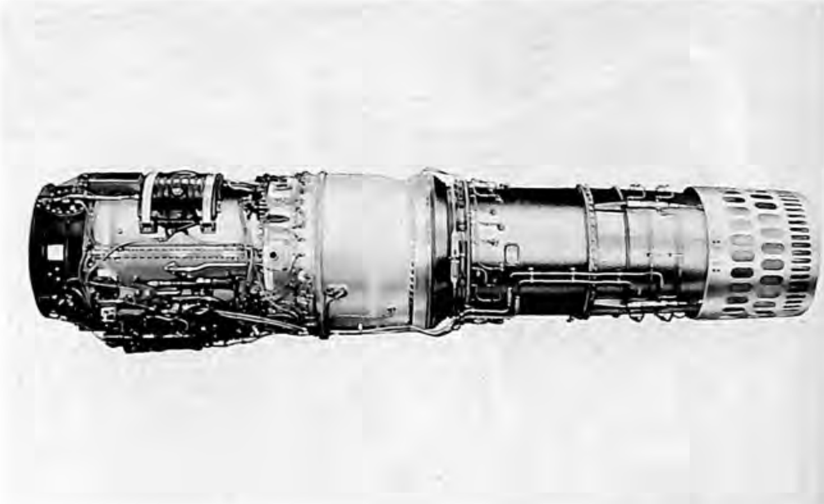
The J65-W-7, used by the military in the F/RF-84F aircraft, is a single-spool, axial-flow, compressor-type jet power plant.

Specifications

Dry weight 2,795 pounds; length 115 inches; diameter 37.5 inches; 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

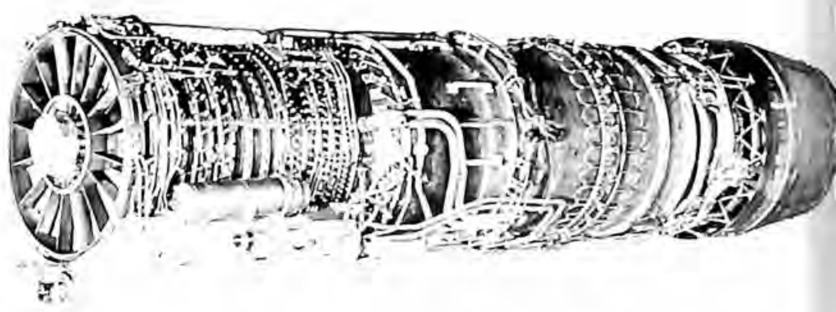
The J65-W-16, used by the military in the A-4A, A-4B, A-4C series aircraft, is a single-spool, axial-flow, compressor-type jet power plant.

Specifications

Length 108 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 Rockwell OV-10A aircraft, in service with U.S. Air Force and Marine Corps units. A commercial version, designated TPE 331, is offered in a family of horsepower ratings from 575 to 840 shaft horsepower. Applications include the Mooney/Mitsubishi MU-2, Aero Commander's Turbo Commander, Fairchild Heli-Porter, Pilatus Turbo Porter, Volpar's Super Turbo 18 and Turboliner conversions, Carstedt's Jet Liner 600 Dove conversion, Short's Skyvan and Swearingen's Merlin IIB. Among the features of this engine are opposite counterrotation props for twin-engine installations, immediate response to load requirements and rapid reverse thrust.

Specifications

Length 44.5 inches; width 19.25 inches; height 27 inches; weight 335 pounds; compressor 2-stage centrifugal; turbine 3-stage axial.

Performance

T76, 715 shaft horsepower; TPE 331 series, 575 shaft horsepower; TPE 331-1 series, 665 shaft horsepower; TPE 331-2 series, 715 shaft horsepower; TPE 331-3 series, 840 shaft horsepower.

YJ93 MILITARY TURBOJET

Prime Contractor: General Electric Company

Remarks

The YJ93 is a Mach 3 engine designed to power the 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 Douglas F-4 Phantom. Current production models are the J79-10, J79-17 and J79-19.

Specifications

Length 208.69 inches; diameter 39.6 inches; weight 3,800 pounds; compressor stages 17; turbine stages 3.

Performance

Thrust with afterburner 17,900 pounds.

J85 MILITARY AFTERBURNING TURBOJET

Prime Contractor: General Electric Company

Remarks

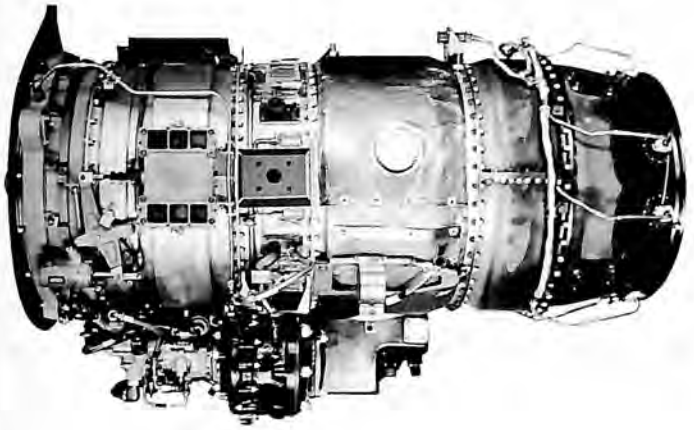
Power plant for high-performance aircraft and air-breathing missiles, the J85 turbojet is available in both afterburning and non-afterburning configurations. It has the highest power-to-weight ratio of any production engine in its class in the free world. Afterburning versions provide power for Northrop's F-5 and T-38A and Fiat's G.91Y. An advanced version, with 5,000 pounds of thrust, is designated J85-21.

Specifications (J85-5A, -13, -15)

Length (J85-15) 105.6 inches; flange diameter 21 inches; compressor stages 8; turbine stages 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, (-15) 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 power plant for transports, trainers, fighters, VTOL aircraft, missiles and take-off boost applications. This engine provides power for the Lockheed XV-4B, Canadair CL-41G, Cessna A-37B, McDonnell Douglas ADM-20, GE/Ryan XV-5B, Bell X-14A and Fairchild Hiller C-119K and C-123K.

Specifications (J85-17)

Weight 398 pounds; thrust-to-weight ratio 7.2:1; length 40.5 inches; diameter 17.7 inches; compressor stages 8; turbine stages 2.

Performance (J85-17)

Military thrust 2,850 pounds.

TF39 MILITARY TURBOFAN

Prime Contractor: General Electric Company

Remarks

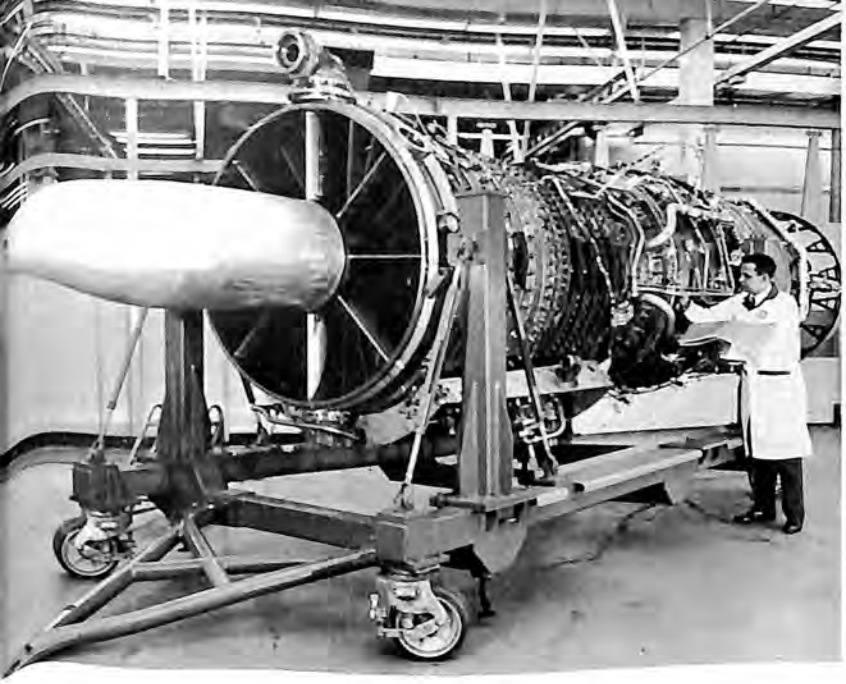
The TF39 is a high bypass ratio turbofan powering the Air Force's Lockheed C-5 heavy logistics transport over exceptionally long distances. Engine parts are designed for unusually long life.

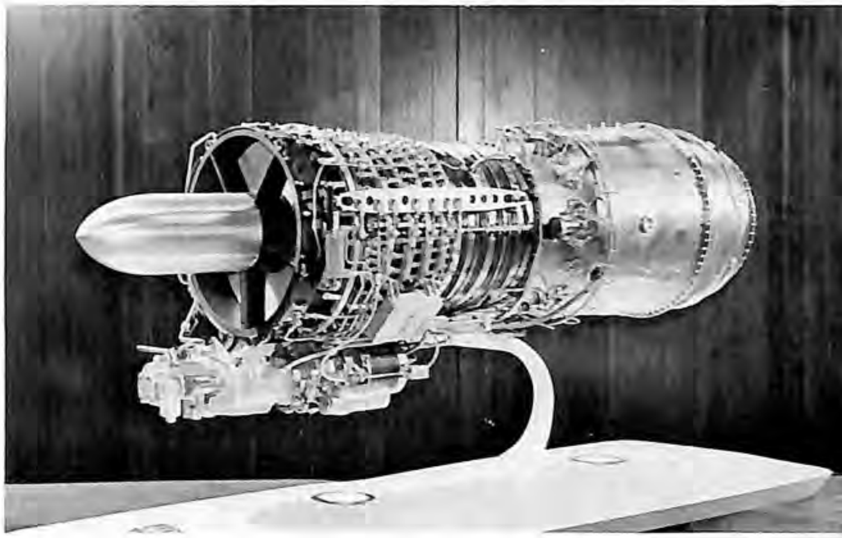
Specifications

Length 189.5 inches; maximum diameter 100 inches; thrust-to-weight ratio 5.85:1 plus; bypass ratio in the 8:1 class; pressure ratio at cruise altitude in the 25:1 class.

Performance

Maximum thrust 41,100 pounds.





GE4 COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

The GE4 is the augmented turbojet engine which will power the U.S. supersonic transport. The GE4 incorporates proven design features of the J79 and YJ93 engines as well as advanced technology. Full-scale engine testing began in mid-1966 and is continuing along with major component testing.

Specifications

Length 308 inches; maximum exhaust nozzle diameter 90 inches; weight 11,300 pounds; fuel commercial aviation kerosene.

Performance

Take-off thrust 67,000 pounds.

GE1 MILITARY/COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

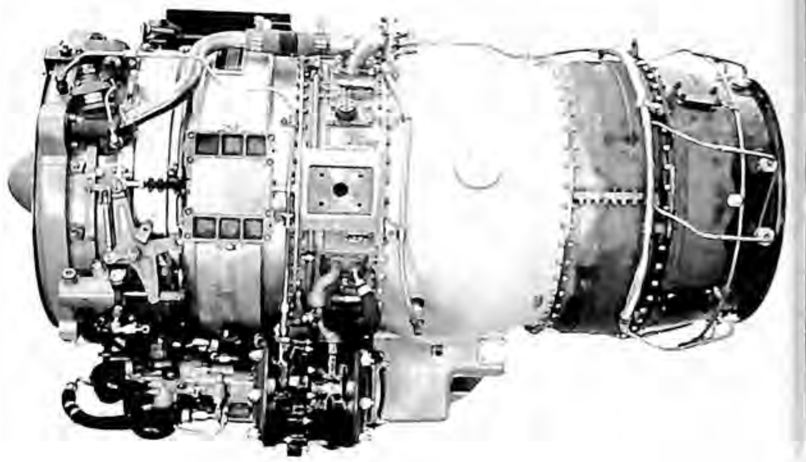
The GE1 Building Block approach provides for one gas generator as the basis of a family of advanced propulsion systems. Building Block components—turbofans, afterburners, thrust vectoring devices—are added to the GE1 gas generator to provide performance and configurations tailored to specific aircraft missions and designs. The GE1 features application versatility, time and cost savings and hardware standardization.

Specifications

The GE1, compared with the earlier J47 engine, represents a 51 percent reduction in length and 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 Fan Jet Falcon 10-passenger business jet aircraft. It is used also in the Bell lunar landing training vehicle to equalize the forces of gravity and rockets for pilot control movements.

Specifications (CF700-20)

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 4,250 pounds; maximum continuous thrust 4,120 pounds.

CJ610 COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

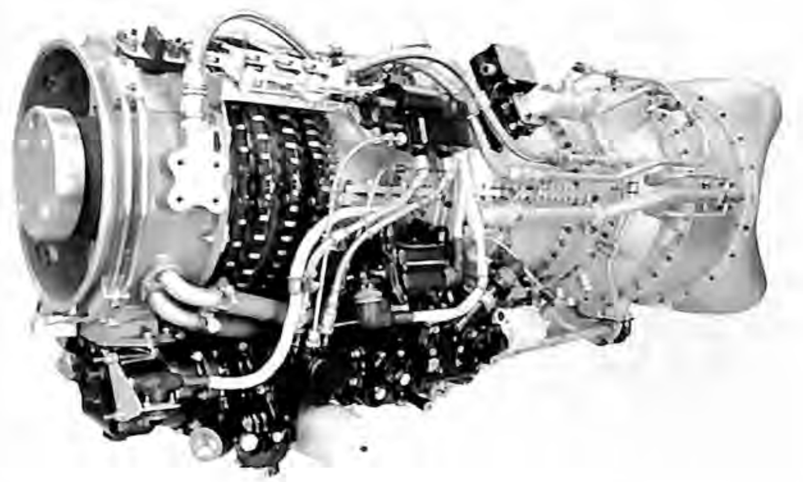
The CJ610 is a derivative of the J85 turbojet and has been produced in 4 configurations. Twin CJ610 engines power the Jet Commander, HFB 320 Hansa and the Learjet business aircraft.

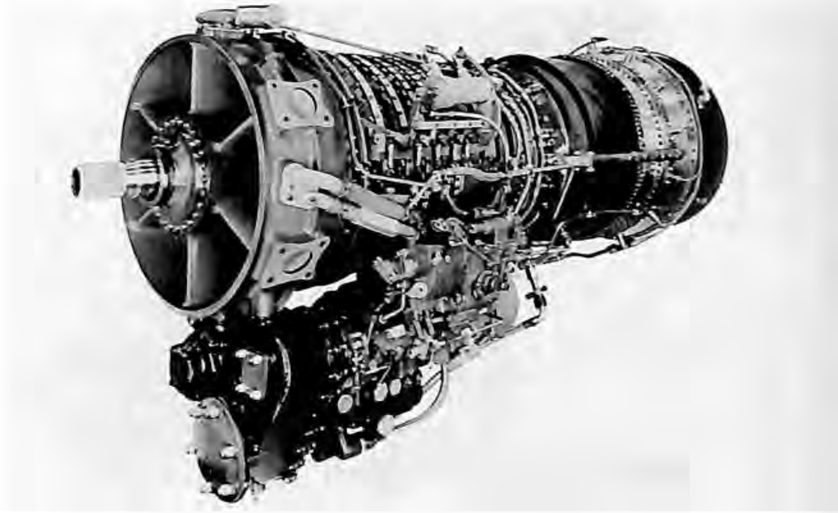
Specifications (CJ610-6)

Length 51.1 inches; flange diameter 17.7 inches; weight 392 pounds; thrust-to-weight ratio 7.5:1; compressor stages 8; turbine stages 2.

Performance

Take-off thrust 2,950 pounds.





T58 MILITARY TURBOSHAFT

Prime Contractor: General Electric Company

Remarks

The T58 turboshaft engine is produced in several configurations for a wide variety of helicopters and VTOL aircraft. Applications include Sikorsky SH-3A/D, Boeing Vertol CH-46A/D, Kaman UH-2A/B/C, Sikorsky CH-3C/E, Sikorsky HH-52A, Sikorsky HH-3E/F, Bell UH-1F, Agusta Bell 204B and Bell X-22A. The engine models currently in service are T58-1, -3, -5, -8, and -10; a higher-rated version, the T58-16, is under development.

Specifications

The T58 engines in service employ a 10-stage axial-flow compressor with variable geometry stator, annular combustor, 2-stage gas generator turbine and 1-stage (free) power turbine; length 59 inches; diameter 21 inches; weight 340 pounds. The T58-16 engine utilizes the same compressor and combustor and employs air-cooled gas generator turbine, 2-stage (free) power turbine; length 64 inches; diameter 24 inches; weight 440 pounds.

Performance

In-service models 1,300-1,500 pounds thrust, (-16) 1,870 pounds thrust.

T64 MILITARY TURBOSHAFT/TURBOPROP

Prime Contractor: General Electric Company

Remarks

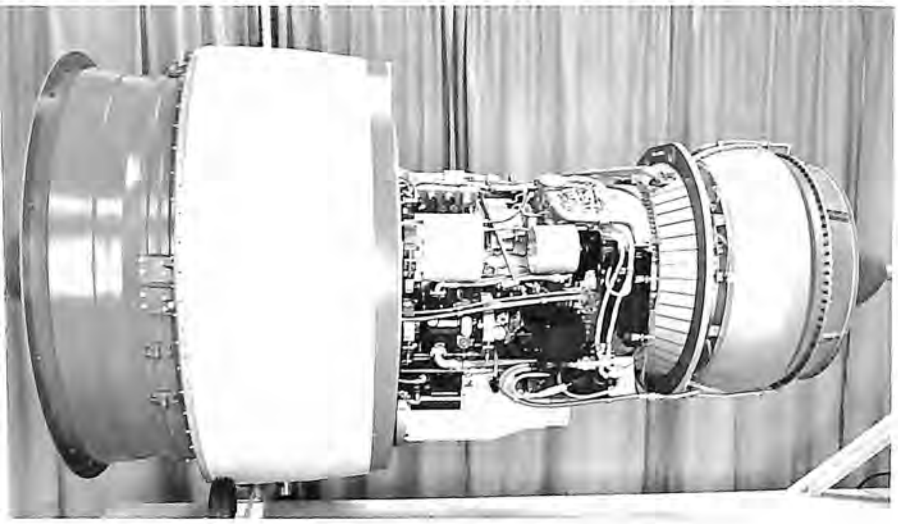
The T64 is a free turbine power plant for helicopter and V/STOL aircraft. Produced in turboprop and turboshaft configurations, major design considerations were low fuel consumption, high reliability, ease of maintenance, application versatility and growth potential. Initial production models produced up to 3,080 shaft horsepower, and as a result of growth development current engines in production provide capability to 3,925 shaft horsepower. Applications include Sikorsky CH-53A, C and D, Sikorsky HH-53B and C, the de Havilland Buffalo, Fiat G.222, Kawasaki P2J, Shin Meiwa PS-1, Ling-Temco-Vought XC-142A and Lockheed AH-56A.

Specifications

The basic engine consists of a 14-stage axial-flow compressor, through flow annular combustor, 2-stage gas generator turbine and 2-stage axial-flow power turbine. The power output is provided by an axial forward extending drive shaft. Addition of a planetary speed decreaser gear allows creation of a turboprop configuration with a centerline above or below the engine centerline. The T64-16 is 68 inches in length; maximum diameter 20.1 inches; horsepower/weight ratio 4.9; weight 700 pounds.

Performance

(T64-3) maximum 3,080 shaft horsepower; (T64-6) military 2,850 shaft horsepower; (T64-12) military flat rated at 3,400 shaft horsepower; (T64-7, -16) without fuel flow limit, maximum flat rated at 3,370 shaft horsepower.

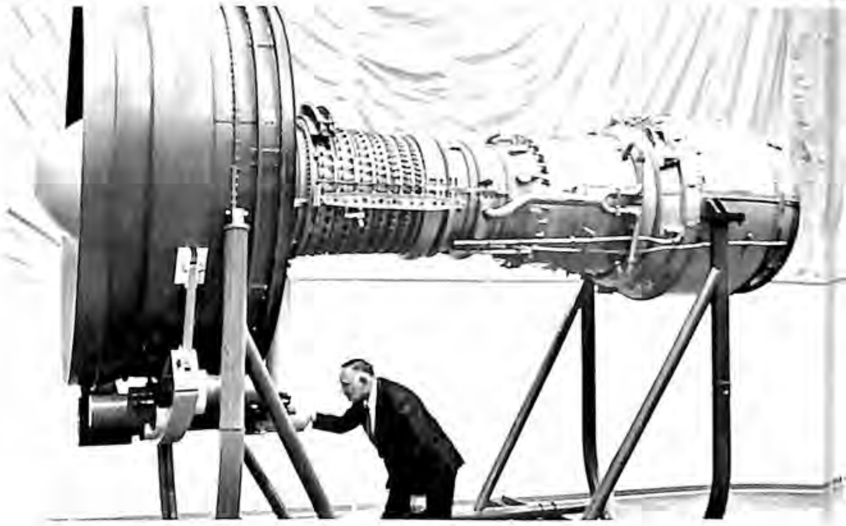


TF34 MILITARY TURBOFAN

Prime Contractor: General Electric Company

Remarks

A new General Electric high bypass ratio turbofan, the TF34 has been selected to power the U.S. Navy's proposed VSX antisubmarine warfare aircraft. The engine provides low specific fuel consumption over a broad operating range and utilizes a variable stator compressor, annular combustor and air-cooled turbine, features which have proved so successful on other GE engines.



CF6 COMMERCIAL TURBOFAN

Prime Contractor: General Electric Company

Remarks

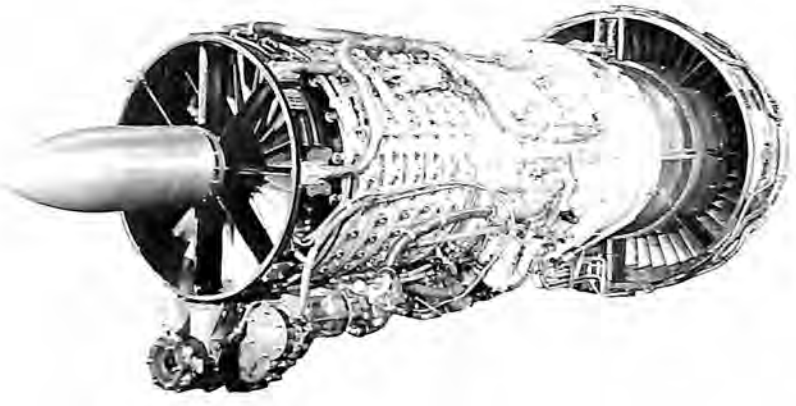
The CF6 is an advanced technology high bypass ratio turbofan selected to power the McDonnell Douglas DC-10 trijet. The engine uses a 16-stage variable stator compressor driven by a 2-stage, air-cooled, high-pressure turbine, and a 1¼-stage fan driven by a 5-stage low-pressure turbine. The CF6 is designed to meet stringent commercial standards of long life and reliability, easy maintenance, very low specific fuel consumption, low sound levels and virtual smokelessness. Full-scale CF6 engines are being manufactured and tested, and the engine is scheduled to enter airline service in 1971.

Specifications

Length 172.5 inches; maximum diameter 92 inches; engine weight 7,350 pounds.

Performance

Take-off thrust 40,000 pounds.



CJ805-3 COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

The CJ805-3 turbojet is a single rotor compressor and turbine engine which features split compressor, combustion and turbine sections for easy access and maintenance. Its conical construction reduces engine weight and assures optimum strength-to-weight ratio. Other features include variable stators, hydromechanical externally mounted control systems and single rotor compressor and turbine requiring only 3 main bearings. Following an extensive testing program, the CJ805-3 entered commercial airline service in May 1960 and is currently in service with 10 operators.

Specifications

Length 181.93 inches; maximum diameter 31.6 inches; engine weight 2,817 pounds.

Performance

Take-off thrust 11,650 pounds.

CJ805-23 COMMERCIAL TURBOFAN

Prime Contractor: General Electric Company

Remarks

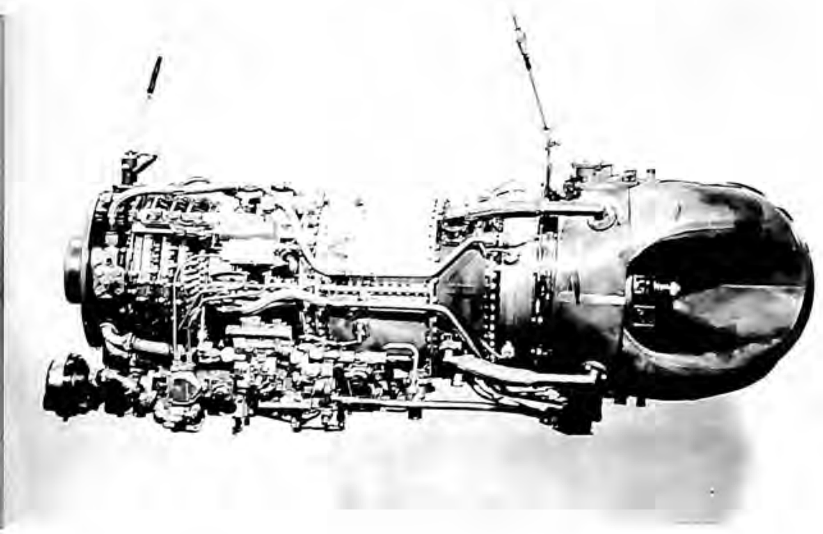
The CJ805-23 is a turbofan version of the CJ805-3 turbojet. It features split compressor, combustion and turbine section casings for ease of maintenance. Conical construction reduces engine weight. Its single rotor compressor and turbine require only 3 main bearings. Other features include variable stators and external hydromechanical control systems for easy servicing. The addition to the basic CJ805-3 of an aft fan with a single-stage turbine compressor increases take-off thrust by over 35 percent and fuel economy by 10 to 15 percent. The CJ805-23 is in service with 7 domestic and overseas carriers.

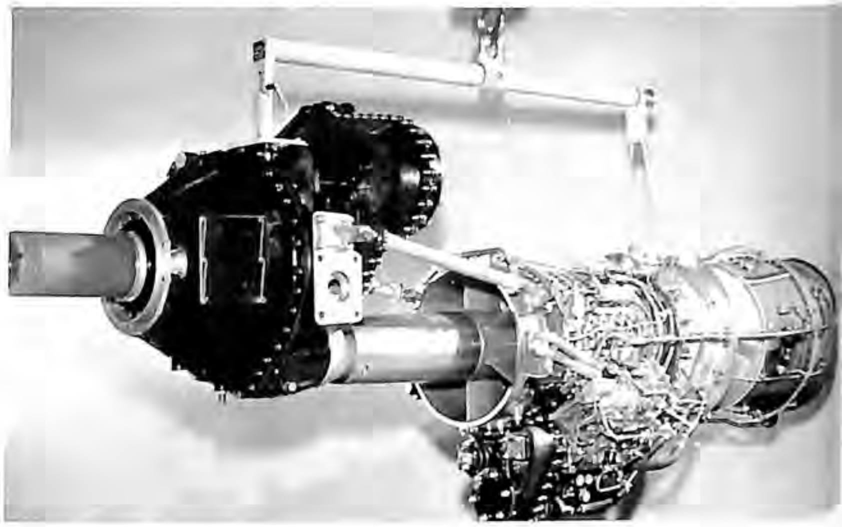
Specifications

Length 149.6 inches; maximum diameter 53.34 inches; engine weight 3,766 pounds.

Performance

Take-off thrust 16,100 pounds.





CT58 COMMERCIAL TURBOSHAFT

Prime Contractor: General Electric Company

Remarks

The CT58-110 configuration, serving a variety of helicopter applications, has been succeeded by the higher rated CT58-140, which began production in 1965. Modification of the -110 engines to the higher power rating is accomplished through kit conversion. Applications include the Boeing Vertol 107 and the Sikorsky S-61 and S-62.

Specifications

Length 59 inches; maximum width 21 inches; weight 340 pounds (CT58-140).

Performance

Take-off rating 1,400 horsepower (CT58-140), 1,250 horsepower (CT58-110).

CT64 COMMERCIAL TURBOSHAFT/TURBOPROP

Prime Contractor: General Electric Company

Remarks

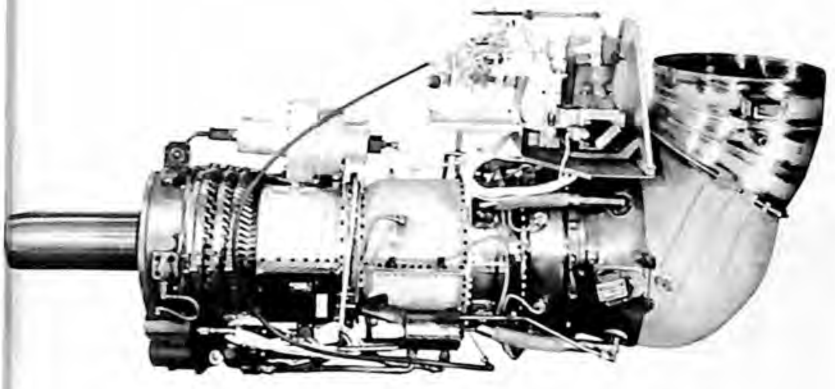
Commercial configurations of the military T64 turboshaft/turboprop are in production and certified for civil use. The CT64-410-1 and CT64-810-1 are turboprop engines, and the CT64-610-1 is a direct-drive power plant.

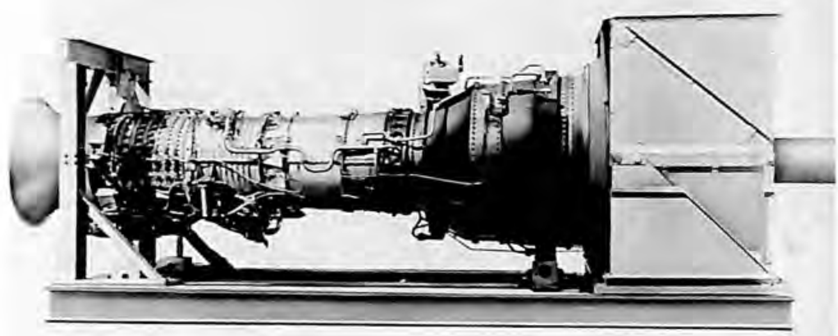
Specifications (CT64-810-1 Turboprop)

Length 112.9 inches; maximum height 46 inches; weight 1,167 pounds; compressor stages 14; turbine stages 4.

Performance

Maximum equivalent shaft horsepower 2,850.





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 oil well fracturing units, gas pipeline pumping and emergency power generation.

LM1500 GAS TURBINE

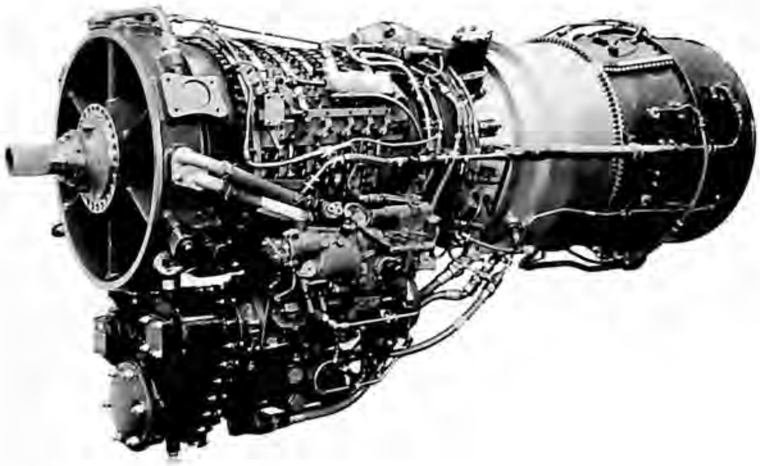
Prime Contractor: General Electric Company

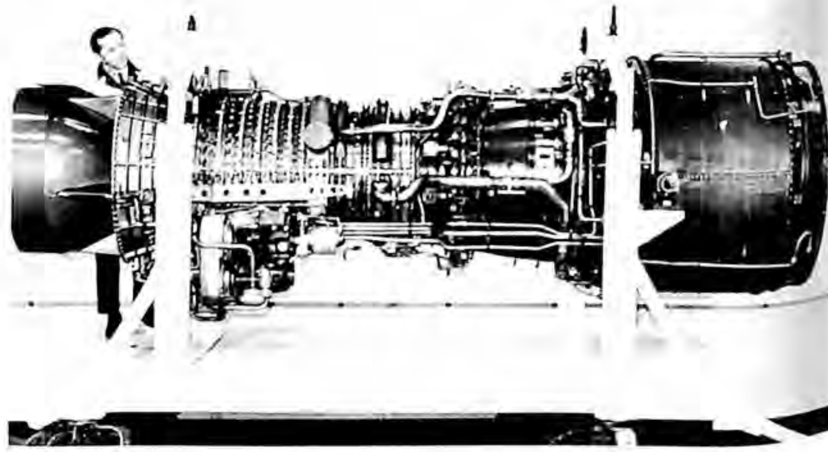
Remarks

Available as a shaft power engine or as 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 USS *Plainview*. The LM1500 is used also for gas pipeline pumping and power generation for electric utilities.

Performance

14,000 horsepower at normal 80 degrees Fahrenheit.





LM300 GAS TURBINE

Prime Contractor: General Electric Company

Remarks

The LM300 is an advanced design, lightweight gas turbine derived from General Electric's T64 aircraft engine series. It is available for use in a wide variety of applications such as airborne power units, marine and land-based transportation systems, and industrial drive and power generation. From the initial design through the total development program, the engine has been designed to achieve high reliability, long life, simplified maintenance and maximum corrosion resistance.

Performance

3,000 horsepower class.

LM2500 GAS TURBINE

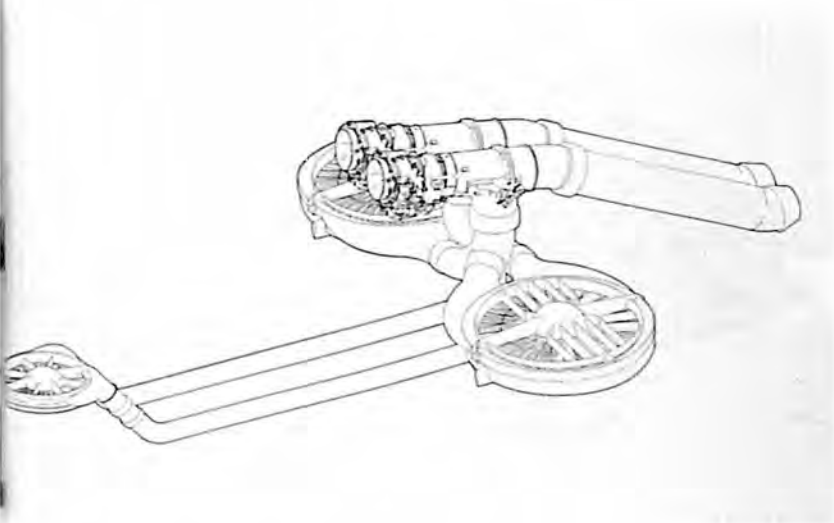
Prime Contractor: General Electric Company

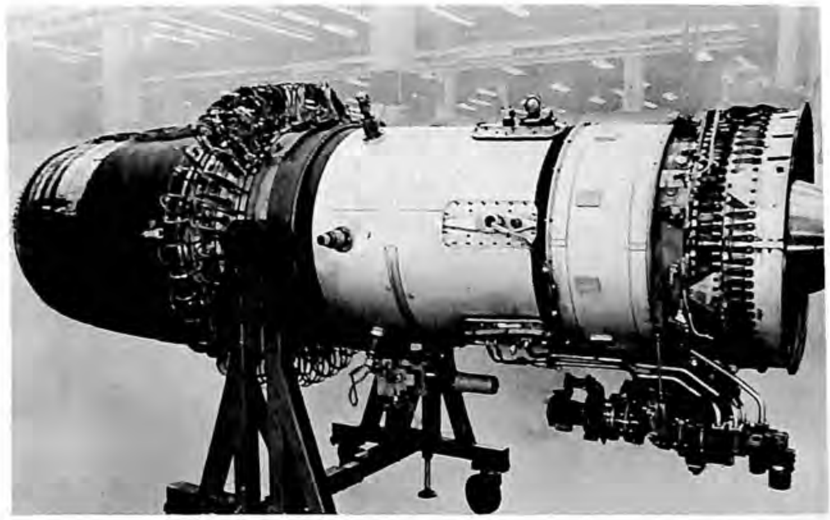
Remarks

The LM2500 is derived from the GE TF39 high bypass turbofan engine. For marine and industrial applications the TF39 front fan is removed, and, with suitable modifications, shaft power is extracted from the low-pressure turbine system through a power takeoff at the aft end of the engine. The LM2500, which is designed as a marine power plant, will deliver more power per pound of fuel burned and air ingested than any other marine gas turbine in its class.

Performance

25,000 horsepower class.





LF1 "TURBOTIP" LIFT FAN SYSTEM

Prime Contractor: General Electric Company

Remarks

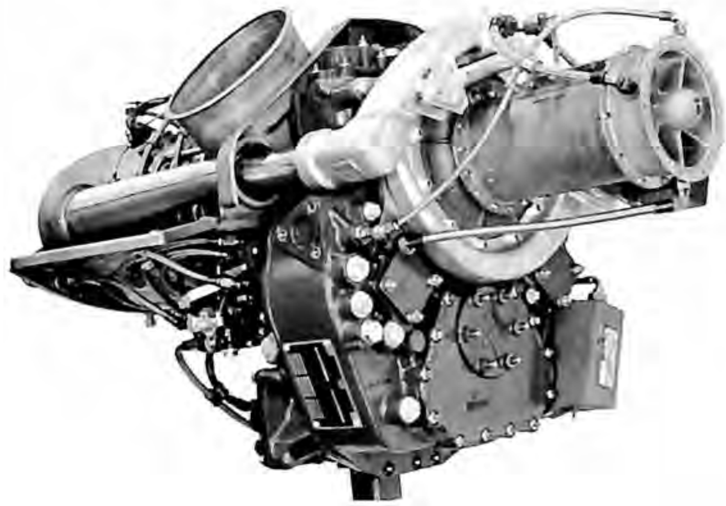
A convertible "Turbotip" propulsion system, the LF1 is designed to power high-speed vertical take-off and landing aircraft. The "Turbotip" fan system consists of 2 wing-mounted lift fans and a nose fan to control pitch of the aircraft. The lift fans installed in the XV-5B NASA VTOL research aircraft 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 and attack aircraft. The GE1/10 is approximately 38 inches in diameter and 143 inches in length and has a turbine inlet temperature in excess of 2,000 degrees Fahrenheit.



501-D13D COMMERCIAL TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

The 501-D13D is the power plant for the Convair 580, operating with 4 airlines, 14 corporations, the Federal Aviation Administration, 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.

250-C20 COMMERCIAL TURBOSHAFT

Prime Contractor: Allison Division of General Motors

Remarks

Scheduled for production in early 1970 for light helicopters.

Performance

Rating 400 shaft horsepower.

501-D22 COMMERCIAL TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

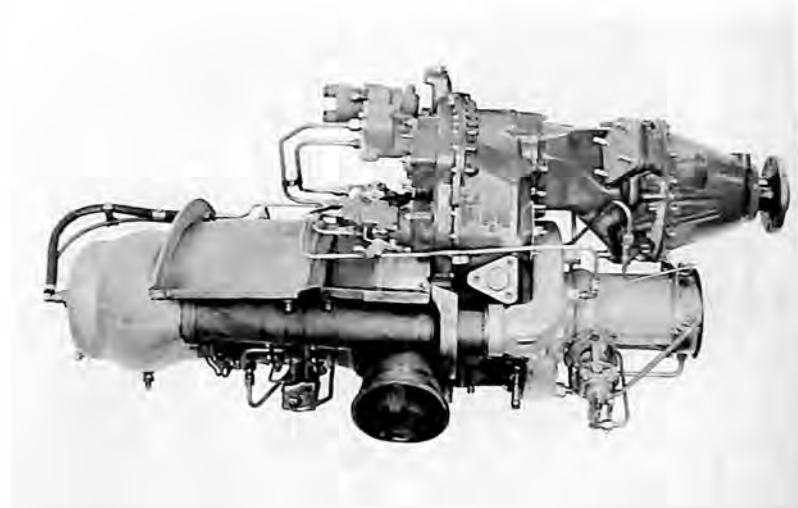
The 501-D22 turboprop engine powers the Lockheed 100, commercial version of the military Hercules.

Specifications

Length 146 inches; width 27 inches; height 39 inches; weight 1,833 pounds; compression ratio 9.55:1; compressor stages 14; turbine stages 4.

Performance

Rating 4,680 equivalent shaft horsepower.



250-B15 COMMERCIAL TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

Entered production in late 1968 for light single- and twin-engine aircraft.

Specifications

Length 44.5 inches; width 19 inches; height 22.5 inches; weight 144 pounds; compression ratio 6.2:1; compressor stages 6 axial, 1 centrifugal; turbine stages 4.

Performance

Rating 317 shaft horsepower.

250-B17 COMMERCIAL TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

Scheduled for production in early 1970 for light single- and twin-engine aircraft.

Performance

Rating 400 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, Navy, Coast Guard, Marine Corps and Military Airlift Command, 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

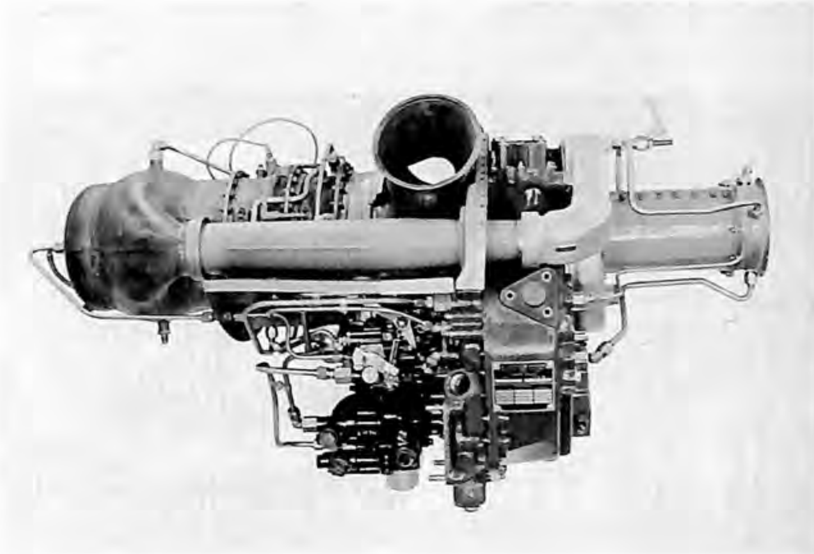
The T56-A-14 is a follow-on military engine for the Lockheed P-3 antisubmarine warfare plane.

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 the power plant for the Lockheed HC-130H search, rescue and recovery aircraft.

Specifications

Length 146 inches; width 27 inches; height 39 inches; weight 1,825 pounds; compression ratio 9.55:1; compressor stages 14; turbine stages 4.

Performance

Rating 4,910 equivalent shaft horsepower.

T63-A-5A MILITARY TURBOSHAFT

Prime Contractor: Allison Division of General Motors

Remarks

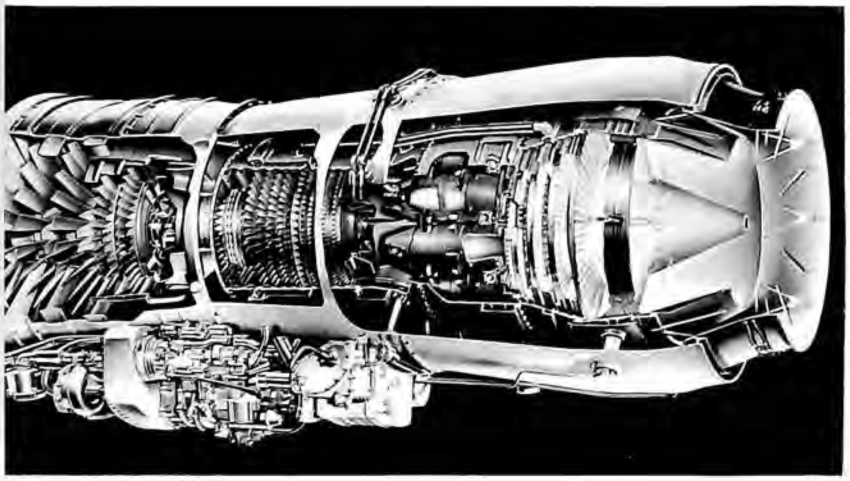
The T63-A-5A powers the Army OH-6A light observation helicopter.

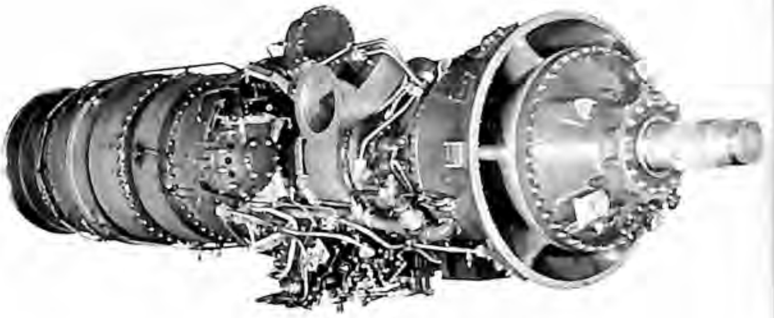
Specifications

Length 40 inches; diameter 22.5 inches; weight 136 pounds; compression ratio 6.2:1; compressor stages 6 axial, 1 centrifugal; turbine stages 4.

Performance

Rating 317 shaft horsepower.





TF41 MILITARY TURBOFAN

Prime Contractor: Allison Division of General Motors

Remarks

Allison undertook the TF41 development jointly with Rolls-Royce Ltd. TF41-A-1 is in production for the U.S. Air Force's A-7D close-support tactical fighter. TF41-A-2 is being developed for the U.S. Navy's A-7E Corsair II carrier-based attack fighter.

Specifications

The TF41 is a 2-shaft turbofan with a 3-stage front fan, bypass and 2-stage low-pressure compressor. It also incorporates an 11-stage high-pressure compressor, can-annular combustor and 4-stage turbine. Length (TF41-A-1) 106 inches.

Performance

Thrust (TF41-A-1) 14,250 pounds, (TF41-A-2) 15,000 pounds.

T34 MILITARY TURBOPROP

Prime Contractor: Pratt & Whitney Aircraft

Remarks

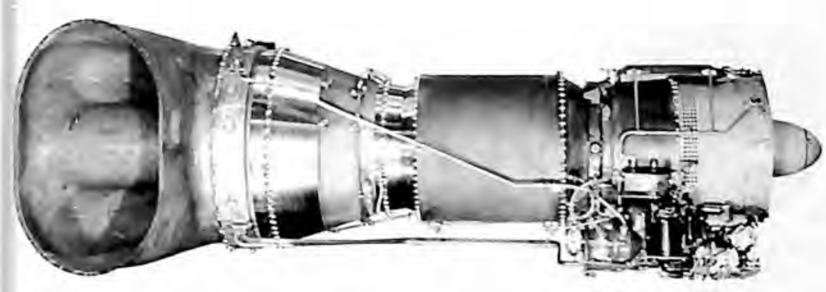
Development of the T34 (PT2) axial flow turboprop engine began in 1945. The engine was put into production in 1953. It powers the Douglas C-133 Cargomaster.

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

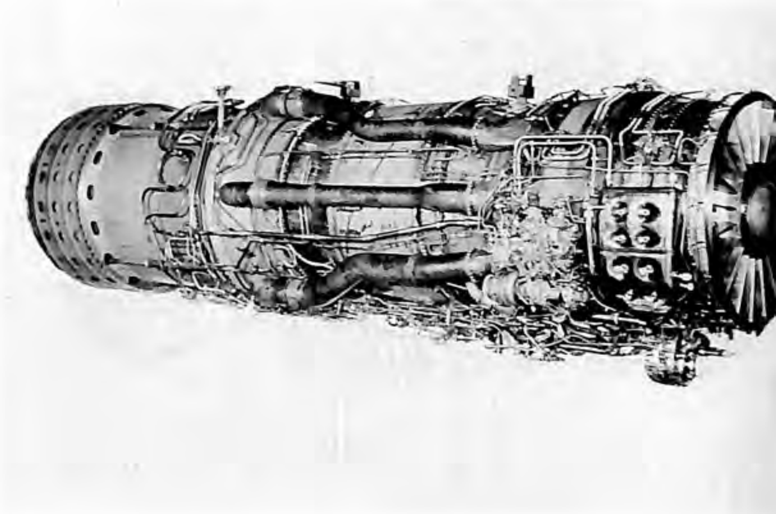
A turboshaft adaptation of the JT12 engine, the JFTD12 has a 2-stage free turbine added in the rear. Two of these engines power the Sikorsky S-64 Skycrane, an all-purpose, heavy-lift transport helicopter.

Specifications (JFTD12A-4A)

Length 107 inches; diameter 34 inches; weight 920 pounds; compression ratio 6.85:1; free turbine drive; compressor stages 9; turbine stages 4.

Performance

Rating 4,500 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, the McDonnell F-101, the Convair F-102, the Ling-Temco-Vought F-8 and the Douglas F-6 and A-3. Over 48,000,000 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 12.5:1; weight 3,870 pounds; axial flow, dual rotor; compressor stages 16; turbine stages 3.

Performance

Thrust 13,750 pounds, afterburning versions 18,000 pounds.

J75 MILITARY TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

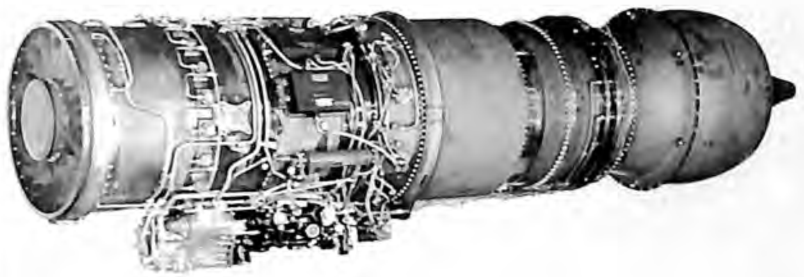
Design work on the J75 (JT4 commercial) began in 1952. To design an engine with 50 percent more output but only slightly larger than the similar J57 (JT3) at the time, engineers took the advanced step of increasing the hub-to-tip ratio. This essentially reduced the diameter of the hub which reduced weight 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.

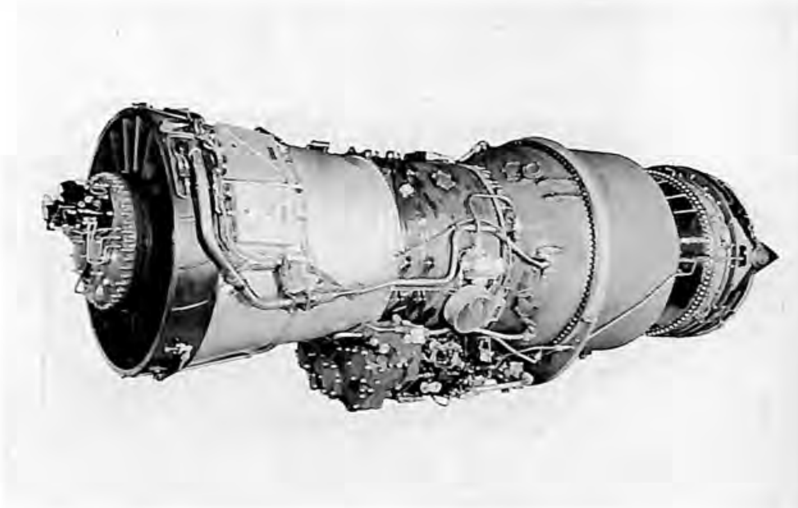
Specifications

Length (J75-P-17) 237.6 inches, (-P-19W) 259.3 inches; diameter 43.5 inches; compression ratio 11.9:1; 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-4F, the Grumman A-6A and the North American Rockwell Hound Dog missile.

Specifications (J52-P-8A)

Length 116.9 inches; diameter 30.15 inches; compression ratio 13.1; weight 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

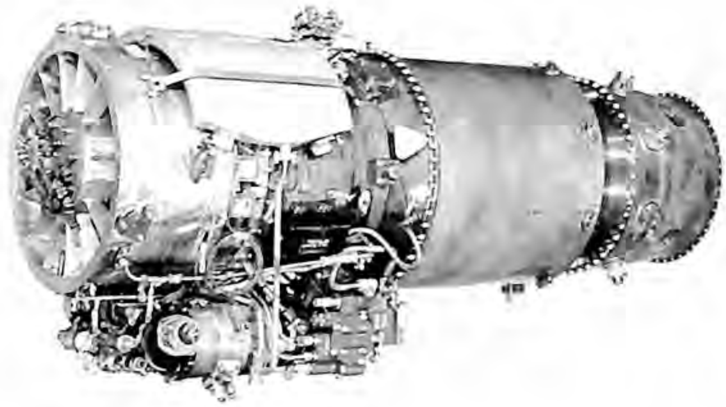
On October 26, 1958, the JT3 Turbo Wasp ushered in the American commercial jet age. A commercial version of the J57, this engine was produced from 1958 to 1961. Configurations are in wide service on the Boeing 707-120 and 720 and the McDonnell Douglas DC-8-10.

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 McDonnell Douglas DC-8-20, -30 airliners. Built between 1959 and 1961, it has attained a time between overhaul (TBO) of 11,500 hours.

Specifications (JT4A-11)

Length 144.1 inches; diameter 43 inches; weight 5,100 pounds; compression ratio 12; axial flow, dual rotor; compressor stages 15; turbine stages 3.

Performance

Thrust 17,500 pounds.

JT12/J60 TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

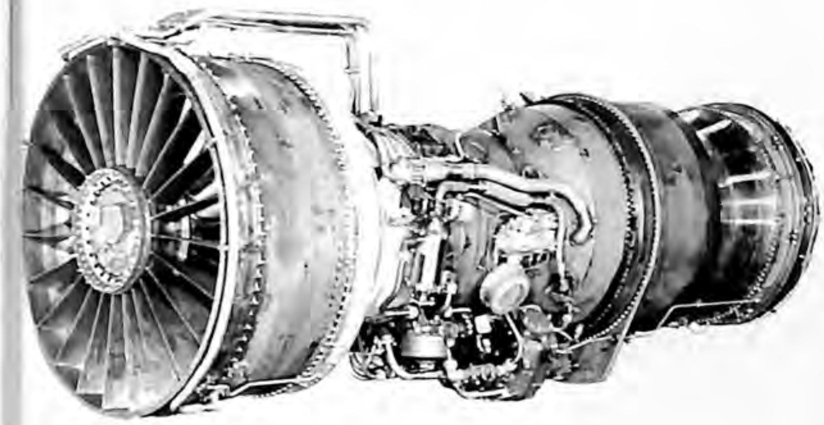
The JT12A-8 (military designation J60), smallest in the company's jet engine family, powers the 4-engine Lockheed JetStar and twin-engine North American Rockwell Sabreliner business aircraft.

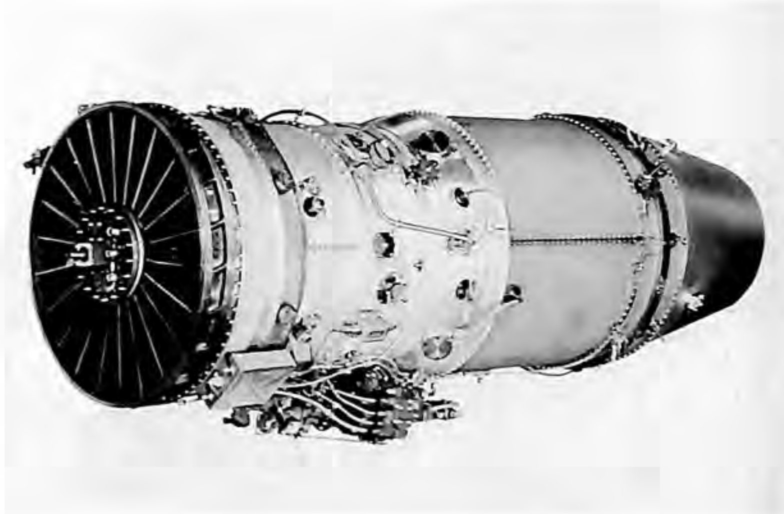
Specifications (JT12A-8)

Length 78 inches; diameter 21.9 inches; weight 468 pounds; compression ratio 6.7:1; axial flow, single rotor; compressor stages 9; turbine stages 2. J60-P-4 same except for length: 70.6 inches.

Performance

Thrust 3,300 pounds, 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 and 707-320B and -320C and the McDonnell Douglas DC-8-50, DC-8F and Super Sixty series.

Specifications (JT3D-7)

Length 134.4 inches; diameter 53 inches; weight 4,260 pounds; compression ratio 13.5; axial flow, dual rotor; compressor stages including fan 15; turbine stages 4.

Performance

Thrust 19,000 pounds.

JT8D COMMERCIAL TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

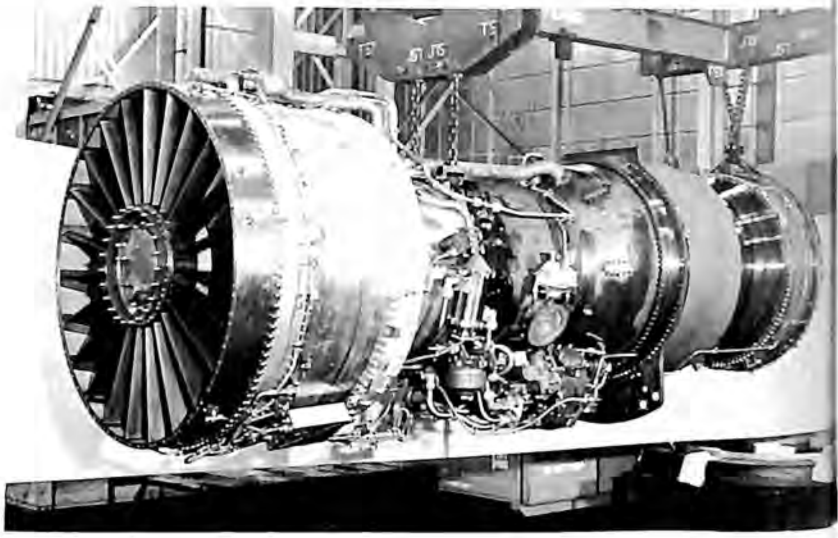
The company-financed JT8D was designed and developed from the outset for application to short- and medium-range aircraft. This engine has reached a maximum time between overhaul (TBO) of 9,050 hours. The JT8D turbofan engine powers the Boeing 727 and 737, the twin-engine McDonnell Douglas DC-9 and the Sud Aviation Super Caravelle 10B, 10R and 11R.

Specifications (JT8D-9)

Length 120 inches; diameter 42.5 inches; weight 3,218 pounds; compression ratio 16.9:1; axial flow, dual rotor; compressor stages including fan 13; turbine stages 4; full-length fan duct.

Performance

Thrust 14,500 pounds.



TF30 MILITARY TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

The 20,000-pound-thrust-class TF30 was the first afterburning turbofan engine to complete an official 150-hour qualification testing. Configurations of this engine power the twin-engine General Dynamics USAF F-111A variable-sweep-wing supersonic fighter. A non-afterburning version is the power plant for the LTV A-7A, -7B and -7E aircraft. Specifications for afterburning versions are classified.

Specifications (TF30-P-8)

Length 128.1 inches; diameter 42.1 inches; weight 2,526 pounds; compression ratio 18.1:1; axial flow, dual rotor; compressor stages including fan 16; turbine stages 4.

Performance

Thrust 12,200 pounds (non-afterburning).

TF33 MILITARY TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

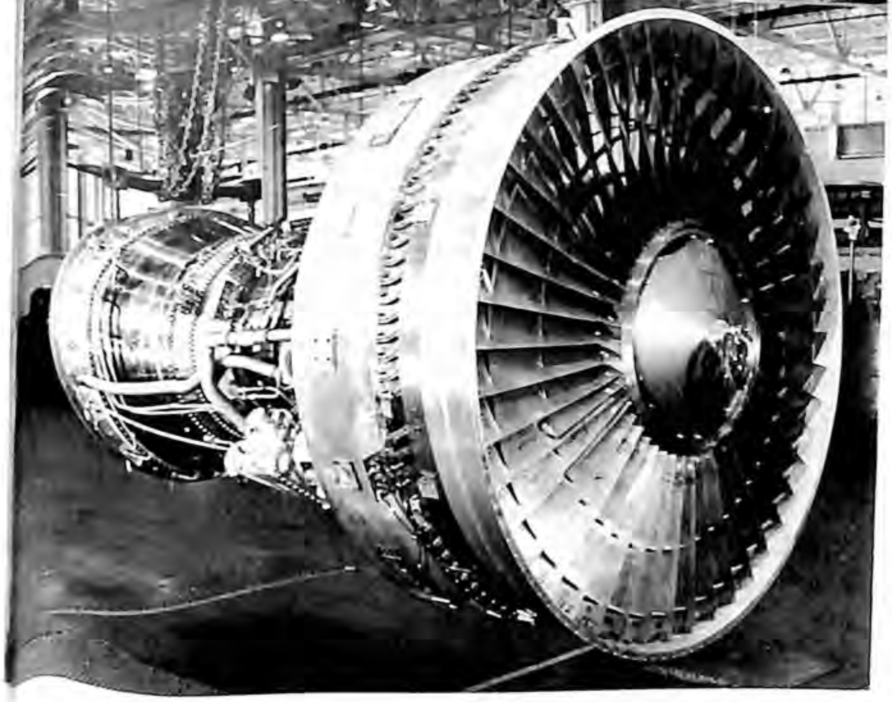
Configurations of the TF33 (JT3D in the commercial version) power the Boeing B-52H bomber, C-135B and KC-135B and the Lockheed C-141A.

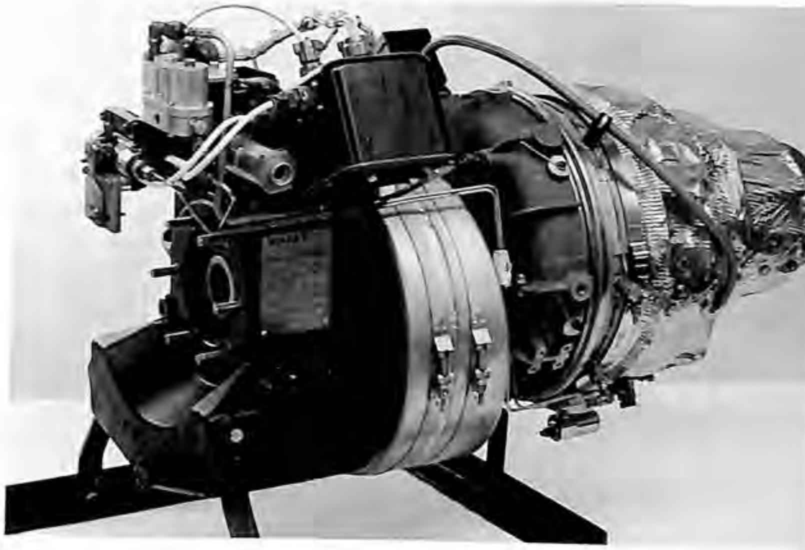
Specifications (TF33-P-7)

Length 142.3 inches; diameter 53 inches; weight 4,605 pounds; compression ratio 16.1:1; axial flow, dual rotor; compressor stages including fan 16; turbine stages 4.

Performance

Thrust 21,000 pounds.





JT9D COMMERCIAL TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

The Pratt & Whitney Aircraft JT9D, which powers the 490-passenger Boeing 747, is a turbofan engine of an advanced design producing 45,500 pounds of thrust. The JT9D has an 8-foot-diameter inlet—almost twice that of the 19,000-pound-thrust JT3D turbofan engine which is the workhorse of the long-range Boeing 707 and McDonnell Douglas DC-8 jet fleets and the military Lockheed C-141 StarLifter. 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 8,470 pounds. The JT9D utilizes advanced cycle and design concepts which have been under development for several years. New combustion chamber components substantially shorten the combustion section and, by making individual compressor stages produce higher pressure, also reduce the number of compressor stages required. The JT9D uses a rotary spinner to improve airflow conditions and has a plug nozzle in the exhaust section. The engine has a total airflow of 1,484 pounds per second (19,000 cubic feet) and a bypass ratio of 5:1. It has 1 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 has 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; at cruise altitudes, 61 percent.

T62T GAS TURBINE ENGINE

Prime Contractor: Solar Division of International Harvester Company

Remarks

The T62T Titan is an extremely rugged, compact gas turbine engine which has been service-proven in both military and commercial applications. It is being used as the auxiliary power unit (APU) in every major U.S. military cargo helicopter program. In these applications, the APU provides power necessary to start main engines and to operate all hydraulic and electrical systems, allowing aircraft operation completely independent of ground support equipment. Titan commercial applications include installations in F-27 and FH-227 aircraft of several airlines and in Falcon 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 are listed under system contractor, giving manufacturer's nomenclature, type, stages and thrust, launch weight and overall length, performance, remarks and using organizations.

AEROJET-GENERAL CORPORATION, SPACE DIVISION

AEROBEE 150 & 150A

Boosted single-stage sounding rocket; sustainer—liquid IRFNA and aniline-furfuryl-alcohol mixture; engine (4,100 pounds thrust for 51.8 seconds), booster—Aerojet 2.5KS-18,000 solid motor; weight (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 feet, (300A) 33.3 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; 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 36 g; length 336.2 inches; weight at lift-off without payload 1,591 pounds; payload area 79 inches by 7.75 inches diameter.

ATLANTIC RESEARCH CORPORATION, A DIVISION OF THE SUSQUEHANNA CORPORATION

ARCAS

Single-stage solid sounding rocket; 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.

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 and 3rd—Hercules M-5 Nike (48,700 pounds thrust each), 4th—Hercules X-248 (3,000 pounds thrust); weight 7,400 pounds; length 48.7 feet; 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 and 3rd—Lockheed Lance (47,000 pounds thrust each), 4th—Hercules X-248 (3,000 pounds thrust); weight 14,000 pounds; length 62 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.

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; altitude 5,000 feet; Army.

NIKE-ARCHER

Two-stage solid sounding rocket; 1st—Hercules M-5 Nike (48,700 pounds thrust), 2nd—ARC Archer 35KS-1375; weight 1,650 pounds; length 25 feet; 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.

ARCTURUS

Single-stage meteorological and research rocket with separable payload; 9-pound payload to 300,000 feet; burnout altitude approximately 66,000 feet; thrust, boost phase 485 pounds, sustainer phase 350 pounds; weights with standard payload 85.8 pounds at launch, 38 pounds at burnout; company-sponsored program.

SUPER ARCAS

Simple, versatile vehicle for probing the mesosphere and ionosphere; single-stage system with separable payload; employs a MARC 60A rocket motor of 370 pounds thrust, burning time 32.6 seconds; payloads from 8 to 25 pounds; vehicle weight 95.8 pounds at launch, 40.5 pounds at burnout.

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

TERRIER/551C

Ground-launched 2-stage research rocket; 1st—A.B.L. Terrier Mk 12 booster, 2nd—NWC Mod 551C; launch weight 2,750 pounds plus payload; 250-pound payload to 250 nautical miles; in flight test.

HYDRA-IRIS

Two-stage research rocket capable of remote water-launch from free-floating launcher; 1st—NavMisCen-designed cluster of 3 Aerojet Sparrow III motors, 2nd—Atlantic Research Corporation Iris; 200-pound payload to 100 nautical miles; booster and launcher being modified. (See also Atlantic Research.)

SANDIA CORPORATION

NITEHAWK 9

Two-stage solid propulsion sounding rocket; 1st—Nike M-5 (48,700 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,500 pounds thrust); 9-inch diameter; 125-175-pound payloads to altitudes between 165 and 200 miles; Mach 8.5; Atomic Energy Commission.

NITEHAWK 12

Two-stage solid propulsion sounding rocket; 1st—Nike M-5 (48,700 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,500 pounds thrust); 12-inch diameter; 200-260-pound payloads to altitudes between 95 and 110 miles; Mach 6; Atomic Energy Commission.

ADVANCED TERRIER TOMAHAWK 9

Two-stage solid propulsion sounding rocket; 1st—Hercules BT-3 Advanced Terrier (66,800 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,500 pounds thrust); 9-inch diameter; 175-pound payload to 255-mile altitude; Mach 9; Atomic Energy Commission.

NIKE CAJUN

Two-stage solid propulsion sounding rocket; 1st—Nike M-5 (48,700 pounds thrust), 2nd—Thiokol TE-M-82-1 Cajun Mod 1 (8,800 pounds thrust); 6½-inch diameter; 70-pound gross payload to 98 miles altitude; Mach 6; Atomic Energy Commission.

NIKE APACHE

Two-stage solid propulsion sounding rocket; 1st—Nike M-5 (48,700 pounds thrust), 2nd—Thiokol TE-M-307-2 Apache (5,300 pounds thrust); 6½-inch diameter; 100-pound gross payload to 85 miles altitude; Mach 5.5; Atomic Energy Commission.

SANDHAWK

Single-stage solid propulsion sounding rocket; Thiokol TE-M-473 Sandhawk (24,500 pounds thrust); 13-inch diameter; length 24.1 feet; 200-pound gross payload to 110 miles altitude; Mach 6.2; Atomic Energy Commission.

ADVANCED TERRIER-SANDHAWK

Two-stage solid propulsion sounding rocket; 1st—Advanced Terrier (66,800 pounds thrust), 2nd—Thiokol TE-M-473 Sandhawk (24,500 pounds thrust); 13-inch diameter; length 87.4 feet; 200-pound gross payload to 263 miles altitude; Mach 8.9; Atomic Energy Commission.

DUAL HAWK

Two-stage solid propulsion sounding rocket; 1st—Thiokol TE-M-473 Sandhawk (24,500 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,500 pounds thrust); 9-inch diameter; length 35.7 feet; 135-pound gross payload to 380 miles altitude; Mach 10.9; Atomic Energy Commission.

TALLEY INDUSTRIES, INC.

HOPI CHAFF DART

Single-stage RPI 2.4-5600 HOPI-II solid motor; weight 95 pounds; length 11 feet; 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.

THIOKOL CHEMICAL CORPORATION, ASTRO-MET DIVISION

NIKE-TOMAHAWK

Two-stage solid sounding rocket; 1st—Hercules M-5, M-5E1 or M-88 Nike (48,700 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,500 pounds thrust); weight 1,850 pounds; length 23.83 feet; 80 to 290 pounds, 6¾-12-inch-diameter payloads to altitudes between 95 and 300 miles; NASA, AF, USN, 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 Mark 12 Mod 1 Terrier (17,000 pounds thrust); 2nd—Thiokol TE-473 Sandhawk (24,500 pounds thrust); weight 3,899 pounds; length 41.5 feet; 100-pound payload to 350 miles or 350-pound payload to 225 miles; approximately 500 seconds flight time above 300,000 feet.

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