THE 1966 AEROSPACE YEAR BOOK

FORTY-FOURTH EDITION

AIA

Official Publication of the

AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.

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FOREWORD

by **Karl G. Harr, Jr.**

President, Aerospace Industries Association

The 1966 edition of the *Aerospace Year Book* marks the resumption of publication of the industry's annual history after a three-year lapse.

The industry's technological goals, responsibilities, product lines and outlook have dramatically broadened and expanded in the brief period since the 1962 edition of the *Year Book*. This is reflected in the contents and organizational format.

Coverage of the aerospace industry's product line has doubled, and a Systems Section has been added which includes more than 100 major systems ranging from a fuel cell to a complete ground radar. The Space Section is prominent in the 1966 edition; in the 1962 *Year Book*, space activities were reported as part of the Research and Development Section.

The progress made in the three years since the last *Year Book* was published solidly underscores the momentum and the dynamic nature of the aerospace industry. For example:

• In 1961, Astronaut Alan B. Shepard, Jr. became the first American in space when he made a sub-orbital flight of 15 minutes and 22 seconds in a Mercury capsule. In 1965, Astronauts Frank Borman and James Lovell in a Gemini capsule orbited the earth 206 times in a flight lasting 330 hours and 35 minutes. During their 14-day journey, they achieved a rendezvous in space with another two-man Gemini capsule.

• Ranger I was launched into a low earth orbit in 1961. Rangers 8 and 9 in 1965 together transmitted 12,000 high-quality televised photographs of the moon's surface; Mariner 4, after an eight-month flight, reached the vicinity of Mars and transmitted across 134 million miles the first TV photographs of the Red Planet; and the Early Bird satellite started commercial communications service.

• The largest military transport in development in 1961 could carry 70,000 pounds of cargo across a 3,600-mile range. Contracts were let in 1965 for a logistics transport aircraft which will carry nearly 250,000 pounds across the same range.

• A world speed record for a fighter plane of 1,600 miles per hour was set in 1961. An operational aircraft in 1965 flew at more than 2,000 mph.

• The Atlas (intercontinental ballistic missile) weapons were placed in hardened sites (silos) in 1961. By 1965, these weapons had been supplanted by a third "generation" of ICBMs—the Titan II and the Minuteman II. The Atlas missiles have been completely retired from the USAF missile inventory. New generations of the various "families" of missiles—air-to-air, surface-to-surface, surface-to-air and air-to-surface—were in operational status in 1965. Advanced versions of the submarine-launched Polaris missile were on station in 1965.

• Revenue ton-miles (passengers and cargo) of the U.S. scheduled airlines in 1961 amounted to about 5.4 billion, and the carriers that year showed a net loss of nearly $38 million. In 1965, the airlines flew 9.3 billion ton-miles and earned profits of about $346 million. This was largely due to the operating efficiency and convenience of jet transportation.

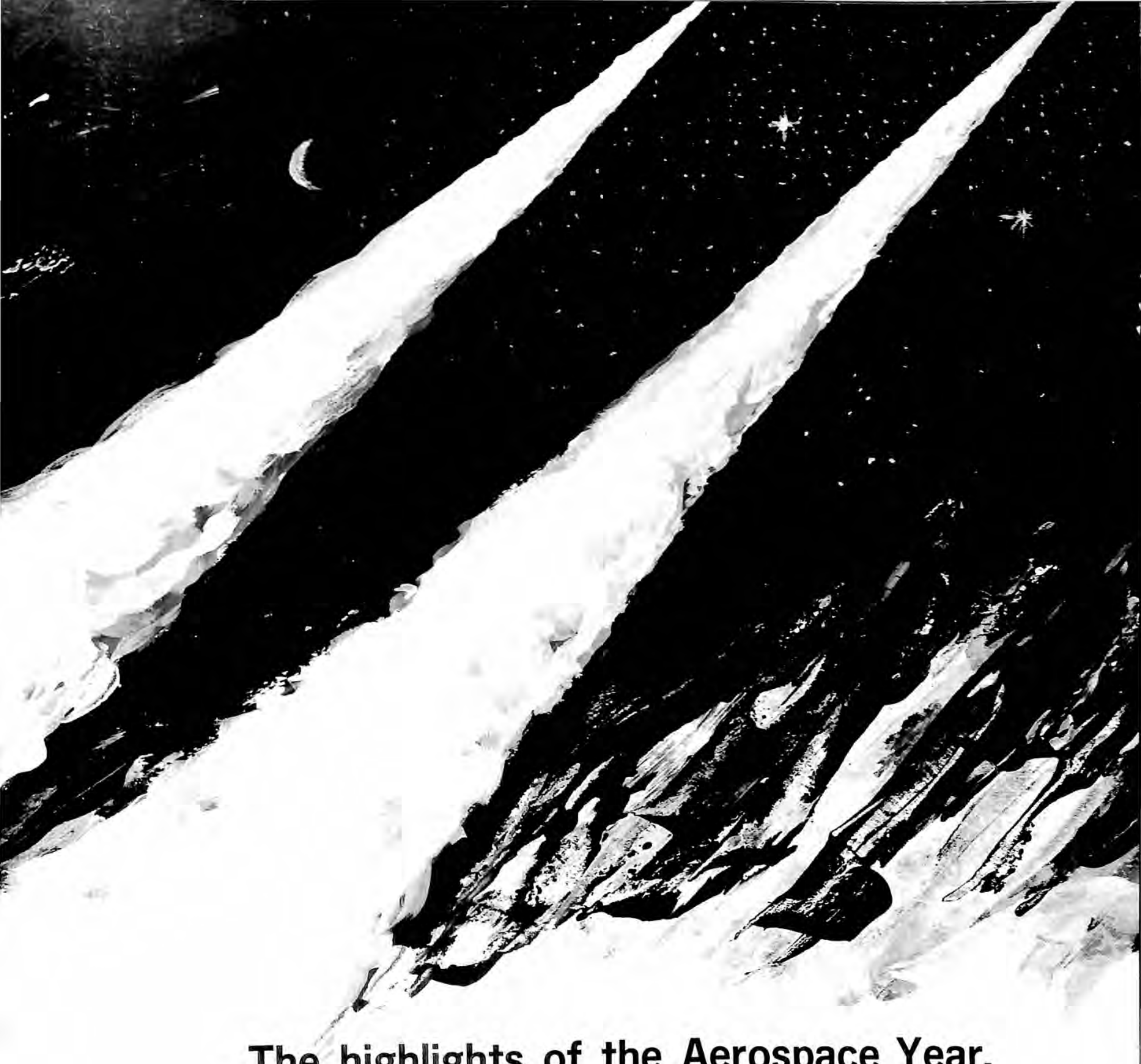
• Production of utility aircraft in 1961 was 6,778 units with a retail value of $165 million. In 1965, 11,852 utility aircraft were produced with a retail value of $422 million. In production during 1965 were seven models of turbojet- and turboprop-powered utility aircraft. There was one model in 1961.

• There were 1,179 helicopters in civil use in the U.S. and Canada in 1961; in 1965, there were 2,053 The number of operators doubled during the same period. In Viet Nam operations in 1965, the Army doubled its fleet of helicopters in six months.

These are only brief highlights of the aerospace industry's gains in the past three years. Comparisons of progress, by any measurement, are nearly endless. In one field—application of aerospace systems analysis techniques to such socio-economic problems as high-speed intra- and inter-city transportation and water and air pollution—a comparison is not possible. In 1965, the realization at national and state government levels of the capabilities of the aerospace industry beyond aviation and space became clearly evident. This is a part of the distinguishing pattern of the aerospace industry's growth through innovation and imagination.

The future, as it should, beckons attractively to the aerospace industry.

AEROSPACE EVENTS of 1965

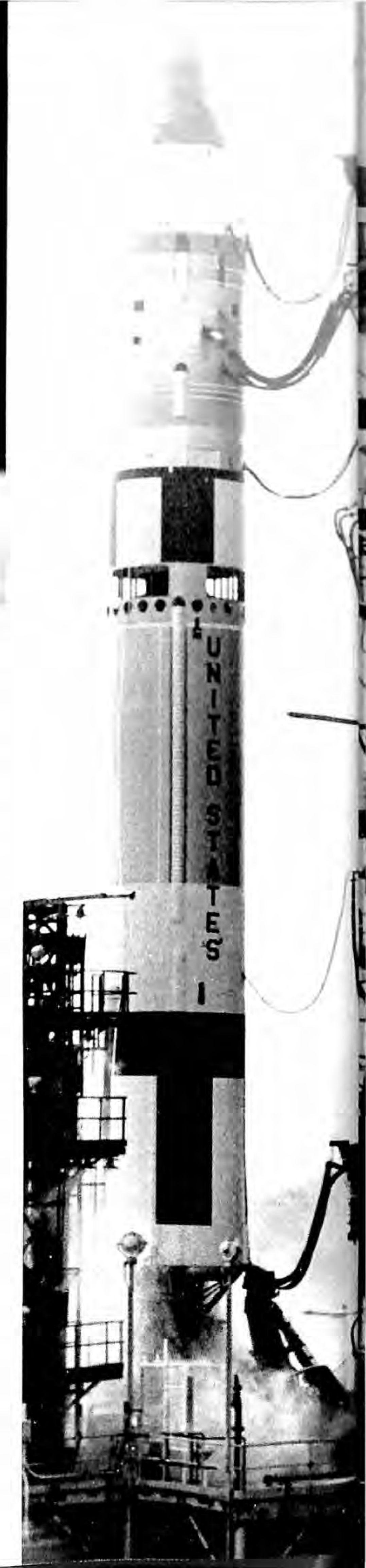


The highlights of the Aerospace Year, including major developments involving Aerospace People and Equipment and the Aircraft, Missiles, Spacecraft, Engines and Systems which passed notable milestones in 1965.

2

GEMINI

The National Aeronautics and Space Administration's manned space flight program moved into high gear in 1965 with 6 highly successful flights, 5 of them carrying manned crews. After the second unmanned checkout flight in January, the first U.S. two-man mission was launched on March 23. Gemini 3, with astronauts Virgil Grissom and John Young aboard, made a 3-orbit flight which included the first manned orbital maneuvers. Launched on June 3, James McDivitt and Edward White flew Gemini 4 for 62 orbits; White made the first extravehicular experiment in history, "flying" outside the spacecraft for 21 minutes. L. Gordon Cooper and Charles Conrad recaptured the space duration record from the USSR with a 190.9 hour flight August 21-29 in Gemini 5. In December came the historic dual Gemini mission. Gemini 7, containing astronauts Frank Borman and James Lovell, was launched on December 4. On December 15, Gemini 6, carrying Walter Schirra and Thomas Stafford, took off from the same pad at Cape Kennedy. A few hours later it "caught up" with Gemini 7 for the world's first space rendezvous. Gemini 6 landed the following day after a 25 hour 52 minute flight. Gemini 7 remained in orbit until December 18, completing a planned 2-week mission. Major contractors contributing to the year's Gemini successes were McDonnell Aircraft (spacecraft), Martin Company (launch vehicle), AiResearch (environmental control), General Electric (fuel cell), IBM (guidance system and computer) and Westinghouse (rendezvous radar). In photos: 1) pre-launch view; 2) the rendezvous; 3) the principals of the Gemini 7/6 mission.



3

Walter Schirra

Thomas Stafford

James Lovell

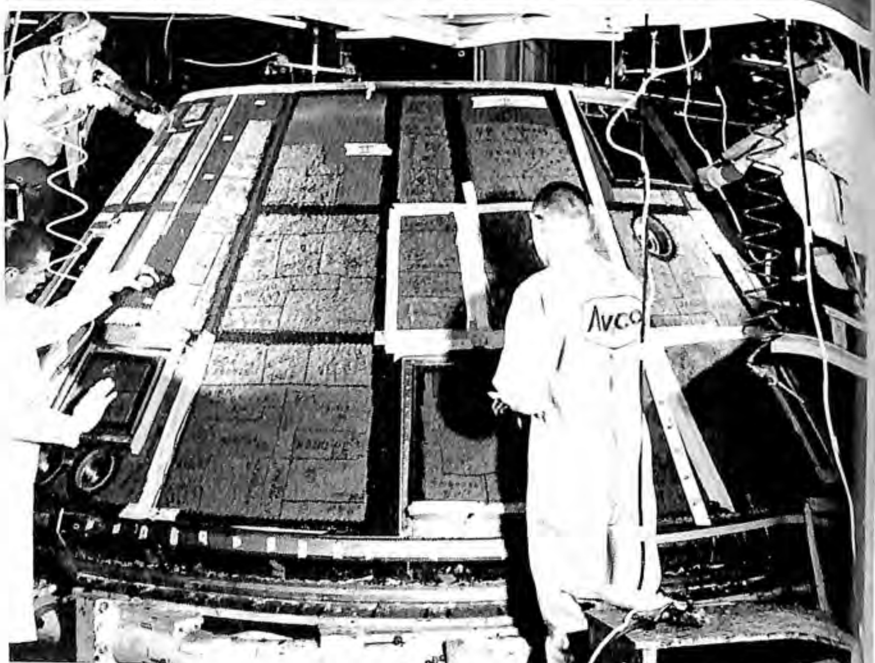
Frank Borman

1

MANNED ORBITING LABORATORY

In August, the Department of Defense gave formal approval to hardware development of the USAF's Manned Orbiting Laboratory, designed to investigate the utility of military man in space. MOL is to consist of a modified Gemini re-entry vehicle together with a 41-foot laboratory canister. The spacecraft will be initially capable of 30-day missions and it will first fly in 1969. Douglas Aircraft was named prime contractor; General Electric was assigned responsibility for integration of on-board experiments and Aerospace Corporation charged with technical management.

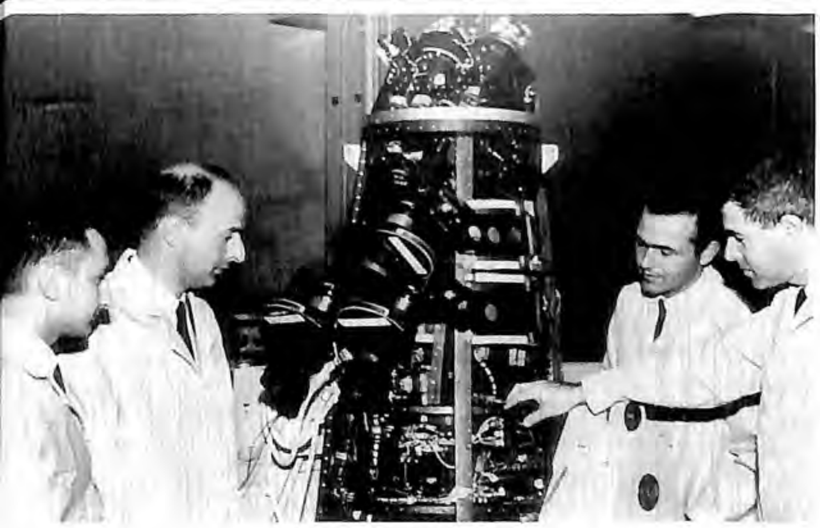
APOLLO



The spacecraft portion of NASA's lunar landing project progressed on schedule during the year. North American Aviation and its subcontractors completed work on the first flight model Apollo, Spacecraft 009, and delivered it to Cape Kennedy. The command and service modules were scheduled for a test flight in February, 1966. In photo, Avco technicians apply plastic ablative material to the crew compartment section of 009.

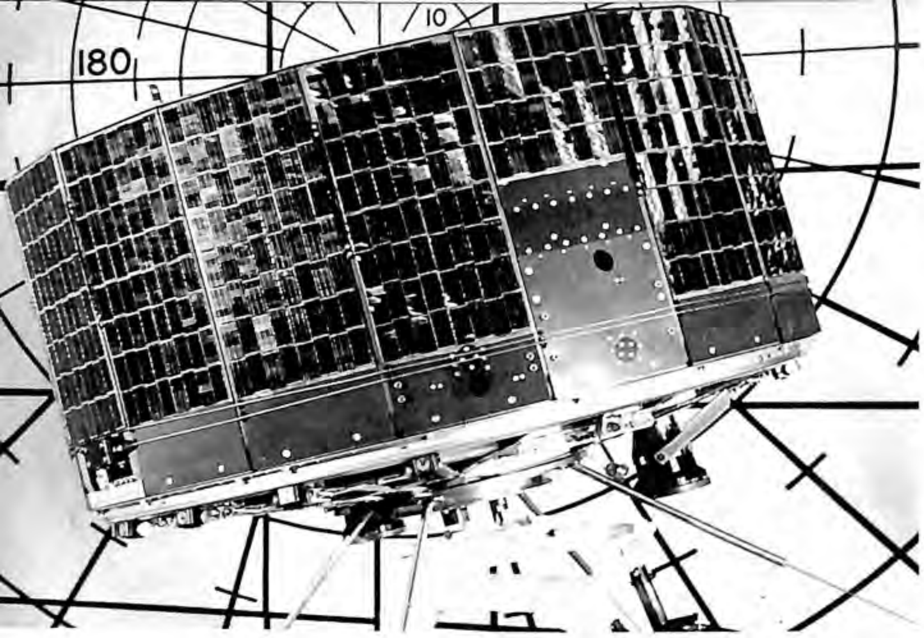
MARINER

The most dramatic unmanned space event of the year took place on July 14, when Mariner IV reached the vicinity of Mars after a 228-day, 325,000,000-mile flight and started sending to earth TV pictures of the Red Planet. Over the next 10 days, Mariner returned 21 photos and part of a 22nd, together with telemetered scientific data on Mars. NASA's prime contractor for the Mariner project, which will continue into 1969, is Jet Propulsion Laboratory.



RANGER

On March 24, Ranger IX impacted the moon within 3 miles of its target spot within the crater Alphonsus, after having sent almost 6,000 close-up photos of earth's satellite. Earlier, on February 17, Ranger VIII had concluded a similar mission which produced more than 7,000 photos. The two 1965 flights concluded the Ranger program which, including 1964's Ranger VII, provided scientists with more than 17,000 valuable pictures. Major Ranger contractors included Jet Propulsion Laboratory (prime), Northrop (support), Hercules Powder (retro-rockets) and RCA (television system). Photo shows assembly of the 6-camera TV system.

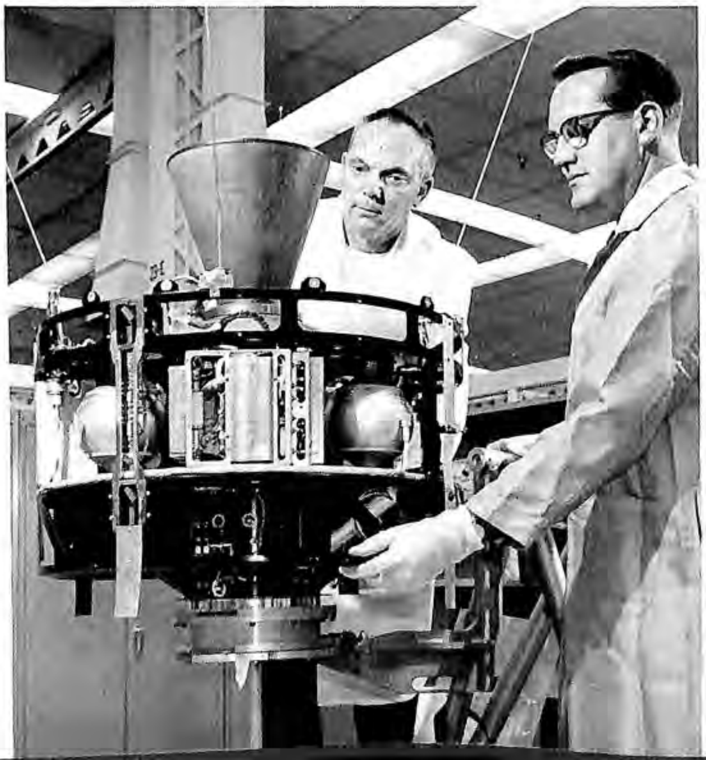


TIROS

Two additional spacecraft of the NASA/Weather Bureau Tiros series of meteorological satellites were launched during the year, Tiros IX on January 22 and Tiros X on July 2. Both were successful, giving Tiros a perfect record through 1965 of 10 successes in 10 attempts. RCA is prime spacecraft contractor for the Tiros project, which will include 4 additional launches for an interim national operational system.

NIMBUS

The second generation weathersat Nimbus I, launched in 1964, continued to transmit data until September 23, 1965, when it quit after more than 13 months' operation. The earth-stabilized, polar-orbiting Nimbus provides greater coverage than Tiros. A second spacecraft was being readied for 1966 launch. Goddard Space Flight Center serves as prime contractor, RCA builds the cameras and General Electric handles integration and testing.

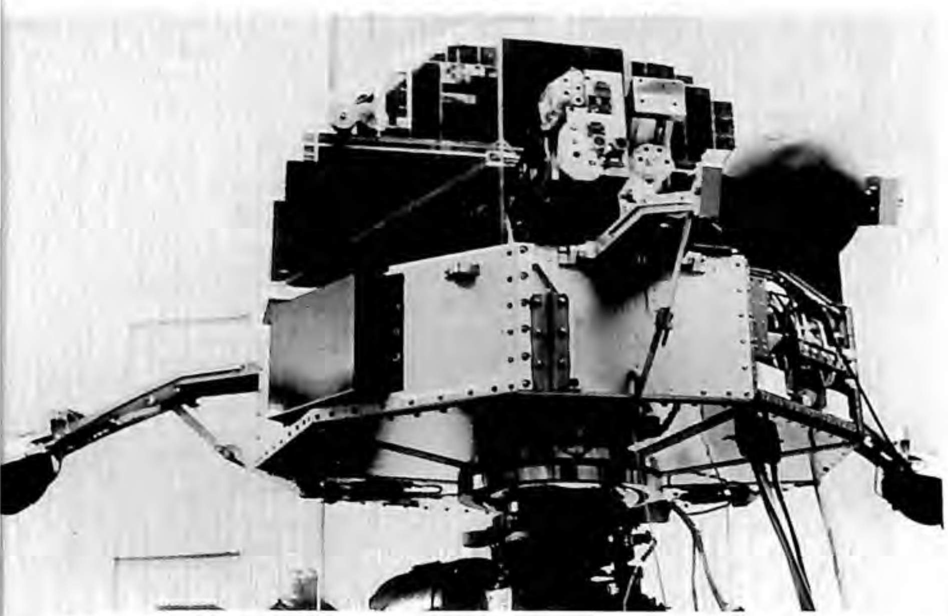


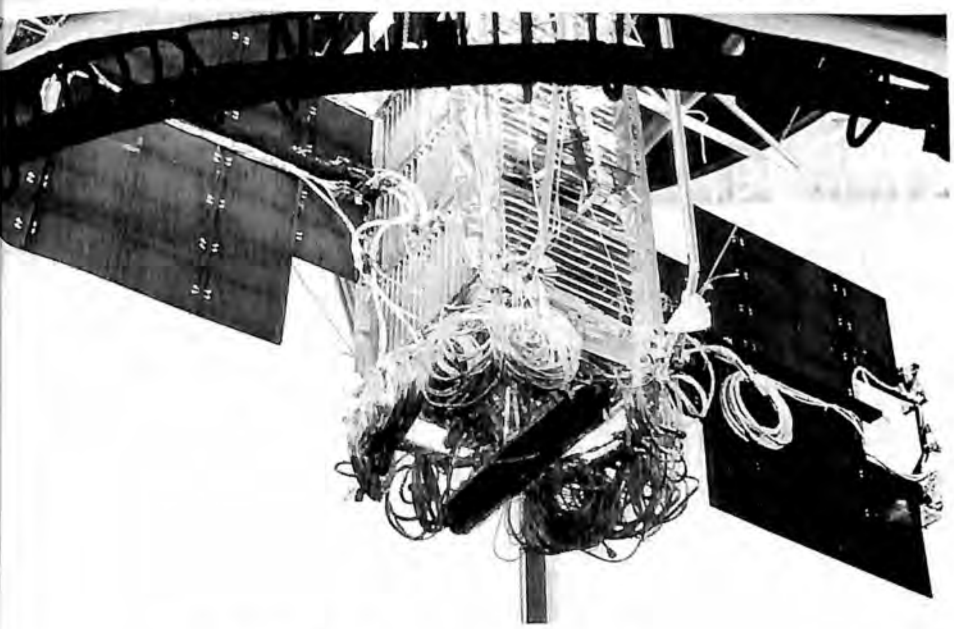
EARLY BIRD

The first commercial communications satellite, Early Bird, was launched April 6 into synchronous orbit over the Atlantic. It continued to transmit between the U.S. and Europe throughout the year. Hughes Aircraft built the spacecraft for Communications Satellite Corporation.

ORBITING SOLAR OBSERVATORY

The second spacecraft of the Orbiting Solar Observatory series was launched successfully on February 27. A third OSO was launched August 25, but it failed to achieve orbit. The fourth in the series of 9 was scheduled for early 1966 launch, Ball Brothers is NASA's prime contractor.





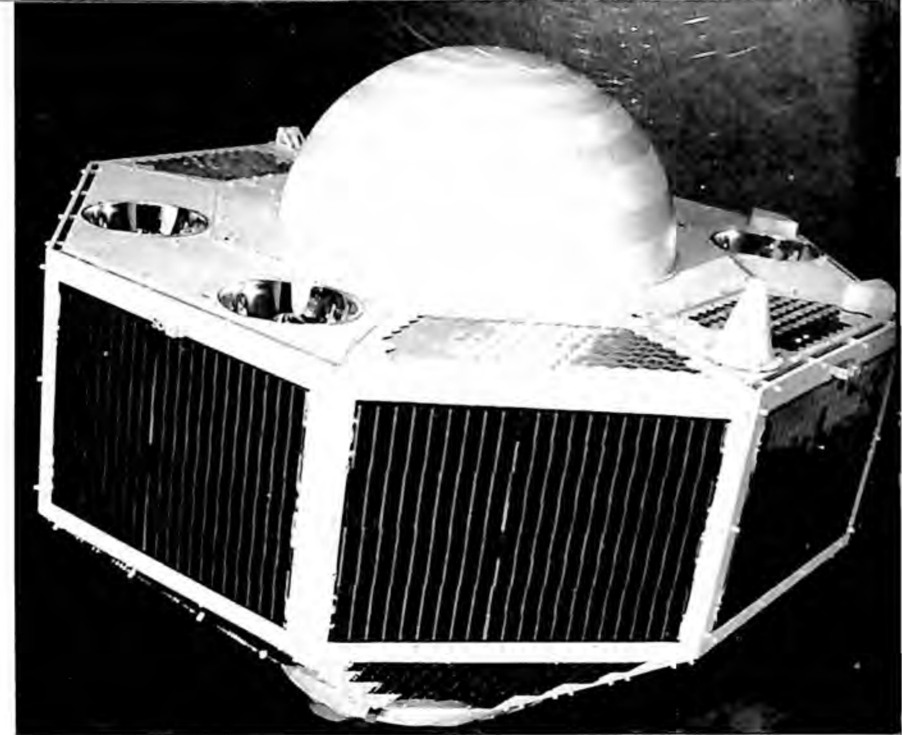
PEGASUS

The large meteoroid detection satellite Pegasus was successfully orbited three times during the year. Launch of Pegasus III on July 30 concluded the program. Fairchild Hiller built the spacecraft.

ORBITING GEOPHYSICAL OBSERVATORY

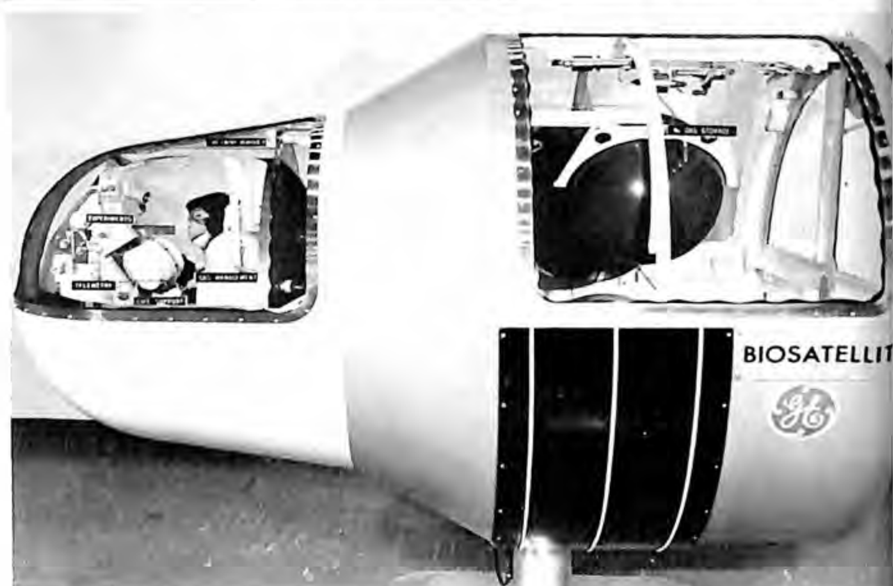
The Orbiting Geophysical Observatory program scored a partial success with OGO II, launched October 14. The spacecraft, designed to investigate a wide variety of scientific areas, transmitted until October 24, when it was silenced by an electrical power failure. TRW Systems is NASA's prime contractor.

GEOS



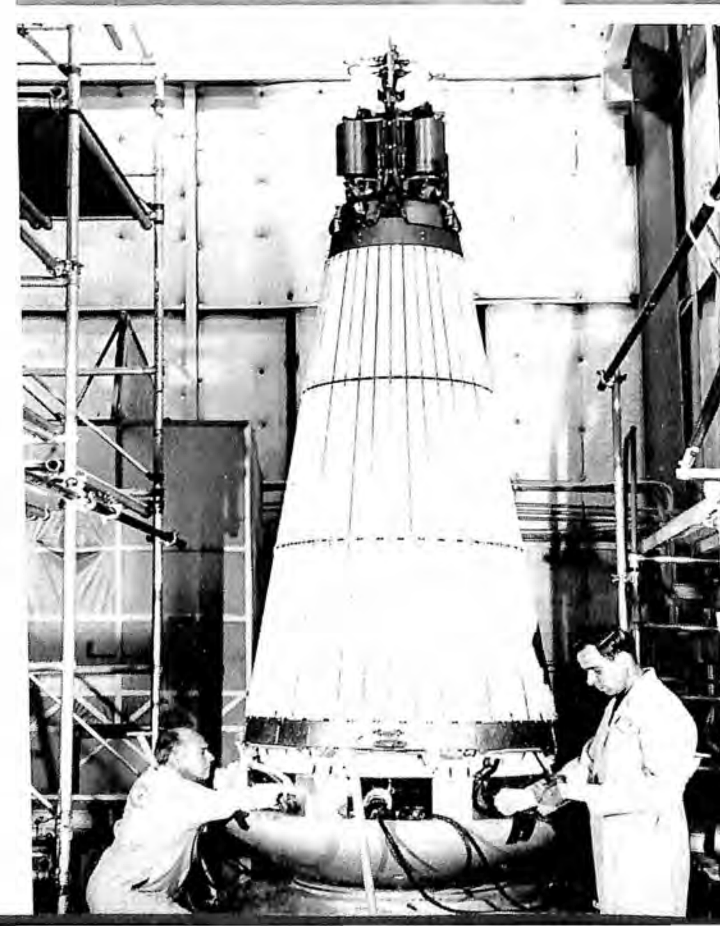
A geodetic satellite equipped with flashing light beacons, electronic beacons, optical and radar reflectors, GEOS I was launched successfully on November 6 into a 700/900 mile orbit. Prime contractor is Johns Hopkins Applied Physics Laboratory.

BIOSATELLITE

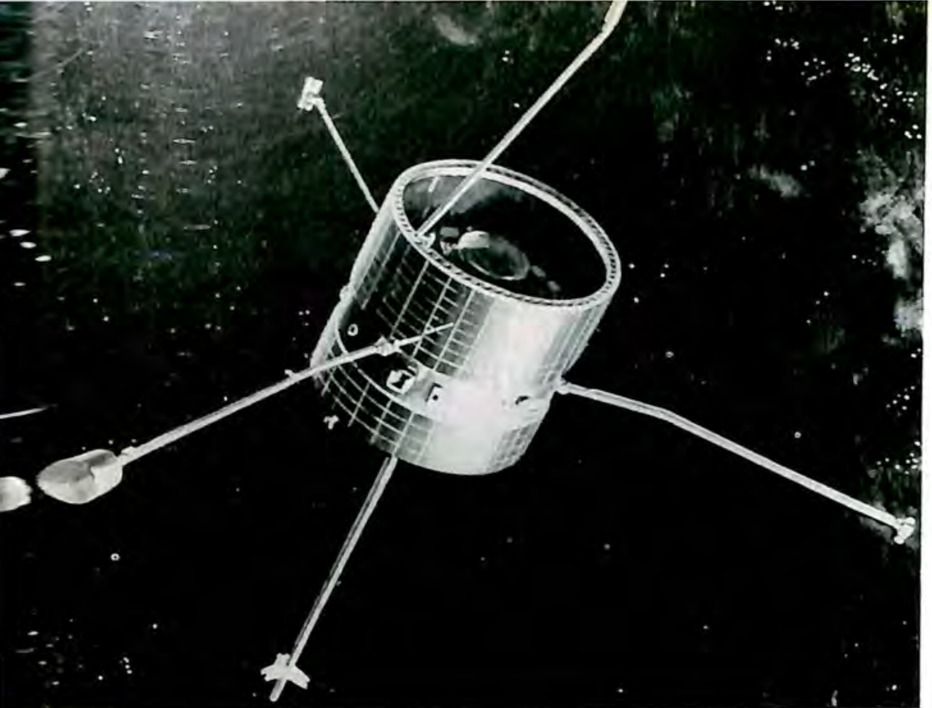


Construction started on a new type spacecraft, the Biosatellite, being developed by General Electric for NASA in a program designed to demonstrate the effects of prolonged space travel on plants, animals and other biological specimens. GE is building six spacecraft, the first scheduled for 1966 launch.

SNAPSHOT

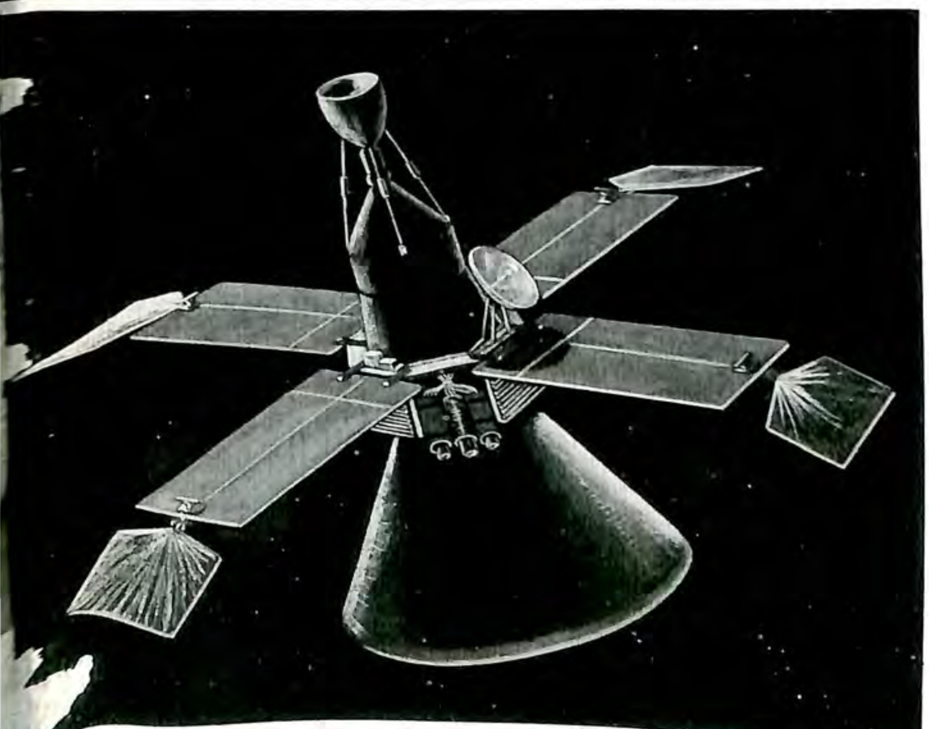


Snapshot, launched April 3, was a joint USAF/Atomic Energy Commission mission designed to test the SNAP-10A space nuclear power unit, built by North American Aviation's Atomics International Division. The reactor operated at more than 500 watts for 43 days. In photo, AI technicians check out the SNAP-10A.



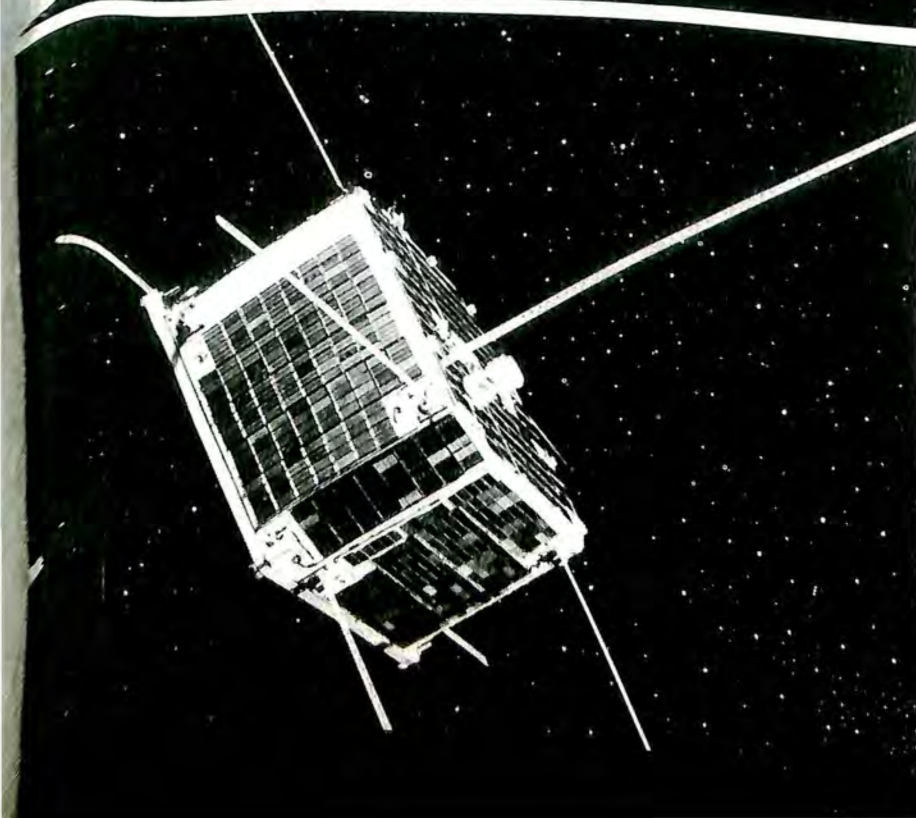
PIONEER

The first of a new series of Pioneer interplanetary probes was successfully launched December 16, carrying five experiments and communications equipment making it possible to transmit to earth from a distance of 90,000,000 miles. TRW Systems built the spacecraft.



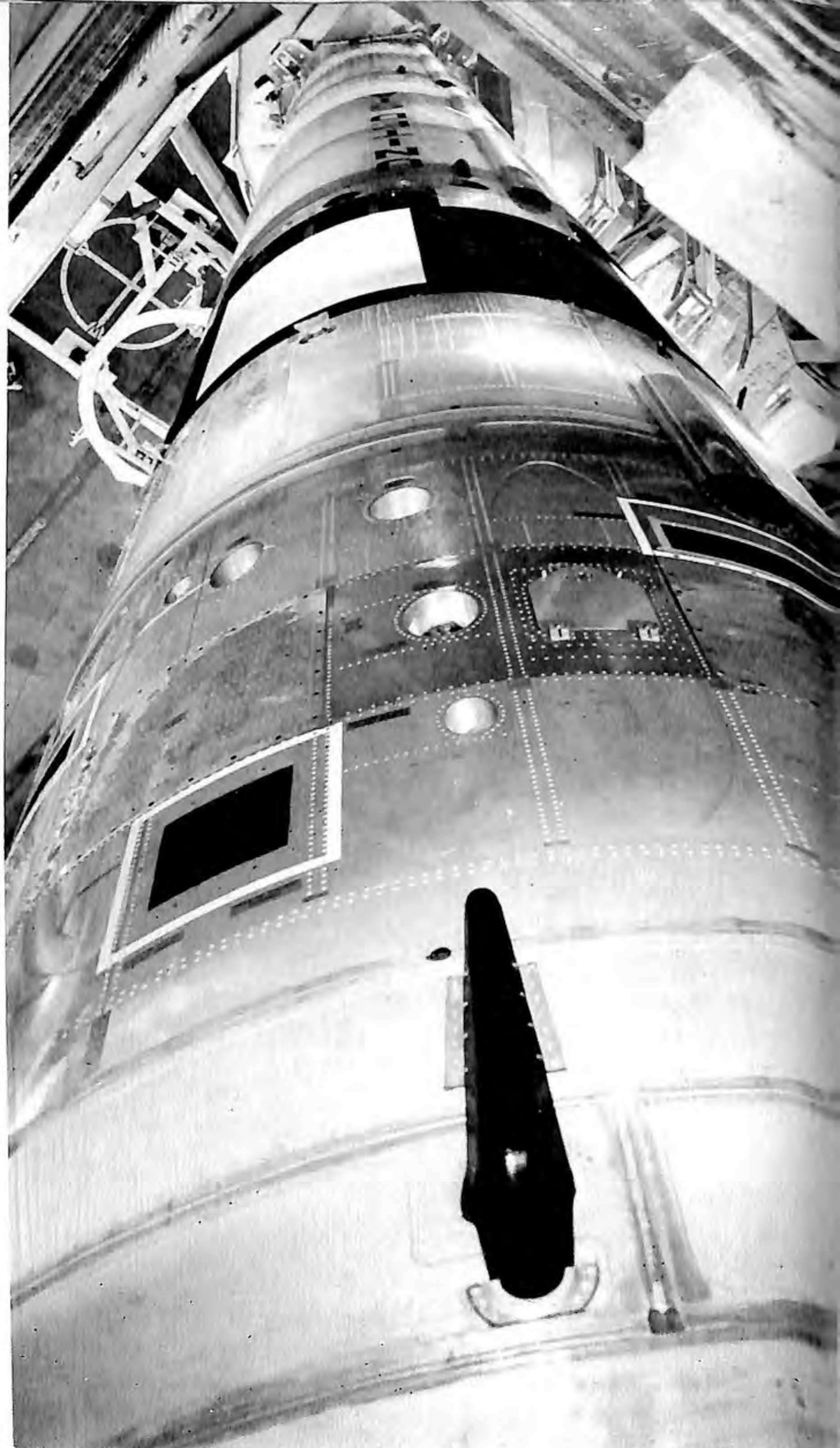
VOYAGER

In 1965, NASA formally initiated the Voyager program, aimed at development of a spacecraft bus capable of orbiting Mars and carrying a landing capsule for investigation of the Martian surface. A follow-on to Mariner, Voyager will first be launched in 1973. Selection of contractors was expected in 1966.



SECOR

An Army satellite built by ITT Federal Laboratories and Cubic Corporation, SECOR is a geodetic satellite employed in a precision earth-mapping program. Fifth of the series was launched on August 10.

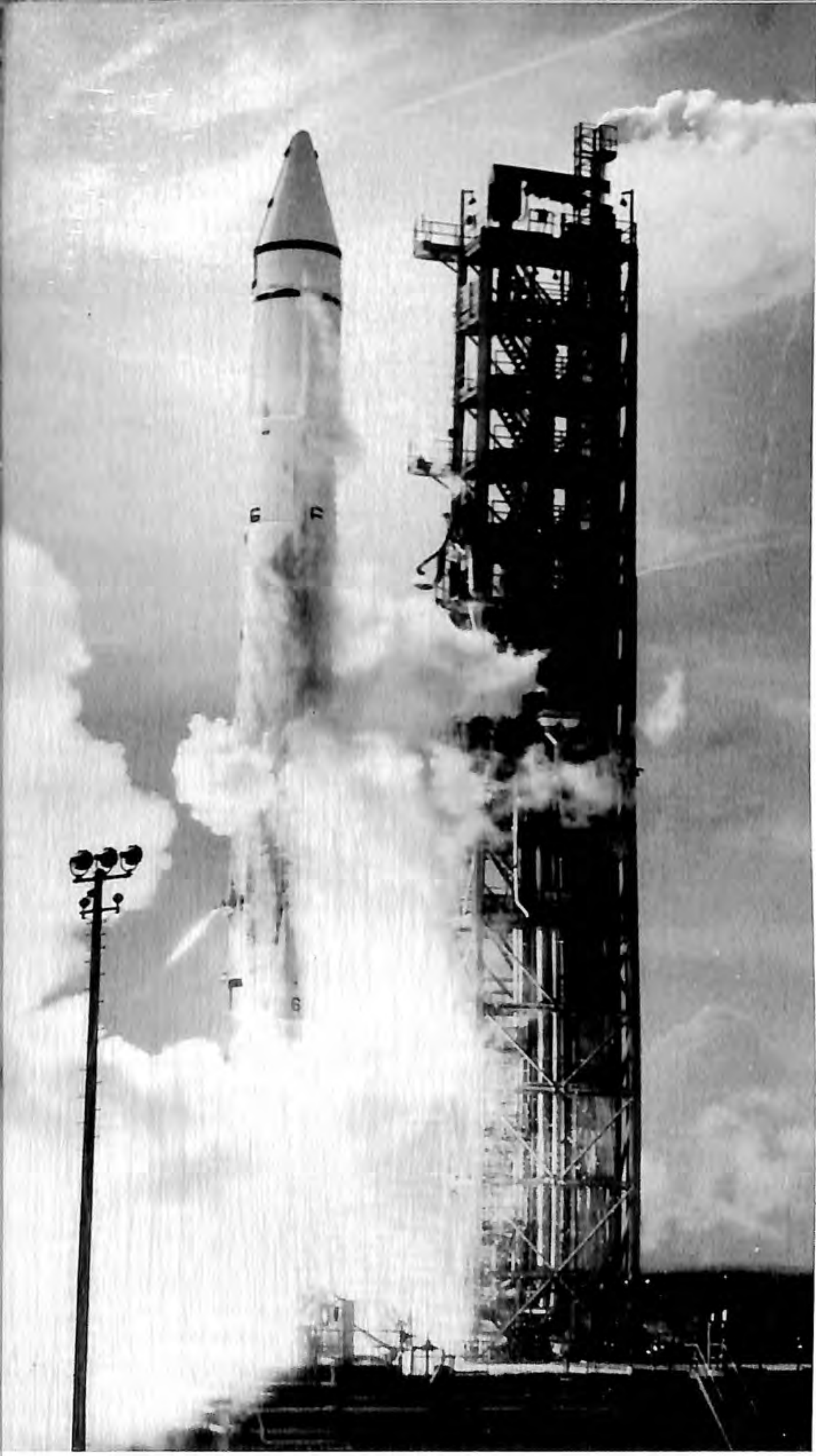


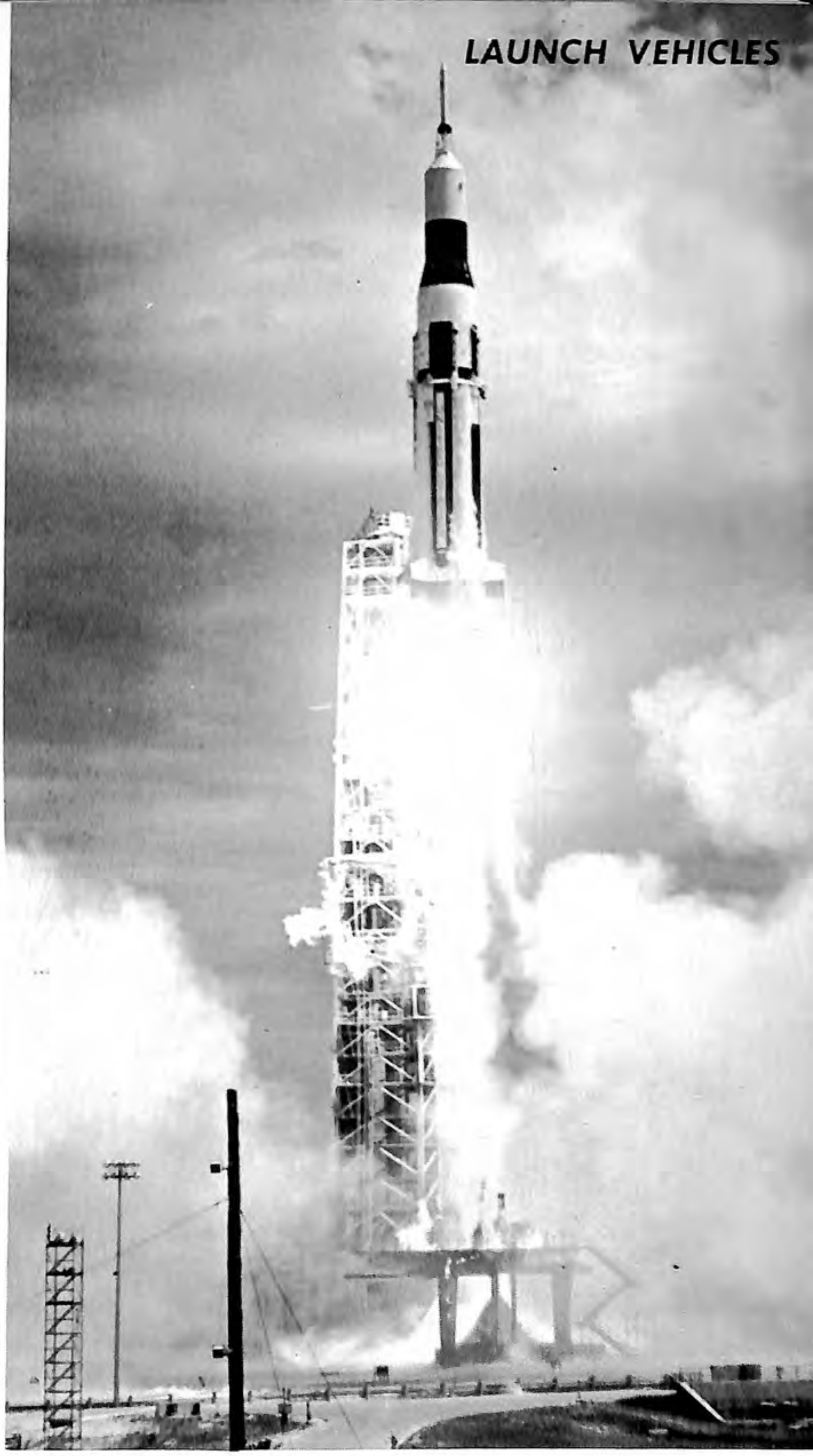
TITAN III-C

Initial flights of the Titan III-C, Air Force heavy duty booster, highlighted the year's military space activity. The launch vehicle made its first flight, completely successful, on June 18. There were two additional flights on October 15 and December 21, successful in the boost stage but with partial failures of the transtage, or topmost stage. Principal contractors are Aerospace Corporation (technical direction), Martin (core, upper stage and systems integration), United Technology (solid boosters) and Aerojet-General (liquid-fuel engines).

TITAN II

The Air Force-developed Titan II had a perfect record in the NASA Gemini program during 1965, with six launches, including the unmanned GT-2 and five manned missions. Martin Company is Titan II prime contractor, Aerospace Corporation provides technical direction. Photo, an unusual view of the booster from the top down.



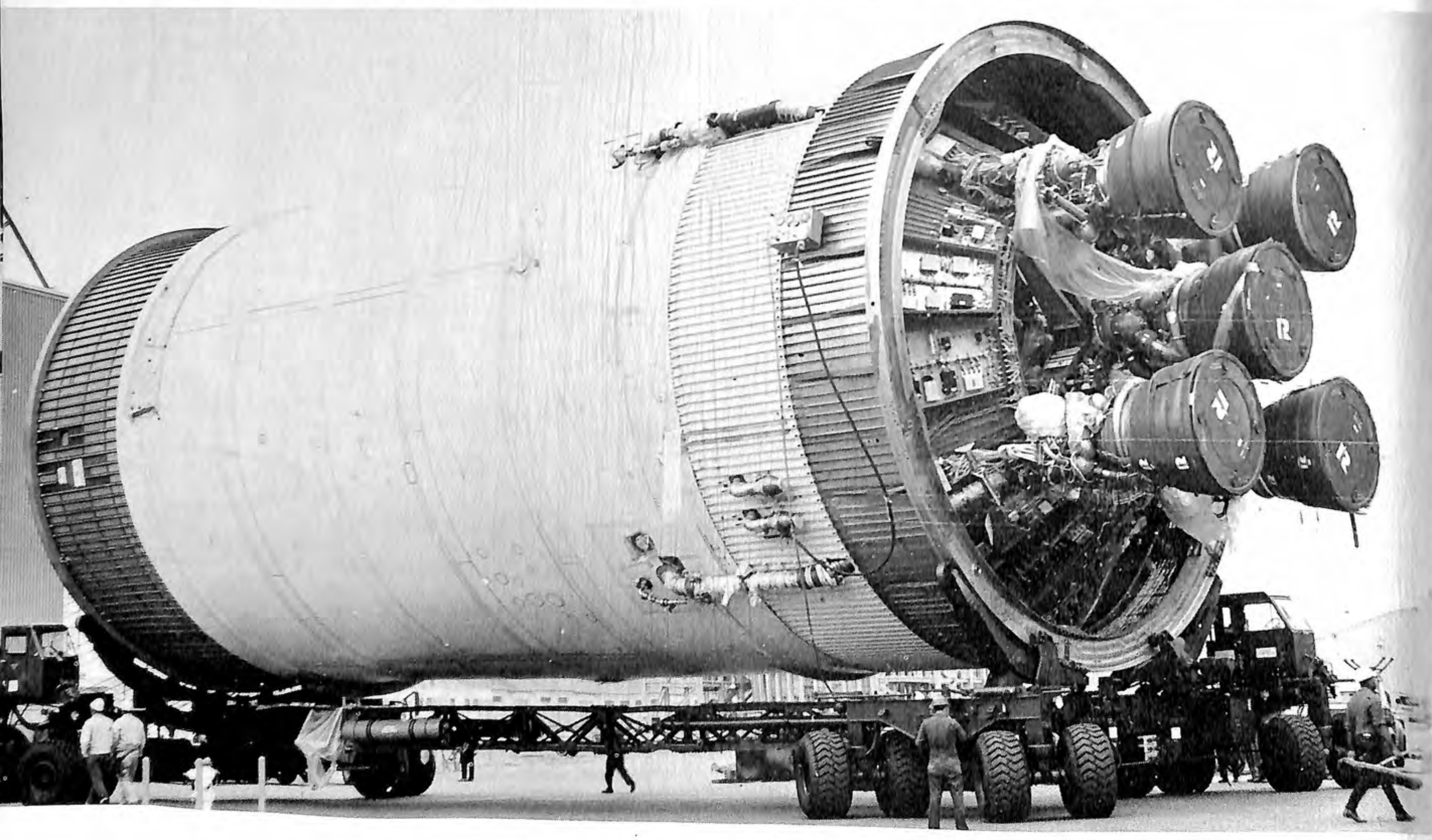


CENTAUR

The Centaur, which consists of an Atlas basic stage and a high energy upper stage composed of 2 liquid hydrogen engines, completed a highly successful flight on August 11 following a failure in March. Seventh test in the series was scheduled for early 1966, and later in 1966 Centaur was to boost the first Surveyor moon flight. General Dynamics/Convair is prime contractor, propulsion is provided by Rocketdyne and Pratt & Whitney and Honeywell builds the guidance system.

SATURN I

One of the most successful of all U.S. space programs concluded on July 30 with the 10th launch of Saturn I and a success score of 10 for 10. On its last three flights, Saturn I carried Pegasus meteoroid detection satellites. Marshall Space Flight Center and Chrysler Corporation built the basic stage, Douglas the upper stage; power systems were supplied by Rocketdyne and Pratt & Whitney. In photo, the last launch.



SATURN IB

Follow-on booster to Saturn I, the Saturn IB was in advanced ground test status during 1965. The vehicle is a 2-stage booster, with 8 engines producing 1,600,000 pounds thrust in the basic stage and a single liquid hydrogen engine providing upper stage thrust of 200,000 pounds (in photo, the S-IVB upper stage in a successful preflight test). First flight booster of the Saturn IB series was delivered to Cape Kennedy late in 1965, where it was being checked out prior to first launch in February, 1966. Chrysler and Douglas built the stages, Rocketdyne provides power plants for both stages.

SATURN V

NASA's moon-booster, Saturn V, was in component test status during 1965, and considerable progress was made toward a targeted first flight in 1967. A notable step was completion and delivery to NASA's Mississippi Test Facility of the S-II, the second of the 3 Saturn V stages. S-II (photo) was slated for static firing test early in 1966. The 1,000,000 pound thrust stage is built by North American's Space and Information Systems Division; Boeing produces the basic 7,500,000 pound thrust S-IC stage, Douglas the topmost S-IVB and Rocketdyne builds the engines for all stages.

MINUTEMAN

By mid-year, the USAF had emplaced 800 Minuteman I ICBM's and was starting the process of replacing them with the more advanced Minuteman II. The latter weapon has far greater accuracy than its predecessor, and it also offers increased range and payload. By the end of 1965, the USAF had completed almost half of the test shots in a 36-flight Minuteman II program, and the new ICBM was expected to be fully operational early in 1966. Late in 1965 the Air Force was authorized to proceed with development of an even more advanced system with a more effective re-entry vehicle, Minuteman III. Contractors in the Minuteman I/II programs include Boeing (prime), TRW Systems (technical direction), Autonetics (guidance), Avco (re-entry vehicle) and Thiokol, Aerojet-General, Hercules Powder (propulsion for the 3 stages).

SRAM (Short Range Attack Missile)

Late in 1965, the Department of Defense authorized the USAF to begin hardware development of the SRAM, a short range air-to-surface "stand off" missile designed for use with the F-111 and B-52 aircraft. No contractors were selected by year-end, but Boeing and Martin were working on studies.

SPRINT

The high-acceleration member of the Army's Nike X antimissile system (Nike Zeus is the complementary weapon), Sprint made its first test flights during 1965, including a silo launch in November. Martin-Orlando is prime contractor, Hercules Power and Lockheed Propulsion Company build the power plants and Bell Telephone Laboratories provides the guidance system.

POSEIDON

The Navy started development of Poseidon, an offshoot of the Polaris family with the same range as the Polaris A-3 (2,500 nautical miles) but with greater payload and accuracy. Lockheed is prime contractor, Hercules Powder and Thiokol will supply propulsion systems.

SAM-D

In 1965, the Department of Defense authorized full development of SAM-D, an advanced surface-to-air missile designed to fill both the battlefield and continental air defense requirement. SAM-D will also have a limited capability against tactical missiles. It will eventually replace Hawk and Nike Hercules. No contractors were named.

CHAPARRAL

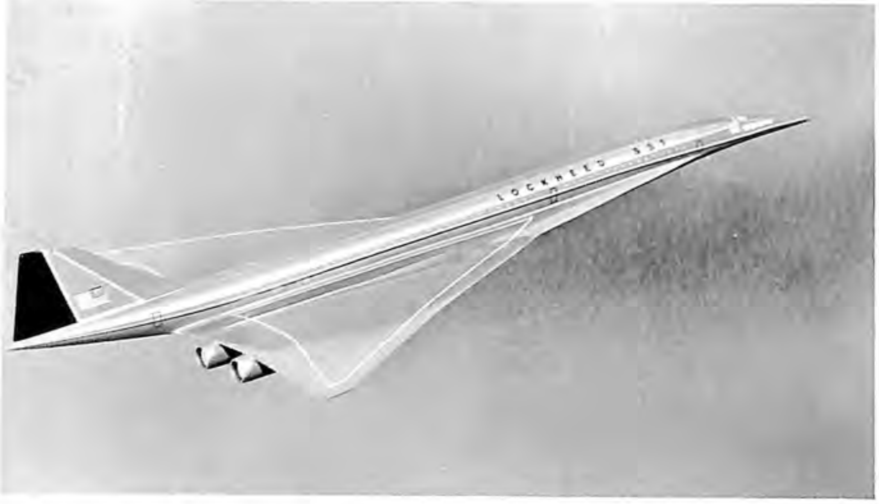
In test status during the year, Chaparral was ordered into production for use by the Army as a forward area air defense weapon. Chaparral is a surface-to-air adaptation of the Navy's air-to-air Sidewinder. Prime contractor is Philco's Aeronutronic Division.

LANCE

A highly successful flight test program in 1965 resulted in a decision by the Department of Defense to procure the Lance missile system in quantity. An Army division support weapon, Lance is designed to replace Honest John and Lacrosse. DoD also provided funding for a Navy investigation of the shipboard utility of the Lance. Prime contractor is LTV Aerospace.

STANDARD

The Navy was authorized to proceed with production of the Standard, a new fleet air defense weapon capable of handling the functions of the Tartar and Terrier in a single system. Standard will be built in 2 versions, a short range (10 nautical miles) system and a 30-mile weapon, the latter equipped with an extra booster. No contractors were announced.



SUPERSONIC TRANSPORTS

In mid-1965, the U. S. program for development of a commercial supersonic transport entered a stepped-up, 18-month design and test phase aimed at certification of an SST by 1974 or earlier. The two airframe competitors are The Boeing Company with a variable sweep wing design (upper left), and the Lockheed Aircraft Corp. design which features a double delta wing (middle left).

LOCKHEED C-5A

In October, the Department of Defense directed the USAF to initiate development of a super transport, the C-5A, which will gross more than 700,000 pounds and have a payload capability up to 220,000 pounds. Development and production contract, awarded to Lockheed, involves some $2 billion for 58 airplanes.

DOUGLAS DC-3

The "Grand Old Lady" of air transportation marked the 30th anniversary of her first flight, which took place December 17, 1935, at Clover Field (now Santa Monica Municipal Airport), California. The DC-3 and its military counterpart, the C-47, were still very active in 1965, even being used as an armed "fighter" in Viet Nam.

DOUGLAS DC-9

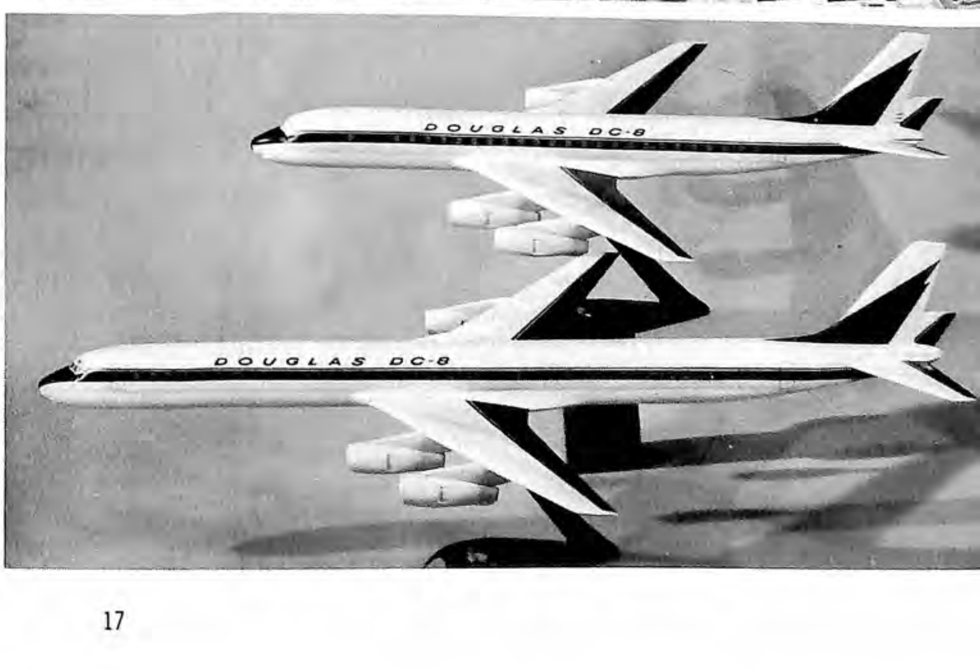
The short-to-medium range Douglas DC-9 made its first flight on February 25 from Long Beach, California, Municipal Airport, remaining aloft for 2 hours and 13 minutes. The plane was in full production at year-end and first commercial service was scheduled for 1966.

BOEING 737

Boeing's new entry in the short range jetliner category is the twin-engine 737. Production go-ahead was given early in 1965.

DOUGLAS DC-8

In April, Douglas announced plans to build three new and greatly advanced versions of the DC-8. First of the new planes is the Model 61, some 37 feet longer than the standard Series 50 DC-8 and capable of carrying 251 passengers in an all-coach configuration. The Model 61 was scheduled for roll-out early in 1966. Model 62, designed as an ultra long-range transport, will have 6 additional feet of wing span and a fuselage extension 80 inches longer than the Series 50. It was scheduled for May, 1966, roll-out. The Model 63 will combine the high density of the 61 and the range of the 62. In photo, model comparison of the Model 61 (foreground) with the Series 50.



GENERAL DYNAMICS F-111

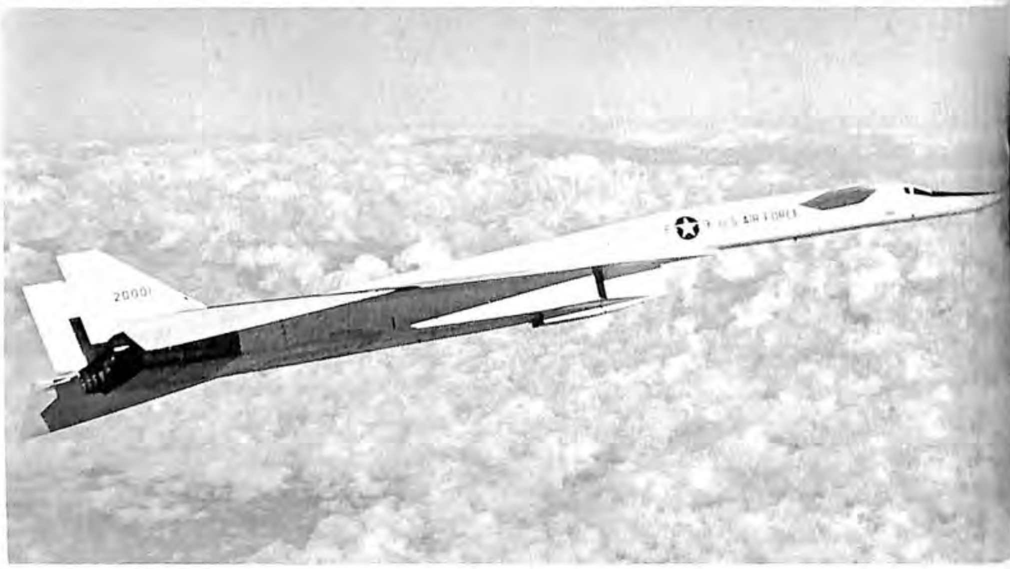
In February, the General Dynamics' Fort Worth Division F-111 demonstrated its wing-sweep capability in flight for the first time and by year-end 6 Air Force F-111A's and 2 Navy F-111B's had logged more than 300 test hours. The plane was in large-scale production for the two U.S. services and the Royal Australian Air Force. Late in the year, the Department of Defense announced plans for a bomber version designated FB-111. In photo, F-111A at full sweep of 72.5 degrees.

LING-TEMCO-VOUGHT A-7A

At the Ling-Temco-Vought facility near Dallas, Texas, the Navy's A-7A Corsair II successfully completed its first flight on September 27. The plane was ordered into quantity production.

NORTH AMERICAN XB-70A

On October 19, the USAF's experimental North American XB-70A bomber exceeded for the first time its design speed of Mach 3 in a flight from Edwards AFB, California.



NORTH AMERICAN OV-10A

The North American OV-10A completed its first test flight at the company's Columbus, Ohio, Division on July 16. A twin-engine turboprop, the OV-10A is specifically designed for counterinsurgency operations. The original contract called for 7 prototypes, to be evaluated by the Air Force, Army, Navy and Marine Corps.

DOUGLAS TA-4E

A new Navy jet trainer, the TA-4E made its first flight on June 30. The plane was adapted from the the A-4E attack craft and, in addition to its primary role as a trainer, it will retain the A-4E's combat capability with bombs, rockets, missiles and guns. First deliveries to the Navy were scheduled for February, 1966.

NORTH AMERICAN T-2B

On May 21, the T-2B Buckeye twin-jet trainer took to the air for the first time. A production aircraft, the T-2B will be used by the Navy in the Basic Training Command.

TURBO COMMANDER

The first Turbo Commander rolled off the line on April 27 and deliveries started in the second half of the year. The executive aircraft is built by Aero Commander.

LEAR JET MODEL 24

In October, Lear Jet announced a new Model 24, sister ship to the Model 23 in production, with a number of improvements, including a 500-pound increase in gross weight.

HILLER HELI-PORTER

Fairchild Hiller placed in production its Heli-Porter, a versatile STOL aircraft seating up to 8 and adaptable to either military or commercial operations.

CESSNA AGWAGON

Cessna's Agwagon, shown here in a test of its "quick dump" valve, first flew on February 19. The agricultural plane was scheduled to go into production in 1966.

BELL JET RANGER

Textron's Bell Helicopter Company completed and was readying for 1966 introduction the five-place turbine powered Jet Ranger, which will have a speed of more than 140 miles per hour.

HILLER 1100

Early in the year, Fairchild Hiller started production of the FH-1100 commercial helicopter. The turbine-powered 4-place craft features ease of maintenance and low cost per flight hour.

SIKORSKY CH-53A

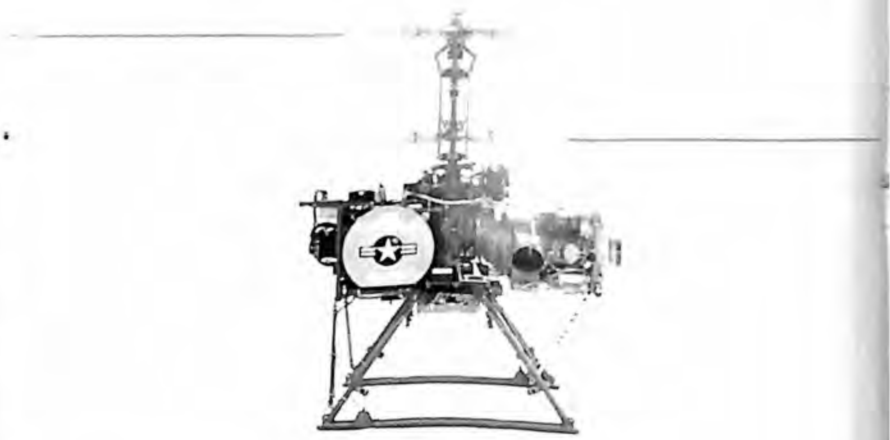
Sikorsky started deliveries to the Marine Corps of its CH-53A assault helicopter. During the year, the 38-troop helicopter was undergoing Navy/Marine evaluation tests.

ENSTROM F-28

A new entry in the helicopter field was the F-28, built by R. J. Enstrom Corporation. Production started in 1965 on the basic 3-place craft, a trainer version and an "executive sedan." A single-place agricultural version was to follow.

PIASECKI PATHFINDER II

The Piasecki 16H-1A Pathfinder II compound helicopter made its first flights in November. The craft features a unique "ring tail" which replaces the conventional helicopter tail rotor.

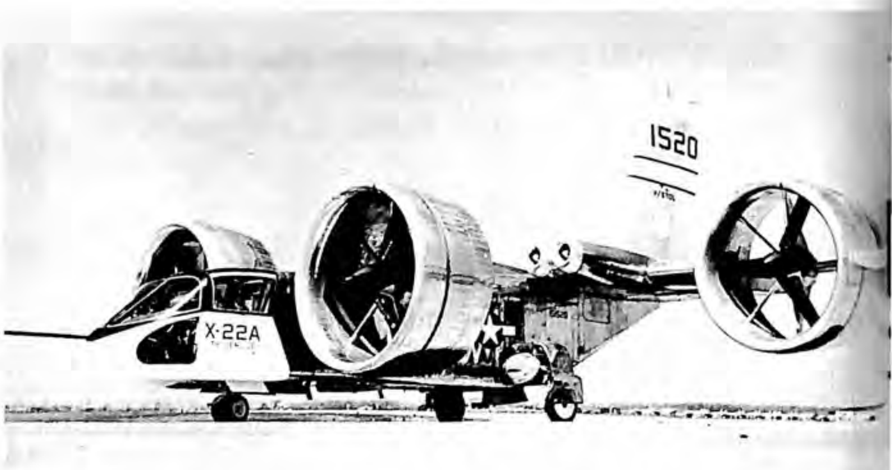


GYRODYNE DASH DRONE

Gyrodyne introduced a new model of its Navy Dash antisubmarine drone helicopter, the QH-50D. It made its initial flight on February 20. The drone was scheduled to replace the fleet's "C" model in 1966.

SIKORSKY SKYCRANE

Sikorsky continued development of the Army YCH-54A Skycrane and flew tests with a detachable van used for hauling cargo and troops. The mammoth helicopter was introduced to combat service in Viet-Nam.



BELL X-22A

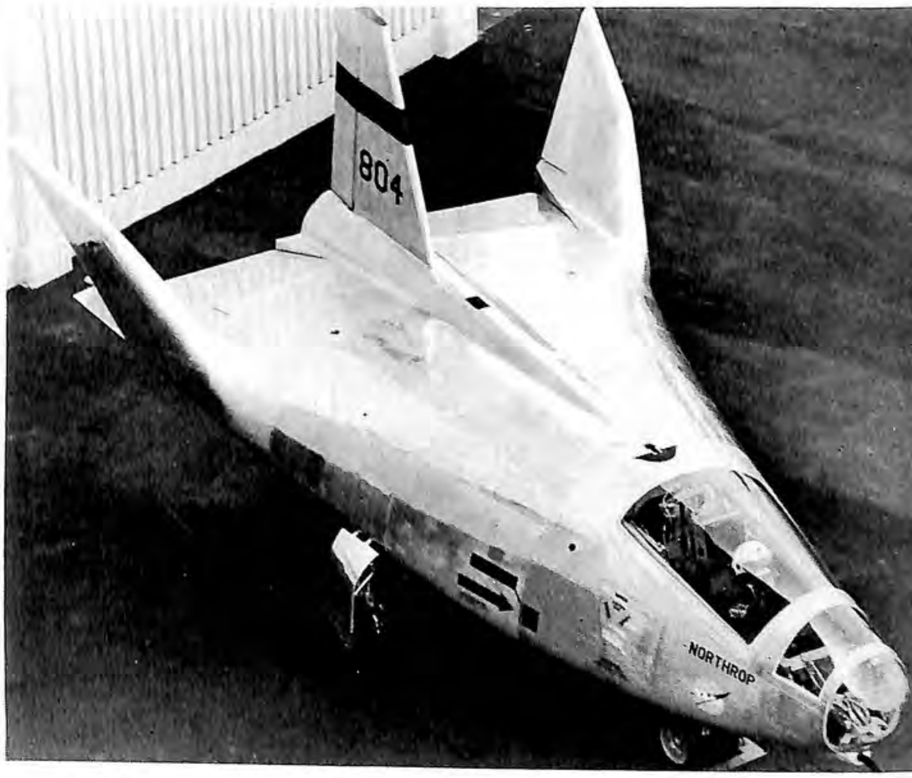
The first of two Bell Aerosystems X-22A rotating ducted-propeller VTOL research aircraft was delivered in May for tri-service evaluation. Flight testing was scheduled to begin in 1966.

NORTH AMERICAN X-15

The 3 X-15's continued to provide data on manned hypersonic flight. During 1965, they completed 32 flights, the greatest number in any calendar year, in studies of boundary layer skin friction and noise, horizontal tail loads, ultraviolet stellar photography, micrometeorite collection, horizon scanners, infrared earth and sky scanners and a reaction control system. Also being studied were various ablative coatings, in an effort to find one suitable for Mach 8 flights planned for 1966.

NORTHROP M2-F2

NASA's M2-F2 lifting body research vehicle, built by Northrop, was delivered in June. Shown here mated to its B-52 carrier, the craft was undergoing ground tests preparatory to 1966 flights.

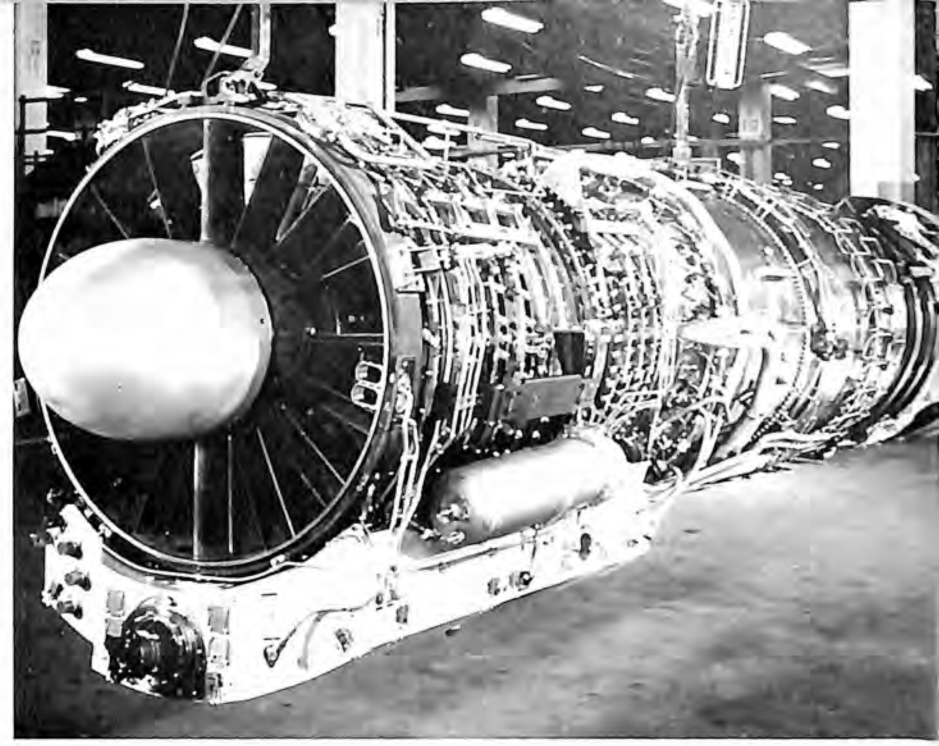


NORTHROP HL-10

Companion craft to the M2-F2, the Northrop-built HL-10 was completed late in the year. Plans called for delivery of the lifting body vehicle early in January and first flights in mid-1966.

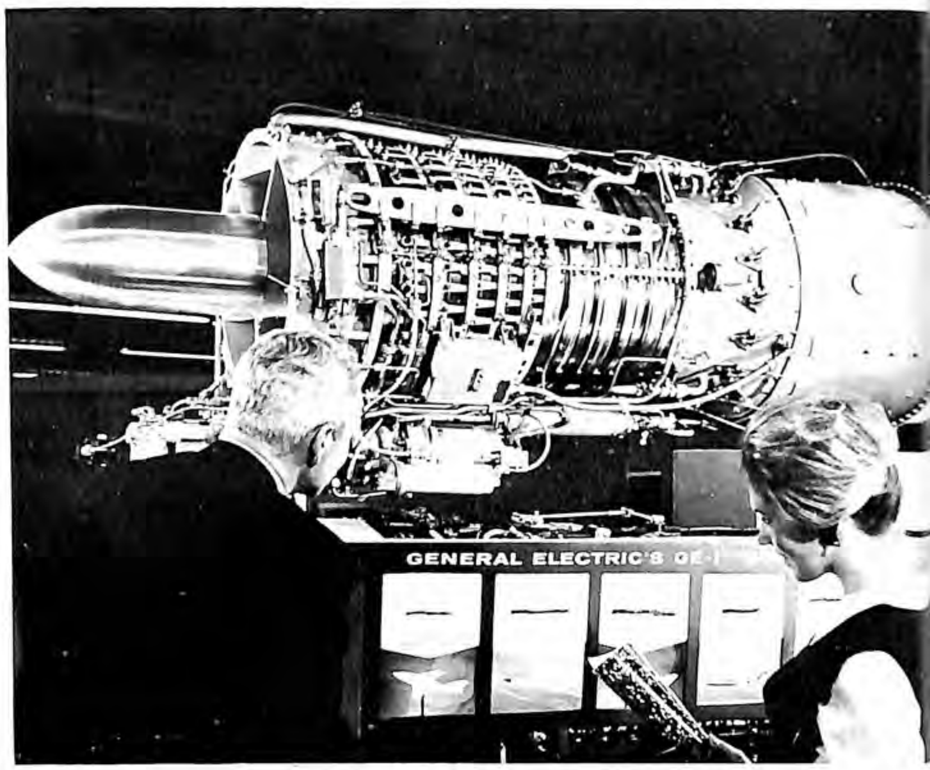
GENERAL ELECTRIC YJ93

General Electric's YJ93 30,000-pound-thrust turbojet powered the XB-70A to a speed of more than 2,000 miles per hour during the year. The huge engine has a thrust to weight ratio of better than 5 to 1.



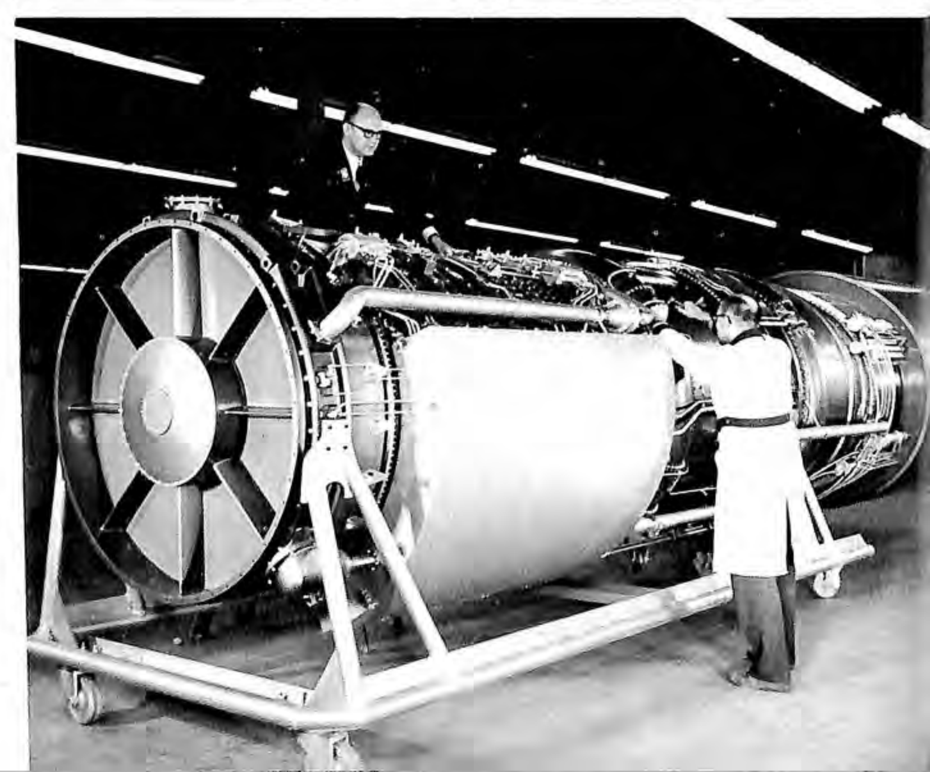
GENERAL ELECTRIC GE1

General Electric unveiled the GE1 turbojet at the 1965 Paris Air Show. The GE1 is a "building block" engine; "add-on" components allow its use for a broad variety of aircraft, cutting down on long development time.



GENERAL ELECTRIC GE4/J5

At Paris, GE displayed its proposed engine for the U.S. commercial supersonic transport. The GE4/J5 is 25 feet long, nearly 6 feet in diameter and produces thrust in the neighborhood of 50,000 pounds.

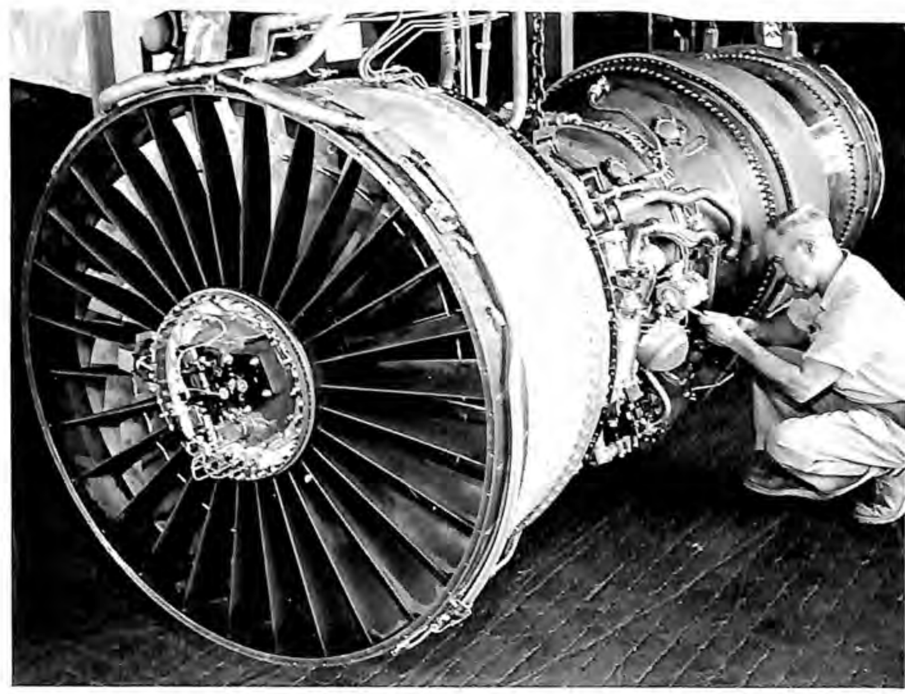


PRATT & WHITNEY AIRCRAFT JT8D

The Pratt & Whitney JT8D first entered service in February, 1964 with the Boeing 727. The engine also powers the Douglas DC-9, the Sud Super Caravelle and will power the new Boeing 737 twin-engine transport.

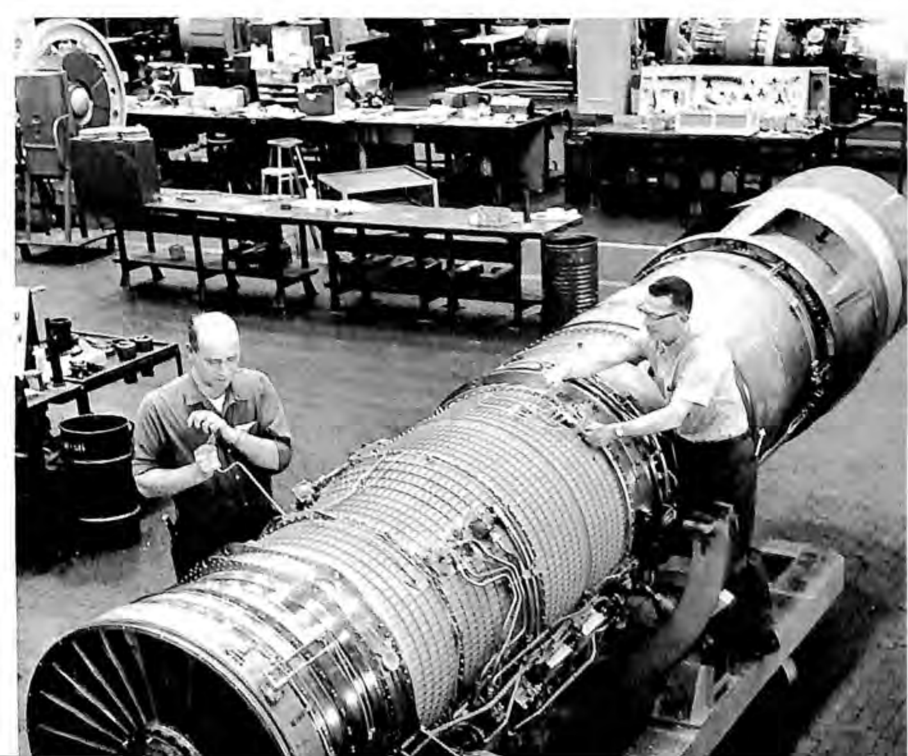
PRATT & WHITNEY AIRCRAFT JT3D

The Pratt & Whitney JT3D turbofan engine entered commercial service in March, 1961. It is the powerplant for the Douglas DC-8, the Boeing 707 and the 720B. The takeoff thrust is 18,000 pounds.



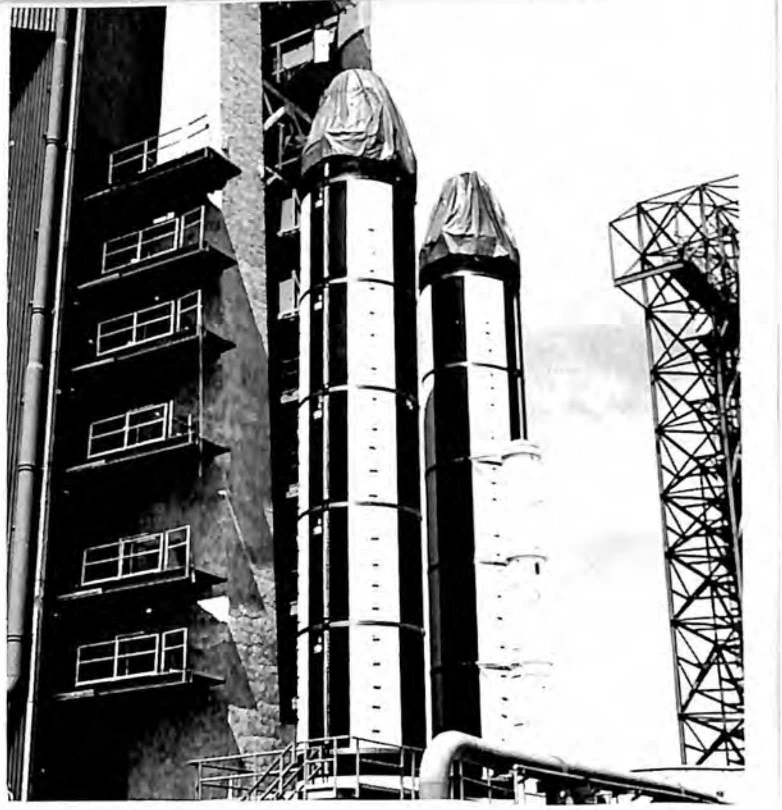
PRATT & WHITNEY AIRCRAFT TF30P-1

The advanced TF30P-1 turbofan, designed and built by Pratt & Whitney Aircraft, completed official ground endurance tests required for its military qualification in July. The engine powers the USAF/Navy F-111.



AEROJET-GENERAL 260-INCH SOLID ROCKET

Smoke cloud climbs thousands of feet into the sky during the September firing of Aerojet-General's 260-inch diameter solid motor. The motor generated 3,500,000 pounds thrust. A second firing was scheduled for early 1966.

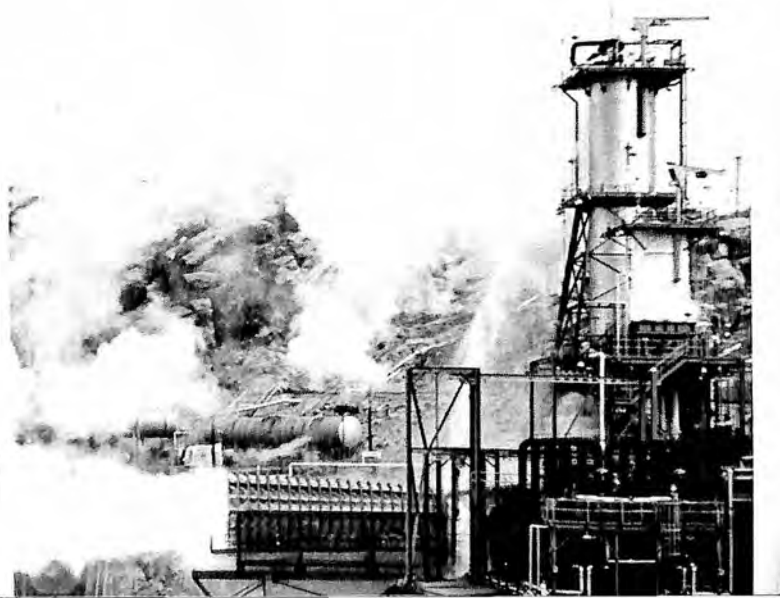


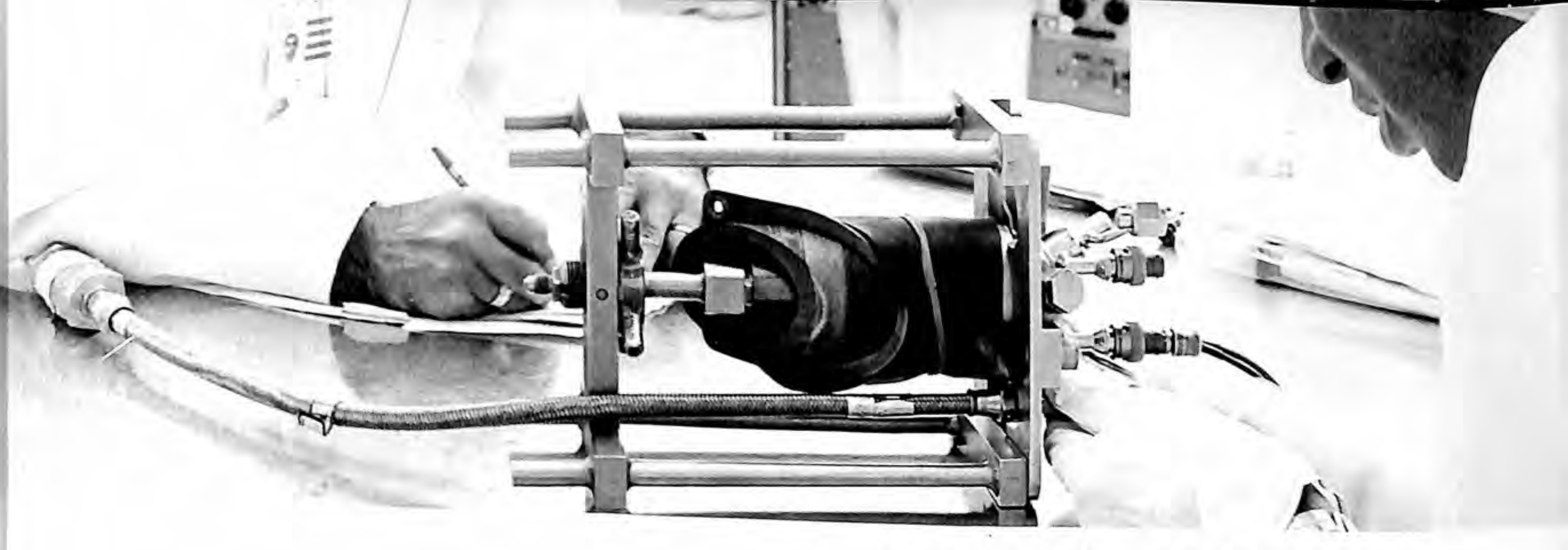
UNITED TECHNOLOGY 120-INCH SOLID ROCKET

United Technology Center's 120-inch diameter solid rocket made its flight debut as auxiliary booster for the Titan III-c launch vehicle. The 75-foot motor produces 1,000,000 pounds thrust.

ROCKETDYNE J-2

At year-end, the Rocketdyne J-2 hydrogen-fueled engine had virtually completed its qualification tests. In some tests, the engine ran 8 times as long as it will be required to on Apollo missions. At the end of the year, the J-2 had amassed more than 100,000 seconds of firing time. In photo, J-2 is tested at simulated altitude of 60,000 feet in a vacuum chamber.



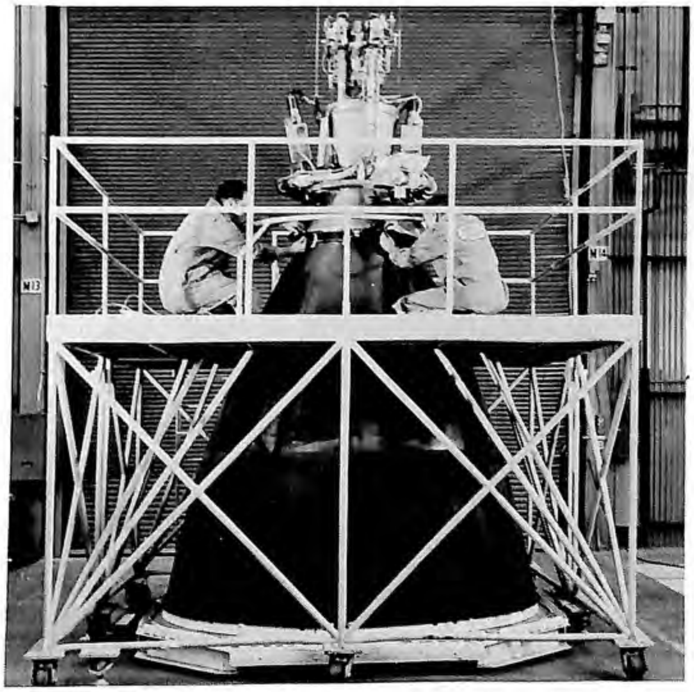


ROCKETDYNE GEMINI THRUSTER

The small Gemini rocket thruster went into service aboard the 5 manned spacecraft launched during the year. In photo, the engine is checked out in a Rocketdyne clean room. Two groups of thrusters provide propulsion to maneuver Gemini.

MARQUARDT CONTROL ENGINE

The Marquardt Corporation delivered the first rocket engines used for attitude and ullage control on the Apollo service module. Fired in micro-second bursts, 16 of the 100-pound-thrust rockets make possible pitch-over and spacecraft flight path maneuvers.

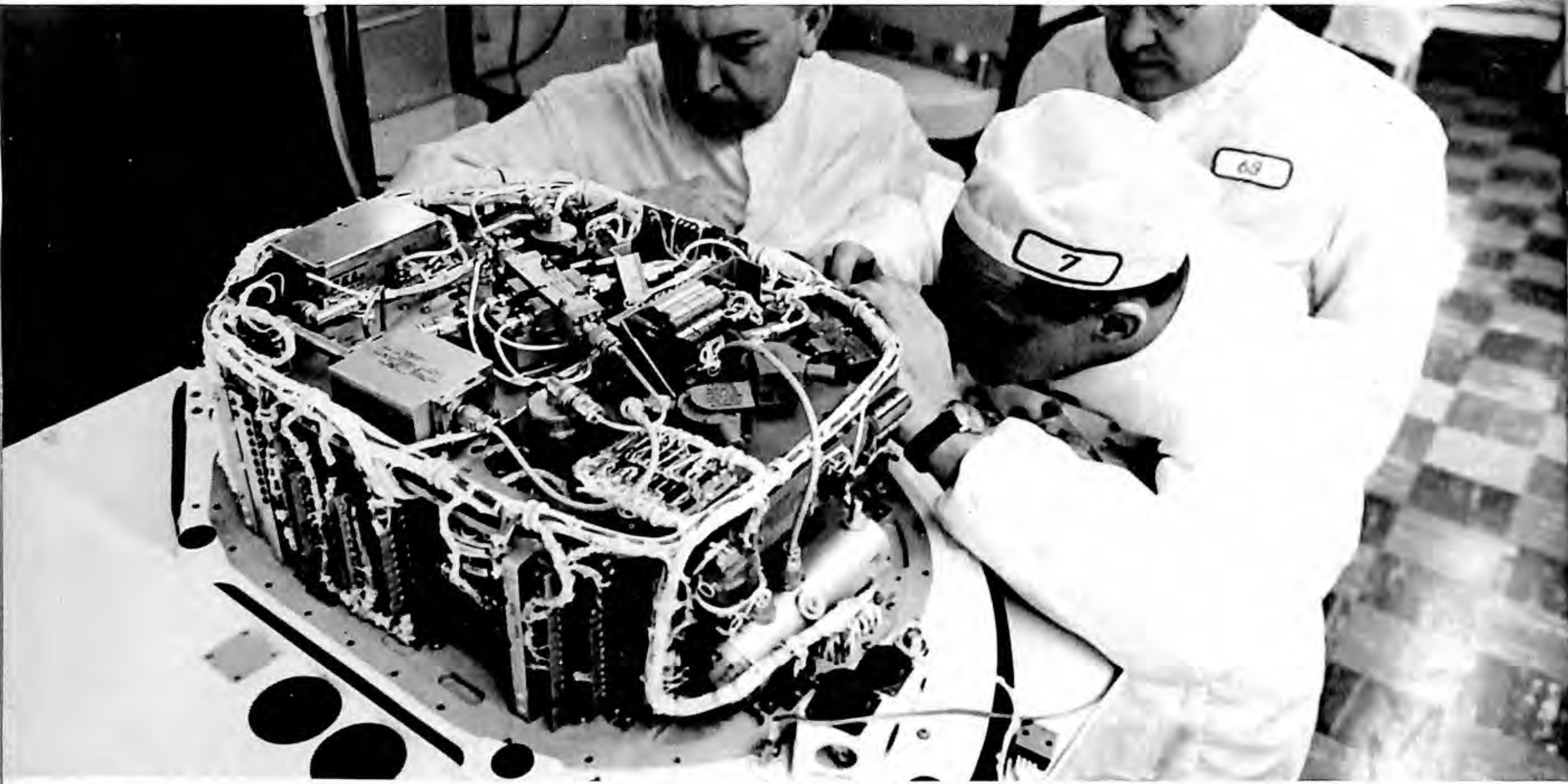


AEROJET-GENERAL APOLLO ENGINE

Aerojet-General delivered the initial Apollo service module propulsion system, to be flight tested early in 1966. The engine develops 21,900 pounds thrust.

SYSTEMS

The term "systems" is used here to cover equipment developed by the aerospace industry other than primary products, like aircraft, missiles and spacecraft. The systems shown here are representative of developments throughout the industry.

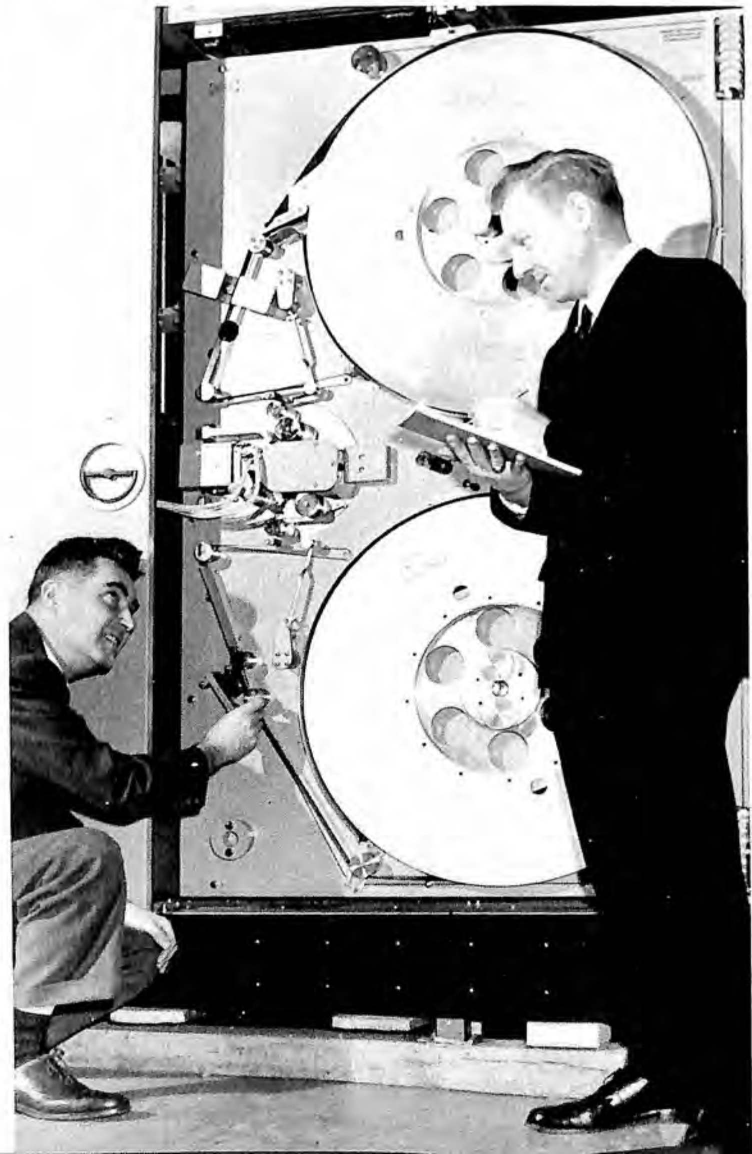


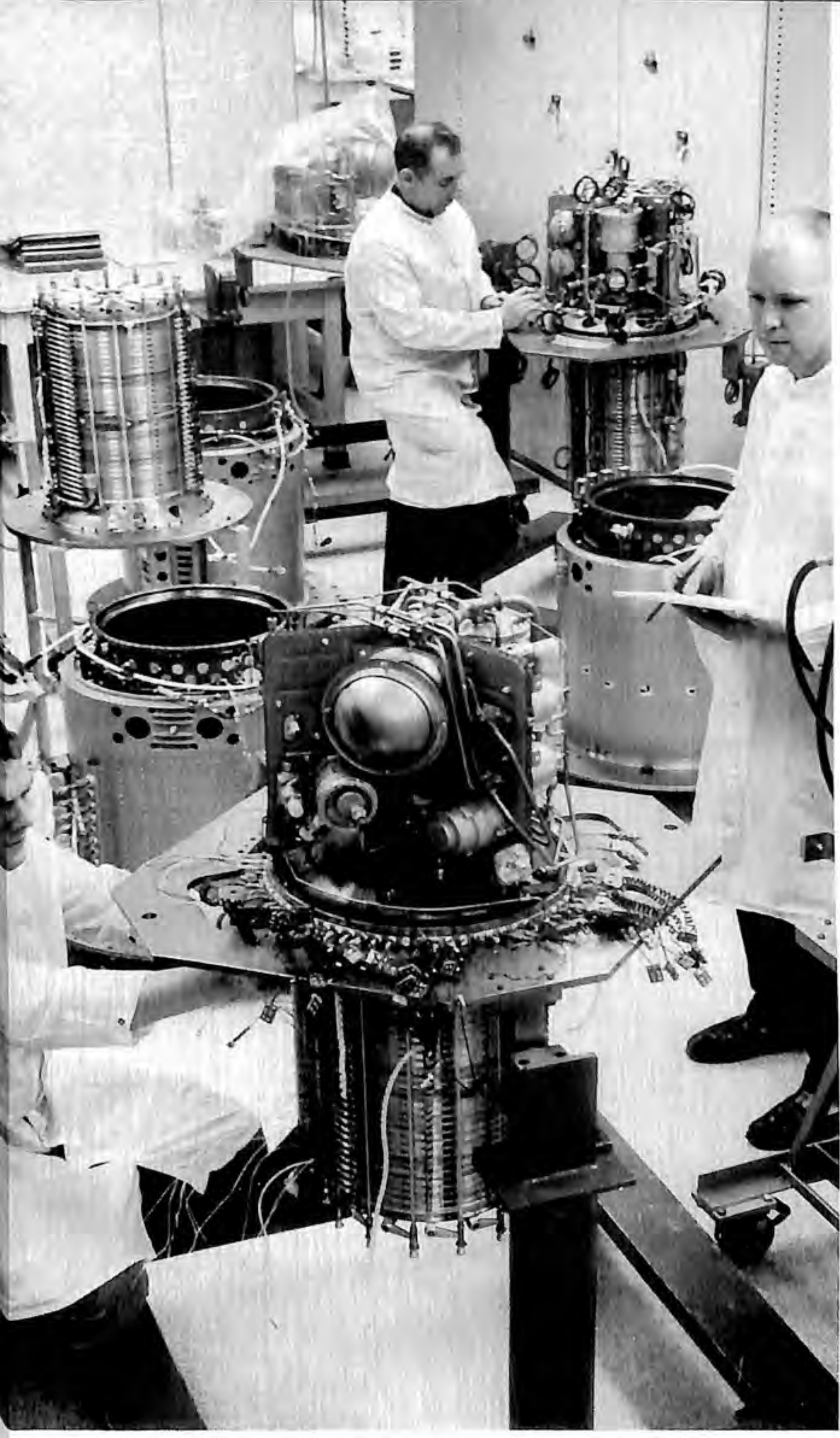
WESTINGHOUSE RENDEZVOUS RADAR

The Westinghouse rendezvous radar figured prominently in the first space rendezvous mission, made by Gemini 7/6 in December. The radar is used to guide astronauts to its target when the rendezvousing spacecraft are about 250 miles apart. The system was scheduled for further test in the 1966 Gemini/Agena series of rendezvous missions.

RCA RECORDER

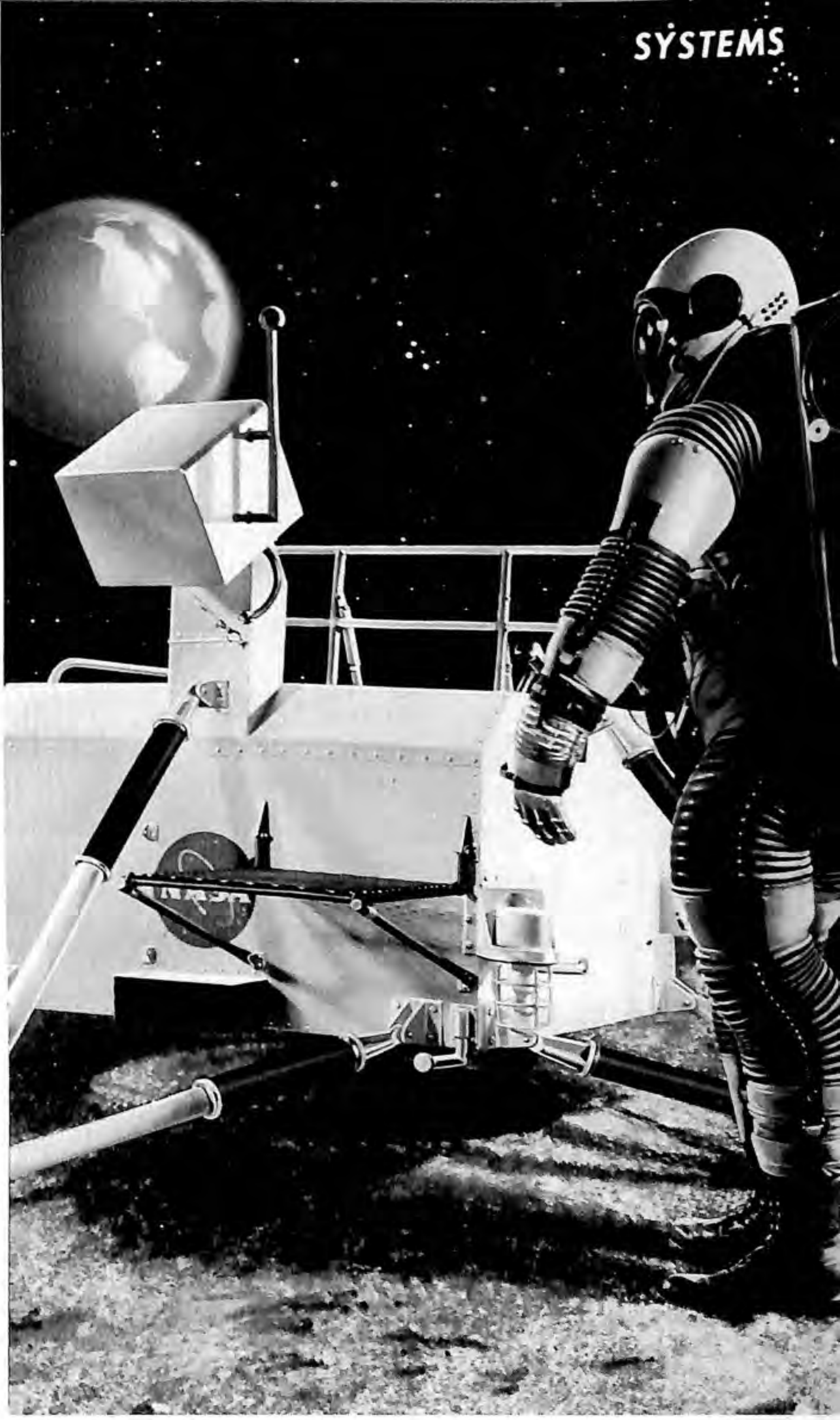
Radio Corporation of America made a March delivery to the Advanced Research Projects Agency of a giant tape recorder to be used by ARPA in its PRESS (Pacific Range Electromagnetic Signature Study) program. The machine will record signals obtained from ballistic missiles. Its huge reels hold 7 miles of tape which hurtles through its guides at a speed of more than 60 miles per hour.





PRATT & WHITNEY FUEL CELL

Pratt & Whitney Aircraft designed and developed a new fuel cell for the Apollo spacecraft. The power plant will supply on-board power and drinking water for three astronauts on a lunar landing mission. Electrical power is produced directly from an electrochemical reaction of hydrogen and oxygen; potable water is a by-product of the reaction. The fuel cell has a range of 563 to 2,295 watts of electrical power and each Apollo spacecraft will have three power plants.

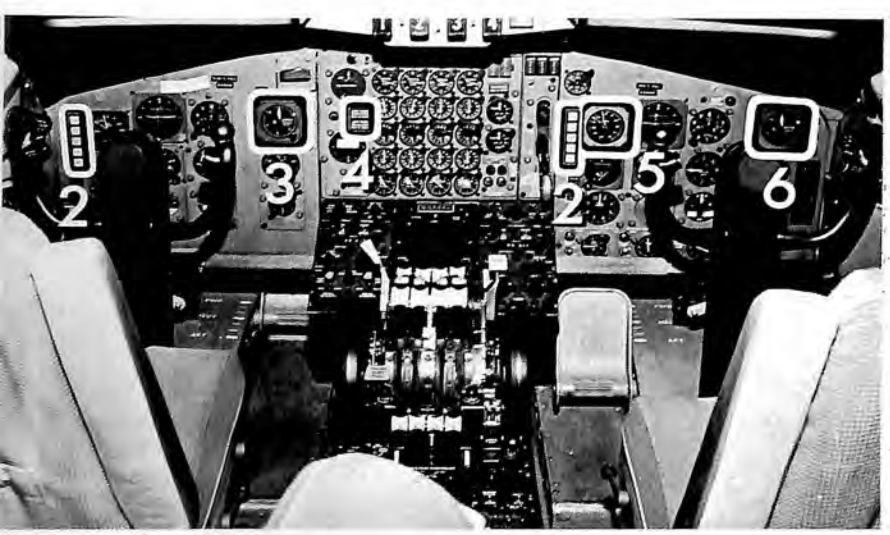


BELL AEROSYSTEMS MFS

Textron's Bell Aerosystems designed for NASA a Manned Flying System in which future astronauts may explore the moon's surface. Shown here in mock-up, the MFS weighs 400 pounds and is powered by a cluster of five 100-pound-thrust rockets at the base of the vehicle. Small reaction control rockets steer the MFS, which has a range of 15 miles. The system is being studied by NASA for possible inclusion in the Apollo Applications program.

USAF PARASAIL

The Air Force Flight Dynamics Laboratory developed a 51-foot diameter parasail parachute for high altitude cargo drops. The parasail can be guided automatically or manually into an impact zone by a guidance and control unit on the parachute which homes on a signal from a ground transmitter.



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

BENDIX LANDING SYSTEM

A major step toward all-weather operation in scheduled air service was Federal Aviation Agency approval for automatic landings with the Precision Approach and Landing System, developed by Eclipse Pioneer Division of The Bendix Corporation. In photo, the PALS installation on a Boeing 720B jetliner.

WESTINGHOUSE OXYGEN MAKER

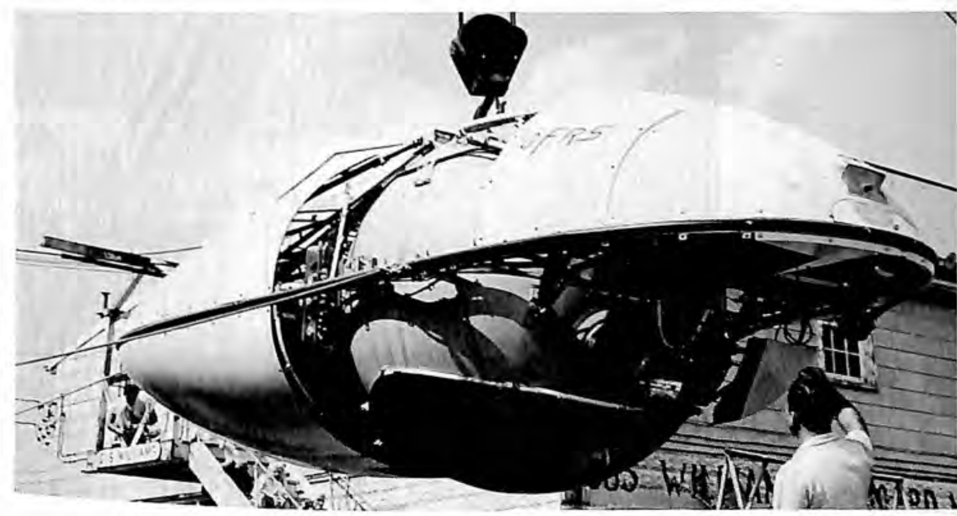
An offshoot of the fuel cell is Westinghouse Research Laboratories' oxygen maker, which can generate pure oxygen from the waste products of breathing. The process involves essentially a reversal of the fuel cell operation, or the use of electrical power to generate oxygen instead of burning it up. The system has utility in long duration space missions.

BELL AIR CUSHION VEHICLE

In line with its program of product diversification, the aerospace industry was active in a number of nonaerospace fields. Typical was Bell Aerosystems' SK-5 Air Cushion Vehicle, which was introduced to scheduled passenger service in August between Oakland and San Francisco International Airports.

AEROJET-GENERAL PROBE

Aerojet-General developed a cryogenic probe, shown here in use by a neurosurgeon in a brain operation. Tip of the probe applies precision controlled freezing temperature to a carefully defined treatment area.



WESTINGHOUSE DEEPSTAR

A submersible designed to dive to 4,000 feet, the 3-man Deepstar-4000 was delivered to Annapolis, Maryland, for test. Assembled in France for the Westinghouse Underseas Division, it was the second in a series of vehicles scheduled for use by the Westinghouse World Wide Charter Facilities that provide complete diving services for scientific, commercial and military applications. Westinghouse plans to develop vehicles with dive capabilities of 20,000 feet.

AIA LEADERSHIP

In November, Karl G. Harr, Jr., (top) was re-elected president of Aerospace Industries Association. J. S. Parker (lower left), vice president and group executive of General Electric Company with responsibility for the Aerospace and Defense Group, was named chairman of the board for 1966. He succeeded J. L. Atwood, president of North American Aviation, Inc.

LOCKHEED YF-12A RECORDS

On May 1, the USAF's Lockheed YF-12A fighter set a series of official world records, including 2,070 miles per hour over a straight course and an absolute sustained altitude of 80,258 feet.

WASHINGTON-NEW YORK RECORD

FAA Administrator General William F. McKee set an unofficial downtown-to-downtown Washington-New York record. Departing from the rooftop heliport of the FAA building, he flew by helicopter to Washington National Airport, by the FAA's JetStar to Kennedy International Airport, then to the rooftop heliport atop the Pan Am building in downtown New York. Total elapsed time was 1 hour 3 minutes. In photo, General McKee (right) in New York Airways helicopter en route to the Pan Am building.

WORLD RECORDS

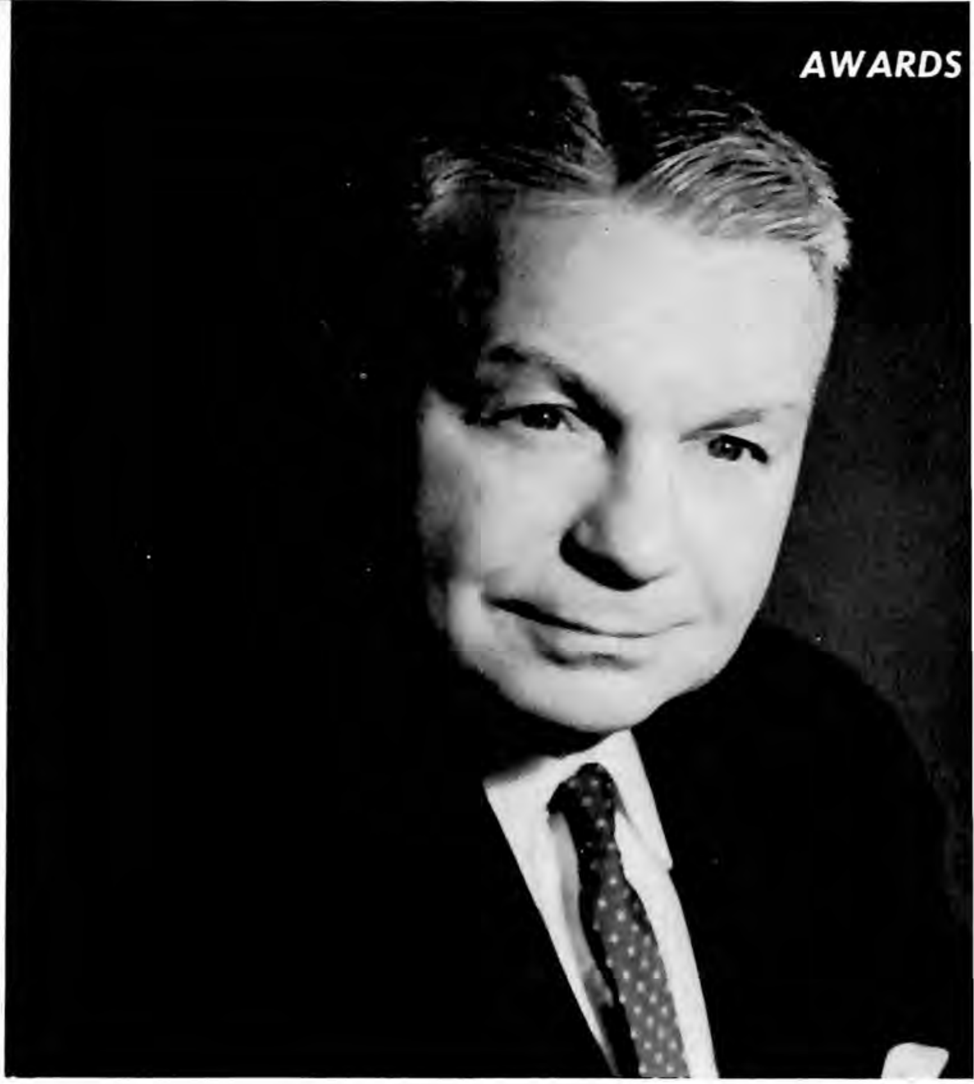
The National Aeronautic Association, which represents the United States in the Federation Aeronautique Internationale, sanctions, certifies and registers all record attempts within the U.S. in order that they be officially recognized by other nations. NAA's Contest Board compiled this list of records completed in the U.S. during 1965.

CLASS	DATE	AIRCRAFT	PILOT	RECORD DESCRIPTION	RECORD
WORLD RECORDS (Absolute)					
MANNED SPACECRAFT					
C*	8/21–29/65	Gemini 5	L. Gordon Cooper Charles Conrad	Duration in Earth orbit	190 hrs., 55 mins., 14 secs.
C*	8/21–29/65	Gemini 5	L. Gordon Cooper Charles Conrad	Distance in Earth orbit	3,312,997 miles
C*	12/4–18/65	Gemini 7	Frank Borman James A. Lovell, Jr.	Duration in Earth orbit	330 hrs., 35 mins., 04 secs.
C*	12/4–18/65	Gemini 7	Frank Borman James A. Lovell, Jr.	Distance in Earth orbit	5,713,977 miles
AIRCRAFT					
–––	5/1/65	Lockheed YF–12A	Col. R. L. Stephens, USAF	Speed over a straight course	2,070.101 MPH
–––	5/1/65	Lockheed YF–12A	Maj. Walter F. Daniel, USAF	Speed over a closed circuit	1,688.880 MPH
–––	5/1/65	Lockheed YF–12A	Col. R. L. Stephens, USAF	Altitude in horizontal flight	80,257.86 ft.
WORLD "CLASS" RECORDS					
K—MANNED SPACECRAFT					
K*	12/15–16/65	Gemini 6	Walter M. Schirra and Thomas P. Stafford—Gemini 6	Duration in group flight	20 hrs., 22 min.
		Gemini 7	Frank Borman and James A. Lovell—Gemini 7		
K*	12/15–16/65	Gemini 6	Walter M. Schirra and Thomas P. Stafford—Gemini 6	Distance in group flight	358,189.4 miles
		Gemini 7	Frank Borman and James A. Lovell—Gemini 7		
JET AIRPLANES (Unrestricted Weight)					
C–1	5/1/65	Lockheed YF–12A	Col. R. L. Stephens, USAF	Altitude in horizontal flight	80,257.86 ft.
C–1	5/1/65	Lockheed YF–12A	Col. R. L. Stephens, USAF	Speed over a 15/25 kilometer course	2,070.101 MPH
C–1	5/1/65	Lockheed YF–12A	Maj. Walter F. Daniel, USAF	Speed in a 500 km. closed circuit	1,643.041 MPH
C–1	5/1/65	Lockheed YF–12A	Maj. Walter F. Daniel, USAF	Speed in a 1000 km. closed circuit	1,689.889 MPH
C–1	5/1/65	Lockheed YF–12A	Maj. Walter F. Daniel, USAF	Speed in a 1000 km. closed circuit with 1000 kilograms payload	1,689.889 MPH
C–1	5/1/65	Lockheed YF–12A	Maj. Walter F. Daniel, USAF	Speed in a 1000 km. closed circuit with 2000 kilograms payload	1,689.889 MPH
C–1*	11/14–17/65	Boeing 707/320C	Jack L. Martin; Fred L. Austin; Harrison Finch; Robert N. Buck; James R. Gannett	Speed around the world	414.43 MPH
				Speed over Recognized Courses:	
C–1*	11/17/65	Boeing 707/320C	Jack L. Martin; Fred L. Austin; Harrison Finch; Robert N. Buck; James R. Gannett	Buenos Aires/Christchurch, N.Z.	430.52 MPH
C–1*	11/17/65	Boeing 707/320C	Jack L. Martin; Fred L. Austin; Harrison Finch; Robert N. Buck; James R. Gannett	Christchurch/Honolulu	538.63 MPH
C–1*	11/15/65	Boeing 707/320C	Jack L. Martin; Fred L. Austin; Harrison Finch; Robert N. Buck; James R. Gannett	Honolulu/London	520.20 MPH
C–1*	11/16/65	Boeing 707/320C	Jack L. Martin; Fred L. Austin; Harrison Finch; Robert N. Buck; James R. Gannett	Lisbon/Buenos Aires	496.08 MPH
C–1*	11/16/65	Boeing 707/320C	Jack L. Martin; Fred L. Austin; Harrison Finch; Robert N. Buck; James R. Gannett	London/Buenos Aires	415.33 MPH
C–1*	11/16/65	Boeing 707/320C	Jack L. Martin; Fred L. Austin; Harrison Finch; Robert N. Buck; James R. Gannett	London/Lisbon	413.92 MPH
C–1*	11/15–17/65	Boeing 707/320C	Jack L. Martin; Fred L. Austin; Harrison Finch; Robert N. Buck; James R. Gannett	North Pole/South Pole	356.72 MPH

* Certification pending.

CLASS	DATE	AIRCRAFT	PILOT	RECORD DESCRIPTION	RECORD
BUSINESS JET AIRPLANES (Light)					
C–1.e (6,614 to 13,227 lbs.)					
C–1.e*	12/14/65	Lear Jet, Model 23	Henry G. Beaird	Time to climb to 12,000 meters	7 mins., 21 secs.
				Speed over Recognized Courses:	
C–1.e	5/21/65	Lear Jet, Model 23	John M. Conroy	Los Angeles/New York	478.47 MPH
C–1.e	5/21/65	Lear Jet, Model 23	John M. Conroy	New York/Los Angeles	428.68 MPH
C–1.e	5/21/65	Lear Jet, Model 23	John M. Conroy	Los Angeles/New York/Los Angeles	424.18 MPH
PISTON ENGINE LIGHT AIRCRAFT					
C–1.b (1,102 to 2,204 lbs.)					
C–1.b	9/28/65	Aero Commander 200	Geraldine L. Mock	Speed in a 500 km. closed circuit	206.73 MPH
C–1.c (2,204 to 3,858 lbs.)					
C–1.c	7/20/65	Cessna 210	Marvin G. Smith	Altitude	35,070.8 ft.
HELICOPTERS (Unrestricted Weight)					
E–1	3/6–7/65	Sikorsky SH–3A	Cdr. J. R. Williford, USN	Distance in a straight line	2,105.49 miles
E–1	4/24/65	Sikorsky CH–54A	Maj. T. J. Clark, USA	Altitude with payload of 1,000 kilograms	29,340.5 ft.
E–1	4/24/65	Sikorsky CH–54A	WO U. V. Brown, USA	Altitude with payload of 2,000 kilograms	28,743.4 ft.
E–1	4/24/65	Sikorsky CH–54A	Maj. T. J. Clark, USA	Altitude with payload of 5,000 kilograms	21,370 ft.
HOT AIR BALLOONS					
AX–3 (400 to 600 cubic meters capacity)					
AX–3	9/3/65		Brenda Bogan	Altitude	9,770 ft.
AX–6 (1,200 to 1,600 cubic meters capacity)					
AX–6	10/5/65		Donald L. Piccard	Altitude	15,691 ft.
U. S. NATIONAL RECORDS (Commercial)				**Speed on a Commercial Air Route:**	
Comm.	4/29/65	Boeing 707	George C. Dent (American Airlines)	Boston/Los Angeles	562.57 MPH
Comm.	2/16/65	Convair 990	Alden Young (American Airlines)	Chicago/Boston	692.28 MPH
Comm.	4/20/65	Boeing 727	Glen L. Stockwell (American Airlines)	Chicago/Ft. Worth	548.85 MPH
Comm.	4/9/65	Boeing 707	P. G. Cook (American Airlines)	Chicago/Indianapolis	494.93 MPH
Comm.	8/21/65	Boeing 727	W. J. Callahan (American Airlines)	Chicago/New York	624.85 MPH
Comm.	10/28/65	Boeing 727	W. J. Callahan (American Airlines)	Chicago/New York	644.36 MPH
Comm.	1/29/65	Boeing 727	Warren Julliard (American Airlines)	Chicago/Rochester	601.70 MPH
Comm.	2/3/65	Lockheed Electra L–188	A. B. Perriello (American Airlines)	Chicago/Washington	510.58 MPH
Comm.	1/27/65	Boeing 727	J. Jastrab (American Airlines)	Cincinnati/New York	619.81 MPH
Comm.	9/28/65	Boeing 707	E. H. Reish (American Airlines)	Cleveland/Boston	577.00 MPH
Comm.	4/5/65	Boeing 727	Kenneth B. Nace (American Airlines)	Cleveland/Cincinnati	439.52 MPH
Comm.	1/29/65	Boeing 727	R. O. Robbins (American Airlines)	Cleveland/New York	570.61 MPH
Comm.	10/28/65	Boeing 727	James F. Bell (American Airlines)	Cleveland/New York	599.50 MPH
Comm.	3/12/65	Boeing 707	James B. Smay (American Airlines)	Dallas/Baltimore	647.96 MPH

CLASS	DATE	AIRCRAFT	PILOT	RECORD DESCRIPTION	RECORD
				Speed over Recognized Courses:	
Comm.	2/25/65	Boeing 707	E. O. Medlin (American Airlines)	Dallas/El Paso	495.54 MPH
Comm.	7/6/65	Boeing 727	A. B. DeSalvo (American Airlines)	Dallas/Little Rock	504.50 MPH
Comm.	2/19/65	Boeing 707	W. W. Gosnell (American Airlines)	Dallas/Los Angeles	614.89 MPH
Comm.	3/8/65	Convair 880	Earl R. Epperson (Delta Air Lines)	Dallas/Orlando	664.59 MPH
Comm.	3/12/65	Boeing 707	William F. Bonnell (American Airlines)	Dallas/New York	686.73 MPH
Comm.	2/18/65	Boeing 707	W. R. Swain (American Airlines)	Dallas/San Francisco	580.46 MPH
Comm.	3/12/65	Boeing 707	W. T. Fleming (American Airlines)	Dallas/Washington, D.C.	643.06 MPH
Comm.	2/3/65	Boeing 727	Lawrence B. Hauser (American Airlines)	Detroit/Newark	607.89 MPH
Comm.	2/4/65	Boeing 727	John Clark (American Airlines)	Detroit/New York	577.62 MPH
Comm.	7/6/65	Boeing 727	A. B. DeSalvo (American Airlines)	Little Rock/Memphis	384.22 MPH
Comm.	11/26/65	Boeing 707	S. P. Bittner (American Airlines)	Los Angeles/Boston	666.61 MPH
Comm.	4/5/65	Boeing 707	George Dent (American Airlines)	Los Angeles/Cleveland	620.28 MPH
Comm.	11/23/65	Boeing 707	W. W. Gosnell (American Airlines)	Los Angeles/Cleveland	674.31 MPH
Comm.	3/8/65	Boeing 707	O. J. Feroe (American Airlines)	Los Angeles/Dallas	637.02 MPH
Comm.	3/9/65	Boeing 707	W. R. Hunt (American Airlines)	Los Angeles/Dallas	689.00 MPH
Comm.	3/9/65	Boeing 707	P. F. Willis (American Airlines)	Los Angeles/Memphis	692.82 MPH
Comm.	2/21/65	Convair 990	O. P. Brunsvold (American Airlines)	Los Angeles/Nashville	576.86 MPH
Comm.	11/25/65	Boeing 707	Conway F. Candler (American Airlines)	Los Angeles/Newark	673.13 MPH
Comm.	9/28/65	Boeing 727	R. O. Robbins (American Airlines)	Los Angeles/Oklahoma City	633.98 MPH
Comm.	4/13/65	Boeing 727	George B. Fell (American Airlines)	Los Angeles/St. Louis	648.82 MPH
Comm.	1/6/65	Boeing 707	E. M. Kruse (American Airlines)	Los Angeles/Wash., D.C.	637.52 MPH
Comm.	3/13/65	Boeing 707	L. E. Burns (American Airlines)	Los Angeles/Wash., D.C.	667.33 MPH
Comm.	3/13/65	Boeing 707	R. M. Sanderson (American Airlines)	Louisville/New York	567.90 MPH
Comm.	7/6/65	Boeing 727	A. B. DeSalvo (American Airlines)	Memphis/New York	566.28 MPH
Comm.	7/14/65	Boeing 707	James W. Knight (American Airlines)	Nashville/Los Angeles	491.40 MPH
Comm.	2/22/65	Convair 990	O. P. Brunsvold (American Airlines)	Nashville/San Francisco	492.80 MPH
Comm.	7/23/65	Convair 880	J. W. Bishop (Delta Air Lines)	New York/Houston	570.70 MPH
Comm.	7/6/65	Boeing 727	A. B. DeSalvo (American Airlines)	New York/Memphis	549.21 MPH
Comm.	3/24/65	Convair 990	James F. Bell (American Airlines)	Phoenix/Chicago	634.75 MPH
Comm.	6/12/65	Boeing 727	C. P. Evans (American Airlines)	Toronto/New York	527.40 MPH
Comm.	2/25/65	Boeing 707	E. O. Medlin (American Airlines)	Tucson/Los Angeles	486.10 MPH
Comm.	2/17/65	Boeing 727	Arthur Duffey, Jr. (American Airlines)	Tulsa/New York	537.91 MPH
Comm.	4/1/65	Boeing 707	W. T. Fleming (American Airlines)	Wash., D.C./Dallas	567.97 MPH



WRIGHT BROTHERS MEMORIAL TROPHY

The Wright Brothers Memorial Trophy, administered by the National Aeronautic Association, was presented to Jerome Lederer, executive director of the Flight Safety Foundation. The trophy, awarded annually for "significant public service of enduring value to aviation in the United States", was presented at the Wright Memorial Banquet in Washington, D. C., on December 17. Lederer was cited for more than 35 years of pioneering effort in the field of air safety.

COLLIER TROPHY

General Curtis E. LeMay (USAF, Ret.) was 1965 recipient of the Collier Trophy, administered by NAA and sponsored by LOOK magazine. The award was presented by Vice President Hubert H. Humphrey on October 21 in the White House Executive Offices. General LeMay retired on February 1 after 35 years' service.

BREWER TROPHY

The Frank G. Brewer Trophy, for outstanding achievement in the field of aviation education, was awarded to Dr. Gill Robb Wilson, retired aviation writer and publisher. Lieutenant General William K. Martin, Inspector General, USAF, made the presentation on June 26, during the Ninth Annual Conference on Aerospace Education, sponsored by the National Aerospace Education Council. John F. Loosbrock of the Air Force Association accepted the trophy in behalf of Dr. Wilson.

HARMON TROPHIES

The Harmon International Aviator's Trophy for 1965 went to Max Conrad for his 7,878-mile solo flight in a Piper Twin Comanche from Capetown, South Africa, to St. Petersburg, Florida. The Aviatrix Trophy was awarded to the late Joan Merriam Smith, who made an equatorial round-the-world solo flight in a Piper Apache. The trophies were presented on December 14 by Vice President Humphrey. In photo, left to right: Edward F. X. Ryan, Harmon trustee; Lieutenant Commander Jack Smith, USN, who accepted his wife's award; the Vice President; Max Conrad; Mary V. Bronsnahan and Ansel E. Talbert, Harmon trustees.

A

AMERICAN HELICOPTER SOCIETY AWARDS

The American Helicopter Society's Honorary Fellowships, awarded for distinguished service, were presented to Herbert M. Toomey of the Federal Aviation Agency and Charles W. Kuehne of Air Force Systems Command (Photo A). Other awards, presented at the AHS Honors Night Dinner in Washington, D. C., on May 14, included: the Frederick L. Feinberg Award, to Colonel George P. Seneff, USA (Photo B), Director of Army Aviation, "for his personal efforts in developing and testing flight techniques of the 11th Aviation Group"; the Dr. Alexander Kemin Award, to Elliot Daland (Photo C) of Piasecki Aircraft Corporation, "for his continuous contributions to the helicopter industry for more than two decades"; and the Captain William J. Kossler Award, jointly to the USAF, Army, Navy, Marine Corps, Coast Guard and civilian organizations for their participation in rescue and supply missions during the December, 1964, floods in the U.S. northwest.

B

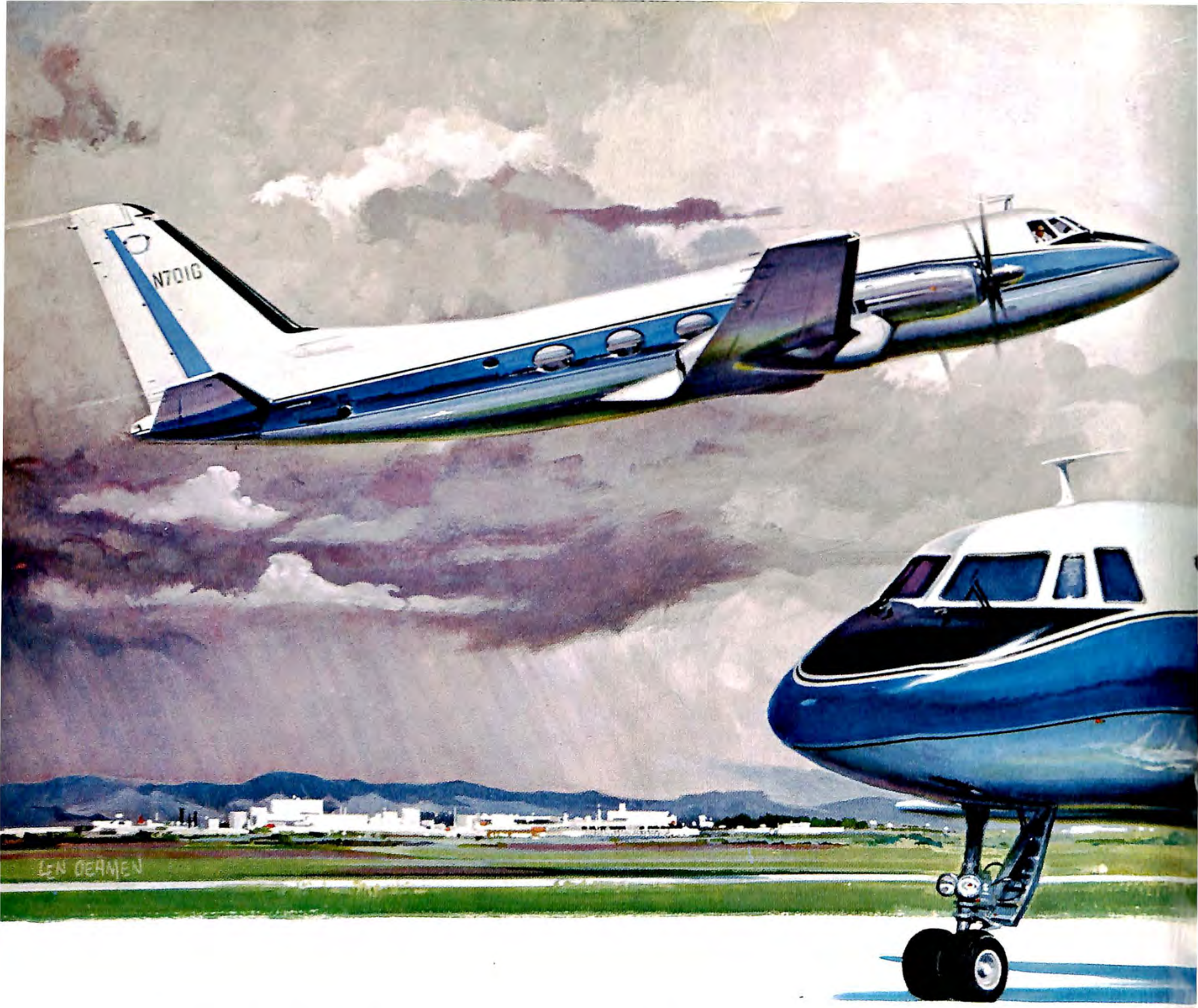
C

ARMY AVIATION AWARDS

The Army Aviation Association of America presented its James H. McClellan Aviation Safety Award to Ralph B. Greenway, air safety specialist in the office of the Director of Army Aviation. In photo, Greenway (left) accepts the award from Brigadier General O. Glenn Goodhand, USA (Ret.), AAAA president. Other awards presented at the association's Honors Luncheon on October 29 included: Army Aviator of the Year, to Major Paul A. Bloomquist, USA; Aviation Soldier of the Year, to Master Sergeant Cyril G. Manning; and Outstanding Army Aviation Unit, to the 13th Aviation Battalion serving in Viet Nam.

AIAA AWARDS

Turbojet pioneer Sir Frank Whittle (photo) was the 1965 recipient of the American Institute of Aeronautics and Astronautics Goddard Award for his "imagination, skill, persistence and courage in pioneering the gas turbine." Other major AIAA awards included: the Sylvanus Albert Reed Award, to Arthur E. Raymond, for "numerous and distinguished contributions to the aeronautical sciences"; the Research Award, to Wallace D. Hayes; the Space Science Award, to Eugene N. Parker; and the Louis W. Hill Space Transportation Award, to Wernher von Braun.



Gulfstream I: success

- Over 160 sold.
- Of the 130 leading corporations who own Gulfstreams, 25 operate two, three, or four of these aircraft. The U.S. Coast Guard, FAA and NASA, also operate Gulfstream I's.
- Safe design, reliability, low maintenance, and operational flexibility characterize Gulfstream I. Backed by the reputation of the company that has produced more than 25,000 aircraft of all types.
- Grumman continues to improve Gulfstream I. Performance has been improved in such areas as increased takeoff power, more cruise power, and higher maximum gross weight.
When you have a good thing, you keep making it better; it's not surprising that Gulfstream I continues to set the standard among corporate aircraft.


N765G

COMMONALITY

F-4B

Commonality is a product characteristic sought after by defense planners. Commonality permits planners to meet economically and effectively the multiple mission weapon requirements of multiple services. Commonality is a characteristic of the Phantom.

The McDonnell engineering team that designed commonality into the multiple-mission Phantom has proved that commonality can be achieved without performance compromises. This team is now designing even more advanced fighters in which commonality will be a fundamental characteristic.

F-4B

F-4C

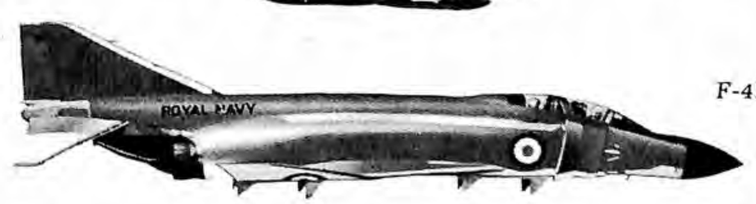
RF-4B

RF-4C

F-4D

F-4E

F-4J



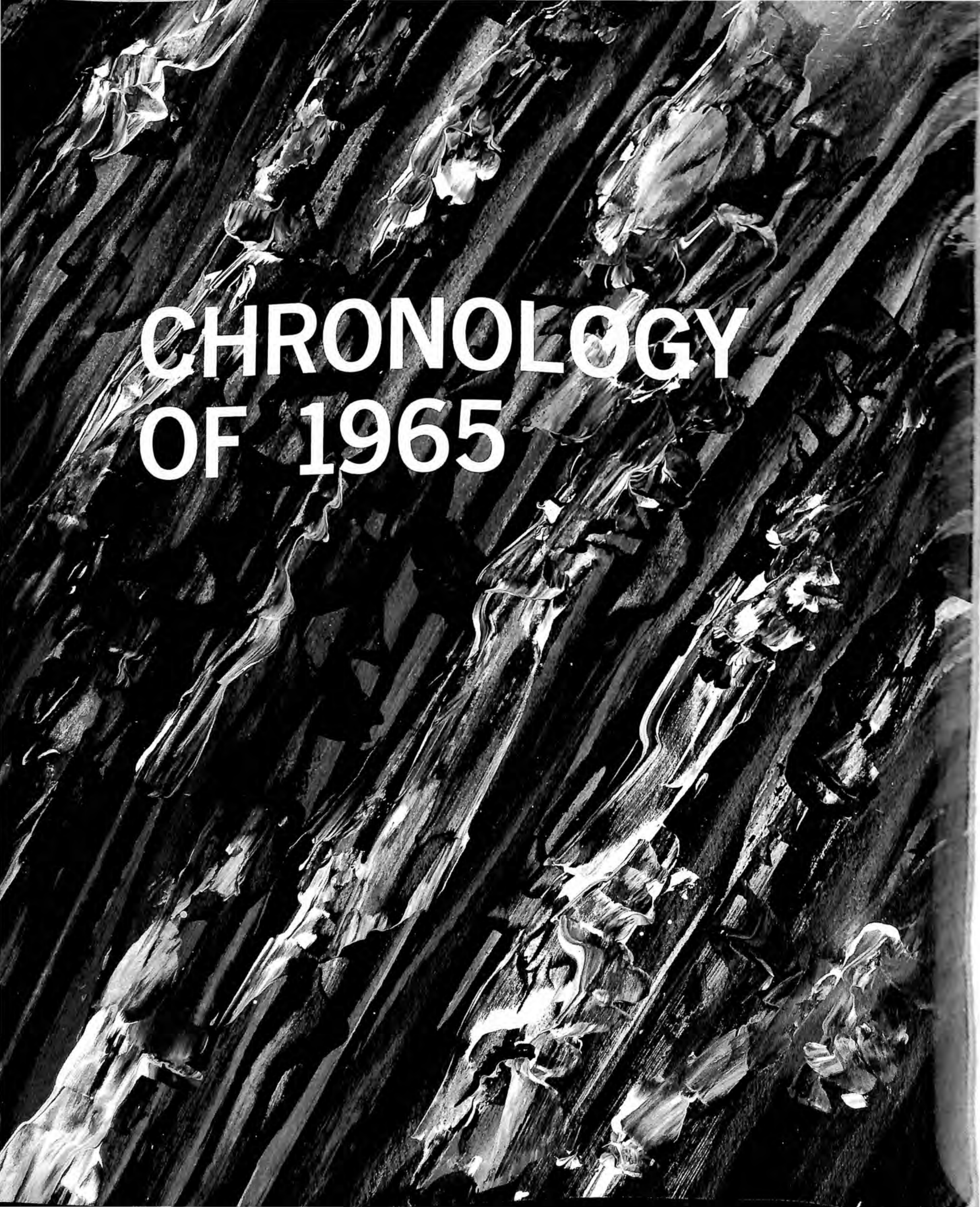
F-4K

F-4M

TSF

MCDONNELL
ST. LOUIS

CHRONOLOGY OF 1965



JANUARY

•January 5

Pan American World Airways announces it set new passenger and cargo records in 1964. The airline flew 8,187,149,000 passenger miles, an increase of 17.5 percent. Cargo ton-miles totalled 264,673,000, up 34.6 percent, and making PAA the first airline to top 200,000,000 ton-miles a year.

RKO-General, Inc., wholly owned subsidiary of General Tire & Rubber Company, assumes majority stock ownership of Frontier Airlines.

•January 6

Variable sweep wing of the General Dynamics F-111A (formerly TFX) successfully demonstrated in a one hour, two minute flight at Carswell AFB, Texas.

NASA announces it will negotiate a contract with Lockheed Missiles & Space Company to modify five Agena-D vehicles for use in the Lunar Orbiter program. The incentive contract is expected to total about $6,000,000. First of the moon-circling flights is scheduled for 1966.

•January 7

The Civil Aeronautics Board announces the passenger fatality rate per 100-million passenger-miles flown by U. S. certificated route air carriers was 0.27 in 1964—the 13th consecutive year the figure has been less than one per 100-million passenger-miles. Supplemental airlines had a zero passenger fatality rate for the third consecutive year.

•January 8

Curtiss-Wright's X-19 V/STOL completes its first in-flight conversion tests. The tri-service aircraft made a vertical takeoff, flew forward by tilting its propellers, returned and landed vertically.

FAA announces that 18 percent more people took private pilots' license examinations in 1964 than in 1963. Total was a record 51,548, of which about two-thirds passed the exam.

•January 11

Robert A. Bailey is named vice president of Lockheed Aircraft Corporation and manager of the company's supersonic transport program.

NASA announces that the contract for the interrogation recording and location system(IRLS) to be tested on Nimbus B meteorological satellite will go to Radiation, Inc., of Melbourne, Florida.

Dr. Walter J. Hesse is named program director of Ling-Temco-Vought's XC-142A V/STOL program.

•January 12

First Douglas DC-9 twin jet transport rolls off the assembly line a month ahead of schedule.

•January 13

NASA's Manned Spacecraft Center, Houston, Texas, discloses it received approximately 1,500 applications and letters of interest from potential scientist/astronauts by the December 31 deadline. From 20 to 25 percent matched up to NASA qualifications.

The XC-142A, largest vertical takeoff and landing airplane in existence makes flawless first transition flight—taking off vertically like a helicopter, lowering its tiltable wing to fly forward like a conventional airplane, and then reversing the process for a vertical landing, at the LTV plant at Dallas, Texas.

William Greer Knapp, retired Navy officer and holder of Navy Helicopter Certificate No. 1, dies at Bethesda Naval Hospital.

Cessna Aircraft Company reports record sales for 1964, the ninth consecutive year the company has produced more airplanes than any other manufacturer in the world. Cessna produced 4,188 new business and personal aircraft in 1964, an increase of 20 percent over the 1963 total of 3,456.

The trisonic F-111A successfully demonstrates its variable sweep wing.

•January 14

Alan S. Boyd is reappointed chairman of the Civil Aeronautics Board.

American Airlines announces it flew 8,158,961,000 revenue passenger miles in 1964, an increase of 13.2 percent over 1963. The number of passengers was 10,131,000—11 percent more than the previous year. AA set a new domestic industry record for air freight ton-miles with a 190,057.000 ton-mile total—14.7 percent better than 1963.

•January 15

The U. S. Air Force launches a TAT-Agena D with a classified payload from the Western Test Range at Vandenberg AFB, California.

The U. S. Air Force launches a Thor-Altair with a classified payload from Vandenberg AFB, California. It is the first use of the Thor-Altair launch vehicle.

The Boeing Company announces it is considering three new commercial subsonic jet transports. They are the Model 737 short haul plane; the Model 707-620, a 330,000-pound extended fuselage version of the 707 intercontinental series; and the Model 707-820, described as "a new airplane with a larger wing area and many other changes."

Hughes Aircraft Company is awarded a $13,042,000 Navy contract for continued work on the Phoenix air-to-air missile.

•January 19

President Johnson, in a defense message to Congress, announces two "new missile systems"—Poseidon, an improved Polaris, and SRAM(Short Range Attack Missile).

NASA launches GT-2, the last of the unmanned tests preparatory to the first manned Gemini flight, from Cape Kennedy.

Sikorsky Aircraft says its twin turbine CH-53A helicopter has reached speeds as high as 170 knots as gross weights up to 35,000 pounds, making it the world's fastest production helicopter.

•January 20
Kaman Aircraft Company's high-speed compound UH-2 helicopter makes its first flight. The UH-2 has a J-58 engine mounted on one side of the fuselage to provide auxiliary thrust, supplementing the aircraft's regular T-58 powerplant, and stub wings. Speeds up to 200 knots are expected.

•January 21
Nominations of Paul Ignatius, former Under Secretary of the Army, as Assistant Secretary of Defense for Installations and Logistics, and General John P. McConnell as Air Force Chief of Staff are approved by the Senate Armed Services Committee.

•January 22
The first of the "cartwheel" configuration of Tiros weather satellites is launched from Cape Kennedy into an elliptical polar orbit. The Weather Bureau says it plans to launch six more of the cartwheels in its Tiros Operational System (TOS).

Thirty of 31 firms invited to submit proposals on the Voyager Mars probe attend a bidders conference at the Jet Propulsion Laboratories, Pasadena, California.

•January 25
Details of a new side-looking radar capable of penetrating heavy cloud cover are revealed by the Navy. Designated AN/APD-7, the all-weather radar can "photograph" wide areas on either side of an aircraft in flight.

NASA's Goddard Space Flight Center, Greenbelt, Maryland, signs a $9,347,450 contract with Dynatronics, Inc., Orlando, Florida, for equipment to be used in the Manned Space Flight Network to decommutate pulse code modulation (PCM) signals received from Apollo spacecraft.

•January 26
President Johnson presents a $99.3 billion FY 1966 budget to Congress, and discloses that three major space programs are casualties of governmental belt-tightening. They are the 1.5 million pound thrust M-1 engine, the 260-inch solid propellant booster, and the SNAP-8 nuclear reactor system. FY 1966 space programs total $6.89 billion, with allocation as follows: NASA, $5.03 billion; DOD, $1.61 billion; AEC, 227.9 million; Weather Bureau, $16.6 million, and National Science Foundation $3.6 million. In the aviation field the President proposes an end of the helicopter subsidy as of December 31, 1965, increased "user" charges, a 100 percent increase in the aviation gasoline tax to four cents a gallon, a two-cent a gallon tax on kerosene, a two percent waybill tax on air freight and charges for the issuance of pilots' licenses and aircraft certificates.

Igor I. Sikorsky and Michael Gluhareff, pioneer helicopter developers, are awarded the Elmer A. Sperry Award.

•January 29
General Dynamics Corporation reports net earnings of $42,611,105, equal to $3.77 a share, and announces it will pay its first cash dividend in four years.

•January 31
Two prototypes of the XV-5A V/STOL are accepted by the Army for a six-month flight evaluation program.

FEBRUARY

•February 1
The International Air Transport Association announces that airline traffic in 1964 passed the three million passenger mark for the first time. IATA airlines carried 3,551,188 passengers—a 25.2 percent increase over 1963. North Atlantic scheduled cargo traffic also increased—22 percent—to 121,284 tons.

Lieutenant General William H. Blanchard, Air Force Deputy Chief of Staff for Plans and Operations, is nominated by President Johnson to be the new Vice Chief of Staff, with four star rank. He fills the vacancy created when General John P. McConnell moved up upon the retirement of General Curtis E. LeMay.

•February 2
Lieutenant General W. A. Davis, Vice Commander of the Air Force Systems Command, reveals that one of the advantages of Minuteman II missile will be its capability of being launched by radio signal from an airborne command post. Minuteman II also will have increased payload, range, target flexibility, and attack invulnerability.

Aerojet-General Corporation is given a $10,000,000-plus contract for liquid hydrogen, regeneratively cooled exhaust nozzles for the Phoebus nuclear rocket test program.

Lockheed Aircraft Corporation receives a $26,601,966 Navy contract for research and development on a reentry system for Polaris missiles.

•February 3
Orbiting Solar Observatory 2 is launched from Cape Kennedy atop a Delta launch vehicle, is returning good solar X-ray, gamma ray and ultraviolet data.

•February 4
Lyman C. Josephs III, veteran designer of high performance jet and V/STOL aircraft, is named director of aircraft development for the Martin Company. He formerly was program director of Ling-Temco-Vought's XC-142 tilt-wing transport.

NASA's Langley Research Center issues proposal request for the Mars probe/lander study. The probe/lander will (1) obtain information on the Martian atmosphere, and (2) obtain data on surface characteristics of Mars.

First public flight demonstration of the Ling-Temco-Vought XC-142A V/STOL transport is conducted at the Dallas (Texas) Naval Air Station. Five of the aircraft have been built.

•February 5
Hughes Tool Company proposes commercial helicopters using its hot-cycle propulsion system as a solution to the intercity transport problem. A 50-passenger version could be operated at costs comparable with the "most economical fixed-wing short haul aircraft," the company says. The hot-cycle concept involves ducting high energy gases from the turbojet engines to the rotor tips.

•February 8
Formation of a Voyager Mars probe project office at the Jet Propulsion Laboratories in Pasadena, California, is announced by A. R. Luedecke, JPL deputy director, who also announced the appointment of Dr. Donald P. Burcham as Voyager project manager and Geoffrey Robillard as deputy manager,

•February 9

NASA picks astronauts Gordon Cooper and Charles Conrad as primary crew for GT-5—the third manned Gemini flight—planned for later this year.

Harding L. Lawrence resigns as executive vice president of Continental Air Lines to become president and chief executive officer of Braniff Airways. Lawrence, 44, succeeds Charles E. Beard, 64, who is retiring after 30 years with Braniff.

President Johnson nominates Kenneth E. BeLieu to succeed Paul B. Fay as Under Secretary of the Navy. BeLieu has been Assistant Secretary of the Navy for Installations and Logistics.

•February 10

Admiral Arthur C. Davies, USN (Ret.), who was largely responsible for the development of the Norden bomb sight, dies at the Naval Medical Center, Bethesda, Maryland.

•February 11

LES-1, an experimental communication satellite on a Titan III-A booster, is launched by the Air Force from Cape Kennedy. Feature of the flight is transtage ignition which puts the satellite in three different orbits at prescribed intervals.

A complicated series of telemetry commands from the Goldstone, California, tracking station removes the cover from the television camera in Mariner IV, now speeding toward a July 14 photographic rendezvous with Mars.

The Federal Aviation Agency reports that about 80 percent of the sonic boom measurements made during the six-month tests at Oklahoma City were lower than predicted.

•February 12

Bendix Corporation purchases the Transponder Division of Transco Products, Inc., Venice, Calif., including all rights and patents for air traffic control transponders and military IFF(Identification, Friend and Foe) developments by Transco, and a new transponder which Bendix will manufacture and market to the general aviation field.

Hughes Tool Company's hot-cycle propulsion system concept involves ducting high energy gases from engines to rotor tips.

•February 15

Mrs. Gay Maher becomes the first woman to complete a solo transcontinental flight in a helicopter. She ferried a Hughes 300 from Culver City, California to Medford, New Jersey.

•February 16

The Pegasus I meteoroid detection satellite is launched by a Saturn I booster from Cape Kennedy. The satellite will gather data on meteoroid distribution, size and velocity.

New York Airways receives FAA authorization to use the Decca navigator system in its Boeing V-107 helicopters for full instrument operations. Use of the system is expected to result in the lowering of landing minimums from 500 feet and one mile to 200 feet and a half mile.

Comsat Corporation issues invitations to companies to bid on procurement of 24 satellites for its proposed Department of Defense satellite communications system.

•February 17

The Ranger VIII lunar probe is launched from Cape Kennedy, using an Atlas-Agena B booster. Photographic target of Ranger VIII is the moon's Sea of Tranquillity.

Mrs. Joan Merriam Smith, who in 1964 flew her small plane around the world, and Trixie Anne Schubert, pilot and aviation writer, are killed in the crash of their Cessna 180 on a California mountain.

•February 19

Pan American World Airways discloses its 1964 net profit was $37,140,000—a new record for the airline industry.

Dr. Homer Newell, NASA associate director, tells House Space Committee that Voyager will be NASA's basic tool for unmanned scientific exploration of the solar system for at least a decade and a half. Mars is the prime target, then Venus, he says.

•February 20

Ranger VIII impacts on the moon—in the Sea of Tranquillity—after returning 7,162 photos of the lunar terrain.

•February 22

Ranger IX spacecraft arrives at Cape Kennedy even as scientists study the 7,162 moon pictures obtained by Ranger VIII.

•February 23

USAF launches delta-winged ASSET reentry vehicle from Cape Kennedy. The craft carries a wide variety of metals and ablative materials to be tested for reentry effects.

•February 24

The Defense Department rejects Comsat Corporation's proposal to run a defense satellite communications system.

•February 25

President Johnson visits NASA headquarters and is briefed on the progress of Mariner IV, now en route to Mars on a photographic mission.

•February 26

Colonel John H. Glenn, Jr. is sworn in as a NASA consultant by Administrator James E. Webb.

MARCH

March 1

A Minuteman ICBM is successfully launched from an underground silo 10 miles north of Newell, South Dakota. It is the first ICBM to be launched from any point other than Cape Kennedy or Vandenberg AFB.

The U. S. Air Force announces that preliminary design studies on the Manned Orbiting Laboratory (MOL) will be carried out by four companies—Boeing, Douglas, General Electric and Lockheed.

San Francisco-Oakland Helicopter Airlines, Inc., begins using its new Oakland rooftop heliport located atop the Alameda County Parking Garage.

•March 2

Rear Admiral Ignatius J. Galantin is named Chief of Naval Materiel and nominated for promotion to vice admiral. He succeeds Vice Admiral William A. Schoech, who retired March 1.

An AC-5 Atlas/Centaur blows up on its pad at Cape Kennedy. It is the first Atlas booster failure, after 28 perfect flights.

Wiley R. Wright, retired military and civilian aviation official, dies at his home in Washington, D.C. He organized the aviation development section of the CAA, and served as executive secretary of the Aviation Development Advisory Committee until his retirement.

•March 3

General Bernard A. Schriever, head of the USAF Systems Command, reveals first details of START(Spacecraft Technology and Advanced Reentry Tests). The Air Force's newest space shape will be a wingless, V-shaped plane with a flat bottom, rounded top, and vertical tail fins. It will explore hypersonic flight regimes from orbital altitudes through the earth's atmosphere.

The U. S. Navy endorses "airfields in the round" as a result of tests at the General Motors circular test track at Mesa, Arizona. The Navy found in the Arizona tests that a 32,000-foot-circumference circle, parabolically banked so an aircraft steers itself, would result in substantial space saving for airports.

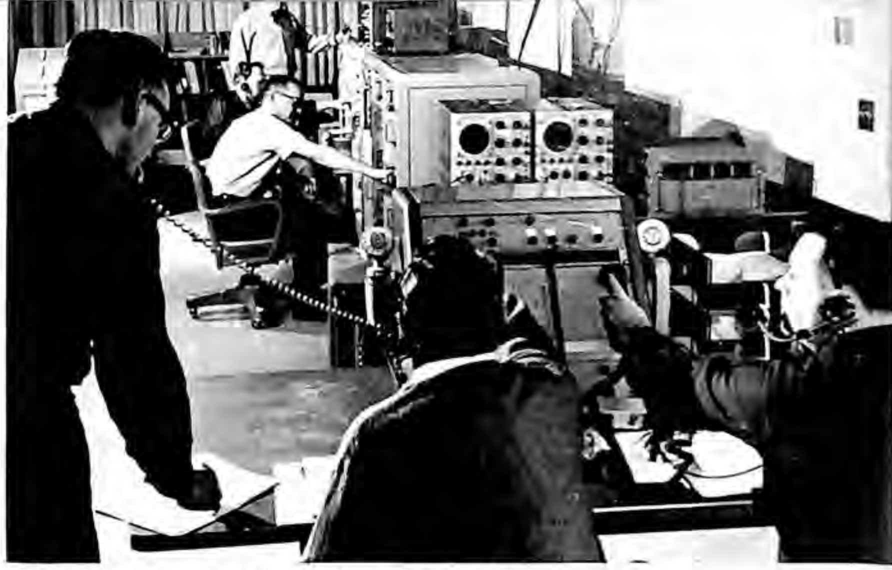
A. Carl Kotchian is named executive vice president of Lockheed Aircraft Corp. The position has been vacant since organizational changes following the death in 1961 of Robert E. Gross. Kotchian has been with Lockheed for 24 years.

New York Airways starts demonstration and qualification flights from the Pan American Building rooftop heliport in New York City.

•March 5

Signal strength of Mariner IV is increased by 40 times in preparation for its July 14 fly-by of Mars. The switch from the omnidirectional antenna to the high gain fixed antenna was made automatically from commands stored in the spacecraft's central computer and sequencer.

The Department of Defense announces that Lockheed Aircraft Corporation, for the third successive year, was the largest defense contractor in 1964. Lockheed received $1,455,400,000, or 5.8 percent of the total. Boeing was second with $1,365,200,000; McDonnell Aircraft jumped from ninth to third, with $1,157, 400,000.



Technicians monitor signals from Ranger IX.

The F-111 bi-service fighter makes its ninth flight, and its first at supersonic speed, over Fort Worth, Texas. The aircraft hit Mach 1.2 at 30,000 feet after pilot R. L. Johnson swept the wings back to their most extreme 72.5-degree angle.

•March 8

NASA begins launching sounding rockets from the deck of the USNA Croatan off the coast of South America. The program calls for one or more launchings a day for the next two months.

General Curtis E. LeMay, retired Air Force Chief of Staff and one of the world's most famous military pilots, receives his private pilot license from FAA.

The USAF launches the first eight-payload vehicle from Vandenberg AFB via a Thor Agena-D booster. Payloads include a solar radiation satellite, a gradient stabilization experiment, geodetic satellite, amateur radio satellite, surveillance calibration satellite and spasur calibration satellite.

•March 10

Successful hydrostatic pressure testing of a 206-inch solid chamber is conducted by Aerojet General Corporation.

•March 11

A joint Army-Air Force sponsored geodetic satellite is placed in orbit by a Thor-Able booster fired at Vandenberg AFB.

•March 12

The USAF launches an Atlas-Agena-D with a classified payload from Vandenberg AFB.

•March 13

The U. S. Army announces that its Bell YUH-1B compound research helicopter, equipped with a new four-blade rigid rotor, has flown 225 miles per hour in level flight.

•March 16

First firing of the Army's mobile Lance surface-to-surface division support missile is conducted at the White Sands Missile Range, New Mexico. The system is carried on a modified armored vehicle.

A $1.5 million study contract in the project definition phase of the Advanced Aerial Fire Support System (AAFSS) is awarded the Sikorsky Aircraft Division of United Aircraft Corporation by the Army Transportation Research Command.

•March 17

The USAF launches a Thor-Altair with a classified payload from Vandenberg AFB.

•March 18

Ground is broken at Wallops Station, Virginia, for a $4 million antenna that will become part of the Weather Bureau's Tiros Operational System(TOS). The installation will receive data from Tiros satellites and transmit the information to the National Weather Satellite Center in Washington, D.C.

•March 19

Charles A. Lindbergh is elected to the board of Pan American World Airways. The famed pilot has been a technical adviser to Pan Am for 26 years.

•March 20

John G. Adams, chief enforcement officer of the Civil Aeronautics Board, is nominated by President Johnson to membership on the CAB, succeeding Chan Gurney.

•March 21

Ranger IX spacecraft is launched from Cape Kennedy on a lunar photo mission, with the Atlas-Agena-D launch vehicle performing perfectly.

•March 23

Gemini 3, first U. S. two-man space flight, is blasted off at Cape Kennedy after an almost flawless 420-minute countdown. Crew of the GT-3 on its three orbit mission is Virgil "Gus" Grissom and John Young. Another "first" was accomplished when GT-3 changed orbit during the mission.

NASA unveils a new satellite program, to be known as the Optical Technology Satellite (OTS), to prove out the technology of laser operation in space.

Bell Helicopter Company announces a new aircraft design capable of vertical takeoff and landing, hovering, and level flight at jet aircraft speed. Helicopter-type rotor blades mounted at the wing tips would fold in flight.

•March 24

Ranger IX impacts on the moon after taking and transmitting to earth 6,150 "excellent" photographs of the crater Alphonsus and surrounding lunar terrain.

Douglas Aircraft reports a surge in aircraft orders has pushed its commercial backlog to $799,000,000, an all-time Douglas high for the jet era.

The North American XB-70 reaches and sustains a speed of Mach 2.1 for one hour and 20 minutes during its sixth flight from Edwards AFB, California.

•March 25

NASA Administrator James E. Webb reports to President Johnson that Ranger IX pictures indicate the moon's surface is strong enough to support the manned Apollo landing.

FAA reports that for the second year in a row 1964 aircraft operations increased 10 percent over the previous year, and set a new record.

Dr. Wolfgang B. Klemperer, 72, pioneer zeppelin expert and a Douglas Aircraft scientist since 1936, died at his home in Los Angeles, Calif.

The USAF launches a TAT-Agena D with a classified payload from Vandenberg AFB.

•March 26

First successful flight test of the Army's Sprint antimissile missile is conducted at the White Sands Missile Range, New Mexico.

•March 29

John E. Steiner, chief project engineer on the Boeing 727 tri-jet, is named Seattle's Aviation Man of the Year.

•March 30

A four-stage Blue Scout (SLV-18) is launched by the USAF from Cape Kennedy in a cosmic radiation probe.

APRIL

•April 1

A tri-nation test of VTOL aircraft begins in England. The U.S., Great Britain and West Germany are participating in a study of the concept of VTOL with combat troops in the field.

•April 2

FAA certificates a new version of the Fairchild Hiller Turbo-Porter STOL aircraft.

•April 3

Snapshot, the Atomic Energy Commission's SNAP-10A nuclear reactor, is successfully orbited by an Atlas-Agena booster from Vandenberg AFB.

NASA narrows to three the field of competition in the hypersonic ramjet experiment. Garrett Corporation, General Electric, and the Marquardt Corporation each will get contracts in the conceptual and preliminary design phase.

•April 6

The Communications Satellite Corporation's Early Bird, commercial communications satellite, is launched from Cape Kennedy and placed in synchronous equatorial orbit over the Atlantic Ocean.

Model of Early Bird commercial comsat.

United Air Lines signs orders for the largest commercial transport program in industry history, with 144 aircraft to be purchased, optioned or leased. Orders in the $750,000,000 program are 40 Boeing 737 short haul jets, plus options for 30 additional; six Douglas DC-8-61's, and options for three more; six quick-change passenger/cargo Boeing 727's; four regular Douglas DC-8's; and 20 Boeing 727's.

The House passes a $2,100,000,000 supplemental appropriation bill which eliminates the helicopter subsidy for the balance of the fiscal year.

A Bell compound helicopter, Army designation YUH-1B, flies 250 miles per hour in level flight during a test at Fort Worth, Texas.

•**April 8**
James H. Binger is elected chairman, and Stephen F. Keating president of Honeywell Inc. Binger replaces Paul B. Wishart, who is retiring. Keating has been executive vice president.

NASA's Goddard Space Flight Center awards a $4,600,000 contract to RCA for an RFQ-6 radar beacon at Bermuda which will be the first to pick up signals from the Saturn V/Apollo flight.

•**April 9**
Members of the International Air Transport Association vote to eliminate in-flight movies.

The USAF launches a Scout missile carrying a scientific payload intended to assess biological hazards of natural space radiation.

•**April 12**
Major General Clifton F. von Kann, who retired in February as commanding general of the Army Aviation Center, Fort Rucker, Alabama, is named vice president-operations and engineering of the Air Transport Association.

•**April 14**
The $100,000,000 525-foot high Saturn V/Apollo vertical Assembly Building at NASA's new launch complex at Merritt Island, Florida, is "topped off" in ceremonies attended by government and industry executives.

April 15
Bendix Corporation names A. P. Fontain as chairman and chief executive officer, and G. E. Stoll as president. M. P. Ferguson, who has served as president and chief executive officer since 1946, is elected chairman of a newly organized finance committee.

The first of four Air Force Stellar Acquisition Feasibility Flights (STAFF) ends in failure 73 seconds after launch at Cape Kennedy.

A series of tests on the Apollo Lunar Excursion Module (LEM) ascent engine is begun at White Sands Missile Range, New Mexico.

•**April 16**
FAA certificates the British-built BAC-111 twinjet airliner, and Braniff International Airways announces it will inaugurate service with the BAC-111 on April 25.

•**April 20**
North American Aviation's XB-70 reaches an altitude of 58,000 feet, and a speed of Mach 2.3, on its 10th flight at Edwards AFB, California.

Cessna Aircraft Corporation delivers its 10,000th Model 172 Skyhawk to an Elaine, Arkansas, flying club.

•**April 21**
Lieutenant General L. F. Chapman, Jr., Marine Corps Chief of Staff, says the Corps will transfer its main transport needs to VTOL by 1985.

•**April 23**
Comsat Corporation successfully conducts two-way television transmission via its Early Bird satellite between the Andover Ground Station and ground terminals in England, France and West Germany.

•**April 24**
First five-engine cluster ignition test of the Saturn V second stage—the hydrogen powered S-II—is conducted at North American Aviation's test facility in the Santa Susana Mountains, California.

•**April 27**
In a major reshuffle of government aviation posts President Johnson nominates CAB Chairman Alan S. Boyd as Under Secretary of Commerce for Transportation, and names Charles S. Murphy, Under Secretary of Agriculture, to succeed Boyd at CAB. The President also appoints General William F. McKee as the new administrator of the Federal Aviation Agency to replace Najeeb E. Halaby.

•**April 28**
The Senate confirms John G. Adams as a member of the Civil Aeronautics Board to replace Chan Gurney, retired.

The crawler-transporter which will carry the Saturn V/Apollo from the Vehicle Assembly Building to the launch pad at Merritt Island, Florida, makes its first demonstration run successfully.

•**April 29**
Thompson Ramo Wooldridge, Inc., officially changes its name to TRW, Inc. because, officials say, the company is getting better known by its initials than by its full legal name.

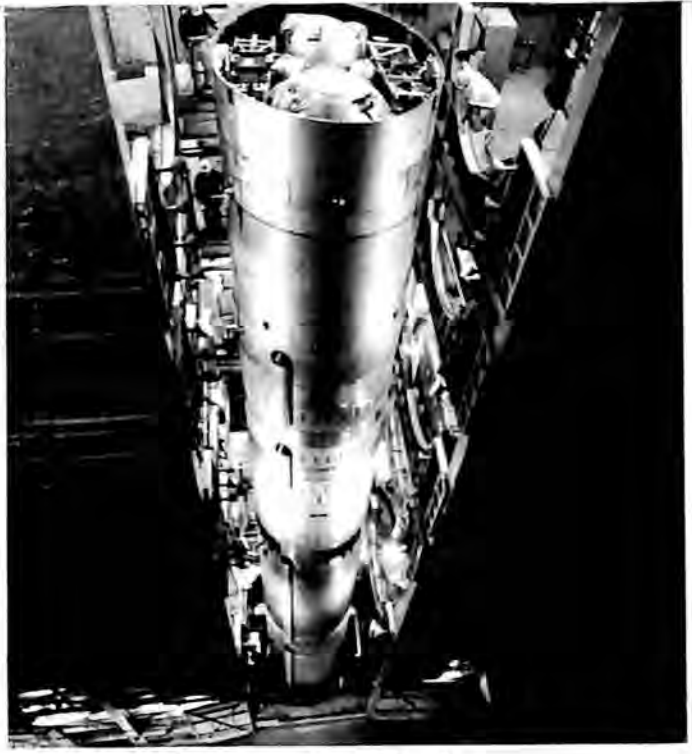
Explorer XXVII geodetic and ionosphere research satellite is orbited from NASA's Wallops Island (Md.) facility.

•**April 30**
Eastern Air Lines celebrates the fourth anniversary of its Washington-New York-Boston shuttle service, and announces that more than 8,000,000 passengers have been carried thus far.

MAY

•**May 1**
The Lockheed YF-12 sets a series of new records at Edwards AFB, California: 1,642 miles per hour around a 500-kilometer closed course; 1,688 miles per hour around a 1,000-kilometer closed course, and 2,062 miles per hour on a straight course.

•**May 6**
Western Air Lines seeks to liberalize the traditional 40-pound baggage allowance for air travelers.



Titan III-A undergoes pre-launch checks.

A Titan III-A is launched from Cape Kennedy in a four-burn test of the transtage upper stage. The booster carries an experimental LES-2 satellite and an LCS aluminum sphere designed to serve as an orbiting calibration target for worldwide radar stations.

•May 8
Lockheed's "rigid rotor" XH-51A helicopter flies 259 miles per hour during its Army test program.

•May 10
The Northrop F-5 completes a year of operations with the 441st CCTS, Williams AFB, Arizona, without an accident of any kind.

Shipboard firings to evaluate Seaspar, a surface-to-air anti-aircraft missile, are begun from an LST (Landing-Ship-Tank) off Point Mugu, California.

•May 11
The F-111B-Navy version of the TFX—is rolled out at the Grumman Aircraft Engineering Corporation plant.

•May 12
Comsat Corporation receives sole responsibility from the Federal Communications Commission for design, construction and operation of the initial ground stations in the global communications satellite system.

NASA awards a $15,000,000 contract to Grumman Aircraft Engineering Corporation for a fourth Orbiting Astronomical Observatory (OAO).

A four-stage Blue Scout (SLU-1B) launches a cosmic radiation experiment from Cape Kennedy.

•May 16
SNAP-10A, the Atomic Energy Commission's first orbiting space nuclear reactor power system, mysteriously stops operating after producing more than 500,000 watt-hours of electricity during its six weeks of life.

•May 18
The Navy F-111B successfully completes its first flight, with its variable sweep wing and low speed landing characteristics demonstrated during the one hour and 20 minute test.

•May 19
The Minuteman II missile will have a kill capability eight times that of Minuteman I, Major General E. B. LeBailly, USAF chief of information, tells the San Francisco chapter of the Aviation/Space Writers Association.

NASA successfully launches a "mother-daughter" sounding experiment from Wallops Island. Two payloads are sent to a 605-mile altitude to measure electron densities and ion composition of the ionosphere.

•May 22
NASA completes its FIRE program with a second successful re-entry test. Launched from Cape Kennedy by an Atlas booster, the 200-pound FIRE payload came down near Ascension Island after transmitting data on heat transfer, materials behavior and radio attenuation during re-entry at a velocity of 37,000 feet per second.

The second Pegasus meteoroid satellite is launched from Cape Kennedy in the ninth consecutive successful Saturn I (SA-8) test.

•May 25
Bell Aerosystems' X-22A tri-service V/STOL is rolled out at Buffalo, New York. Four General Electric YT-58-8D turboshaft engines power the dual-tandem ducted propeller craft.

•May 26
Hughes Tool Company's Aircraft Division is officially named the winner of the Army's long LOH (Light Observation Helicopter) competition.

•May 28
NASA issues RFPs—Requests for Proposal—to 40 firms for its proposed Optical Technology Satellite (OTS).

The Civil Aeronautics Board grants a one-year authority to San Francisco & Oakland Helicopter Airlines to operate air cushion vehicles in the bay area.

•May 29
Explorer XXVIII, NASA's new Interplanetary Monitoring Platform (IMP), is launched from Cape Kennedy by a Delta booster and is returning data on magnetic fields and radiation. It is traveling the longest earth orbit to date—an apogee of 158,000 miles, and a perigee of 117 miles.

JUNE

June 1
Alan S. Boyd and Charles Murphy are sworn in as Under Secretary of Commerce for Transportation and Chairman of the CAB, respectively, at the White House.

•June 2
Scramjet—Supersonic Combustion Ramjet Engine—is the most promising approach to sustained hypersonic flight, General Bernard A. Schriever tells a retired officers luncheon at Bolling AFB, Washington, D. C.

Storer Broadcasting Company, Miami, Florida, agrees to purchase the 55 percent Hughes Tool Company stock holdings in Northeast Airlines for $6.30 a share. Hughes holds 973,226 shares of Northeast stock.


STAFF vehicle in final assembly.

Gemini IV, with astronauts James McDivitt and Edward H. White aboard, is launched by a Titan II booster from Cape Kennedy. Astronaut White also becomes the first American to step into space, spending approximately 21 minutes outside the capsule. A scheduled docking maneuver with the spent Titan II second stage is cancelled when McDivitt and White are unable to maneuver the spacecraft close enough with the available fuel.

•June 4
The Aero Club of New England names Robert C. Seamans, Jr., associate administrator of NASA, the recipient of the Godfrey L. Cabot Award for his contributions to aeronautics.

•June 7
The Gemini IV spacecraft carrying astronauts James McDivitt and Edward H. White splashes down in the Atlantic 400 miles west of Bermuda after completing 63 orbits of the earth in 97.9 hours.

•June 9
First trans-Atlantic record transmissions are made via Early Bird satellite. Involved are tests of telegraphy, facsimile, telex, photos and other data.

Pan American World Airways conducts a 90-minute demonstration using the Early Bird satellite for alternate voice-data communication with a regularly scheduled London to New York flight.

•June 10
The 50,000-pound-thrust engine General Electric proposes for the supersonic transport is unveiled at the Paris Air Show.

•June 11
NASA succeeds in its second attempt to static fire the Saturn V S-IC stage for 90 seconds at the Marshall Space Flight Center, Huntsville, Alabama. A previous attempt failed because of a faulty transducer signal.

•June 14
The Mariner IV spacecraft successfully performs its final tracking correction preparatory to its July 14 photo fly-by of Mars. The correction is made on a pre-programmed command in Mariner's central computer and sequencer.

Carl L. Norden, 85, inventor of the Norden bombsight used in World War II, dies at his home in Zurich, Switzerland.

•June 16
The second of four scheduled flights in the USAF's Stellar Acquisition Feasibility Flight (STAFF) program is launched from Cape Kennedy by a modified Polaris booster.

Defense Secretary Robert McNamara announces organization of a new airmobile Army division comprising 15,787 men and 434 aircraft. It will be designated the 1st Cavalry Division (Airmobile).

•June 18
Titan III-C is launched from Cape Kennedy and places what is believed to be the heaviest payload—21,400 pounds—in a circular orbit. It is the maiden flight of Titan III-C, which develops 2,500,000 pounds of thrust.

•June 19
NASA Administrator James E. Webb reports to President Johnson that a rendezvous in space between a Gemini spacecraft and an Agena will be made this year.

•June 21
Athena re-entry tests are resumed by the USAF with two launches from Green River, Utah, into the White Sands Missile Range, New Mexico.

The first of two six-million-pound crawler-transporters designed to carry the Saturn V/Apollo to its launch pad makes its maiden test trip at Merritt Island, Florida.

•June 23
Nomination of General William F. McKee as FAA Administrator is sent to the Senate Commerce Committee by President Johnson following passage of a bill which allows McKee to retain his Air Force status and retired pay while occupying the civilian post.

•June 24
The 100th firing in the F-1 engine program is accomplished at NASA's Rocket Engine Test Site near Edwards, California.

The Navy's Bureau of Weapons orbits a navigational satellite from Vandenberg AFB.

•June 27
The Air Defense Command marks its 15th anniversary of continuous air alert.

•June 28
Comsat Corporation inaugurates commercial satellite communications service between the U. S. and Europe.

Dr. Eugene G. Fubini resigns as assistant secretary of defense, effective July 15, to become a vice president of IBM Corporation.

•June 29
A small SNAP radioisotope generator completes its fourth year of operation in space aboard the Navy's experimental navigational satellite 4-A. The SNAP-3, built for the AEC by the Martin Company, was launched June 29, 1961, to supply supplementary power for the 175-pound satellite.

•June 30
The nation's inventory of 800 Minuteman I ICBM's is officially declared operational with the turnover of the Fifth Wing to the Strategic Air Command at Warren AFB, Wyoming.

JULY

•July 1
President Johnson says he will ask Congress for a $140,000,000 supplemental appropriation to finance the next phase of the supersonic transport program—18 months of study and tests of proposed engine and airframe designs.

The North American XB-70 completes its 14th test flight from Edwards AFB, reaching a speed of Mach 2.8 and an altitude of 68,000 feet.

The Navy's F-111B(TFX) flies supersonic for the first time on its fifth flight, reaching a speed of Mach 1.2.

•July 2
Tiros X, the first satellite funded by the Weather Bureau, is launched from Cape Kennedy by a Delta booster. It is programmed to take 400 weather photos daily.

NASA discloses that the Pegasus II meteoroid satellite has reported 73 meteoroid penetrations since its launch on May 25.

•July 5
Four of the Navy's new Grumman A-6A Intruders make their first combat strike in Viet Nam. Flying from the carrier Independence, the aircraft dropped eight tons of bombs on two bridges.

•July 6
Fairchild Hiller Corporation announces the start of production of its single engine, turbine-powered Turbo-Porter STOL airplane. It is being produced under a license agreement with Pilatus of Switzerland.

•July 7
North American Aviation unveils the first of seven prototype OV-10A counterinsurgency (COIN) aircraft during ceremonies at Columbus, Ohio.

•July 8
Paul Mantz, 61, famed movie stunt flier and race pilot, dies in the crash of a rebuilt plane during the filming of a movie at Yuma, Arizona.

•July 9
Test of the Northrop F-5 fighter in actual combat in Viet Nam is approved by Defense Secretary Robert McNamara.

First of five Vought-Hiller-Ryan tri-service XC-142A V/STOL aircraft arrives at Edwards AFB for flight test and evaluation.

•July 10
Dr. Harold Brown is named Secretary of the Air Force to succeed Eugene M. Zuckert, and Norman S. Paul to replace Under Secretary Brockway McMillan. Brown has been Director of Defense Research and Engineering.

•July 14
Mariner IV, after a flight of 228 days and 325 million miles, begins photographing the surface of Mars. Over the next 10 days 22 photographs are to be transmitted back to earth by Mariner's cameras.

Under Secretary of Commerce LeRoy Collins presents the President's "E" Award to the Aerospace Industries Association for excellence in export promotion. Karl G. Harr, Jr., AIA president, accepts the award on behalf of the association.

Bell Helicopter Company receives a $100,000,000 Army order for 720 UH-1 Iroquois helicopters.

The OV-10A COIN aircraft successfully completes its first flight.

•July 15
The CAB approves a proposal by the airlines to liberalize the free baggage allowance. The new system is based on the number and size of pieces of luggage rather than weight.

•July 16
First flight of the OV-10A counterinsurgency (COIN) aircraft is conducted successfully at North American Aviation's Columbus plant.

•July 19
The U. S. and West Germany announce agreement to cooperate on launch of a radiation belt monitoring satellite. First of three proposed satellite launches is scheduled for 1968.

•July 20
NASA announces that the eight-day GT-5 Gemini flight is set for 19 August. During the mission astronauts Gordon Cooper and Charles Conrad will attempt to maneuver their spacecraft to within a few feet of a Rendezvous Evaluation Pod in preparation for a docking exercise later on the GT-6 mission.

•July 21
Fourth test firing of the Lance missile is conducted by the Defense Department at White Sands Missile Range, New Mexico.

•July 27
The Air Transport Association reports that the 11 U. S. trunk airlines in the first six months of this year flew 593.4 million ton-miles of cargo—23 percent more than in the same period in 1964.

•July 28
Brigadier General Joseph S. Bleymaier, deputy commander for Manned Systems, Air Force Systems Command, is cited by President Johnson for cost reduction efforts on the Titan III space booster program.

•July 30
The final Saturn I, carrying Pegasus C—the last in a series of micrometeoroid detection satellites—is launched from Cape Kennedy.

•July 31
First live television program from the Soviet Union, showing the U. S.-Soviet track meet in Kiev, is transmitted to the U. S. via Early Bird satellite.

AUGUST

•August 3
Comsat Corporation issues Request for Proposals to 11 firms for synchronous satellites and transportable ground stations for use in space exploration programs.

The Navy's new Simplified Inertial Guidance System (SIGS) is successfully tested aboard a Sergeant missile fired at White Sands Missile Range, New Mexico.

•August 5
The destroyer escort Brunby, equipped with Drone Anti Submarine Helicopter (DASH), Anti Submarine Rockets (ASROC) and anti submarine rocket launchers, is commissioned at Charleston, South Carolina.

First test firing of the Lance surface-to-surface missile from a tactical version of a self-propelled launcher vehicle is conducted at White Sands Missile Range.

First full duration test firing of the Saturn V booster is conducted at the Marshall Space Flight Center, Huntsville, Alabama. The five motors produced 7.5 million pounds of thrust.

•August 6
Dulles International Airport, the Federal governments, $110,000,000 jetport near Washington, logs its 2,000,000th passenger. Dulles was opened in November, 1962.

•August 7
General Electric Company is chosen by the Air Force to produce the engines for the giant C-5A transport.

•August 9
First full duration firing of the S-II second stage of the Saturn V launch vehicle is conducted at North American Aviation's Santa Susana, California, facility.

•August 10
Initial flight of the uprated Scout Evaluation Vehicle (SEV) from Wallops Island, Virginia, is a complete success, and provides a bonus by placing an Army Secor sattellite in orbit.

•August 11
NASA launches the AC-6 Centaur and puts a 2,100-pound dummy Surveyor satellite into almost perfect orbit.

Centaur stage is readied for mating with Atlas booster.

Northeast Airlines announces purchase of 22 new jet transports valued at more than $100,000,000.

•August 12
President Johnson formally asks Congress for a $140,000,000 supplemental appropriation to carry the supersonic transport research program through the current fiscal year.

•August 13
The Navy's Bureau of Naval Weapons orbits a second navigational satellite from Vandenberg AFB to augment its all-weather satellite system and allow for more frequent position fixes by ships at sea.

•August 16
Clarence N. "Clancy" Sayen, president of the Air Line Pilots Association and the International Federation of Air Line Pilots from 1951 through 1962, is killed in the crash of a United Air Lines airliner in Lake Michigan.

•August 17
The Air Force's Minuteman II is successfully launched for the first time from an operationally configured underground silo at Vandenberg AFB.

•August 18
A Lance missile is successfully launched from a tactical mobile launcher at White Sands Missile Range, New Mexico.

•August 19
Technical difficulties—a telemetry problem in the spacecraft and a power surge on the launch complex—necessitate scrubbing of the GT-5 launch.

•August 20
Aero Spacelines' "Very Pregnant Guppy," a Boeing 377 modified and enlarged to carry outsize cargo—the Douglas-built S-IVB third stage of the Saturn V launch vehicle, for instance—is rolled out at Van Nuys, California.

•August 21
Gemini 5, with astronauts L. Gordon Cooper and Charles "Pete" Conrad aboard, is launched from Cape Kennedy.

•August 23
The first Mach 2 flight in the F-111 program is accomplished at 40,000 feet over Fort Worth, Texas.

Gemini 5 is manipulated in space to successfully rendezvous with a phantom Agena upper stage.

Brigadier General Jewell C. Maxwell is selected to head FAA's supersonic transport development program.

•August 24
Astronauts Cooper and Conrad, orbiting earth in Gemini 5, report they saw a Minuteman firing at Vandenberg AFB.

A Nike-Apache sounding rocket is launched from Wallops Island, Virginia, in the first of a series of cooperative launches by the U. S. and Brazil.

Major General Orvil A. Anderson, 70, who in 1935 piloted a balloon to a world altitude record of 72,395 feet, dies at Montgomery, Alabama. His altitude record stood until 1951.

•August 25
The third Orbiting Solar Observatory (OSO) is launched from Cape Kennedy but fails to achieve orbit because of premature ignition of its third stage.

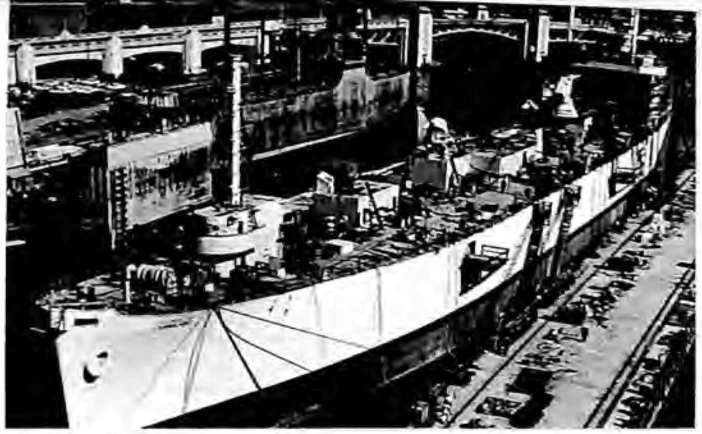
•August 26
President Johnson announces that the Defense Department has ordered development of the Manned Orbiting Laboratory by Douglas Aircraft Company. General Electric Company will plan and develop the MOL experiments.

The X-15 rocket aircraft reaches a speed of 3,409 miles an hour (Mach 4.66) and an altitude of 240,000 feet in a test flight by Major Robert Rushworth, USAF, at Edwards AFB, California.

•August 28
Ellen Church Marshall, San Francisco nurse who became the nation's first airline stewardess (United Air Lines), dies of injuries sustained in a horseback riding mishap.

•August 29
GT-5 splashed down in the Atlantic 300 nautical miles southwest of Bermuda after setting new space records for the U. S., which now leads Russia in space flight hours.

•August 31
General Bernard A. Schriever is designated director of the Manned Orbiting Laboratory program in addition to his duties as commander of the Air Force Systems Command. He will report directly to the Secretary of the Air Force.



The Vanguard, Apollo instrumentation ship, is floated out of its construction basin.

SEPTEMBER

•September 1
Samuel F. Pryor, Jr., 67, vice president of Pan American World Airways and one of the most widely known aviation figures, retires after 25 years' service.

NASA launches a Nike-Apache vehicle carrying a payload to measure electron and ion densities and temperatures from Wallops Island, Virginia.

The USAF fires an Athena missile from Green River, Utah, to White Sands Missile Range, New Mexico.

•September 2
Brigadier General Joseph S. Bleymaier is named commander of the Air Force's Western Test Range, Vandenberg AFB, California, succeeding Brigadier General Jewell C. Maxwell, who was named recently to be director of FAA's supersonic transport development program.

•September 3
FAA announces it has allocated $84,500,000 in federal matching funds for the fiscal year 1966 Federal Airport Aid Program, the largest allocation on record. Approximately 445 civil airports will benefit.

•September 8
The Small Business Administration cites Martin Company and 11 subcontracting firms for their work on the Gemini program.

•September 9
Astronauts L. Gordon Cooper and Charles "Pete" Conrad, Jr., after 11 days of debriefing by NASA scientists, medical experts and engineers, make their first public appearance in Houston, Texas, since their record eight-day GT-5 spaceflight.

The Defense Department announces that small business firms received $5,035,000,000 or 20.3 percent of all defense prime contract awards during Fiscal Year 1965. This was $463,000,000 more than in FY 1964.

The first Apollo instrumentation ship, the Vanguard, is floated out of the General Dynamics building basin at Quincy, Massachusetts. The Vanguard will track the Apollo spacecraft on its first leg of the journey to the moon.

•September 10
FAA announces that 90,935 civil aircraft were in use at the end of 1965. Of these, 2,193 belong to airlines.

NASA announces it is recruiting another crop of pilot-astronauts to report for duty in the summer of 1966.

NASA completes the first exercise of the Inter-American Experimental Meteorological Rocket Network, in which 15 sounding rockets were fired during a 39-hour period.

•September 13
President Johnson announces he will nominate Whitney Gilliland for a second six-year term on the Civil Aeronautics Board. A Republican, Gillilland was appointed originally by former President Eisenhower.

•September 14
The Army claims it has the nation's second busiest airport—Lowe Army Field at Fort Rucker, Alabama. It has 424,248 landings, compared with 462,227 at Chicago's front-running O'Hare International Airport.

Najeeb E. Halaby, former FAA Administrator , is elected a vice president and member of the board of Pan American World Airways.

•September 15
The Pratt & Whitney TF-30 engine used in the F-111 and the General Dynamics Charger counterinsurgency aircraft are shown publicly for the first time at the Air Force Association fall meeting in Washington.

NASA announces that Mariner IV continues to send back scientific measurements of cosmic dust, magnetic fields, cosmic rays and radiation as it passes its 400,000,000th mile in space. Mariner IV has exceeded its design mission lifetime by more than 500 hours.

•September 17
The first of 10 OV-1 Air Force research satellites is launched from Vandenberg AFB aboard an Atlas booster. The satellite will measure ambient radiation environment and also detect radiation attenuated by various thicknesses of shielding material.

•September 21
NASA announces that H. Julian Allen will become director of the Ames Research Laboratory, California, when Dr. Smith J. DeFrance retires on October 13.

•September 22
Trans World Airlines directors authorize the purchase of 23 Boeing fanjet aircraft at a cost, including spares, of approximately $160,000,000.

Lieutenant General James H. Doolittle (USAF, Ret.) is elected vice chairman of the board of trustees and chairman of the executive committee of Aerospace Corporation.

Ling-Temco-Vought, Dallas, Texas, is selected by NASA to negotiate a contract to provide engineering support services at White Sands Test Facility, New Mexico. The facility is used to test propulsion systems of Apollo modules.

•September 23
Lockheed-California Company announces it will flight test a prototype supersonic combustion ramjet (Scramjet) engine in a research program sponsored by the USAF. The Scramjet will by mounted atop a rocket booster for the test.

•September 25
Aerojet-General's 260-inch solid rocket engine is static fired and generates a peak thrust of 3,570,000 pounds.

•September 26
NASA's Relay II communications satellite launched January 21, 1964, makes its final demonstration for the opening of a textile exposition in Atlantic City. The Mojave Tracking Station, only U. S. ground station able to send and receive via relay, is being closed down to be modified for use in the Application Technology Satellite program.

•September 27
The Navy's new A-7A Corsair makes its first flight at the Ling-Temco-Vought facility near Dallas.

First flight model S-IC booster stage for Saturn V is rolled out at Marshall Space Flight Center, Huntsville, Alabama. After static tests it will be shipped to Cape Kennedy to prepare for launching of the first Saturn V/Apollo combination.

•September 29
J. R. Dempsey resigns as president of the Convair Division of General Dynamics. He is replaced by Jack L. Bowers as general manager of the division.

•September 30
Ceremonies honoring departing Air Force Secretary Eugene M. Zuckert—including a fly-by of late model USAF aircraft—are conducted at the Pentagon. Zuckert is being succeeded by Dr. Harold Brown.

Defense Secretary Robert McNamara announces that Lockheed Aircraft Corporation has been selected to develop and produce the C-5A heavy logistics transport—a $2,000,000,000 program.

OCTOBER

•October 1
Robert H. Charles, Assistant Air Force Secretary for Installations and Logistics, announces the Air Force has options to buy up to 115 of the new giant C-5A heavy transports.

•October 7
The first of two OV2 research satellites is launched from Cape Kennedy atop a Titan III-C. The OV2 will assess biological hazards of travel through the Van Allen radiation belt.

New and additional space investigations will keep the X-15 research airplane flying at least through 1968, it is disclosed at the fourth X-15 Technical Conference at Edwards AFB, California.

Comsat Corporation receives a go-ahead from the Federal Communications Commission to construct a ground station in Hawaii.

•October 11
NASA discloses its hypersonic research plans call for a delta-wing configuration of the X-15 airplane.

•October 12
FAA estimates a market potential for the supersonic transport at between 400 and 800 aircraft, according to testimony before the House Appropriations Committee released today.

An Air Transport Association survey shows U. S. airlines have ordered 704 new turbojet and turboprop aircraft worth more than $3,700,000,000 for delivery between 1965 and 1969.

•October 14

OGO II, second polar Orbiting Geophysical Observatory, is launched successfully from Vandenberg AFB.

Douglas Aircraft Company unveils a business version of its DC-9 transport at the National Business Aircraft Association convention in Los Angeles.

•October 15

Major General James McCormack USAF (Ret.), is elected chairman and chief executive officer of the Communications Satellite Corporation, effective December 1.

Second test launch of the USAF's Titan III-C is conducted successfully at Cape Kennedy.

Lockheed-Georgia Company dedicates its new $3,500,000 research laboratory at Marietta, Georgia.

Major General Don R. Ostrander, head of the Air Force Office of Aerospace Research, retires after 28 years' service. He is succeeded by Brigadier General Ernest A. Pinson, deputy commander of OAR.

•October 19

The FAA reports operating costs of U. S. jet passenger transports declined for four years and in 1964 stabilized at close to 1963 levels. Cost for four-engine jets averaged 1.5 cents per seat mile.

The USAF announces that the XB-70 has exceeded Mach 3 for the first time. The speed was registered in a 1,900-mile circular flight from Edwards AFB lasting one hour, 43 minutes.

The Military Air Transport Service (MATS) announces it airlifted almost 50 million pounds of cargo and 95,000 passengers, across the Pacific during July, August and September—a new record.

•October 21

General Curtis E. LeMay, who retired recently as U. S. Air Force Chief of Staff, is presented the Collier Trophy, one of aviation's highest honors.

•October 25

Gemini 6 is scrubbed after the modified Agena space vehicle—scheduled for a docking maneuver in space—fails to orbit.

•October 26

Kraft Ehricke, pioneer rocket and space scientist, is named assistant director of astrionics at North American Aviation, Inc., Autonetics Division. He formerly was director of advanced studies at General Dynamics.

NASA announces that in view of yesterday's failure of GT-6 it will advance the date of GT-7, originally scheduled for the first quarter of 1966.

•October 28

Thirty-seven representatives of the International Air Transport Association, meeting in Vienna, reach agreement permitting the showing of movies aboard airliners. The decision is subject to ratification by all 84 IATA members.

NASA and the White House announce that GT-6 and GT-7 will be combined and will attempt a space rendezvous with each other.

NOVEMBER

•November 1

Gemini 7 Astronauts Frank Borman and James Lovell disclose at a press briefing in Houston that they will doff their space suits for 10 days during their two-week space mission. The astronauts also will be subjected to numerous medical tests and experiments during the flight.

•November 2

The Navy unveils the new Ling-Temco-Vought A-7A Corsair II in Dallas. The aircraft, flown 26 days ahead of schedule, is a heavily armed subsonic "truck" capable of carrying 20,000 pounds of weapons.

North American Aviation, Inc., successfully conducts a one-man paraglider flight. A two-man flight is expected to be attempted soon, the company says.

•November 3

Lockheed-California Company is announced the winner in the Army's Advanced Aerial Fire Support System (AAFSS) competition.

•November 6

A blinking beacon satellite, the GEOS-I Geodetic Explorer, is orbited from Cape Kennedy by the new thrust-augmented (fat tank) Delta launch vehicle. The new Delta is capable of putting a 1,400-pound payload in earth orbit, as compared with the 800-pound capability of earlier models. The GEOS satellite will be used as a precision marker in space to aid scientists to more accurately map the earth.

•November 8

A $22,000,000 follow-on contract is awarded Avco Corporation to fabricate ablative heat shield material for Apollo spacecraft. The heat shield will protect the three astronauts from fiery temperatures encountered when the vehicle re-enters the earth's atmosphere.

Dr. Harry A. Goett, former director of NASA's Goddard Space Flight Center, begins new duties as director of advanced technology for plans and programs at the Western Development Laboratories of Philco Corporation.

Frederick H. Rohr, 69, veteran aerospace executive and chairman and chief executive officer of the Rohr Corporation, dies of a stroke.

•November 11

The Federal Communications Commission authorizes the Comsat Corporation to construct four communications satellites for use with the Apollo Project.

•November 12

The fourth of the USAF's Stellar Acquisition Feasibility Flight (STAFF) is launched from Cape Kennedy by a Polaris A-1 launch vehicle.

•November 14

First round-the-world polar flight starts from Palm Springs, California. A Boeing 707 jetliner is carrying a group of scientists on the 27,000-mile flight.

The USAF discloses that the venerable DC-3 (C-47) is being used as a fighter in Viet Nam. A squadron of 16 aircraft—vintage 1933—are armed with three "minigun" pods.

●November 16
NASA fires the first of two sounding rockets from the White Sands Missile Range in an effort to capture some of the meteoroids from the current annual Leonid shower. The second rocket will be fired November 17.

●November 17
The Army awards a contract to Hughes Tool Company for preliminary design for a hot cycle helicopter that converts in flight to a 400-mile an hour jet airplane.

The first round-the-world polar flight ends at Burbank, California, claiming five new world records: fastest time from pole to pole, around the world, Honolulu to London, Buenos Aires to Christchurch, and Christchurch to Honolulu.

●November 18
A Naval Research Laboratory solar monitoring satellite is launched from Wallops Island, Virginia. Known as the IQSY (International Quiet Sun Year) Solar Explorer, the satellite will measure solar X-ray emissions.

●November 19
The Army announces that its Sprint antimissile missile has been launched successfully from an underground cell at White Sands Missile Range.

●November 22
Lockheed-Georgia Company, prime contractor for the world's biggest airplane—the C-5A—tells 25 top aviation firms bidding for subcontracts on the project that the "total package" concept will be carried through the subcontractor level. Under the concept each contractor submits a price for development, production and support of his product.

●November 23
The Defense Department announces that Lockheed Aircraft Corporation heads the list of DOD prime contractors for the fourth consecutive year.

NASA asks industry to submit proposals for a study of the possibility of building a space satellite able to broadcast directly to home or short wave radios.

●November 24
Comsat Corporation awards a $11,700,000 contract to Hughes Aircraft Company to build four new communications satellites which will link two-thirds of the world by telephone and television. The new satellites also will provide voice contact between the Apollo moon astronauts and ground stations.

●November 28
Two scientific satellites—a Canadian Alouette and a U. S. Direct Measurements Explorer (DME-A)—are put into polar orbits from Vandenberg AFB by a single Thor-Agena B. The double launch project, known as ISIS-X, is the first in a cooperative program for International Satellites for Ionospheric Studies.

●November 29
Delta Air Lines puts first certificated Douglas DC-9 in service as an extra section to its Atlanta-Memphis-Kansas City flight.

●November 30
The Airways Club, organization of regular air travelers, announces that a survey discloses slightly over 50 percent of airlines passengers do not want inflight movies or recorded music.

DECEMBER

●December 2
Dr. Hugh L. Dryden, Deputy Administrator of the National Aeronautics and Space Administration, dies of cancer.

President Johnson announces appointment of Dr. Finn J. Larsen, corporate vice president of Honeywell Inc., as Principal Deputy of Defense Research and Engineering.

●December 4
Gemini 7, carrying astronauts Frank Borman and James Lovell, launched from Cape Kennedy to start record-breaking 14-day mission.

●December 8
NASA completes the sixth and last test of the Apollo launch escape system at White Sands Missile Range.

●December 10
Defense Secretary McNamara announces plans for development and production of a bomber version of the General Dynamics F-111 fighter.

NASA announces cancellation of the Advanced Orbiting Solar Observatory, which was to have been operational in 1969.

●December 12
Dr. William Randolph Lovelace, president of the Lovelace Foundation in Albuquerque, New Mexico, and director of space medicine for NASA, is killed in a plane crash near Aspen, Colorado.

●December 14
Lockheed Propulsion Company fires the first flight prototype of its 156-inch diameter solid propellant rocket's stage one. At the company's Petrero, California facility, the motor developed 3,000,000 pounds thrust for one minute.

●December 15
Gemini 6, with astronauts Walter Schirra and Thomas Stafford aboard, is launched. Later, Gemini 6 "catches up" with Gemini 7 and the pair effect the world's first space rendezvous, coming as close as three feet.

●December 16
Gemini 6 lands.

●December 18
Gemini 7 lands after 330 hours and 35 minutes in space. The record flight gave the U. S. a total of 1,352 man-hours in space as compared with 507 man-hours for the Soviet Union.

●December 20
The Navy starts sea trials of the *USS Brooke*, first of a new class of guided missile escort carriers, three of which are to be built by Lockheed Shipbuilding and Construction Company. The ships are armed with Tartar missiles, Asroc ASW weapons and the DASH drone helicopter.

●December 21
Tital III-C launch vehicle, built by Martin Company, launches four satellites simultaneously. Malfunction of transtage causes loss of OV2-3 environment sensor, but LES-3 and LES-4 advance comsat technique explorers and a ham radio satellite go into orbit.

BEHIND TODAY'S ACCOMPLISHMENTS OF

Beech "Imaginuity"

...A BROAD RANGE OF FAST-GROWING CAPABILITIES FOR TOMORROW

Long known for its achievements as a producer of outstanding aircraft for corporate, personal and military use, Beech Aircraft Corporation is a leader today in many areas of activity. Beech capabilities now include nearly the entire spectrum of research, development and manufacture in aircraft, flight equipment, aerospace and related fields. The wide range of Beech capabilities is illustrated by Beech activities in such fields as...

• **Business Aircraft.** Beginning with the first Beechcraft ever built, Beechcraft airplanes have always been meticulously engineered for the most desirable combination of quality, comfort, usefulness, efficiency and performance. Today, there are 15 different Beechcraft models available. These extend from the speedy pressurized twin-turboprop Beechcraft King Air which seats 7 to 10 people, to the popular single-engine Beechcraft "3 Musketeers" which offer 3 power choices and seating for 2 or 4 people.

• **Military Aircraft.** Since 1940, Beech off-the-shelf airplanes have continuously served military aviation needs. Virtually every U. S. Navy and U. S. Air Force pilot, and pilots of eleven other nations, receive their primary flight training in the Beechcraft T-34 Mentor. For the U. S. Army, Beech now builds the T-42A instrument trainer (the military version of the famous Beechcraft Baron) and the versatile U-8 series of Mission Support Transports.

• **Aircraft Assemblies.** A long list of military aircraft have vital components built by Beech. Four of these aircraft are shown on the following two pages.

• **Target Missile Systems.** Beech has designed *and produced* a complete family of target missile systems, for a wide variety of defense training missions, with speeds from Mach .52 to Mach 3 – with altitude capabilities from sea level to 90,000 feet. Beech is now conducting feasibility studies beyond Mach 7 and at orbital altitudes.

• **Cryogenics for Aerospace.** A pioneer in cryogenics, Beech is fulfilling vital responsibilities in connection with the Gemini, Apollo and LEM spacecraft. These responsibilities, too, are briefly described on the following two pages. One Beech accomplishment is especially noteworthy – a "breakthrough" in Flight-Weight Thermal Protection Systems, which will be applied to the cryogenics storage subsystems of the Apollo spacecraft. The new Beech system provides significantly better thermal protection while reducing insulation weight by 75% of original project specifications.

• **R&D and Testing.** Whether a project involves electronics, fluids or metallurgy; 100 G's of acceleration or the operating environment of outer space; the handling of liquid helium at minus 452° F or transient heat to 1,500° F, Beech has capabilities and facilities to deal with it.

• **Management.** Beech also offers complete systems management capabilities which have been tested and proved through a wide variety of assignments in many diverse areas.

Added to all this is Beech "Imaginuity" – perhaps the greatest capability of them all. It's the creative imagination to penetrate to the heart of a problem that didn't even exist yesterday – plus the knowledge, talent and ingenuity required for a satisfactory solution.

Whatever field your project may involve, it will pay you to "take a look at Beech." We will be happy to discuss with you how we may put Beech capabilities to work for you.

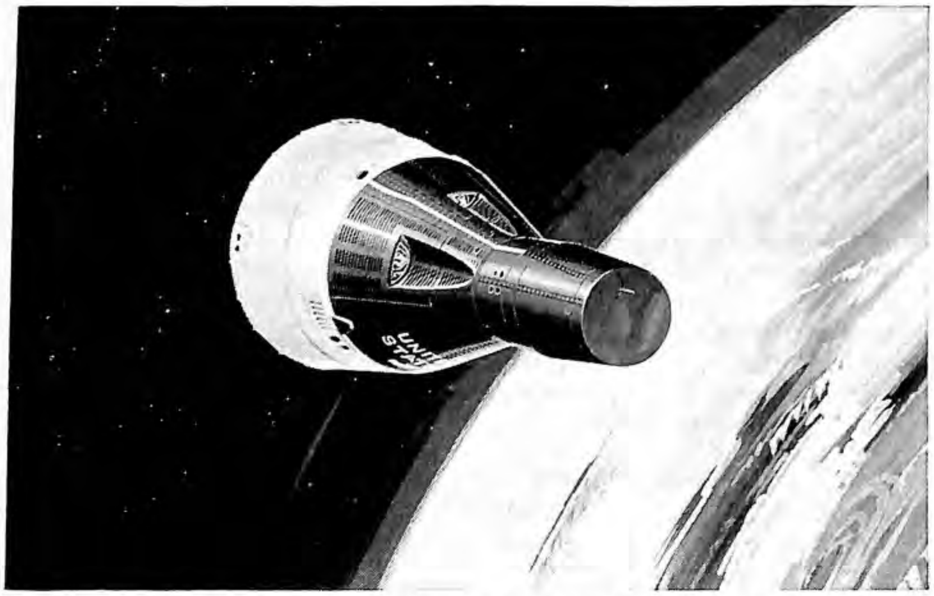
Beech *Aerospace Division*

BEECH AIRCRAFT CORPORATION • WICHITA, KANSAS 67201

BEECH "IMAGINUITY" AT WORK:

For Lockheed, Beech builds several wing sections, nose landing gear doors and emergency exit doors for the huge new U. S. Air Force C-141A "StarLifter" turbofan jet transport. This massive military cargo aircraft has speeds up to 550 mph.

For McDonnell, Beech builds wing sections, flaps, ailerons, speed brakes, spoilers, landing gear doors and nose gear doors for the 1,500 mph Navy/USAF "Phantom II" jet fighter, considered one of the most versatile fighter-bomber-interceptors ever built.

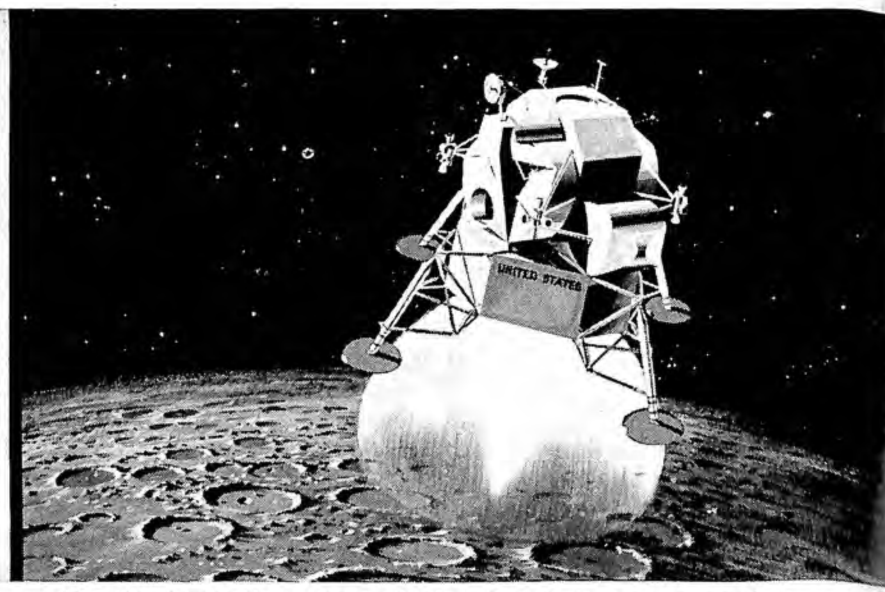


For NASA's Project Gemini, Beech was chosen by McDonnell to design, develop and build the ground support equipment that supplies liquid hydrogen and liquid oxygen for the reactant supply system and the environmental control system aboard the Gemini spacecraft. Beech equipment is used at 11 vital points.

MAY WE BE YOUR "PARTNER", TOO?

Beech's facilities, people and experience are ready now for you to use as your own on vital projects of any size.

The U. S. Air Force F-105 "Thunderchief" jet fighter-bomber, which can deliver weapons at twice the speed of sound, flies on Beech-built ailerons and aft fuselage assemblies. Beech has built major components for virtually every Century-series fighter.



For the LEM, Grumman selected Beech to assure complete systems responsibility for the design, development, fabrication, and testing of equipment required for storage, transfer, and loading of liquid helium – used aboard LEM to pressurize propellant tanks to assure proper flow in weightless environment.

For Bell, Beech builds metal bonded fuselage panels which contribute to the exceptional structural strength of the U. S. Air Army HU-1D "Iroquois" jet-powered helicopter. One of the fastest and most effective rotary-winged aircraft in our military services, the "Iroquois" also has Air Force and Marine use.

Chosen by North American to develop and build the Cryogenic Storage Subsystem to supply "shirtsleeves" atmosphere to the astronauts and generate electrical power for the Apollo command module. A cryogenics pioneer, Beech has made vital contributions in weight reduction and mission duration for space vehicles.

On these pages are just a few examples of how Beech's broad range of capabilities help many of America's leading prime contractors fulfill their responsibilities for vital military and aerospace projects.

Beech's extensive experience since the early days of World War II in meeting prime contractor's requirements ...Beech's reputation as a developer of new techniques ...and Beech's extensive facilities...have earned the respect of such outstanding industry leaders as Bell, Convair, Lockheed, McDonnell, North American, Republic, and others.

In addition, Beech has the ability to assume complete systems management responsibility for a wide range of space-age projects. An example is the U. S. Navy AQM-37A missile target system—the *first* missile target system to match the performance of the fastest enemy jets. A Beech project from concept to hardware, it is also the first supersonic target system ever to be designed, developed, tested and put into production by *one* company.

Among other special advantages that make Beech a preferred choice for any type of assignment are:

- **Unusually quick adaptability** to your processes and systems. No wasteful "break in" period while we learn. In fact, Beech so closely synchronizes with your own operation that it's almost like having another highly capable division of your own...overnight!
- **Immediate "go to work" capability.** Beech has pioneered in the development of new techniques of manufacture and is capable of applying them to your projects "right now." For example:

1. The forming and welding of titanium and other exotic metals—a relatively new field in which Beech is an "old hand."

2. Beech helped pioneer chemical milling methods for aluminum and stainless steel. This enables large and complex shapes to be milled more accurately and economically than by conventional methods.

3. Metal bonding facilities are outstanding at Beech—and experienced Beech craftsmen have exceptional capabilities in this field.

Beech "Imaginuity" in research, development and technical fabrication is already being utilized by leading prime contractors on many of today's military and aerospace projects.

Beech Aerospace Division projects include R & D on manned aircraft; missile target and reconnaissance systems; complete missile systems; space systems management; programs pertaining to liquid hydrogen propellants and cryogenic tankage systems; environmental testing of missile systems and components; and GSE.

The facilities, personnel and experience of Beech are at your disposal. A large staff of engineers, designers and technical specialists are ready for important assignments of any size.

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.

Beech *Aerospace Division*

BEECH AIRCRAFT CORPORATION • WICHITA, KANSAS 67201

HELPING BUSINESS GROW FASTER. Only Beechcraft offers such a complete line of planes with so much speed, range, comfort and quiet to help business multiply the money-making decisions that each top man can make. That's how thousands of Beechcrafts have paid for themselves.

EXECUTIVES: Write today for free booklet, "Answers To The 19 Most Asked Questions About Business Flying." It could point the way to major new profits for your company. Address Beech Aircraft Corp., Marketing Services, Wichita, Kansas 67201, U. S. A.

Beechcraft's General Office at Plant I in Wichita, Kansas.

Beechcraft's Plant I production facility at Wichita.

Extensive Beech facilities include 2,000,000 sq. feet of plant production, research and development areas

REFLECTING the steady growth of Beech Aircraft Corporation, are three major plants located at Wichita along with the company's general offices and landing facilities. Other Beech engineering and manufacturing facilities are located at Liberal, Kansas and at Boulder, Colorado.

Also at Boulder, Beech has space environment simulation facilities that are among the finest and most advanced in industry. Environments that may be simulated include vibration, vacuum, shock, acceleration, gravity forces, temperature extremes, and solar radiation.

In addition to its physical facilities, Beechcraft has more than 8,000 employees with a wide range of space age skills.

Beech is ready—and able—to accept new project responsibilities now. May we help you? Write, wire or phone Contract Administration, Beech Aircraft Corporation, Wichita, Kansas 67201.

Beechcraft Plant II production facility, located at Wichita.

Beechcraft Plant III, home of Beech Aerospace Division at Wichita.

Beech Aerospace Division

BEECH AIRCRAFT CORPORATION • WICHITA, KANSAS 67201

Boulder Division administration and engineering building, hub of Beech's space R&D operations.

Beech has a wide range of sophisticated testing equipment at Boulder.

Part of the 1,230,000 square feet of production area at Beechcraft's Wichita Plant I. Shown in production are Beechcraft King Airs, Queen Airs and Super H18's.

What we do.

Aerial Target Systems
Rocket-powered drone aircraft; propeller-driven drones; scoring systems; command and data link components research; altitude control systems.

Aeronautical Research
Laminar Flow Control; subsonic, supersonic, and hypersonic environments; vertical take-off and landing aircraft; instrumentation; vehicle flight dynamics; structural dynamics; vehicle flight controls.

Architectural Systems
Window walls; pre-stressed entrance doors; store fronts; aluminum and other decorative architectural metals; sunshade control systems.

Automatic Test and Checkout Equipment
Tape-controlled and computer-controlled automatic checkout systems for missiles, spacecraft, radar, ultra high frequency communications, inertial guidance, propulsion, fire control, and reconnaissance, navigation, defensive and strategic aircraft, and naval combat vessels.

Chemicals
Propellants, explosives, pyrotechnics, commercial chemicals.

Combat Surveillance Systems
Propeller-driven, autogyro, and turboprop drones.

Communications Systems
Intercontinental tropospheric and ionospheric scatter systems; ring antennas; microwave, VHF systems; antenna research; relay stations; telecommunications networks; traffic analysis; site survey and selection; construction, installation, operation; maintenance; training; satellite terminals.

Computers
Analog, digital, airborne stabilization and pre-launch computers; special purpose computers; airborne general purpose computers; solid-state electronics research; thin-film microcircuit development.

Countermeasures and Ordnance Systems
Explosive ordnance research; chaff rockets; rocket launchers; Hawk missile launcher; aerial delivery and dispensing systems; advanced anti-personnel munitions; penetration aids.

Electronic and Electromechanical Systems and Equipment
Aircraft and spacecraft air data sensors; voice warning systems; high-noise environment communication systems; automatic flight stability systems; remote handling devices; pressure switches; frequency meters; servos.

Ground Support Equipment
Multi-purpose ordnance vehicles; aircraft equipment carts.

Guidance, Tracking, and Navigation Systems
Astro-inertial guidance systems; ships inertial navigation systems; advanced inertial platforms; space vehicle guidance and control electronics; precision Vidicon tracker; long-range VLF navigation system components; tracking and sensor systems research; daytime star-tracking.

Industrial Equipment
Electro-mechanical equipment for industrial process and control in fiber, textile, and plastics industries.

Inertial Systems and Components
Rate and integrating gyroscopes and accelerometers; stabilized platforms; gas-bearing gyros; precision miniature gyros.

International Activities
Product licensing; overseas investments; marketing programs; market surveys; Organization for Development Assistance Programs (ORDAP): Operations research, systems analysis and management science support to military planning, national development, and industrial operations.

Life Sciences
Bioastronautics; biochemistry; biodynamics; behavioral sciences; human engineering; biotechnology.

Management Systems
Performance and Cost Evaluation (PACE); Integrated Management Systems (Automated Operations Control; Automated Material, Logistics, and Production Planning Systems); Value Analysis; Target Cost; Quality Assurance; Procurement Control; Integrated Cost Control.

Manned Aircraft
Supersonic trainers; supersonic tactical fighters; combat trainers; Laminar Flow Control demonstration aircraft; V/STOL development.

Marine Equipment
Ships automation systems; anti-submarine warfare command and control systems; periscopes and periscope drive systems; automatic plotting equipment; radiometric sextant; navigation monitor systems; shipborne gyro stabilizers and stabilization computers; speed and indicating systems; hydrostatic bearings; oceanography and underseas technology.

Materials Research and Fabrication Techniques
Plastics; reinforced plastics; honeycomb; titanium; brazing; bonding; welding; steel and beryllium extrusions.

Missile Systems
Air-to-ground missiles; sea-launch concepts research; missile structures; instrumentation systems; tactical ballistic missile research; trajectory optimization; supersonic and hypersonic flow field analysis.

Nuclear Sciences
Transient radiation effects; radiochemistry; space radiation research; research reactor operation; nuclear materials handling equipment.

Optical Systems
Command and control display systems; rangefinding, sighting, and tracking instruments; stereometric comparison viewers; viewer-computers; ballistic cameras; precision information display projectors; photogrammetric systems; ultra violet systems.

Physical Sciences
Theoretical physics; plasma physics (diagnostics, acceleration, and power generation); electro-magnetics; space materials research (sealants and structures; meteoroid impact protection; spacecraft materials and fabrication); zero-gravity research; planetary physics and chemistry; geophysical research.

Precision Mounts and Directors
Multi-mode tracking mounts; launch phase simulator; tracking and antenna mounts.

Propulsion Systems
Development and production of propulsion systems and subsystems; controllable solid rockets.

Recovery, Escape, Survival, Re-Entry and Landing Systems
Manned satellite and spacecraft landing systems; re-entry test vehicle recovery and flotation system; escape capsule parachutes; brake parachutes; spacecraft retrorocket landing decelerator; controlled descent parachutes; location aids.

Space Systems Development
Advanced systems and subsystems (propulsion, power, thermal control, structures, and support equipment) design and integration; space environment simulation and analysis; lunar, cislunar, and interplanetary spacecraft research; satellite research.

Subcontract Production
KC-135, Boeing 707 and 720 outer wing and aft fuselage panels and subassemblies; B-70 brazed panels; industrial metal fabrication.

Support Services
Missile site activation; space center support; test range support; complete target flight operation and maintenance; operations and systems analysis; engineering services.

Underseas Services and Equipment
Communications cables; underwater communications networks; underwater repeaters; surveying, cable laying, and maintenance.

Where we do it.

DIVISIONS, ORGANIZATIONS, FACILITIES

Northrop Corporation 9744 Wilshire Boulevard, Beverly Hills, California 90212 *(Corporate Offices)* *(Area Code 213)* 274-8061

Northrop International Division 9744 Wilshire Boulevard, Beverly Hills, California 90212 *(Area Code 213)* 274-8061

Northrop Norair Division 3901 West Broadway, Hawthorne, California 90250 *(Area Code 213)* 675-4611

Flight Test Facility, P.O. Box 278, Edwards, California 93523 *(Area Code 805)* 258-2111

Production Flight Facility, P.O. Box 215, Palmdale, California 93550 *(Area Code 805)* 947-5611

Materiel Facility, 2031 E. Mariposa Avenue, El Segundo, California 90245 *(Area Code 213)* 678-0411

Northrop Space Laboratories, 3401 West Broadway, Hawthorne, California 90250 *(Area Code 213)* 675-4611

Northrop Space Laboratories, Huntsville Department, 6025 Technology Drive, P.O. Box 1484, Huntsville, Alabama 35805 *(Area Code 205)* 837-0580

Northrop Nortronics Division 1 Research Park, Palos Verdes Peninsula, California 90274 *(Area Code 213)* 772-2321

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500 East Orangethorpe Ave., Anaheim, California 92801 *(Area Code 714)* 871-5000

Applied Research Department, 2323 Teller Road, Newbury Park, California 91320 *(Area Code 805)* 498-4531

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Precision Products Department, 100 Morse Street, Norwood, Massachusetts 02062 *(Area Code 617)* 762-5300

Northrop Ventura Division 1515 Rancho Conejo Boulevard, Newbury Park, California 91320 *(Area Code 805)* 498-3131

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Central Regional Office 349 West First Street, Dayton, Ohio 45402 *(Area Code 513)* 222-8606

Southeastern Regional Office Holiday Office Center, Suite 39, 3322 Memorial Parkway, S.W., Huntsville, Alabama 35801 *(Area Code 205)* 881-2141

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Houston District Office 1730 NASA Boulevard, Houston, Texas 77058 *(Area Code 713)* 928-5476, 929-2560

Huntsville District Office Holiday Office Center, Suite 39, 3322 Memorial Parkway, S.W., Huntsville, Alabama 35801 *(Area Code 205)* 881-2141

Rocky Mountain District Office Swanson Building, Suite 17, 8401 West Dodge Road, Omaha, Nebraska 68114 *(Area Code 402)* 391-7474

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Northrop Architectural Systems 999 South Hatcher, City of Industry, California 91745 *(Area Code 213)* 686-1950, 964-6511

Pacific Curtainwall, Inc. 600 West 15 Street, Long Beach, California 90813 *(Area Code 213)* 775-1752

Northrop Carolina, Inc. P.O. Box 3049, Asheville, North Carolina 28802 *(Area Code 704)* 298-7941

Page Communications Engineers, Inc. 3300 Whitehaven Street, N.W., Washington, D.C. 20007 *(Area Code 202)* 337-7600

Northrop/SA 12 bis Place St. Francois, Lausanne, Switzerland *Phone:* 23.66.22

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Société d'Etudes et de Préfabrication 1 Rue des Lilas, Genlis (Cote d'Or), France *Phone:* 34.70.86

Construcciones Aeronauticas, S.A. Calle del Rey Francisco, 4, Madrid 8, Spain *Phone:* 24.72.500

Edison-Page S.p.A. Via Liszt (EUR), Rome, Italy *Phone:* 59.44.41

Shinko-Northrop Company, Ltd. Yokohama-Ginko Building, No. 2, 2-chome, Nihonbashi-Edobashi, Chuo-ko Tokyo, Japan *Phone:* 271-1431

NORTHROP

High-voltage cable test laboratory

ABC³

A-7A Corsair II

Ling Altec "Giant Voice" speakers

THE HORIZON IS WHERE WE PUT IT

. . . And our horizon is never at our elbows.

A highly diversified, advanced-technology company, Ling-Temco-Vought, Inc., is engaged in the design, development and fabrication of numerous products in such vital fields as aeronautics, missiles and space, electronics, acoustics and high-power electrical wire and cable.

Planned for growth and flexibility, LTV consists of four major subsidiaries. Three of these — LTV Aerospace Corporation, LTV Electrosystems, Inc., and LTV Ling Altec, Inc. — were formed late in 1964 as part of "Project Redeployment," a dramatic move undertaken by LTV to further advance it to a greater leadership position in today's swift-moving electronics/aerospace industry. Through Project Redeployment, 11 experienced operating divisions were consolidated into three strong publicly owned subsidiaries in which LTV holds a substantial interest. The fourth subsidiary, The Okonite Company, an established leader in the field of electric wire and cable, was acquired in 1966 by the purchase of its assets and is wholly owned by LTV.

Project Redeployment is a continuing program within LTV. Subsequent phases will lead to further selective acquisitions by LTV that will add both financial and technical strength, and at the same time, combine with growth performance from within — to further shape the destiny of LTV.

At sea, on land, in the air and in outer space, LTV forges ahead — meeting problems with startling new concepts . . . challenge with innovation. The super-power NATO fleet communications station near Anthorn, England . . . the installation of 245 modulators for Stanford University's two-mile long atomic particle accelerator . . . Pacific missile range operations and management . . . rocket-powered SCOUT launch vehicles for NASA and DOD . . . A-7A *Corsair II*, the Navy's new light attack aircraft . . . ABC³ — Airborne Battlefield Command and Control Center. . .display systems that graphically chart NASA spacecraft . . . electronic shipboard instrumentation for Apollo Re-Entry Ships . . . astronaut maneuvering units (AMU) for the Air Force . . . XM561 high-mobility vehicles designed to go anywhere the Army fights . . . LANCE, the Army's newest battlefield missile . . . XC-142A tri-service transport, the world's largest flying V/STOL. These brief descriptions highlight only a few of the diverse products and activities in which LTV is engaged today.

To meet the needs of tomorrow, LTV invests substantially in Research and Development. At its corporate LTV Research Center and in each of its subsidiaries, scientists, engineers and technicians are charged daily with the challenging task of forging their own and the company's future.

LING-TEMCO-VOUGHT, INC.
DALLAS, TEXAS

LTV COMPUTER CENTER
ARLINGTON, TEXAS

LTV RESEARCH CENTER
DALLAS, TEXAS ANAHEIM, CALIF.
HONOLULU, HAWAII

LTV AEROSPACE CORPORATION
A Subsidiary of Ling-Temco-Vought, Inc.

LTV Aerospace Corporation is engaged primarily in the design, development and production of aircraft, missiles, space maneuvering systems, ground vehicles, management of range and launch operations and providing support services. It is composed of four divisions—Vought Aeronautics, Astronautics, Michigan and Range Systems — and one subsidiary, Kentron Hawaii, Ltd. Customers include the major military services and NASA. Corporate headquarters: Dallas.

LTV ELECTROSYSTEMS, INC.
A Subsidiary of Ling-Temco-Vought, Inc.

LTV Electrosystems, Inc., is a primary source for total capability in many vital phases of defense electronics, including reconnaissance and surveillance systems; command and control systems; high-power radar and radio; information display systems; commercial radio transmitters, and guidance systems. Facilities: Dallas, Garland, Greenville and Arlington, Texas; Greenville, S.C. Corporate headquarters: Greenville, Texas.

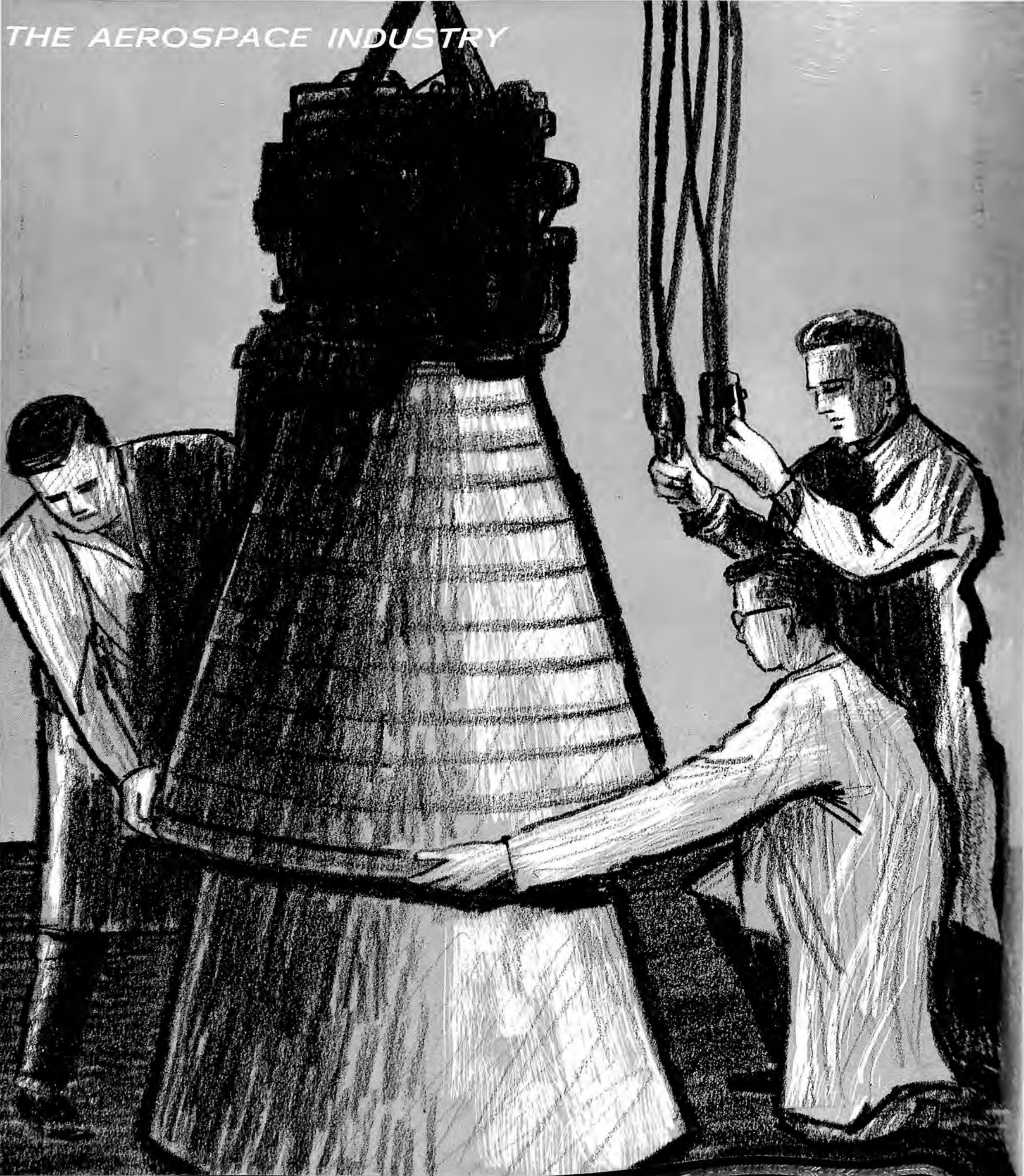
LTV LING ALTEC, INC.
A Subsidiary of Ling-Temco-Vought, Inc.

Composed of four divisions — Ling Electronics, Altec Lansing, Peerless Products, and University Sound — and two subsidiaries — Altec Service Corp. and Gonset, Inc. — LTV Ling Altec, Inc., is an acknowledged leader in the field of acoustics. Products include vibration test equipment; high-fidelity sound units; commercial sound systems; transformers and modulators. Facilities: Anaheim, Calif.; Oklahoma City, Okla. and Winchester, Mass. Corporate headquarters: Anaheim.

THE OKONITE COMPANY
A Subsidiary of Ling-Temco-Vought, Inc.

The Okonite Company, a wholly owned subsidiary of LTV, is one of the leading developers and manufacturers of high-voltage electrical wire and cable. Its customers include many of the nation's leading power utilities, large industrial companies which install their own power distribution networks, and independent telephone companies. Facilities: Passaic, Paterson and North Brunswick, N. J., and Providence, R. I. Corporate headquarters: Passaic.

THE AEROSPACE INDUSTRY



The aerospace industry, in 1965, achieved new records in such economic categories as sales, backlog and civil aircraft deliveries, and continued to make significant gains along a broad technological front of national defense, space exploration and civil aircraft projects.

Sales and Profits

Industry sales amounted to $20.9 billion, the highest in history, and 1965 marked the third successive year that sales had exceeded $20 billion.

Profits of the industry, as a percentage of sales, reached 3.1 percent, the highest in recent years. This compares with a profit of 5.5 percent for other manufacturing industries.

Sales to the Department of Defense declined 11 percent in 1965, but this was offset by sales increases of 22 percent to the National Aeronautics and Space Administration and 39 percent in commercial aerospace sales.

Exports

Aerospace exports in 1965 amounted to $1.4 billion, a 15.5 percent increase over the previous year. Commercial transport exports accounted for $314,000,000 and other civil aircraft exports $121,000,000; military aircraft amounted to $290,000,000; exports of aircraft engines and parts reached $230,000,000. Aircraft flight instruments, missile engines and a wide variety of ground handling and support equipment for aerospace products accounted for another $162,000,000. This leaves $288,000,000 in a miscellaneous "other" category which includes such items as aircraft landing gear, aircraft engine instruments and other parts and accessories.

Employment and Wages

In December, 1965, the industry employed 1,190,000 persons, a gain of 64,000 over the same month in 1964. Production workers increased to 594,000, accounting for 31,000 of the total gain over 1964. The balance of 33,000 is largely made up of scientists, engineers and technicians, reflecting the technological character of the aerospace industry.

Average weekly earnings in the aerospace industry was $130.32 in 1965 compared with $124.40 in 1964. Average weekly hours increased to 41.3 in 1965 from 40.7 in 1964. Total payroll of the aerospace industry in 1965 was nearly $9 billion, an increase of about $330,000,000 over 1964

Backlog

Backlog of the aerospace industry, at the end of the third quarter of 1965, was $18.6 billion, more than $3 billion higher than 1964. The backlog was made up of $12.3 billion in government orders and $6.3 in commercial orders. The commercial backlog for 1965 was nearly 80 percent higher than it was at the comparable time in 1964.

Capital Expenditures

Expenditures for facilities and equipment in the aerospace industry, which are paid for from earnings, were estimated at $360,000,000 for 1965. However, these expenditures were expected to increase nearly 50 percent in 1966, to $530,000,000.

Commercial Aircraft Deliveries and Orders

The aerospace industry delivered an estimated 12,332 civil aircraft in 1965 valued at about $1.7 billion. This represents an increase of 23 percent in units and 38 percent in value over 1964. Deliveries and value break out to: 232 turbine-powered transports (up 19 percent) valued at $1.13 billion (up 44 percent); 11,700 utility and executive aircraft (up 25 percent) valued at $304,000,000 (up 53 percent); 400 helicopters (down 27 percent).

Industry gains would continue in 1966, according to Karl G. Harr, Jr., President of Aerospace Industries Association, with commercial sales providing the largest increment. He estimated that 1966 sales would exceed $22 billion. He predicted that the 1966 average employment of production workers would be about 1,220,000 with a peak in December of about 1,250,000.

THE AEROSPACE INDUSTRY

AEROJET-GENERAL CORPORATION

While maintaining its traditional position as one of the nation's foremost producers of rocket propulsion systems. Aerojet-General Corporation made great strides in diversification during 1965. Continued vigorous efforts to seek new applications for the skills of its technological staff broadened the company's areas of activities significantly.

In its principal field, a number of noteworthy events in liquid, solid and nuclear rocketry highlighted the Aerojet year:

September brought the spectacularly successful firing of the nation's biggest (80 feet long, 260-inches in diameter) solid rocket motor. It was the first of two identical motors to be tested in a NASA program to determine suitability of very large solid systems for future space launches.

The flawless performance of the Gemini Titan II first and second stage engines which sent a pair of U. S. astronauts into orbit for the first time also marked the debut of Aerojet propulsion in the manned space flight program. By the end of the year, five manned Gemini flights had been completed, and 10 Aerojet engines had powered 10 men through some 10,000,000 miles of orbital flight.

Continued progress on development of NERVA (Nuclear Engine for Rocket Vehicle Application) was demonstrated by successful test results obtained during the year. Aerojet's position in nuclear propulsion was further strengthened by award of a Space Nuclear Propulsion Office contract for design and development of three nozzles for the Phoebus nuclear rocket reactor.

The Air Force announced plans to replace 800 Minuteman I ICBM's with the greatly improved Minuteman II. Aerojet is building the advanced second stage, which is largely responsible for substantial increases in range and payload capabilities of Minuteman II.

The Air Force also chose Aerojet for pre-developmental work on ARES, a concept for a high chamber pressure engine using liquid storable hypergolic propellants.

Advanced rocket propulsion technology from Aerojet research and development projects was demonstrated in such areas as dual thrust and multipulse solids, pulsing hybrids, controlled thrust toroidal solids.

Meanwhile, development and production continued in other major rocket programs such as Polaris, Titan, Delta, Apollo, Sparrow and numerous others.

Army Special Forces officer tries on Aerojet's new light weight armored vest.

A most significant diversification milestone in 1965 was Aerojet's emergence as major producer of torpedoes when the company was selected as prime production contractor for the Navy's Mark 46 antisubmarine torpedo. Fueled by rocket propellant and equipped with highly sophisticated guidance, the Mark 46 can seek out, overtake and destroy the fastest submersibles known to be operating, including nuclear powered submarines.

Investigation of Aerojet's reverse osmosis water purification process was carried on vigorously during 1965, under Department of the Interior programs to perfect the technique. Both the Army and the Navy were conducting pilot programs testing small reverse osmosis systems in the field; Aerojet was exploring commercial applications of the technique.

The State of California chose Aerojet to apply space age systems engineering approaches to the study of socio-economic problems in waste management and in prevention and control of crime and delinquency.

From technology developed to chill infrared systems sensors, Aerojet scientists produced a cryogenic surgical probe which was used successfully for delicate brain operations. In another medically oriented program, the company began work on a computerized mannikin for student training which will realistically simulate symptoms of a human patient.

The quickened tempo of U. S. military actions in Viet Nam generated a heavy demand for increased production and delivery of Aerojet's lightweight armor for protection of Army helicopter crewmen. The armor, of a new composite material, is installed around helicopter seats and in lightweight vests. The company was also called on for stepped-up production of advanced ordnance equipment for the forces in Viet Nam.

Diversification activities were conducted also in such fields as fissiochemistry; radioisotope power systems for ground and underwater applications; systems management for hospitals and laboratories; production and marketing of electrical and electronic equipment for commercial use.

AERONCA MANUFACTURING CORPORATION

During 1965, Aeronca continued to strengthen its "defense products mix" position with new and follow-on production contracts at its three divisions.

A continuing important program during 1965 was the production of brazed stainless steel honeycomb panels for the heat shielf of the Apollo command module. For this program Aeronca is a first tier subcontractor to North American Aviation. To strengthen its position as a major producers of stainless steel honeycomb panels, Aeronca acquired facilities to produce honeycomb core at its Middletown plant, and started fabricating its own stainless steel honeycomb.

In 1965 Aeronca neared completion of three 60-foot diameter antenna systems. Two are under prime contracts from the U. S. Navy for communications, satellite tracking and deep-space research, while the third is a prime contract from NASA.

During the year, development work was done for a fiberglas mine case for the Navy's Mark 57 mine. Production of the mine cases started in the last quarter of the year.

Additional follow-on orders were received for 50 gallon wing tip external fuel tanks and 150 gallon underwing external fuel tanks for the Northrop F-5 airplane. Aeronca also continued production of blast panels and brazed honeycomb stainless steel stabilators for the F4C Phantom II. Follow-on orders for the pylons for the same aircraft were also received. For Boeing's commercial aircraft, Aeronca was producing various airframe assemblies.

At the annual meeting of the Board of Directors in April, 1965, A. G. Handschumacher was elected Chairman of the Board of Directors and Chief Executive Officer of Aeronca.

AEROSPACE CORPORATION

Aerospace Corporation completed five years of technical and scientific endeavor in the national interest contributing to more than 50 programs and projects for the U. S. Air Force in the areas of military space and advanced ballistic missile systems. When formed in 1960, Articles of Incorporation of the company set forth its purpose ". . . to engage in, assist and contribute to the support of scientific activities and projects for, and to perform and engage in research, development and advisory services to or for, the United States Government." To facilitate success in this mission, the company was set up as a nonprofit corporation, under the supervision of a Board of Trustees made up of distinguished, public-spirited citizens.

During 1965, the fiscal and management policy and control of Aerospace Corporation was studied by the Subcommittee for Special Investigations of the Committee on Armed Services of the House of Representatives. Hearings were held in May, and in August the Subcommittee issued its report containing recommendations on ways for the Corporation to increase its administrative efficiency and fiscal control. The Board of Trustees and corporate management are studying the report most carefully, and are continuing to work with the Air Force in reviewing management policies and fiscal controls.

During the hearings and again when the report was issued, the Air Force commented on the role of the company. "The continued need for the unique capabilities represented by the Aerospace Corporation has been reemphasized and revalidated many times over by events subsequent to its formation . . . the objectivity and across-the-board technical competence of Aerospace are more essential than ever," said General B. A. Schriever, Commander of the Air Force Systems Command. He continued: "It is essential that the combined talents of a broad spectrum of this country's scientific-industry capabilities be brought to bear on such an undertaking (as the Manned Orbiting Laboratory). No single company has the know-how for such a program. The Aerospace Corporation provides the vital link between the Air Force and the scientific and industrial organization—it is the center or hub of these widespread, tremendously complex technical efforts."

In the MOL program, during 1965, Aerospace Corporation aided in formulation of general specifications for the system and decisions regarding types of experiments to be performed. The company will serve as general systems engineer and technical director during future phases of the program, and it also has responsibilities for the man-rating of the Gemini Titan II booster and the pilot safety program, an outgrowth of similar duties in Project Mercury.

Other programs on which Aerospace Corporation was active in 1965 include: the Titan III family of versatile, powerful boosters; Atlas and Thor Standard Launch Vehicles; the Advanced Ballistic Reentry Systems program; re-entry systems for Minuteman; the Spacecraft Technology and Advanced Re-entry Tests (START) program; and the Stellar Acquisition Feasibility Flight (STAFF) program. Among satellite systems on which corporate scientists and engineers were concentrating efforts were the Vela Nuclear Detection Satellites and an experimental Defense Communications Satellite Program.

Aerospace Corporation planners were working in the areas of future launch vehicles, large solid rocket motors and advanced ballistic missile concepts.

In order to contribute to the Nation's scientific progress and to maintain the Corporation's ability to assess the potential of the latest discoveries, the company maintained active research and experimentation programs in fields pertinent to ballistic missile and space systems. These include: work on properties of the space environment, flying experiments "piggy-back" on various Air Force satellites; evolution of ground test devices to help develop maneuvering lifting-body vehicles; and experiments with millimeter waves advancing toward practical use of this little exploited region of the radio frequency spectrum.

At year-end, the company employed some 400 persons, including approximately 1800 scientists and engineers. Company general offices and its El Segundo Technical Operations and Laboratory Operations are in El Segundo, California, adjacent to Los Angeles International Airport. Another major installation is the San Bernardino (California) Operations located in that city. Field offices are maintained at the three national missile test ranges and in the nation's capital.

ALLISON DIVISION OF GENERAL MOTORS

Marking its 50th anniversary and starting production of the T63 turboshaft engine for the Army's new Light Observation Helicopter were two of 1965's major milestones for the Allison Division of General Motors. At the same time, Allison reported a substantial gain in sales of the larger military and commercial gas turbine aircraft and industrial engines. Significant advances also were reported in the development of regenerative engines and lightweight lift and lift-cruise gas turbines.

To speed all phases of design and development as well as production and to reduce costs wherever possible, Allison inaugurated a hardhitting Zero Defects program built around the concept of doing every job right the first time.

Production of the T63-A-5A for the Army's Hughes OH-6A Light Observation Helicopter started in November under an initial $4.4 million contract. Combined military and commercial production was expected to reach 100 engines a month by early 1967. This same 317-horsepower, 136-pound engine that produces 2.3 horsepower for each pound of engine weight also will power three new four-place commercial helicopters now being marketed worldwide.

The commercial craft include the Bell Jet Ranger, the Hiller FH-1100 and the Hughes 500. The initial Hiller order for 100 engines marked the aviation industry's largest single purchase of small commercial turbines. The Federal Aviation Agency in October awarded Allison a type certificate for commercial use of the engine and approved 750 hours operating time between overhauls.

During 1965, Allison became the first U.S. gas turbine manufacturer to begin full-scale production of aircraft engines incorporating air-cooled turbine blades and vanes for greater efficiency and higher horsepower.

The Allison T56-A-15 turboprop, the first such engine ever to successfully complete an official 150-hour military qualification test, was in quantity pro-

Laid out on tables in the Allison Research and Engineering Center are the several thousand components of the company's T56-A-15 engine.

duction for the USAF Lockheed HC-130H Hercules search-rescue-recovery aircraft. Rated at 4,910 horsepower, the A-15 is 30 per cent more powerful than the original T56.

A Navy version of the engine, the T56-A-14, was also in production and was embarked on an extensive flight test program in a P3A ASW plane at Lockheed's Burbank facility. The A-14 is a follow-on engine to the Allison T56-A-10W which presently powers the P3A.

Air-cooled blades and vanes, capable of operating in temperatures 200 degrees (F) hotter than similar uncooled components, permit the turbine to operate in higher temperatures for better overall performance. These new techniques for turbine cooling were developed jointly by Allison and the military. The two air-cooled engines reflect the steadily increasing power improvements that have boosted horsepower ratings from 3,750 horsepower to 4,910 horsepower while retaining essentially the same dimensions and weight. Lower-rated engines of the T56 Series continued in use in the C-130 Hercules, the Grumman E2A Airborne Early Warning plane and the cargo version, the C2A.

Sales of 501-D13 propjet engines for the Convair 580 conversion program and industrial gas turbines for stationary installations also showed an appreciable increase during 1965. Allegheny Airlines in announcing a $10,250,000 modernization program became the third local service carrier to convert its piston-powered Convair 340/440 airliners to Allison propjets. Coinciding with Allison's 50th Anniversary was the delivery of the 50th Convair conversion. Seventeen additional conversions were on order and options covered 23 more.

By year end, three airlines, 14 corporate operators and the Federal Aviation Agency had logged 250,000 engine flight hours on converted Convairs. Overall, Allison military and commercial propjets had accumulated nearly 18,000,000 hours in the air.

The first four industrial gas turbines to become operational had compiled 25,000 operating hours by the end of the year. Nine additional compressor sets were scheduled for operation by late December, pumping natural gas for four major pipeline companies. The first of the compact, lightweight Allison industrial generator sets—a rooftop installation at a major telephone company in California—began operation in November.

In the development stage, a prototype regenerative gas turbine engine equipped with a test propeller attached to a unique new unitized gear box ran for 30 hours. The test run, a complete success, included 22 hours of operation at normal rated temperature, three hours at military rated temperature and five hours of propeller control system compatibility testing. This was a continuation of the regenerative testing program which started in March with the highly-successful initial run of the first engine.

Extending further the horsepower growth of current T56 Series engines is the T56-A-18 being developed with Navy funds and now logging time on an Allison test stand. Equipped with air-cooled blades and vanes in its first two turbine stages, the A-18 at a rating of 5,325 equivalent shaft horsepower will be approximately 350 pounds lighter and 30 inches shorter than air-cooled engines which entered production in 1965. The first in a planned series of unofficial 50-hour tests was scheduled for completion by year's end.

Allison in 1965 began running lift-engine component demonstrators evolving from gas turbine technology studies aimed at the design of lightweight lift, lift-cruise and cruise turbines for V/STOL and VTOL transports and fighter aircraft. This program, which was expected to show additional significant developments by the end of the year, is funded jointly by Allison and the government.

Aerospace pressure vessels continued in production for the Minuteman, Apollo and Titan III-C programs. The division also was exploring new fields were its extensive experience in metalworking—and the development of such new technologies as electron-beam welding—might be put to productive use.

Emphasis in pure research continued to be on power and propulsion systems that will come into use during the next decade in a variety of space and ground applications. Allison recorded a major milestone late in the year as scientists successfully ran for more than 100 hours an electrochemical cell designed to convert chemical energy directly into electrical energy. More than 8400 watt hours were delivered during the test which included 19 charge-discharge cycles. Potential applications for such a cell include electric-powered military vehicles, missile auxiliary power systems and underwater primary propulsion systems.

Also in development was a radiant energy converter utilizing photovoltaic cells to convert light directly into electrical energy. This radioisotope-fueled direct energy conversion system is designed for applications requiring low power in remote areas for extended periods. The project is sponsored by the Atomic Energy Commission.

Allison scientists also were at work on phases of a nuclear-powered energy depot covered by three contracts from the U.S. Army. Energy depot is a proposed fuel-producing system where heat from a nuclear reactor would be used with an electrolysis unit to produce, from air and water, ammonia for use in vehicles. An electrolysis unit using full-scale components had been run 1,200 hours by the end of the year. Development of the ammonia fuel production system was proceeding on schedule. In September scientists completed a series of concept studies involving energy depot systems of three different power sizes.

The year marked Allison's entry into a significant new field—production of military tracklaying vehicles—as the division assumed jurisdiction of the Cleveland Army Tank-Automotive Plant. In 1966, Allison was to start building the M-109 self-propelled 155-millimeter howitzer and the XM-551 General Sheridan, an armored assault reconnaissance vehicle that can be air-dropped by Allison-powered C-130's. Both vehicle are equipped with Allison military transmissions.

Employment continued on the increase during the year as Allison reported new business gains. Nearly 15,000 employes were on the Allison payroll at Indianapolis and Cleveland by year end.

ALUMINUM COMPANY OF AMERICA

Aluminum Company of America, during 1965, announced: a multi-million dollar expansion of forging facilities preparatory to entering the titanium forging field; forged aluminum armor components representing a new concept for armored vehicles; production of aluminum components employed in the world's largest cryogenic heat exchanger used to extract helium from natural gas for defense and aerospace applications; providing aluminum plate, tube, and foil for Pegasus satellites; development of an aluminum impact extrusion for "Snakeye" slowly-falling bombs; production of extruded shapes, forgings, plate, and missile skin sheet for Gemini's Titan II launch vehicle; installation of a new mechanical press to increase the size range of aerospace forgings; start-up of a new potline producing primary metal at its Warrick (Indiana) Operations; groundbreaking for the second building in the new Alcoa Technical Center; supplying special aluminum forgings for the X-22A V/STOL; development of a new temper that guards against exfoliation; the first aircraft designed to use extensive quantities of Alcoa-developed alloy 7075-T73; dedication of a South American aluminum producing complex; and plans to build a multi-million dollar rolling mill at Lebanon, Pennsylvania.

Aluminum Company of America's entry into the titanium forging field was revealed in plans for a multi-million dollar expansion of forging facilities. Specialized equipment to process metal at elevated fabricating temperatures will be installed adjacent to two of the free world's largest forging presses at Alcoa's Cleveland (Ohio) Works. The 35,000- and 50,000-ton units are operated by Alcoa for the Air Force. The multi-million dollar Alcoa expenditure primarily will provide new furnaces and auxiliary equipment essential to the fabrication of titanium, which requires forging temperatures approximately twice as high as those employed with aluminum alloys. Commercial production of large titanium forgings was expected to be underway by mid-1967.

A military vehicle with hull structure contours more typical of sports cars than thundering tanks made its debut in 1965 in a concept design unveiled by Alcoa. The rakish curves are achieved by forging the vehicle's aluminum armor, instead of assembling aluminum plate, the conventional approach. The result will be military vehicles with better personnel protection at lower cost. With Army cooperation, Alcoa developed large, heat-treated, forged aluminum armor plate conventionally used in key areas of armored vehicle hulls. Their use presents such advantages for personnel carriers, reconnaisance cars, tanks, and similar vehicles as hull sections with unique, smooth-flowing compound curves that remove the need for box-like designs now standard with plate construction; substantial reduction of the extensive welding required to construct military vehicles employing conventional armor plate; greater resistance than plate to penetration by firepower because of higher strength, and the bullet-deflecting properties of curved surfaces; savings made possible by economies inherent in good forging design and production efficiency.

Packed like the circus midgets who emerge unendingly from a compact car, 200 miles of Alcoa aluminum tube crammed into an aluminum shell less than one hundred feet long today is wringing helium from natural gas. Once used only to inflate balloons and blimps, helium now has assumed an ever-increasing number of critical defense and industrial roles, from shielding joint areas during arc welding to pressurizing liquid fuel systems in missiles and rockets. The jam-packed 6 1/2-foot diameter tube-in-shell aluminum structure, used to extract helium, is regarded as the world's largest cryogenic heat exchanger. Thirty such exchangers are in operation at three new helium-producing plants. It also is the first commercial application of aluminum in a so-called "wound" heat exchanger. Aluminum was selected over traditionally used copper and stainless stell for this "king-sized" unit primarily because its use slashes weight drastically from 155 tons down to 55 tons. Aluminum qualifies for the application because its strength increases and it does not become brittle at the ultra-cold temperatures involved (down to minus 320 degrees F) thus insuring its ability to withstand required operating pressures of 600 pounds per square inch.

A modern version of Pegasus—mythology's great flying horse—now soars overhead on "wings" of Alcoa aluminum. One of the largest man-made satellites (third in size behind Echo I and Alcoa foil-wrapped Echo II) Pegasus is a huge rectangle, 96 feet long and 14 feet high. Its mission is to sweep across the heavens as a target for solid particles of matter flying through space. The particles (meteoroids) range from microscopic motes to substantial chunks that may pose a hazard to be overcome in the design of manned spacecraft exposed for long periods to meteoroid bombardment. A giant aluminum-sheathed Saturn I launch vehicle, fabricated of sheet, plate, castings, and forgings supplied by Alcoa, placed the 3200-pound satellite in orbit. Electric motors flipped the accordion-folded wing panels from a 7-foot furled package to their full length, giving Pegasus a 96-foot wingspread. Wing panel framework, and the satellite center structure housing vital electronic equipment, are fabricated of aluminum plate and square and rectangular drawn tube supplied by Alcoa's Davenport (Iowa) and Lafayette (Indiana) operations. The huge expanse of Pegasus' wings is divided and subdivided by aluminum members into more than 200 miniature rectangles. Each opening is covered with Alcoa foil, backed by a copper-coated plastic film, and "wired for sound" to record and radio to earth each meteroid hid and the force of impact.

Conventional 250- and 500-pound bombs are converted economically to "Snakeye" models with a unique retardation mechanism that permits low-level delivery without danger to the aircraft. Basic structural component of the initial (250-pound bomb) retarder is a 25-inch Alcoa aluminum impact extrusion. The "Snakeye" impact design was developed by Aluminum Company of America engineers and tested at the Naval Ordnance Test Station, China Lake, Calif. A single blow on an Alcoa impact press creates this piece in high-strength 7075-T6 alloy—formed to close wall thickness and concentricity tolerances, eliminating subsequent internal machining. The impact combines integrally a structural shell for mounting to the bomb, and the body supporting the retarder's retractable "wings." The device is carried collapsed. Upon release of the bomb from the aircraft, the tail assembly assumes a retarding configuration if the pilot elects to use this feature. This gives him the option of using it as a regular bomb for targets which need penetration, or as a retarded bomb for improved accuracy or new tactics.

The tremendous Gemini journey of Astronauts Grissom and Young climaxed a magnificent first performance by an aluminum rocket as launch vehicle for manned orbital flight. The Gemini spacecraft was carried safely into orbit by a Titan II—an essentially all-aluminum launch vehicle. The smooth-working rocket was enclosed in aluminum sheet and supported internally by high-strength aluminum structural members produced by Aluminum Company of America, Its success has important implications for the future, since aluminum now is the primary structural material employed by the National Aeronautics and Space Administration in its massive advanced launch vehicles. Alcoa supplied extruded shapes, forgings, plate, and missile skin sheet for the Titan II.

A new 6,000-ton press—largest mechanical press yet used to forge aluminum—started operations at Alcoa's Vernon (California) Works. Installation of the press and related components was accomplished at a cost exceeding $1,000,000. Auxiliary equipment includes two stock preheating furnaces and a 12,240 square-foot building extension to house the new forging facility. The decision to add the big press recognizes a need in the aerospace industry for aluminum forgings in a greater range of sizes. Installation of the 6,000-ton mechanical press is part of an over-all program to improve and expand Alcoa's Vernon forging facilities, which include other mechanical presses up to 3,000-ton capacity, and hydraulic presses up to 8,000-ton capacity.

Alcoa placed in operation in 1965 a new second potline for the production of primary metal at its Warrick Operations smelting works. Energizing of the new unit was to be followed by the start of a third potline. The two additions to Warrick's initial potline, which has been operating since June, 1960, were made necessary to meet the metal requirements of an adjacent new sheet rolling operation, now nearing completion, with sheet finishing capacity in excess of 240 million pounds annually.

Ground was broken in the summer of 1965 for the second building in the new Alcoa Technical Center. The new building will house fabricating metallurgy research and equipment development activities, and will provide additional space for pilot operations of new fabricating processes and equipment. The aluminum-clad building will be approximately 200 by 800 feet. Much of the building will be factory-type space, open from foundation to roof to permit movement of cranes and equipment. The remainder will be divided into three floors to provide office space for the Fabricating Metallurgy Division of Alcoa Research Laboratories, and the Alcoa Equipment Development Division. All told, about 150 research and other personnel now at New Kensingtion and Cleveland will be involved. The present fabricating metallurgy facilities are used mainly for alloy development and, to a lesser extent, for investigating metalworking processes such as rolling, extruding, and drawing. At Merwin, fabricating activities will be enlarged and many items of new equipment will be provided, so that research personnel can investigate metalworking operations performed by Alcoa.

Flown for the first time in 1965 was a prototype X-22A aircraft which utilizes ducts of Alcoa aluminum to increase the thrust of its turbine-driven propellers. Equipped to take off straight up, cruise in a conventional manner, and land straight down the unique plane was designed and built for the U. S. Navy by Textron's Bell Aerosystems Company. Designated the X-22A, the vertical/short take off and landing research plane will explore mechanical and aerodynamic characteristics of dual-tandem, ducted-propeller planes, and evaluate their military potential. Key structural members of the essentiallly all-aluminum craft are formed of high strength alloy 7079-T6 hand forgings produced by Aluminum Company of America's Cleveland Works. Included are the main supporting members for the wings and the four propeller-enclosing ducts. The ducts will be positioned vertically for take off, and will be tilted to a horizontal position for forward flight. They will provide lift in level flight and increase the thrust of the seven-foot propellers.

Development of a metallurgical treatment that immunizes high-strength aluminum alloy 7178 against exfoliation—leafing or blistering from subsurface corrosive attack—was announced by Alcoa. The new Alcoa process is designated the -T76 temper. Its availability virtually eliminates exfoliation as a possible problem source in critical applications of high-strength aluminum alloys. Evaluations of 7178-T76 in a seacoast atmosphere, and by a new rapid test, have revealed a level of protection nearly equal to that afforded alloy 7075 by the Alcoa-developed -T73 temper. Tensile strengths of alloy 7178-T76 are 4000 to 7000 pounds per square inch higher than those of alloy 7075-T73, while fatigue and fracture toughness characteristics are essentially equal to those of widely used alloy 7075-T6. The new -T76 temper resulted from a program of several years' duration by Alcoa Research Laboratories, during which time Alcoa also developed the new method of testing aluminum alloys for exfoliation susceptibility. The new test, which utilizes intermittent exposure to hot (95 degrees F) acidified salt spray, is much fastern than previous procedures, gives excellent correlation with tests in seacoast or salt spray environments, and provides a wide degree of freedom in choice of specimen size and shape.

The first air craft designed to use extensive quantities of Alcoa-developed aluminum alloy 7075-T73, the OV-10A light armed reconnaissance and logistics airplane, was unveiled in 1965 by Columbus Division of North American Aviation, Inc. North American made extensive use of metal supplied by Aluminum Company of America in building ruggedness, simplicity of operation, and low cost into this aircraft, while combining the requirements for weapons delivery, reconnaissance, and light transport. Alcoa's aluminum alloy 7075 in the -T73 temper was chosen for its combination of high mechanical properties and corrosion resistance. Providing strong resistance to both stress corrosion and exfoliation, 7075-T73 also exhibits good fracture toughness, which inhibits failure resulting from a notch or crack. Key structural parts of the OV-10A aircraft provided by Alcoa include: the main wing spar, extruded on a 14,000-ton press at Alcoa's Lafayette Works; die-forged members for main wing to boom attachments; stress-relieved hand forgings for fittings and supports; sheet and plate; and forged components for the extremely rugged tricycle landing gear assembly and wheels. All forgings were made at Alcoa's Cleveland Works; the sheet and plate were rolled at the Davenport Works.

A South American aluminum producing complex—the world's first to incorporate the mining and refining of bauxite and the smelting of metal at a single plant site— was dedicated by royalty in the rapidly developing country of Suriname. Built by Suriname Aluminum Company, a wholly owned subsidiary of Aluminum Company of America, the operation was opened officially by Queen Juliana of The Netherlands. Her husband, Prince Bernhard, and 800 dignitaries from Suriname, Holland and the United States looked on as the queen observed the pouring of Suriname's first aluminum. Located at Paranam, 30 miles south of Suriname's capital city of Paramaribo, the production complex includes a 60,000-ton aluminum smelter and a plant for refining bauxite ore into alumina, the oxide of aluminum, with a projected capacity of 800,000 tons. Power for the smelter is transmitted from Afobaka, 45 miles south of Paranam, where Suralco built a dam on the Suriname River with an installed capacity of 180,000 kilowatts.

Alcoa announced plans to build a multi-million dollar aluminum foil rolling mill at Lebanon, Pennsylvania. Construction of the new fabricating operation began immediately, with first production scheduled to start late in 1966. Simultaneously, Alcoa disclosed it will phase out its 49-year-old Edgewater (New Jersey) Works over the next two years, and, during the same period, make major capital expenditures at its 74-year-old New Kensington Works to realign and revitalize manufacturing operations there. The new Lebanon mill will encompass approximately 600,000 square feet of building area and initially will provide about 250 jobs. At the outset, plant equipment wll include foil rolling mills, and later sheet rolling mills may be added. This will depend largely on the development of potential markets to support added capacity for sheet production.

AMERICAN BRAKE SHOE COMPANY (ABEX)

During 1965, the Aerospace Division of American Brake Shoe Company was furnishing all of the hydraulic equipment on the Lockheed-Georgia C-141A "Starlifter," the new all-jet cargo aircraft being manufactured for the U. S. Air Force. A unique feature of the electric motor driven auxiliary pumping equipment is the high energy produced for the low weight of the package (32 pounds). This unit contains a 110/220 volt electric motor operating on 400 A.C. current which consumes 3.42 horsepower while pumping 8 gallons per minute at 2,200 pounds per square inch. Another feature of this installation is its ability to use less electrical horsepower at high pressures where the aircraft system demands a smaller flow of 6 gallons per minute at 2,950 pounds per square inch. This is due to the incorporation of a special horsepower limiter in the hydraulic pump.

The division also introduced an electric motor package to the commercial airline industry which contains a special provision for cooling the electric motor. The hydraulic fluid that is used for power to retract the landing gear and actuate flight controls is also used to cool the electric motor. The hydraulic fluid flows into the electric motor, surrounds the armature, and carries off heat that is generated during the operation. This enables aircraft engineers to install this electric motor driven pump in areas where cooling air is not available and also saves considerable weight when compared with conventional air-cooled electric motors. This unit is being used by many domestic and international airline operators on the Boeing Model 727 aircraft.

During 1965 substantial shipments of the Aerospace Division's electro-hydraulic servovalves were made to the Vertol Division of The Boeing Company for use on the U.S. Army CH-47 "Chinook" helicopter and on the Marine Corps CH-46 "Sea Knight" helicopter. Several of these electro-hydraulic servovalves are used on each aircraft for the stability augmentation system. Electrical signals are received by the servovalve from the auto-pilot system. These signals are converted by the valve into controlled flow of hydraulic fluid so that the hydraulic power can be used for maintaining stability of the helicopter during flight. This same servovalve is also used on the helicopter for controlling the direction of the nose wheel on the landing gear so that the pilot can steer the aircraft while moving on the ground.

The Abex Research Center continued its support of the Pershing program by supplying high-strength, low-alloy steel castings for a major component. In addition, work was started on an Air Force sponsored program to develop manufacturing methods for large (100 pounds-plus) superalloy castings. This program will involve some of the largest vacuum melted structural castings ever produced.

An Air Force program on heat-resistant, glass-reinforced resins resulted in approximately a tenfold improvement over the original product. A continuation contract was awarded and the work was in progress at year-end.

Brake Shoe's Denison Division continued to support the space program by furnishing hydraulic power and controls to activate missile erectors and space launch equipment. The Division also supplied hydraulic equipment for the many test stands used by the Air Force in ground support.

Jarry Division designed and supplied the wing actuator mechanism for the F-111 aircraft and it proved itself in preliminary flight tests on the plane. Jarry continued to supply wing spoiler controls for the C-141 aircraft and received a contract in excess of $500,000 to supply main landing gear for the new Boeing 737 jet airliner. This contract was the first ever awarded a Canadian firm for landing gear on a commercial airliner manufactured in the U.S.

Dynisco Division announced a new blast pressure transducer known as Model PT119H, originally developed for test stand use at Marshall Space Flight Center and since proven on major rocket test facilities. A high-accuracy, bonded strain gage instrument, the PT119H provides infinite resolution and ultrastable operation under the most severe conditions of temperature, vibration and shock met in rocket test work.

AVCO CORPORATION—LYCOMING DIVISION

The selection of Avco Corporation's Lycoming Division by the Army Tank Automotive Command as the winner in a competition for the development of a new gas turbine engine for tank and other vehicular applications highlighted the division's research and development activities during this past year.

The selection was significant in that Lycoming was awarded the contract over 15 major companies. Taking advantage of its wealth of experience in gas turbines, the division's design incorporates many advances in technology and for the first time will make the gas turbine engine truly competitive with the diesel engine.

Known as the AGT-1500, this new engine will be smaller and lighter than the most modern diesel engine and will offer performance characteristics much advanced over any existing diesel.

The $11,500,000 contract covers only the development of the engine and the fabrication of 25 prototype units for field testing, but the program has a long range potential for sustained high levels of production.

Lycoming also continued development activities in its T53 and T55 series of engines, and early in the year received a contract for the development of the T53-L-13, a 1,400 shaft horsepower version of its current high production model. The L-13 is slated for full qualification in mid-1966 and will enter volume production immediately.

Development work on a higher powered version of the T55 also continued as it did on the high bypass turbofan engine, a program that might have significant application for future generation vertical takeoff aircraft.

Other research activities also continued, in specialized areas related to general gas turbine technology advancement, and in such areas as mechanical servoactuators, an outgrowth of the company's constant speed drive program.

Production rate for Lycoming's prime product, gas turbine engines, virtually doubled during 1965, primarily as a result of the increased activity in Viet Nam. Much of the Army's forces, including the majority of the 1st Cavalry Airmobile Division's airborne equipment, is powered by Lycoming gas turbine engines.

The Army's Bell UH-1 helicopter, main battle helicopter in both troop carrying and armed escort roles, is powered by the Lycoming T53 engine, which has earned for itsself a very creditable record of performance. It demonstrated its original design criteria of ruggedness and ability to operate in very hostile environments, including sustaining severe battle damage in many instances without loss of power.

The T53 is also used in the fixed wing twin engine Grumman OV-1 observation aircraft, also deployed in Viet Nam, and is the powerplant in the Air Force's Kaman HH-43 helicopter, main air rescue vehicle for returning downed airmen.

Also deployed in Viet Nam since the arrival of the 1st Cavalry Division is the more powerful T55, two of which power each of the new Chinook transport helicopters. These helicopters are capable of carrying in excess of 35 fully armed troops.

New applications for Lycoming gas turbine engines during the year included the Bell HueyCobra, an experimental high speed development of the UH-1 helicopter, designed for interim use as an armed helicopter. The HueyCobra is powered by a T53-L-13 and is capable of high speeds while fully loaded with a large assortment of fire power.

Boeing also unveiled an armed version of the Chinook helicopter, using two T55-L-7 engines weighted at 2650 shaft horsepower. A quantity of these aircraft was being produced for military evaluation.

Shortly before the end of the fiscal year, Kaman announced a new design it is proposing to the military also for the armed helicopter mission. This aircraft utilizes a down-rated version of the T55.

Production of Mark 11A re-entry vehicles for the Minuteman II intercontinental ballistic missile continued at a stable level during the year as did production of other space and missile hardware including rocket chambers, airframe components and other related equipment.

Contracts were also received for additional production of constant speed drives for the Douglas A4E and TA4E aircraft and for the tilt wing XC-142 V/STOL aircraft.

While Lycoming is still almost wholly a producer for the government, it has been steadily expanding its commercial activities throughout the world, primarily through the use of the T53 in the Bell 204 commercial helicopter. A total of 15 commerical customers in 13 countries were utilizing Lycoming powered helicopters at year-end. The sale of commerical engines with related spare parts and supporting equipment including training, was running in excess of $4,000,000 per year.

License agreements with both Klockner-Humboldt-Deutz in Germany and Piaggio in Italy were finalized during the year and both agreements were expected to open new market areas throughout Europe.

BEECH AIRCRAFT CORPORATION

Beech Aircraft Corporation in 1965 experienced its biggest peace-time year, with total corporate sales exceeding $122,000,000 to surpass the upward-trend projections of a year ago.

Increased earnings, an increase in total corporate sales, continued production on major aerospace programs, introduction of new Beechcraft business airplanes for the commercial aircraft market, and the achievement of the largest volume of commercial sales in the company's thirty-three year history highlighted the company's 1965 activities.

The all-time high in sales of commercial and business products exceeded $74,000,000 for the fiscal year ended September 30, 1965, representing an increase of 37 percent over the commercial sales total for fiscal 1964. Military-aerospace sales amounted to more than $48,000,000.

During the year, additional firm military contracts were secured for a total of more than $44,000,000; in addition, negotiations were in process for work programs with regard to increased defense spending.

Comparing the growth in total corporate sales of $72,000,000 in fiscal '61 to $122,000,000 in fiscal '65, it is anticipated that the next five years will provide growth in total sales from $140,000,000 forecast for fiscal '66 to $200,000,000 projected for fiscal '70.

These substantial forecasted corporate sales are the result of increasing acceptance of the privately and company-owned airplane as a productive working tool in today's dynamic market situation, and the company's accelerated and aggressive activities in the diversified fields of aerospace.

Sales in the international market also continued to grow at a rapid pace. The acceleration of industrial growth throughout the free world is a prime factor in the projected growth in future sales of Beechcraft airplanes. Export sales for 1965 in excess of $17,000,000 are a positive indication of the increased sales volume being generated by the company the world over.

Travelair GmbH of Germany in 1965 paced the entire Beech retail sales organization, both domestic and export, exemplifying the continued steady growth in the European market. Notable expansion was also taking place in Australia.

Export sales activity included an order exceeding $2,500,000 from the Peruvian Air Force for a number of Queen Air A80's to be delivered between September, 1965, and January, 1966. Lufthansa German Airlines selected the C33 Debonair as its newest pilot trainer aircraft and placed an order for five of the single-engine airplanes. Additional Lufthansa orders are anticipated.

Recognizing the impact of imaginative new concepts and the promise held forth by a burgeoning aircraft market, Beech Aircraft in October adopted a vital, imaginative, new format—the Sales Spectacular—to provide a showcase for the company's line of 15 airplanes for the international retail sales personnel attending the annual meeting.

To meet the expanding requirements for greater business marketing, Beech in October introduced six models ranging from the latest additions to the Queen Air line—the pressurized Queen Air 88 and the Queen Air B80—to the high performance C55 Baron, the new V35 Bonanza and its turbo-supercharged mate, the V35TC Bonanza, the high-powered C33A Debonair, and three new Musketeers, the two-place Sport III, the Custom III and the Super III.

In the domestic markets in 1965, sales were in excess of $56,000,000, following the forecasted trend. Highlights of the year's acceptance of the Beechcraft product line include: Sales of the single-engine

White room facilities at Beech Aircraft's Boulder Division insure contamination control on space projects.

Bonanza, Debonair and Musketeer models exceeded \$15,000,000; sales of the Baron and Travel Air light-twin Beechcraft models exceeded \$13,000,000; sales of the world-famous Super H18 held steady at more than \$5,000,000; sales of the two Queen Air models grew to \$12,000,000.

The dynamic character of the company's commercial sales year was underscored by the unprecedented customer enthusiasm for the turbine-powered, pressurized King Air. Production of the twin-engine King Air was increased to over 100 units a year, and another substantial production increase was being considered. Deliveries to owners at the end of calendar 1965 exceeded 100.

In late November, a King Air—designated VC-6A—was delivered to the U.S. Air Force for the Military Air Transport Service's (MATS) 1254th Special Air Missions (SAM) fleet. Carrying the United States flag on its stabilizer, the USAF's first VC-6A joins Air Force One and the other aircraft assigned to the Special Air Missions fleet headquartered at Andrews AFB, Maryland.

The 8,000th Bonanza rolled from the Beechcraft assembly line during the year, marking the 20th year of production for the "V-tailed" Beechcraft. The first Bonanza Model 35 took to the air on December 22, 1945.

Under the supervision of the Beechcraft Technical Training Program, Beech established a King Air school for the pilots and mechanics who will be associated with the turbine-powered airplane. Staffed with multi-engine professionals, the King Air school accommodated over 200 pilots and 250 service personnel in its program of insuring customer satisfaction with the airplane's operations in the field. Classes included men and women from the world over.

Beech Aircraft's Aerospace Division, formed in 1961 to administer the company's expanding research, development and production activities, increased its scope for the implementation and performance of new programs relating to the space sciences as well as to the development and support of new weapons systems.

Beechcraft at year-end was actively associated with a wide range of space projects, including Gemini, Apollo, and the Lunar Excursion Module (LEM) at its Boulder Division, Boulder, Colorado, an expanding engineering, testing and research and development complex.

Chosen by North American Aviation, Inc., Space and Information Systems Division, to develop and build the cryogenic storage subsystem for NASA's Apollo spacecraft system, Beech made vital contributions in weight reduction and longer mission duration capability for space vehicle application. Beech contracts total \$28,000,000 on the Apollo program.

For the Lunar Excursion Module (LEM), Grumman Aircraft Engineering Corporation awarded the company a significant contract in excess of \$1,000,000 to build aerospace ground support equipment for the LEM's descent propellant pressurization system that will be a vital support factor for the mission's weightless environment.

For Project Gemini, Beech was chosen by McDonnell to design, develop and build the propellant system that supplies liquid oxygen and liquid hydrogen for the spacecraft's environmental control system. The Beech system performed successfully on each of the manned Gemini missions.

A pioneer in cryogenics research and development, Beech's Boulder Division observed its 10th anniversary during the year. Established in 1955 to study the feasibility of liquid hydrogen storage systems, Boulder's creative engineering and management group is now located on a 1,500-acre test site and is engaged in the design, development and fabrication of highly sophisticated spacecraft systems and subsystems.

In February, the U. S. Army selected the B55 Baron as winner of its competition for a fixed-wing twin-engine instrument trainer and awarded the company a production contract totaling more than \$2,500,000. Designated T-42A, the Baron will be used as a primary twin-engine instrument trainer by the Army Aviation School Instrument Training Division at Fort Rucker, Alabama. The secondary mission is the twin-engine transition of single-engine rated Army aviators.

During the year, three new contracts were awarded Beechcraft by the Army for continued support of remote controlled, V-tailed Beech Model 1025 "Cardinal" Target Missile operations. These support contracts continued the Beech-furnished technical assistance at Fort Bliss where factory specialists provide target missile operation service.

One of the contracts, a first for Beech, provided for flight service support of Cardinal target missiles at the White Sands Missile Range. The propeller-driven target has served the Army and Navy since 1959.

Under research, development and testing at year-end was a turbojet version of the Model 1025 capable of providing advanced training for the Hawk, Nike, Mauler and Red-Eye missile systems.

As an associate study contractor with the Radio Corporation of America (RCA), Beech is responsible for the SAM-D weapon system missile airframe, flight control system, propulsion system, and launching container. In preparation for final design and fabrication of the SAM-D system, Beech Aircraft's feasibility study was completed under an Army contract, and at year-end the company was engaged in follow-on development work.

During the year, Beech continued to perform on contracts to build major assemblies of the nation's top military jet aircraft manufacturers. Under contracts totaling over $44,000,000, the company manufactured assemblies for USAF's Lockheed C-141 "StarLifter" turbofan jet transport. Beech was building under contracts totaling $49,000,000 major assemblies for McDonnell's tri-service "Phantom II" fighter. In February, McDonnell awarded Beech a follow-on contract of more than $10,000,000 for Phantom II production work. Beech was also building key components for the Army's UH-1 series of turbojet helicopters under contract to Textron's Bell Helicopter Company, and Bell awarded Beech a contract in March exceeding $2,500,000 for continued "Iroquois" production bringing to more than $9,000,000 the total contracts assigned to Beech on the jet-powered helicopter.

At the end of 1965, Beech Aircraft was engaged in more than 100 highly diversified projects, ranging from classified contracts relating to new weapons systems and space exploration to important subcontracts for other major airframe manufacturers.

BELL AEROSYSTEMS COMPANY

Bell Aerosystems Company in 1965 marked its 30th anniversary of research and hardware contributions to the fields of aviation, avionics, space and transportation.

Bell, one of the diversified manufacturing operations of Textron Inc., is headed by President William G. Gisel, an executive with 25 years of service in the aerospace industry. Company headquarters and main plant are located adjacent to Niagara Falls International Airport, New York.

Employment throughout the year averaged 4,300 at Bell's main plant and at an avionics instrument laboratory in Cleveland, Ohio, and at electronics research facilities in Tucson and Fort Huachuca, Arizona.

Several of Bell's research programs involve transportation of astronauts and scientists over the moon's surface for follow-on efforts to the nation's Project Apollo. One such vehicle on which Bell has done preliminary research and designs for the National Aeronautics and Space Administration is the Lunar Flying Vehicle (LFV), a rocket powered device which can carry astronauts on exploration or reconnaissance missions. It can also be used for surveying, photography or mapping missions on the moon.

In addition to the LFV, Bell was working during the year on a manned flying system which will carry an astronaut-scientist over the moon's surface on missions similar to those of the LFV only with more emphasis on exploration capabilities for 50-mile journeys from a lunar base.

Another moon transportation concept Bell studied in 1965 is a lunar rocket belt for propelling man above the moon's surface. This device is similar in principle to the rocket belt which Bell Aerosystems has demonstrated around the world.

In the United States space effort to get man to the moon and back to earth, Bell was also playing an important role. For its part in Project Apollo, Bell in 1965 was engaged in programs involving propulsion systems, positive expulsion tanks for propellants and other liquids, and training of astronauts.

Bell's air cushion vehicle went into regular passenger service between Oakland and San Francisco International Airports.

Bell was developing for Grumman Aircraft Engineering Corporation and for NASA the ascent rocket engine which will power the Lunar Excursion Module for launch from the lunar surface into a trajectory leading to a rendezvous with the orbiting Apollo Command and Service modules. This engine was being tested by NASA at its White Sands facility.

In the field of positive expulsion propellant tanks, Bell was providing a variety of tanks for Project

Apollo and for several other space programs. Bell's extensive research in this field has made the company the U.S. leader in the development of this highly specialized equipment.

A contract was awarded Bell in 1965 for the positive expulsion propellant tanks for the auxiliary propulsion system of the Saturn S-IVB stage, the third stage of the Saturn V booster. Bell's other tank assignments included the Apollo Command, Service and Lunar Excursion Modules. Other programs were the Lunar Orbiter, the Centaur spacecraft, the Agena target vehicle for Project Gemini and an Air Force satellite program. Bell also has Air Force contracts to develop advanced propellant tankage expulsion methods.

To support Bell's position in positive expulsion tanks the company in 1965 constructed a new "clean room" where tanks are assembled and checked. The room also is used for assembling the LEM ascent engine.

To train astronauts in landing on the moon, Bell built two Lunar Landing Research Vehicles for NASA. The space agency recently completed several successful simulated moon landings with the LLRV at its Edwards, California, Flight Research Center.

In rocket propulsion, Bell's reliable Agena engine continued its outstanding performance with successful participation in such programs as the Ranger and Mariner space probes to the moon, Venus and Mars and satellites including the Nimbus weather satellite; Echo 2, the passive communications satellite; Alouette, the U. S.-Canadian topside sounder satellite; and others.

By year-end, Agena had more than 200 successful space firings to its credit and a reliability record exceeding 99 percent.

Bell's Agena engine on board the target vehicle for Project Gemini rendezvous missions was scheduled to perform in space for the Gemini 8–12 missions. Early in 1965, the U.S. Air Force designated Bell Aerosystems an associate prime contractor to supply the Agena rocket engine.

In August, Bell Aerosystems was selected to provide the propulsion subsystem for the Air Force Minuteman Post Boost Control System being developed by North American Aviation's Autonetics Division. The small rocket motors and associated propellant tankage and controls to be built and tested by Bell will provide Minuteman II with an attitude and velocity control capability following thrust termination of the third stage rocket motor.

Although space programs made up a considerable portion of Bell's activity, much of 1965's work was conducted closer to earth.

A new and growing field in which Bell is a pioneer is in vertical/short takeoff and landing (V/STOL) aircraft. The latest Bell contribution to aviation is the dual-tandem ducted-propeller aircraft, the X-22A, which was rolled out May 25 at the company's main plant.

The X-22A, designed and built under a Navy-managed contract, will investigate problems of V/STOL flight, particularly in the areas of stability and control of these vehicles.

Another new and fast-expanding field where Bell is exhibiting its leadership is with air cushion vehicles (ACVs). Following successful development of the U.S. Navy's 30-ton Hydroskimmer and the small company-built 1-1/2 ton Carabao, Bell acquired rights to build and sell Westland Aircraft Limited's ACVs. Most prominent among them is a medium-sized, 7-ton vehicle identified by Bell as the SK-5.

Two of these vehicles, modified with American engines and navigation equipment, on August 10 began the first United States' scheduled passenger service using ACVs. Called Jet-Skimmers, these SK-5s skim across San Francisco Bay between Metropolitan Oakland International Airport, San Francisco International Airport and downtown San Francisco.

During the year, Bell delivered three SK-5 air cushion vehicles to the U.S. Navy, marking the first United States military application of this new means of transportation. The first Navy crews were being trained in the operation and maintenance of ACVs at Bell's Lake Erie test base at Buffalo.

The U.S. Army Electronic Proving Ground at Fort Huachuca, Arizona, awarded Bell the prime contract for the operation, maintenance, future development and modernization of field test facilities in Arizona. These operations include the Electromagnetic Environmental Test Facility, which is engaged in the evaluation of existing and potential radio interference, and the Systems Test Facility, a huge drone test range on the Arizona desert.

In other product lines, Bell's AN/SPN-10 all-weather aircraft landing system was performing aboard several U.S. aircraft carriers to automatically land returning aircraft.

First delivery of a Bell-designed and developed stabilized sight for the SS-11 antitank missile was made to the Army; it will be installed in Bell UH-1B helicopters. Another sophisticated sight—the Stabilized Optical Tracking Device (SOTD)—was being developed by Bell for the Army. This also will provide helicopter gunners a magnified view of targets free from vibrations.

Some of Bell's research work, originally done for government defense and space programs, evolved into commercial applications. A chief example of this is the Bell accelerometer, originally designed for use in military and space navigation systems and now being used as an integral part of a navigation system in Pan American World Airways entire fleet of Boeing 707 jet airliners. Accelerometers precisely sense acceleration or rate of change of velocity of the aircraft.

BELL HELICOPTER COMPANY

The year 1965 was one of the busiest in the history of Textron's Bell Helicopter Company. The Fort Worth, Texas, manufacturer continued to produce its famed UH-1 Series of military helicopters at an accelerated pace. Three UH-1 models were operational in Viet Nam combat, and Bell continued to receive additional orders for each model throughout the year.

Bell on February 28 completed 100 consecutive months of on-schedule deliveries of aircraft to the U. S. government, a record believed to be unprecedented in the aircraft industry.

Two new production facilities were opened in 1965. Employment increased to more than 7,000, an all-time high.

Bell engineers revealed that they had designed a unique "Trailing Rotor Aircraft," a machine that would take off and perform with the maneuverability of a helicopter and fly at jet aircraft speeds at altitude.

The HueyCobra, a powerful, streamlined machine utilizing the dynamic components of the UH-1B Iroquois, was flown for the first time. This is a two-place aircraft designed for maximum speed, armament payload and crew effectiveness.

Another new model, the Bell Jet Ranger, was announced for Bell's 1965 commercial line. The Jet Ranger is a high-performance, five-place, turbine-powered aircraft.

Progress continued in other research and development programs. Bell's first twin-turbine model, a UH-1D equipped with the first single power plant combining two turbines, was flown April 27.

The company's experimental YUH-1B High Performance Compound Helicopter on April 6 flew 250 miles per hour in level flight, fastest speed attained by any rotorcraft at that time.

West Germany announced approval of Bell's UH-1D for purchase for its air, ground and naval forces. German officials announced that 406 UH-1D models would be purchased at an approximate cost of $125,000,000.

The New Zealand Ministry of Defense announced that it had govermental approval for the purchase of five UH-1 and six 47G-3B-1 Bell helicopters—the first helicopters to be purchased for use by its military forces.

General Hamilton H. Howze, after a distinguished 39-year career in the U. S. Army, joined Bell as vice president for product planning.

Although the bulk of Bell's 1965 production was UH-1B and UH-1D Iroquois models for the Army, the company continued to turn out Marine Corps UH-1E and Air Force UH-1F models in quantity. The UH-1B, UH-1D and UH-1E were operational in Viet Nam.

Two smaller models, the three-place OH-13S and two-place TH-13T instrument trainer, also were in production for the Army.

Commercial production included two three-place models, the 47G-4 and 47G-3B-1, one four-place model, the 47J-2A, and the 10-place 204B, civilian version of the UH-1 Series.

UH-1 helicopters take shape at Bell Helicopter's Fort Worth plant.

At year-end, Bell helicopters held 27 world records in speed, altitude, distance and time-to-climb categories, more than the combined total of all helicopter records held by foreign nations. The UH-1 Series holds 21 world helicopter records, more world records than the total held by any other military aircraft.

Bell helicopters, since 1946 when a Bell 47B was granted the world's first commercial helicopter license, had logged more than 9,500,000 hours, equivalent to more than 1,084 years in the air, through 1965.

For 1966 Bell planned to manufacture the same military models that it produced in 1965. Six commercial aircraft, including three new models, were to be produced in 1966. Bell Helicopter Company is an operating division of Bell Aerospace Corporation, a wholly owned subsidiary of Textron, Inc. of Providence, Rhode Island.

THE BENDIX CORPORATION

BENDIX PRODUCTS AEROSPACE DIVISION

During 1965, Bendix Products Aerospace Division was supplying propulsion control systems for many large gas turbine engines, including such significant new programs as the Pratt & Whitney engines used in the F-111 and A-7A aircraft.

Study and development programs were being carried out on a fuel control system being considered for use on the Pratt & Whitney SST Engine, and new compact, lightweight, prototype fuel control systems were built and were being evaluated for future Allison turbo-propeller engines.

After an extensive development effort, control systems designed to operate in severe high temperature environmental conditions were being supplied for high Mach number aircraft.

Basic research effort was being applied in the gas turbine control field to advance the state-of-the-art of control system performance, optimum reliability, low weight, and a more competitive price.

Rapid expansion was occurring in the lightweight fuel control systems for small gas turbine-powered aircraft. The year's programs included such aircraft as the Beech "King Air," the LOH helicopter and the DASH helicopter.

Initial control programs were getting underway for industrial gas turbine engines which will include vehicular and stationary applications.

Programs were expanding on fuel injection systems for general aviation, reciprocating engine-power aircraft. Aircraft with Bendix injection include products of Piper, Mooney, Riley, Aero Commander, and Beech. Product improvement programs were in process to further improve the performance of the injector.

Design effort continued on freon injection systems for thrust vector controls for such advanced missiles as the Poseidon C3.

During 1965, the Bendix Products Aerospace Division began production on the wheels and brakes for the Boeing 737 aircraft. The year also saw continuance of service programs for the DC-8 and Boeing 707 airliners. Bendix wheels and brakes will be used on the new Douglas models CD-8-61 and 62.

Some major airlines selected Bendix for a wheel and brake retrofit program on the Boeing 720, and the BAC-111 equipped with Bendix wheels and brakes entered service in this country.

During the year, major research and development programs were conducted in such areas as brake cooling, improved materials and designs aimed at increasing the performance and efficiency of Bendix aircraft wheels and brakes.

In the manufacturing and development of aircraft landing gear, 1965 was a productive year for the division. Production was begun on nose struts for the F-111B and the Boeing 737. In addition, the division's engineers continued with programs to improve struts in a variety of commercial and military aircraft. Promising studies were conducted into the application of new materials which would permit important weight savings. In the manufacturing facilities, several multi-axis numerical controlled machines were added to the division's equipment.

Liquid-floated accelerometers, key units of the Minuteman missile's guidance and control system, are assembled under glass at Eclipse-Pioneer.

The work of developing new design concepts for extraterrestrial landing gear progressed during the year with several major development contracts. The Bendix Products Aerospace Division's capability and facility for this vital work has become recognized as among the foremost in the industry. This background permits the study of dynamic phenomena associated with omnidirectional landings of aerospace or spacecraft.

Lightweight, high strength, tension torsion tie bars, consisting of a rectangular package of corrosion-resistant steel wire wound over steel bushings and encapsulated in elastomeric polyurethane, attained high production volume in 1965. This rapid production increase was expected to continue in 1966 and following years.

In high temperature material research, development and evaluation continued on chromium composite materials for gas turbine engine parts, leading edges, and other applications in oxidizing temperature environments from 2000 degrees to 3000 degrees F. Emphasis was being placed on improved high temperature strength, while retaining existing ductility and oxidation resistance. Successful application of more refractory ingredients in aircraft brake friction materials promises satisfactory operation at temperatures up to 2500 degrees F., or 500 degrees above production materials.

ECLIPSE-PIONEER DIVISION

In 1965, activities and products of The Bendix Corporation's Eclipse-Pioneer Division spanned the free world's aerospace industry. Equipment ranged from relatively simple instruments and devices to complex electronic navigation and control systems for missile, space and military aviation programs.

Although follow-on contracts accounted for the bulk of activities in the aviation field, several research and development projects were launched, and an important "first" in all-weather landing, which not only stimulated automatic flight control production but also augured well for the weather-harried airline passenger, was credited to Bendix.

When the Federal Aviation Agency approved Eclipse-Pioneer Division's automatic approach and landing system on March 18, it became the first system to win FAA certification to make fully automatic landings in scheduled service. A month later, the system won another first when the FAA certified the automatic system for use in Category II weather conditions—weather affording only 100-foot ceilings and 1/4-mile forward visibility. This cut previous weather landing restrictions in half and paved the way for eliminating some 60 percent of the estimated $67,000,000 which airlines lose annually by cancelled, diverted and delayed flights at weather-bound U. S. airports. By year's end more than a dozen of the world's airlines had ordered the system for installation in new 707 and 720 aircraft on order with Boeing, and more than seven major airlines had ordered it to retrofit aircraft presently in service.

Also in the all-weather field, the first installation of Eclipse-Pioneer's new Microvision visual landing aid was begun at Atlantic City, New Jersey, for the FAA, which will test and evaluate the system under actual operational conditions. The Microvision system permits a pilot to "see" the runway through obscure weather and visually monitor his approach.

In the aircraft instrumentation systems line, central air data computers and vertical scale indicators were produced for both USAF's F-111A and Navy's F-111B versions of the variable-sweep wing supersonic fighter. The CADC provides such flight data as pressure altitude, Mach number, dynamic pressure and other information vital to the operation of aircraft systems and related equipment. The compact vertical scale indicators register flight information such as vertical speed, Mach number, and indicated airspeed on easily read moving tapes. Eclipse-Pioneer also produced the automatic, tape-controlled programmer which serves as the heart of the F-111 shop automatic testing complex.

The Division's PB-60 automatic flight control systems and central air data computers continued in production for USAF's giant C-141 Star Lifter. FAA certification of the autopilot for commercial use was granted in July.

The PB-60 was also contracted for by Mohawk Airlines for its FH-227 passenger aircraft. It has already been ordered for the Japanese YS-11 turboprop aircraft, the Italian-built Piaggio-Douglas PD-808 twinjet and the American Jet Commander. The versatile system was as equally suited to large commercial and military aircraft as to executive and feeder-line type aircraft.

Engineering development of the automatic flight control system for the Anglo-French Concorde supersonic airliner continued during the year. Working with Elliot Automation of England and SFENA of France, Eclipse-Pioneer was contracted to furnish complete technical support during the development program.

Also, Eclipse-Pioneer began producing automatic flight control systems for the Navy's TA-4E aircraft. For use with its automatic flight control system on USAF's B-58 Hustler bomber, a yaw damper system was developed and ordered.

During the year, both the Navy and Air Force ordered automatic dead reckoning systems from the Division. The Air Force ordered the system for the F-4C, RF-4C and RF-4B fighter aircraft; the Navy, for the F-4B aircraft and EA-6A attack aircraft. These systems continuously compute, transmit and display essential information needed by the pilot in the navigation of his aircraft.

The Division also provided Bendix wind memory computers for the Navy's A-4E attack aircraft. The computer continuously transmits the aircraft's ground speed and ground track to the vehicle's automatic dead reckoning navigation computer. This eliminates the time consuming necessity of the pilot's manually setting in the wind parameters.

Also for the Navy's A-4E attack aircraft, Eclipse-Pioneer designed an aircraft weapons release system which enables the pilot to program automatic release of bomb load in quantity and drop interval he selects.

Because of its long experience in automatic flight controls, Eclipse-Pioneer was selected to provide a stability augmentation system for the FHE-400 DeHaviland hydrofoil boat, being evaluated by the Royal Canadian Navy for antisubmarine warfare. The system is to provide stability control during both hull-borne and foil-borne operations.

Missile and space programs at Eclipse-Pioneer centered mainly on inertial guidance systems and equipment for the Saturn, Pershing and Minuteman.

In its 8th year on the Army's Pershing missile program, the Division continued to produce inertial guidance systems for the 2-stage selective range solid propellant missile.

When the 10th and last of NASA's successful Saturn I rockets was launched on July 30th, it was guided by Eclipse-Pioneer's stable platform, as it had been on the four previous flights. The platform generated velocity and acceleration information that determined accuracy of pitch programming and final insertion of payload into orbit. The Division's platforms were scheduled to be aboard the Saturn IB vehicles when that program is launched early in 1966 and on the Saturn V Apollo vehicle when it carries man to the moon.

Eclipse-Pioneer also continued to supply liquid-floated pendulous integrating Gyro Accelerometers (PIGA) for USAF's Minuteman II missile. As key acceleration-sensing units in the missile's guidance and control system, the PIGA has been described as providing one of the most accurate velocity measuring systems in existence.

Those gyros and accelerometers which the Division produced for the Saturn and Pershing programs were gas-floated; for the Minuteman missile they were liquid-floated. Indicative of the Division's versatility and capabilities in this field, Eclipse-Pioneer is believed to be the only company with production contracts for both gas- and liquid-floated components.

The Division also provided a security system for Minuteman that is used with the missile's electronic launch system to prevent unauthorized firings. This system is composed of two components, a launch enable execute decoder (LEED) and a digital safety control switch (DSCS).

Eclipse-Pioneer continued work on its guided missile systems radar simulator stations for the Army Missile Command. This equipment supplies simulated targets and an electronic countermeasures environment which is used for training Army personnel assigned to Nike missile installations.

Follow-on contracts were issued for Eclipse-Pioneer's AN/GJQ-9 general purpose programmer-comparator which is used on 15 different defense and space programs. Typical was the USAF's HOW NOW project which determined the reliability of re-entry vehicles and associated equipment installed on space vehicles. On another project, the highly adaptable and versatile "Q-9" early in the year passed its 10,000th hour of operational service in checking out Agena D space vehicles.

Activity in the U. S. space program included the development of a range display indicator for NASA's lunar excursion module. The range indicator will provide the LEM astronauts with altitude and rate of altitude change information during descent from the Apollo command and service module to the lunar surface. On return to the mother ship, the indicator will show separation distance and rate of closure between the two vehicles. The indicator features the latest techniques in digitized display tapes and integrated microcircuitry.

Eclipse-Pioneer continued its work on the LEM throttle actuator, an electromechanical device that will provide precise positioning of the LEM ascent-descent engine as the vehicle descends to the moon.

Reflecting the increased activity, employment figures at Eclipse-Pioneer rose to more than 10,000 during 1965.

PIONEER-CENTRAL DIVISION

The years 1962 through 1965 were used most effectively by the Pioneer-Central Division to further solidify its position in the aerospace field. The basic product lines of life support equipment, cryogenic, aerospace, and propellant control instrumentation, aircraft flight instrumentation and oxygen systems were materially changed and enlarged.

Several of the additions made were Mach Warning Switches, Vertical Velocity Indicators, Temperature Compensated Oscillators and Solid State Amplifiers. Probably the most important individual product development was the Airborne Altitude Computer used for the Air Traffic Control Radar Beacon System. This computer is designed for use in high performance subsonic and supersonic aircraft to maximum altitudes of 80,000 feet and speeds of Mach 2.5.

Two new products were developed and at year-end were under test. These are the Cryogenic Flowmeter and the Cryogenic Densitometer. The Cryogenic Flowmeter accurately measures mass rate of flow of cryogenic liquids, while the Cryogenic Densitometer measures the density of cryogenic liquids under dynamic conditions.

Some of the Pioneer-Central products previously used on missiles were adapted successfully for various ground based applications and space vehicle launch boosters. Notable among these were optical type liquid sensors, amplifiers and capacitance probes used in large quantities by NASA for measurement of liquid levels during ground test runs, and on launch boosters. These systems were used for a variety of liquids such as RP-1 fuel, liquid hydrogen, liquid oxygen and water.

The year 1965 also marked the completion and initial use of a new 3250 square foot Class III white room. This room is completely equipped for instrument and component assembly and test, and includes the latest in Sonic Cleaning equipment, also manufactured by Pioneer-Central. The room is designed to handle not only small instrument assemblies but also larger components up to 40 feet in length.

RED BANK DIVISION

During 1965, Bendix Red Bank continued to expand its line of brushless AC generating systems by adding to it a complete family of environmental-free systems. These systems, rated from 15 KVA to 60 KVA, utilize engine oil as a coolant, and therefore do not depend on ambient air for cooling. The units also utilize Red Bank's brushless generator design with flight-proven reliability, long operating life and low maintenance. The addition of these units to the current line of AC systems gives Red Bank the most complete line of AC generating systems available to the aircraft industry.

Development of a new line of small, brushless DC generating systems was also initiated during 1965. These units are designed especially for use in light single and twin engine executive aircraft. Brushless and self-excited, the units have built-in excitation and regulation, and the aircraft's battery is not used to start generator operation. Designed for low cost, the generators will also provide high reliability, long operating life and low maintenance.

Several other new DC generators and starter generators were also developed during the year. Among these was a conventional, brush-type 30-volt, 400-amp unit scheduled for use in several of the new executive jets.

In power conversion, Red Bank added several new multipurpose units to its line of inverters. These new inverters, controlled by a solid-state device, fit several different MS requirements and may be used in both new and retrofit applications.

In this field, Red Bank's 1500 VA static inverter continued to win awards for its contributions to the Gemini space program. One of 54 critical parts in the program, the static inverter produces AC power for guidance equipment installed in the Titan booster.

BENDIX SYSTEMS DIVISION

The Bendix Corporation continued during 1965 to be a leader in the field of lunar exploration. Bendix experience in automotive, electronics and aerospace systems, a combination unique in industry today, has made this leadership possible.

The Bendix Systems Division, Ann Arbor, Michigan, is the corporate focal point for the development of extraterrestrial exploration systems. Contract activity there is directly involved with extensive investigation of the moon's surface and structure following the Apollo program. This next step, known as the Apollo Applications Program (AAP), will provide our astronauts with the means to travel the lunar surface and the instruments to obtain scientific and engineering data on the nature of the moon and its environment. Systems Division was awarded a contract by the Marshall Space Flight Center of NASA to design a lunar surface vehicle known as the Local Scientific Survey Module (LSSM). It will carry the astronaut, in his space suit, over a range of 175 miles and carry up to 600 pounds of scientific equipment. In 1965, Systems Division was also performing for NASA a study of the specific scientific missions which can be accomplished with the LSSM and other lunar vehicles. This effort includes the detailed description of scientific instrumentation, the selection of five lunar sites and the precise method of exploration.

Another contract at Systems Division, performed for the Manned Spacecraft Center of NASA, is a study of the changes which might occur in mineral samples collected on the moon when they are returned to the earth's surface for laboratory examination. The program makes use of a Bendix Time-of-Flight Mass Spectrometer.

The design of vehicles to travel on the lunar surface has been an objective of The Bendix Corporation since 1960. In 1965, Systems Division was selected by NASA to design, build and test a full-scale lunar vehicle to evaluate various mobility concepts of proposed lunar vehicles for post-Apollo exploration. This contract will provide the Marshall Space Flight Center with a 25 foot long, 1,750 pound vehicle capable of being driven by an on-board operator or remotely controlled. Field tests with the vehicle will determine soft soil performance, slope climbing, obstacle and crevice crossing and turning characteristics, and energy consumption.

In recognition of Bendix capability in scientific lunar exploration, NASA selected the Systems Division as one of three contractors to receive awards to design an Apollo Lunar Surface Experiment Package (ALSEP). After a six-month study phase, one of the three contractors will be awarded a multimillion dollar contract to build an instrument package which will be set up by the Apollo astronauts before they return to earth. The unit will operate by itself for a year, measuring and sending back to earth data on the moon's structure, surface characteristics, atmosphere, solar winds, radiation and micrometeorite impact.

During the year, Systems Division continued studies toward the projected exploration of Mars. Consideration was being given to vehicle designs, communications, instrumentation and data processing requirements, environments and surface characteristics in order to define exploration system requirements and operations to be performed on early probes to the Martian surface. The methods of determining the existence of any life forms is an important part of the studies.

YORK DIVISION

During 1965, York Division continued its traditional activity of research, development and production of complex electronic fuzing systems, from a background which involved participation in the Sparrow I, Honest John, Little John, Lacrosse, Redstone, Bomarc, Pershing, Genie, GAR-9, Eagle, Lance, Mauler, and Phoenix programs. The Division was also engaged, during the year, in study contracts for advanced weapons systems.

In conjunction with the fuzing programs, the York Division continued to develop, design and produce evaluation test equipment and tactical test equipment. The York Division designed and produced the Talos Tactical Test Equipment (TATTE) a go-no-go test set utilized to test the entire Talos missile system.

Because of the Division's involvement in many military electronics programs, support capabilities have been developed in many areas. The York Division is a producer of custom high quality, high reliability printed circuit boards and a variety of radar components have been supplied on a custom basis. These include antennas, RF front ends, IF amplifiers, video processing circuitry, transformers, etc. The Division was also working toward further development of lighter weight, smaller volume and higher reliability electronic systems for missile and space applications.

THE BOEING COMPANY

Record sales and deliveries of The Boeing Company's family of commercial jetliners highlighted the company's worldwide activities during 1965.

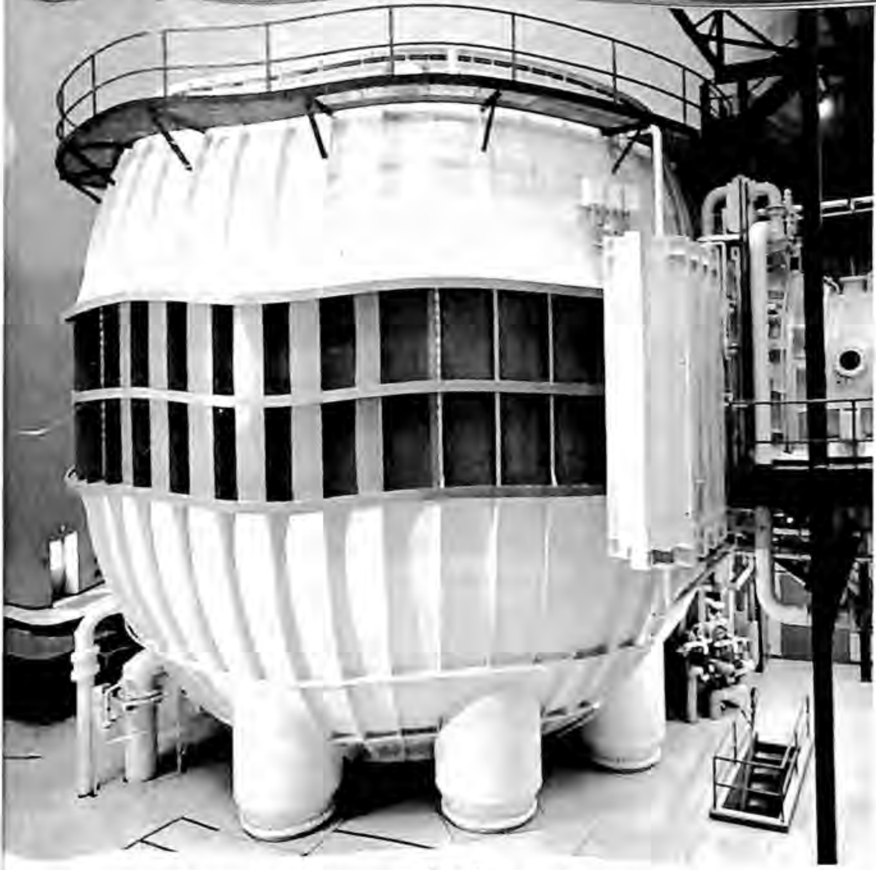
By mid-December, Boeing had sold 417 jet airliners in 1965, raising the overall sales total to 1,112. Deliveries totaled 158 early in December and were scheduled to reach 177 by year's end. Included in 1965 sales were orders from six airlines for 86 short-range Model 737's, which went into production in February. Thirteen new customers for Boeing jetliners were added during the year.

The substantial number of new orders received for all Boeing commercial jetliner models further increased the company's backlog of commercial business in comparison with military aircraft and missile and space programs. At the end of September, approximately 70 per cent of the company's backlog of $3,031,000,000 was for commercial programs.

Increased emphasis was being placed on supersonic transport development during the last half of 1965, following the summer announcement by President Johnson of an 18-month extension of SST studies. In addition, the Commercial Airplane Division was studying numerous designs for a large subsonic commercial transport under the general engineering designation of 747.

Boeing is one of three companies involved in design studies of the proposed Voyager spacecraft. Preliminary designs were submitted to Jet Propulsion Laboratory and studies were to continue in 1966. Plans called for selection of a single contractor in mid-1966. The Boeing Missile Division was working under a $2,500,000 contract to define the proposed Air Force short-range attack missile.

Continued work in connection with the advanced Minuteman II intercontinental ballistic missile, the



Largest of 11 vacuum chambers in the space environment laboratory at Boeing Space Center is this 50-foot giant. The new center was dedicated in October.

S-IC booster for the National Aeronautics and Space Administration and the Lunar Orbiter spacecraft provided major activity in the Aerospace Group.

One hundred per cent acceleration in the production of two military helicopters being built at Boeing's Vertol Division in Pennsylvania was ordered by the Department of Defense. At the Turbine Division in Seattle, production started on a new 330-horsepower helicopter engine, and plans for a new industrial gas turbine engine were announced.

Under the direction of Boeing International Corporation, the company's Airplane Group product development organization entered into a contract with Entwicklungsring Sud (EWR) of Germany to assist in their design analysis of a German supersonic strike fighter aircraft. EWR is owned jointly by Messerschmitt and Boelkow. Boeing has a one-third interest in Boelkow GmbH, the Southern German aerospace firm.

Administrative organization of the company was changed by the establishment of "group" designations. In January, the Airplane Group was formed with two operating divisions, the Military Airplane Division and the Commercial Airplane Division. In July, the company announced formation of an Aerospace Group with two separate operating divisions, the Space Division and Missile Division. The name of the Missile Division was changed to the Missile and Information Systems Division in December.

A 19-day strike against Boeing by the International Association of Machinists was settled in early October.

AIRPLANE GROUP

The addition of the 737 to Boeing's family of commercial jetliners was announced February 19. At the same time, Lufthansa German Airlines placed an initial order for 21 of the new 737's. United Air Lines later ordered 40 twin-jet 737's as part of the largest order ever made by a commercial airline.

In announcing the 737 construction go-ahead, Boeing said its decision was made only after it was convinced the 737 design was clearly superior to those already being offered in the short-range jet market. A corporate version, the 737E, was offered later in the year. Rollout of the first 737 was scheduled for late 1966, with delivery of the first certificated airliner to take place in late 1967.

New models of the 727, the most widely sold jetliner in the world, were announced. The 727-QC, for "Quick Change," was unveiled in April. The QC version can be converted to any passenger-cargo configuration within 30 minutes. The 737 is also available in the regular cargo or convertible passenger-cargo versions.

A longer 727 model, the 727-200, was announced in August. This version, 20 feet longer than the original 727, will carry up to 170 passengers.

The record jetliner sales for 1965 included 707/720, 127 airplanes; 720B, 7; 727, 197; and 737, 86.

Except for B-52 fleet modernization and modification performed at the Wichita, Kansas, Branch of the Military Airplane Division, Boeing's fixed-wing airplane work was chiefly in the commercial field. The last of 732 KC-135A jet aerial tankers was delivered to the Air Force January 12 in Seattle. Between 1956 and 1965, 820 KC-135s, C-135s and variants were built.

Several other milestones were recorded by the Airplane Group. In January, the 500th Boeing commercial jetliner was delivered; in September, Boeing jet airliners carried their 100,000,000th passenger; also in September, orders for Boeing jetliners passed the 1,000 mark; and in November, the 200th Boeing 727 was delivered.

By mid-year, Boeing B-52 bombers had chalked up 10 years of operational duty with the Air Force Strategic Air Command. Late models of the B-52 have been earmarked for service into the 1970's. The B-52 also went into operation over Viet Nam.

The Boeing jet transport prototype, 11 years old on July 15, was flown under NASA contract as a simulator to study the low-speed flying qualities of supersonic transport designs.

AEROSPACE GROUP

In May, it was announced that Boeing's portion of the more than $1,000,000,000 Air Force program for replacement of Minuteman I missiles with the advanced Minuteman II would total more than $400,000,000. Boeing's role as weapon systems integrator involves the replacing of 800 Minuteman I missiles now on operational alert.

Work was also in progress on emplacing 150 advanced Minuteman II missiles in the vicinity of Grand Forks Air Force Base, North Dakota. Installation of a 50-missile Minuteman II squadron at Malmstrom AFB, Montana, was to begin in 1966.

A successful Minuteman II program was indicated in August when a Minuteman II was launched at Vandenberg AFB, California, from an underground silo for the first time. On July 31 the first operational Minuteman II was shipped from the assembly plant at Ogden, Utah, to Grand Forks AFB.

Other Boeing missile activity included work on HiBEX, a high acceleration experimental missile booster. HiBEX was fired from an underground cell for the first time on October 28.

As the first Lunar Orbiter mission in mid-1966 approached, Boeing activity on the program intensified. The first spacecraft built to exact flight specifications was rolled from a company "clean room" in Seattle late in the year. It will be tested in a huge vacuum chamber at Boeing's Kent Space Center to see how it operates in a space environment. This spacecraft is one of three being built for ground tests. Five flight models are being built by Boeing for NASA.

Work on the mammoth S-IC first-stage booster for the Saturn V moon-rocket successfully passed a milestone August 5 when the S-IC-T test stage was ground-tested for full flight burning time of 2-1/2 minutes at NASA's Marshall Space Flight Center, Huntsville, Alabama. Fourteen firings of the S-IC-T had taken place through December 9. Most major components of the first stage were built by Boeing at the Michoud Assembly Facility in New Orleans and the company's Wichita Branch. Boeing has a contract to build eight S-IC flight units, and two ground test vehicles.

The S-IC-D, first Saturn V booster to be completed at New Orleans, was shipped October 7 to Huntsville for a series of ground tests which are designed to prove the rocket's structural strength.

The first flight vehicle, the S-IC-1, was rolled out at Marshall Space Flight Center on September 27. The booster was turned over to NASA's quality and reliability assurance laboratory at Marshall for four months of intensive checkout before static testing begins next February.

In September, the Air Force announced it was awarding a $6,500,000 contract to Boeing's Space Division to develop a highly reliable, low-cost upper stage (called Burner II) for placing small- and medium-sized payloads in orbit.

VERTOL DIVISION

Production was the keynote at the Vertol Division in 1965. Two of the largest helicopter programs in the free world, the CH-46A Sea Knights for the Marine Corps and the CH-47A Chinook for the Army, were under way at the Vertol Division. The Chinook went into action in Viet Nam in late 1965.

In July, the Department of Defense instructed the division to increase Chinook production by 100 per cent, and two months later the same increase went into effect for the Sea Knights.

The first armored Chinook, one of four being built by Vertol for Army evaluation, was rolled out and flown for the first time in late 1965. It was being tested at year's end.

Vertol Division signed a supplementary licensing agreement with Kawasaki Aircraft Company, Ltd., of Japan, giving the firm worldwide sales rights to the Vertol 107 helicopter. The original agreement, signed with Kawasaki in 1961, granted the Japanese firm exclusive sales and service rights in Japan. Kawasaki-built 107's are in service with the Japanese Maritime Self-Defense Force, the government of Thailand and Kanki Airlines of Japan, and will soon be in service with the Japanese Ground Self-Defense Force.

TURBINE DIVISION

The Boeing Turbine Division began production of the T50-BO-10 engine, an advanced 330-horsepower turbine for the Navy's QH-50D antisubmarine helicopter. A new industrial gas turbine, the model 551, was announced early in 1965. It has a power rating of 360 horsepower, and will be marketed for industrial application in the petroleum, vehicular and marine fields.

The Royal Swedish Army revealed in September two additional applications of Boeing gas turbines: as boost power for a giant self-propelled 155 millimeter gun and a fast reacting self-propelled anti-aircraft weapon equipped with two automatic guns.

During the year, a Boeing turbine completed more than 15,000 operating hours before overhaul, marking the first time any small turbine has ever attempted an operating record of such length.

Turbine sales and manufacturing activity increased steadily at the firm of FN-Boeing Turbines S.A. in Belgium.

NEW FACILITIES

With commercial airplane and military helicopter production both increasing, the company kept pace with many significant new facility plans. Also, employment was on the upswing, with more than 55,000 in the Seattle area and more than 95,000 throughout the company in December.

Expansion at the Commercial Airplane Division in Renton, Washington, included a new master model building for 737 parts tooling, additions to the major and subassembly manufacturing buildings and paint facility modifications, valued at $6,000,000; engineering laboratory, $3,000,000; final assembly building, $17,800,000; and a new office building.

At Vertol, the company purchased an existing facility in suburban Philadelphia which contained 3,000,000 square feet of area under cover and 550 acres. A new helicopter wind tunnel was announced in November.

The $20,000,000 Boeing Space Center, in Kent, Washington, under construction for more than a year, was officially dedicated in October. A 1,500-man office building was under construction and scheduled to house Boeing's Space Division on completion in 1966.

Late in the year, work began on a new central fabrication plant at Auburn, Washington, near Seattle. The new plant will support manufacturing operations at Boeing's Seattle-based divisions.

CESSNA AIRCRAFT COMPANY

Cessna Aircraft Company grew at full throttle in all areas during 1965. New products, sales and earnings records, plant additions and record employment all were packed into a banner year.

The largest single project begun during the year, and the greatest effort ever undertaken by Cessna, was the 150 program. In June the company announced that it would build 3,000 Model 150's during the 1966 model year—nearly four times the number built during the preceding model year. The mass production techniques made possible by this volume allowed Cessna to cut the 150's price by more than 10 percent and still add many improvements in the new model.

Motivating Cessna's decision to launch the 150 program was a firm belief, based on market trends and surveys, that the base of the general aviation aircraft market must be broadened to permit the industry to develop to its full potential. The 150 program put aircraft ownership within the economic reach of more people who already want to fly, and its related advertising and marketing campaign has brought flying to the attention of more potential flyers.

Cessna realized that the key to the success of the 150 program lay in the hands of the dealers who would have the most direct contact with the customers, so the dealers' reaction to the program was watched carefully. The enthusiasm of their words at area dealer meetings was soon matched with firm orders—more than 2,500 of them in less than four months.

Closely linked to the 150 program was Cessna's learn-to-fly campaign, which began in January 1965 and continued through the year at an accelerating pace. The 150 is widely used as a trainer, so the 150 and learn-to-fly programs go hand in hand.

Cessna's learn-to-fly program was being supported internationally by the largest single advertising campaign in the company's history. Full-page advertisements appeared in Life, Time and Flying magazines in the United States and in Reader's Digest overseas.

The purpose of the learn-to-fly campaign is to broaden the aircraft market, as well as to stimulate the flight training business. Cessna's market research studies revealed that only a small portion of the potential learn-to-fly market was being developed. The studies also showed a direct relationship between the number of persons learning to fly and the number of airplanes sold. To develop the potential of the aircraft and learn-to-fly markets, Cessna estimated that the number of flight students would have to be tripled by 1968.

The high degree of activity at Cessna is apparent here. The company was producing, at one time during 1965, one airplane every 23 minutes of the eight-hour working day.

Cessna developed the learn-to-fly campaign on the international and national level, and the company's authorized dealers merchandised the campaign on the local level—both keyed to $5 introductory flight lessons to acquaint prospective students with flying. Within four months the success of the campaign could be measured in dollars and cents, with more than $10,000,000 in business already generated within Cessna's worldwide dealership network.

In the midst of new programs, the results of previous efforts were reflected in the form of sales and earnings records. The company's fiscal year, ending September 30, brought all-time high sales and earnings.

Consolidated sales totaled $148,000,000, an increase of $25,000,000 over fiscal 1964 sales. Preliminary figures indicated earnings of at least $3.25 per share, compared with $2.27 per share the previous year.

Commercial aircraft showed the greatest growth, with sales of $93,000,000, $21,000,000 more than the preceding year. All of Cessna's other operations—Industrial Product Division, Military Aircraft Division, Aircraft Radio Corporation, National Aero Finance Corporation and the McCauley Division—also had sales increases during the year.

Cessna delivered 5,038 business and private aircraft during fiscal 1965 for a 25 per cent increase over the previous year's sales. Although much of the increase in unit volume came from single-engine aircraft, Cessna's twin sales increased 49 percent over fiscal 1964.

The end of the 1965 fiscal year also marked the tenth consecutive year Cessna produced more commercial aircraft than any other manufacturer in the world and the eighth straight year the company has led in dollar volume. Two major milestones also came during the year. In April Cessna delivered its 10,000th Model 172/Skyhawk, which was purchased by Elaine Flying Club, Inc., a group of farmers and businessmen in Elaine, Arkansas. In August Cessna delivered its 60,000th airplane, a model 150. It was purchased by a Safeway store manager who was learning to fly in Alva, Oklahoma, just a few miles from the site of Clyde V. Cessna's first flight in 1911.

In February the Model 411 executive twin went on the market. This turbocharged, six-to-eight-place aircraft took its place at the top of Cessna's 14-model line. Sales quickly proved that Cessna has spotted a potentially strong market. Within a few months the 411's production schedule had to be revised upward to meet the market demand for the $108,950 craft.

Another new Cessna, this one designed for an entirely different market, made its first flight the same month the 411 went on the market. Cessna's first on-purpose aerial application plane, the Agwagon, flew for the first time February 19. Noting that more than 30 percent of today's agricultural fleet is 20 or more years old, Cessna designed the Agwagon to fit the specific needs revealed by a survey of agricultural application operators. Later in the year the Agwagon went to selected operators for testing under actual field conditions to insure unity between the Agwagon design and its prospective buyers' needs. Agwagon production is expected to begin in 1966.

Also in the new product area, Cessna scored an industry first with the introduction of turbocharging in a production single-engine plane. The turbocharged Super Skywagon brought to the single-engine pilot many of the performance advantages previously available only in twins like the Skyknight and 411.

Although Cessna's big surge was in commercial aircraft, military aircraft sales also were significant. Orders continued to come in for the T-37 twin-jet trainer, primary jet trainer for all Air Force jet pilots and for many U. S. allies. Delivery was completed in August on an order for 170 T-41A (military version of the 172) trainers for the Air Force's new pre-jet flight training program.

Seventy-seven U-17A's (military version of the 185 Skywagon) were delivered to overseas nations through the U. S. Military Assistance Program. In Viet Nam, the Cessna 0-1 "Bird Dog" played a key role as a spotter aircraft in action against the Viet Cong.

To handle the production demands of these expanding markets, Cessna increased its work force to 9,800 persons, a company record. Facilities also were expanded to include a new service parts center, and more than 200,000 square feet of plant space in the U. S. and 100,000 square feet overseas.

CONTINENTAL MOTORS CORPORATION

MILITARY PISTON ENGINE DIVISION

Of the total new business received in 1965, about one-half involved contracts awarded Continental Motors for products with military applications.

Largest of these was a $36,300,000 contract for approximately 16,000 LDS-465 six-cylinder, turbocharged compression-ignition multifuel engines for the U. S. Army's 5-ton truck series. Initial deliveries under this three-year multiyear procurement contract will begin early in 1966.

The LDS-465 is a supercharged version of Continental's LD-465 multifuel engine in volume production for the Army's 2-1/2 ton truck series under a contract covering a three-year period, and funded for approximately $57,000,000.

The multifuel family of engines designed and developed for the Army by Continental Motors employs one of the most advanced combustion systems in the automotive industry. These engines are capable of operating on all types of petroleum products, ranging from kerosene and diesel fuel to gasoline, or any combination of these fuels. They have also compiled outstanding performance records in field tests under the most grueling conditions, including operating in temperatures ranging from 65 degrees below zero to 115 degrees above.

Another major award during the year was a three-year contract totaling $11,900,000 for production of 28,000 engines for the Army's M-151 quarter-ton military utility tactical trucks.

Year-end contracts called for continuing production of Continental AVDS-1790-2 750-horsepower compression-ignition engines for the Army's M-60 tank through 1966. Continental Motors also received contracts for modification kits to convert 150 gasoline-powered M-48 series tanks into vehicles with Continental AVDS-1790-2A supercharged diesel engines; for approximately 1,600 modification kits to update AVDS-1790 tank engines to the latest Army configuration; and for an overhaul and retrofit program on AVSI-1790-6 and -6A engines utilized in the Army's M-88 Tank Recovery Vehicles.

Over 40,000 engingcs were manufactured during the year under the Military Standard Engine Program, virtually completing the production run called for by existing contracts.

AIRCRAFT ENGINE DIVISION

Extensive, highly effective "Learn to Fly" promotion programs initiated by major aircraft manufacturers played an extremely important role in the continued expansion of public interest in business and personal flying in 1965. Authoritative industry sources estimated that in 1965 approximately 85,000 persons were taking flying instructions in the U. S. alone, and this figure is expected to more than double by 1968.

The sharp increase in sales of Continental aircraft engines and service parts during the 1965 fiscal year reflected this expanded interest, and there is every reason to believe further substantial increases will be recorded in the years immediately ahead.

Continental engines power the majority of business and personal aircraft produced in the United States, with major customers being Cessna Aircraft Company and Beech Aircraft Corporation. Continental Motors also supplies engines for certain models of aircraft manufactured by such firms as Aero Commander, Champion Aircraft Corporation, Maule Aircraft Corporation and Alon, Inc.

Because of proven product excellence and dependability, Continental power packages were selected for many of the new aircraft models introduced by U. S. airframe manufacturers last year. Of particular significance was the new twin engine Cessna 411, powered by Continental GTSIO 520 engines, and the turbo supercharged Beechcraft Bonanza, which features the Continental TSIO 520 engine.

The growing interest in business and personal flying was also quite evident abroad, and several new aircraft powered by Continental engines supplied by Rolls-Royce Limited in Crewe, England, were introduced during the year. Continental Motors has a licensing agreement with Rolls-Royce, under which that British firm manufactures Continental engines for airplane producers in Europe and elsewhere in the free world.

MILITARY APPLICATIONS

Numerous Continental-powered aircraft of the business and personal type were in action with American fighting men in Viet Nam and other world trouble spots, and in military pilot training programs.

Cessna Model O-1 single-engine propeller planes, for example, were being used extensively in Viet Nam on low level missions to search out targets too cleverly camouflaged to be noticed by pilots of fast-moving jets, to make pinpoint aerial supply drops, and for photo reconnaissance.

Other Cessna aircraft in use by the military include the U. S. Air Force U-3 light cargo and administrative airplane; the U-17A, supplied through the Air Force to 14 different free-world countries under the Military Assistance Program; and the T-41A Air Force trainer in which all student pilots receive their first 30 hours of flight indoctrination. In addition, the Cessna T-37 twin jet, used by the Air Force for advanced flight training, is powered by two J69 turbojets manufactured by the company's Continental Aviation and Engineering subsidiary.

INDUSTRIAL-AUTOMOTIVE ENGINE DIVISION

The demand for Continental liquid-cooled engines in the industrial and automotive product area continued strong during 1965. With close to 200 different applications, these engines constantly serve the American public and industry in a wide variety of ways.

Continental's new series of L-478 and LD-478 engines was entering the final testing phase. This family of 478 cubic inch engines, when fully developed, will offer models in the 130- to 180-horsepower range which can burn diesel, gasoline, LPG, natural gas and other fuels. This family feature is of great interest to generator, truck, farm implement, and other industrial equipment manufacturers. With the interchangeability of engine models, industrial equipment manufacturers need design a specific piece of equipment only once in order to meet various end-use customer requirements for different types of fuel. Completed field tests of these models resulted in substantial production orders for their use in various industrial equipment in 1966.

MATERIAL HANDLING ENGINE DIVISION

Continued growth in the material handling equipment field during 1965 was reflected by the substantial increase in the total number of Continental engines, specifically designed to power this type of equipment, that were ordered during 1965. Total material handling engine units ordered exceeded by approximately 25 per cent the number of such units ordered by Continental customers in 1964.

During 1965 Continental Motors introduced a new four- and six- cylinder "F" series engine line which incorporates features designed to meet the increasingly complex requirements of the growing material handling equipment industry. These features include a new valve arrangement with springs, tappets and guides, and a crankshaft with bearing arrangement specifically designed for lift truck type applications. This new "F" series also maintains a high degree of parts interchangeability between engines, including flywheel, flywheel housing, water pumps and pulleys, and gear covers.

Continental-powered material handling equipment can be found all over the world in hundreds of diverse settings—in air terminals, alongside docks and in the holds of ships, in logging camps, factories and warehouses, fruit orchards, mines, steel mills—any situation requiring the lifting, transporting, or special handling and packaging of material.

GRAY MARINE ENGINE DIVISION

Continental's Gray Marine engine division maintained its share of the marine engine market during the 1965 fiscal year, a year in which a number of mergers between engine and boat manufacturers occurred in the boating industry. While several boat manufacturers produce their own engines, it is significant to note the multiplicity of leading independent boat manufacturers who are long-time customers of Gray Marine, including Century, Trojan, Lyman, Tollycraft, Luhrs, Ulrichsen, Aluminum Cruisers, Bellcraft, Grady-White, Inland Seas, and Correct Craft.

Largest volume producers among the basic engines comprising the Gray Marine line were the V8 models ranging from 185- to 280-horsepower, which can be used either singly or in pairs. Substantial gains also were made during the year in shipments of auxiliary engines for sail boats, currently experiencing a boom in popularity throughout the country.

Of particular significance was the 1965 introduction of an important new 150-horsepower six-cylinder engine with stern drive—the Gray Marine Model 232—Continental's entry into the fast growing market for inboard-outboard installations. This engine was being marketed as a complete "package" for such inboard-outboard installation, and comes complete with an installation kit with all necessary through-hull fittings and an instrument panel with electric tachometer. The Model 232 is also available for conventional inboard installation and in "bobtail" model for turbine drive in jet boats.

Continental was also proceeding with development work on a new "family" of diesel marine engines, the first of which, a supercharged diesel in the 250-horsepower range, was undergoing boat tests and was scheduled for introduction the latter part of 1966.

BRANCH PLANT OPERATIONS

As in past years, branch plant operations made a significant contribution to total 1965 business volume through their flexible and diversified services to Continental distributors and customers.

A new branch plant was opened during the year in the Chicago area, augmenting Continental's network of strategic branch locations. The 91,500 square foot leased facility was fully operational by year-end, and was equipped to handle engine and spare parts sales and service requirements, and engine overhaul and rebuilding for Continental customers and distributors in the Midwestern and East Coast states, and in certain areas abroad.

CURTISS-WRIGHT CORPORATION

While continuing the development and manufacture of a wide variety of aerospace products, the Curtiss-Wright Corporation during 1965 concentrated significant effort on research and development oriented toward future applications.

In engine technology, considerable progress was made on an Air Force program to develop a basic gas generator system, designed to serve as a building block for a family of related turbojet and turbofan engines for subsonic, supersonic and V/STOL applications.

Engineers at Wright Aeronautical Division, for example, were successful in operating a test engine at 2,750 degrees Fahrenheit as part of this development effort, a first in engine technology.

A Navy program, also being conducted at Wright Aeronautical Division, called for the development, test and demonstration of a turbofan engine, which, while functioning under a basic gas turbine cycle, uniquely combines a single-stage, axial-flow supersonic compressor and a radial inflow, axial-exit turbine on a single rotor disc.

Component research focused on lightweight high-performance combustion chambers; transpiration-cooled turbine blades; nozzles; exhaust noise suppressors; engine accessories and liquid metal regenerator technology.

Another major effort under way was directed to the further development and perfection of the rotating combustion engine. Considerable design work, with accompanying test programs, was done in 1965, with the objective of readying a series of light, compact power plants, for application in the aircraft, vehicular, industrial, marine and auxiliary power unit fields. Both liquid and air-cooled versions of this basic engine type were being developed, with ratings up to 1,500 horsepower. Single and multi-fuel versions were also under development.

The company initiated work on several Army-funded contracts for advanced vehicular engine component technology, and other engine component research and development for the National Aeronautics and Space Administration.

In the aerospace propulsion field, the company's activities ranged from liquid rocket engines with up to 10,000 pounds thrust to solid pulse rocket engines under development to provide attitude and spin control for advanced meteorological and communications satellites requiring precise control systems.

As a result of a product diversification move previously made, the Curtiss Division in 1965 showed an entirely different face from the days of exclusive propeller production.

While continuing to perfect the design and manufacture of special types of propellers, the division developed an improved missile steering control system while delivering a wide variety of actuation systems and subsystems. Among these were rotor fold actuators, flap drive and weapons bay actuation and drive systems for helicopters and aircraft and variable exhaust nozzle controls (for T-38 and F-5 aircraft).

In addition to research and development of special purpose clutches and power transmission systems, the Curtiss Division also made considerable progress in the sonics field, the most notable example of which was the diagnostic engine analyzer. Several models of the analyzer were developed or under development, with one version undergoing a highly successful test program at the Marine Corps Air Station at Cherry Point, North Carolina, during 1965. The sonic engine analyzer appears to offer great promise to both military and commercial aviation interests, as a diagnostic tool in maintenance and in-use test procedures.

Another 1965 milestone for Curtiss-Wright was the creation of the VTOL Systems Division, lending greater emphasis to the company's interest in V/STOL research and development, begun in 1958. During the year, while a number of study efforts in basic V/STOL engineering were being pursued, extensive flight testing was done on the tilt-propeller X-19 aircraft. Funded under the Tri-Service program, data acquired during the year substantiated engineering design criteria and the soundness of the radial force, tilt-propeller concept of V/STOL flight.

In the electronics area, the company, through the Electronics Division, concentrated on two principal areas: special purpose equipment and simulators. Among the activities worthy of note were the initial delivery of weapon systems trainers incorporating sophisticated passive countermeasure simulation devices, and design of special purpose radar sets, to be used for ground control approach in forward combat areas.

The Electronics Division also continued as a prime supplier of nuclear reactor instrumentation and control systems for installation aboard nuclear-powered submarines and surface ships of the Navy.

In the simulator field, the division began development of a unit related to the Navy's training program in maintenance of airborne fire control systems.

In metallurgy, the company's interests ranged from basic investigations of properties of so-called "exotic" materials, to the rapidly developing technology of powdered metals.

Among the more important efforts, conducted by the Metals Processing Division, were research programs on liquid metal corrosion, composite materials, microstrain behavior, pressure effects in super alloys, wear-resistant coatings and studies of low-cycle fatigue, high-strength, low-density materials, and thin films.

Work in the powdered metal field was largely concentrated on expanding the company's leading position in forming and fabricating pre-alloy powders, including metal, cermet, carbide and ceramics. This effort was largely geared to the design and fabrication problems anticipated in advanced space craft and supersonic aircraft.

The Metals Processing Division continued production of precision blades for use in a variety of components in jet engines, and large extruded steel structurals for aircraft carrier construction as well as other steel extrusions for everything from submarine hulls to steam catapults.

Among other activities of the company in 1965 was the continued production of such diverse items as aircraft windshield wipers (produced at the Marquette Division, the largest supplier in the industry) and a variety of special-purpose tools, air compressors, automotive service equipment, motor generator sets, and pumping units, most of the latter through Canadian Curtiss-Wright, Ltd.

DOUGLAS AIRCRAFT COMPANY, INC.

First flights of new commercial and military jet aircraft; substantially increased sales of passenger and cargo airliners; continued prominence in missile and space programs, including design and production responsibilities for the nation's first manned orbiting laboratory, and entry into the nuclear field were among the signficant 1965 highlights of the Douglas Aircraft Company.

AIRCRAFT GROUP

The new DC-9 short-to-medium range twinjet transport completed its first flight February 25, 1965. First of the DC-9's was accepted by Delta Air Lines in September, three months ahead of schedule.

Nearing completion at Douglas Space Systems Center are two Saturn S-IVB propellant tanks.

By year-end, 19 of the world's airlines had ordered, leased or taken options on more than 300 DC-9's.

Douglas was building the Series 10 DC-9, the larger Series 30 DC-9 and a convertible passenger-cargo model. A business version was also being offered.

A major development in air commerce was the announcement by Douglas in April that it will build three new, enlarged versions of its successful DC-8 jetliner, ordered by 30 airlines. The new DC-8's, the Models 61, 62 and 63, are designed to meet airline growth requirements on high-passenger-density long-range flights. Concurrently in production with these three are the Series 50 and Jet Trader (combination passenger-cargo) DC-8's.

Model 61, with its fuselage lengthened almost 37 feet, will carry 251 passengers, 62 more than any previous DC-8. It was scheduled to roll off the assembly line early in 1966.

Model 62, an ultralong range transport, will transport payloads of 40,000 pounds nonstop from central Europe to the west coast of the United States. First flight was expected in mid-1966, two months after roll-out.

The Model 63 will combine the full fuselage extension of Model 61 with the extended wing and newly designed engine pods and pylons of the Model 62. Its first flight was scheduled for December, 1966. Studies indicated the Model 63 will provide an earning potential nearly double that of any current large passenger or cargo-carrying jet transport.

The new DC-8's also will be available with convertible interiors to handle all-freight, all-passenger or combination freight-passenger loads, similar to the capability of the current DC-8F Jet Trader.

In its military aircraft programs, Douglas was awarded a contract by the Navy to design and build the TA-4E, an advanced jet trainer version of its versatile A-4E Skyhawk attack bomber now in service over Viet Nam. The two-seat TA-4E made its maiden flight June 30, 1965, two months ahead of schedule and only 9 months and 23 days from the start of the program. The TA-4E also has combat capabilities.

Aircraft Group, to assure a continuing supply of proficient structural assemblers, sponsored a training program with the cooperation of the Department of Labor. Unskilled workers graduate from the 16-week course as skilled assemblers and with knowledge of basic blueprint reading and mathematics.

MISSILE & SPACE SYSTEMS GROUP

Noteworthy this year was the announcement by President Lyndon B. Johnson that Douglas had been selected to design and develop the Air Force's Manned Orbiting Laboratory. Work on the MOL project got under way at the company's Space Systems Center in Huntington Beach, California.

The company's highly successful Saturn S-IV program came to a successful conclusion with the orbiting of the Pegasus III meteoroid detection satellite on July 30, 1965. This was the third Pegasus orbited in 1965, the final launch of NASA's Saturn I rocket and its 10th success in 10 launches. The liquid hydrogen-liquid oxygen-powered S-IV was the second stage of the Saturn I.

Progress on the S-IVB upper stage of the Saturn rocket, a more powerful version of the S-IV, continued on schedule with NASA taking delivery of the first flight stage on August 31 following static firing at the company's Sacramento Test Center, Sacramento, California. The S-IVB will provide the final thrust to propel the manned Apollo spacecraft toward the moon during this decade. As third stage of the Saturn V moon rocket, it will inject the Apollo into orbit about the earth, coast in orbit and then restart its liquid hydrogen-liquid oxygen-fueled engine, propelling the Apollo on its lunar voyage. NASA has ordered 27 S-IVB's.

Another Douglas vehicle is the dependable Delta space booster which in 1965 orbited the Orbiting Solar Observatory II, Tiros IX and X weather satellites, Explorer XVIII interplanetary monitoring probe and the Early Bird for an over-all record of 30 successes in 33 firings since 1960.

Early Bird, the world's first commercial communications satellite, was launched into synchronous orbit atop a Thrust Augmented Delta (TAD), which has three solid propellant engines strapped onto the Thor rocket, the Delta first stage.

An improved version of the Delta, with a larger second stage having a restart capability and a longer burn time, was ordered by NASA. Douglas is Delta prime contractor to NASA's Goddard Space Flight Center.

The company also is prime contractor to the Air Force for the reliable Thor rocket. During 1965 the USAF continued to use the Thor in combination with Agena and other upper stages in classified launches from Vandenberg Air Force Base, California.

Douglas also continued to build the nuclear-tipped Genie air-to-air rocket for the Air Force. The high-velocity Genie was in its ninth year of production.

In the nuclear energy field, the Missile & Space Systems Group supplied key personnel to Douglas United Nuclear, Inc., the firm selected by the Atomic Energy Commission to operate its reactor and fuel fabrication facilities at Richland, Washington. Douglas United Nuclear, jointly owned by Douglas and the United Nuclear Corporation, assumed operating responsibility in November, 1965.

Other noteworthy accomplishments included continued studies for NASA of the proposed Manned Orbital Research Laboratory (MORL) and extensive research in biotechnology and other aspects of future manned space flight, including designing high temperature battery cells and investigations of flybys of the planet Mars.

Research and development continued on the Zeus missile, part of the Army's Nike-X antimissile system being developed to engage and destroy enemy intercontinental ballistic missiles and submarine-launched ballistic missiles. In September, the Army announced that development of an advanced Zeus, a longer range version, was under way. Douglas is Zeus airframe subcontractor to Western Electric and Bell Telephone Laboratories.

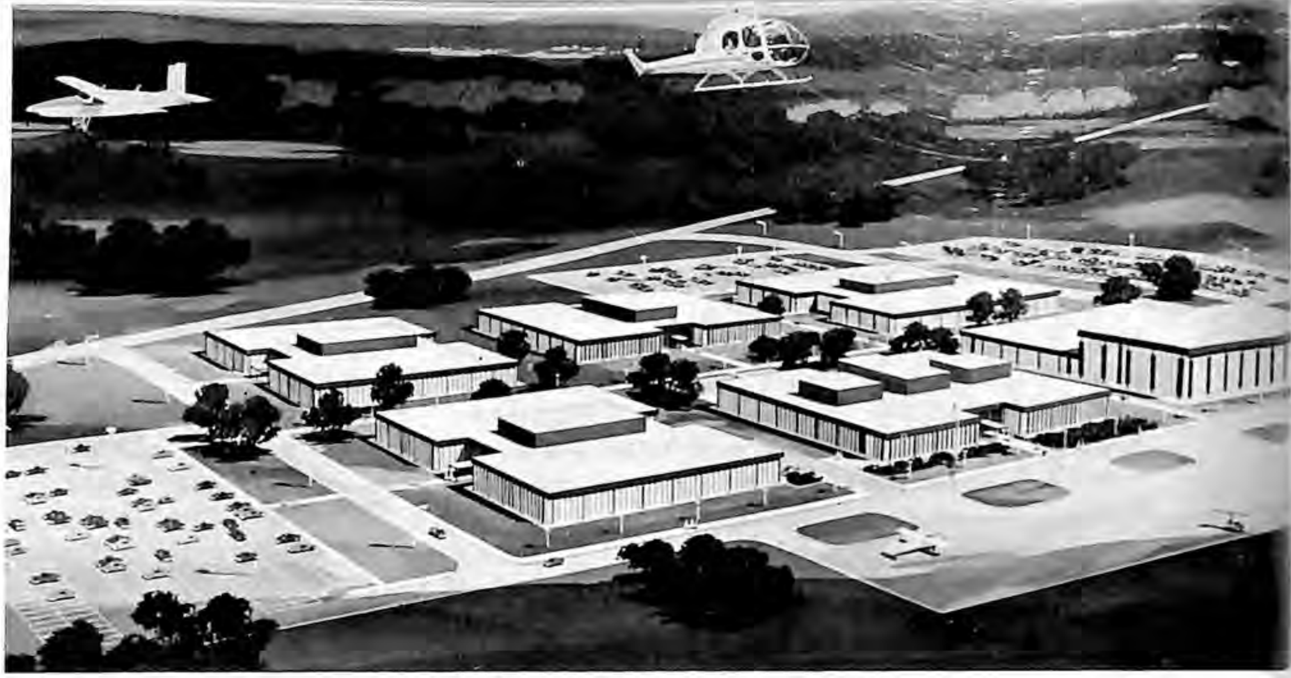
NEW FACILITIES AND EXPANSIONS

At the Space Systems Center, the company opened two 180,000-square-foot engineering administration buildings and constructed a 600,000-square-foot addition to the assembly building and a nearly 100,000-square-foot addition to the laboratory complex. The new buildings and the additions brought the Douglas investment at the 245-acre site to more than $35,000,000.

An advanced Research Laboratory, which will house Douglas scientists engaged in basic research, was being built at the Space Systems Center and was scheduled to begin operations in January 1966. A second research facility, the Donald W. Douglas Laboratories, was to be built on 117 acres of land purchased by Douglas in Richland, Washington. At this facility, expected to be operational in 1966, research and development will be conducted in areas of nuclear energy applications to space vehicles and in energy-conversion systems.

A new three-level, 300,000-square-foot technical office building at Aircraft Group, Long Beach, California, to accommodate the expanding force of office and technical employes engaged on the DC-9 and DC-8 programs, was occupied in October.

Work force at Douglas is now approximately 57,000 at all locations from California to Cape Kennedy, up 15,000 from December 1, 1964.



Construction started on Fairchild Hiller's Sherman Fairchild Technology Center, scheduled for completion in late 1966.

FAIRCHILD HILLER CORPORATION

Fairchild Hiller Corporation's timetable of growth passed another major milestone with the acquisition September 30, 1965, of operating assets of Republic Aviation Corporation. The newly named Republic Aviation Division with its 80-acre facility located at Farmingdale, Long Island, New York, added another significant capability to the company.

At year-end, hundreds of products of Fairchild Hiller, ranging from large transport aircraft to miniaturized missile components, were being developed and manufactured by 10,000 employees in a 14-plant complex in five states. Stretching from corporate headquarters and the Aircraft-Missiles Division at Hagerstown, Maryland, were the Space Systems Division at Rockville, Maryland; Electronics & Information Systems Division at Bladensburg, Maryland, and Winston-Salem, North Carolina; Hiller Aircraft Division at Rockville, Maryland, and Palo Alto, California; Aircraft Service Division at St. Augustine, St. Petersburg and Crestview, Florida; Republic Aviation Division at Farmingdale, Long Island, New York; Stratos Division at Bay Shore, Long Island, New York, and Winston-Salem, North Carolina; and Stratos-Western at Manhattan Beach, California. The company had more than 4-million square feet of plant area situated on over 1200 acres.

The company's long-range facilities plan was further implemented during 1965 with the start of construction on the 165-acre Sherman Fairchild Technology Center. The first building was to be completed August 15, 1966, with an additional building scheduled for completion each two weeks thereafter. One of the buildings will serve as the company's corporate headquarters, with the others designed to house administrative, engineering and laboratory facilities for three of the company's seven operating divisions. These include Space Systems, Hiller Aircraft and Electronics & Information Systems. Manufacturing operations for Hiller Aircraft will remain in Hagerstown, and the manufacturing facilities for the Electronics & Information Systems Division will continue in Winston-Salem.

The Technology Center will be serviced by a unique 600-foot, on-site air strip for rapid liaison between customers and other Fairchild Hiller facilities, provided by the company's Heli-Porter and Hiller Helicopters.

AIRCRAFT-MISSILES DIVISION

Activities of the division during 1965 centered around the new FH-227 and the F-27J turboprop transport aircraft. Order backlog at year's end for these aircraft stood at 55, highest in the seven year history of the program.

The FH-227 is a 300 mile-per-hour high wing aircraft backed by 500,000 miles of operations. The aircraft, longer than its F-27 counterpart, can carry up to 52 passengers and is readily convertible for cargo carrying.

An order from Mohawk Airlines for 18 FH-227's —the largest single equipment order ever placed by a regional airline and the largest commercial aircraft contract ever negotiated by Fairchild Hiller— was soon followed by an even larger 21 aircraft, $32,000,000 order from Ozark Airlines. Another order for 6 transport aircraft was won from Northeast Airlines.

Other significant commercial aircraft sales included 11 F-27's to Allegheny Airlines and Bonanza Airlines. In addition, the company maintained sales of these aircraft to the corporate market. Production was expected to increase from three aircraft per month to five during 1966.

Major subcontract work performed by the Aircraft-Missiles Division during 1965 included substantial numbers of wing pylons for USAF F-105 fighter-bombers. Modification work continued on tail sections for the Strategic Air Command's B-52 bombers. Fuselage panels were manufactured for Bell UH-1 helicopters.

The Fairchild Hiller-built C-123 transports, operating in Viet Nam, continued to receive spare parts support by the division.

AIRCRAFT SERVICE DIVISION

Fairchild Hiller Corporation's Aircraft Service Division has expanded in recent years into one of the largest aircraft modification centers for all types of military and commercial aircraft.

Programs under way at St. Augustine in 1965 included: C-119 twin-engine cargo aircraft overhaul, T-33 jet trainer modification, U-10 observation aircraft inspection and repair, C-121 special mission aircraft outfitting, C-118 cargo transport modification and P5M flying boat overhaul.

During 1965, a new seaplane base was completed, with approved sealanes, ramps and beaching facilities to serve the largest operational seaplanes.

The St. Petersburg facility was performing modification and overhaul on the C-130 Hercules transport aircraft for the Air Force and Coast Guard.

The Crestview facility, organized primarily as a jet maintenance base with long runways, barriers and support equipment, was also being utilized to modify and overhaul conventional aircraft. Large numbers of Republic F-105's were undergoing modification and up-dating. C-123 Providers were also undergoing modification.

The three facilities reconditioned hundreds of aircraft during the year, including electronics repair, corrosion control, fuel cell reconditioning, dope and fabric work, and precision spare parts manufacturing.

ELECTRONICS & INFORMATION SYSTEMS DIVISION

Fairchild Hiller's Electronics & Information Systems Division evolved from the merger, during 1965, of the company's Electronic Systems Division and Republic Aviation's Electronic Products Division.

The division was engaged in expanding technologies in meteorological systems, advanced communications systems, satellite power systems, missile guidance systems, electronic reconnaissance, data acquisition and annotation, special purpose computers and surveillance and countermeasures equipment.

E&IS was producing auxiliary data annotation sets (ADAS), designed and developed for the supersonic reconnaissance aircraft. This equipment provides frame-by-frame film and annotation essential to intelligence interpretation of aerial reconnaissance photographs.

On the space frontier, the division designed and was manufacturing automatic picture transmission systems (APTS), which permit advanced meteorological satellites to scan the earth's cloud cover, transmitting photographs to inexpensive ground stations throughout the world.

Also under development was an airborne central data tape recorder, a magnetic recorder designed to accept and store reconnaissance data as encoded by the division's ADAS. The recorder will store and reproduce this information in a format compatible with ground-based magnetic tape readers.

The division was developing equipment to provide ground photo interpretation units with extremely rapid access to flight data information.

Character data generator systems were also being manufactured by the Electronics & Information Systems Division. The generator was being used in the USQ-28 geodetic mapping system.

HILLER AIRCRAFT DIVISION

The Hiller Aircraft Division was relocated virtually intact during the year with manufacturing moving to Hagerstown and administration and engineering to a new facility at Rockville, Maryland. The division is charged with the responsibility for development and manufacture for the corporation of all light aircraft.

In 1965 production were an initial quantity of 100 Heli-Porters, a unique eight-place light aircraft with short field performance. The division was also manufacturing its first 100 FH-1100's, a commercial turbine-powered light helicopter, as well as six other helicopter models, including SL4's, L4's and 12E's. Two of the 7 models were being produced in military versions for three nations.

During the year, manufacturing was phased out on the Army's OH-23 light observation helicopters. More than 1,400 of these three and four-place aircraft were built for the military during the 15 year program.

Field trials began during the year for the unique, tri-service XC-142A V/STOL aircraft. Designed and manufactured by a three-company team (LTV-Hiller-Ryan), the XC-142A is the first United States V/STOL aircraft built for operational evaluation. It is an outgrowth of an earlier Hiller X-18 aircraft design. Five of these aircraft were built for evaluation during 1965 and 1966.

REPUBLIC AVIATION DIVISION

Republic Aviation, newest member of the Fairchild Hiller aerospace complex, became the seventh operating division during 1965. Republic's modern, fully equipped manufacturing and engineering facility at Farmingdale contained some 1,375,000 square feet of floor space located on approximately 80 acres of land.

In 1965, the division was manufacturing major subassemblies for the McDonnell F-4 Phantom jet fighter, including aft fuselages with fins, rudders, and tail cones, as well as stabilator assemblies and engine access doors.

The world's first government contract for a study on the feasibility of developing a "safety car" was awarded by New York State to Republic. Involved was the eventual submission of two auto designs and recommendations pertaining to performance tests and safety levels. The contract also included a study on how to produce such cars.

Republic Aviation Division was one of 4 U. S. and 2 German aerospace companies which were awarded study contracts in the joint United States/Federal Republic of Germany vertical-short take-off and landing tactical fighter aircraft program. Upon conclusion of the initial studies, one U. S. firm and one German firm will be awarded a contract for joint development of this advanced fighter aircraft.

The division won from the U. S. Marine Corps a contract to produce the Bikini surveillance system. The entire Bikini system (including two drones, launcher, radio control equipment, and photographic film processor) fits into a jeep-drawn M-100 trailer. Two men can have the system operational in less than 10 minutes and have developed film less than 15 minutes after drone recovery.

Republic-built F-105 Thunderchief fighter-bombers continued to fly more than 75 percent of the support missions in the air war over North Viet Nam.

SPACE SYSTEMS DIVISION

Less than three years old, Fairchild Hiller's Space Systems Division scored marked successes with the launching during 1965 of 3 Pegasus meteoroid detection satellites.

Designed and developed for the National Aeronautics and Space Administration, the Pegasus satellites were the largest structured spacecraft ever to be placed into orbit by the United States. Measuring almost 100 feet in length and weighing over 3,000 pounds, the spacecraft provided important data on the hazards of micrometeoroids in space to future manned travel.

The Air Force's mighty Titan III space boosters carried payload fairings designed and developed by the division. Fabricated in two half shells, the honeycomb structures, measuring 10 feet in diameter and 18 feet in height, shield Titan III payloads from heat and buffeting as the vehicles are sent into outer space.

Space Systems Division also developed trailer-mounted microwave data acquisition systems for use in test phases of the Titan III project.

The project FIRE reentry vehicle program was successfully completed, following the second test of a vehicle which reentered the earth's atmosphere at 25,000 miles per hour. The vehicle withstood the most severe temperature and acceleration loads ever subjected to a spacecraft and provided sought-after scientific data.

Space Systems Division was developing an advanced solar array for the Nimbus meteorological satellites which has 19,500 solar cells. Additional contracts won during 1965 included design and fabrication of honeycomb solar cell paddles for the Interplanetary Monitoring Platform (IMP), thermionic diode controlled power systems, deployable solar arrays, and lightweight solar panels.

The division was also providing major support service under contract to NASA's Marshall and Goddard Space Flight Centers.

Research, development and design activity was initiated on deployment mechanisms and extremely long structures for future space programs. These structures, planned to be stored in compact form during spacecraft launch, can be deployed in orbit to hundreds of feet to perform as gravity gradient booms and antennas. These and other activities of Space Systems Division were aimed at future spacecraft systems engineering and integration, large space erectable structures, and technologies associated with large space erectable booms.

STRATOS DIVISION

Specializing in the development and manufacture of aerospace industrial compressors, heat exchangers, high-speed turbo machinery and high temperature pneumatic valves and controls, Fairchild Hiller's Stratos Division provided this equipment to many of the nation's aircraft and missile programs during 1965.

The division was developing a family of 11 low silhouette air conditioners for use in the Army's mechanized equipment. Other contracts included vapor cycle cooling systems for the Navy's E-2A early warning aircraft and air turbine drives for the C-130 Hercules cargo transports.

In addition, air conditioning units to cool electronics and other aircraft compartments were being manufactured for the Navy's A-5A, the RF-4B and RF-4C reconnaissance aircraft, the F-105 fighter-bomber, the F-106 advanced delta fighters and for Fairchild Hiller's own F-27 and FH-227 prop-jet transports.

The division also held contracts to provide cooling for F-111 variable wing fighter aircraft for both the Navy and Air Force, as well as systems for many of the nation's business aircraft including the Pan American Falcon jet, the Lockheed JetStar, and the Aero-Commander.

Products for the nation's space effort included waste disposal locks for the Apollo manned space vehicles and ground pre-launch cooling units for the Gemini manned spacecraft.

STRATOS-WESTERN

Stratos-Western, located in Manhattan Beach, California, was designing, developing and manufacturing intricate valves and regulators required for the nation's space vehicles. The facility was providing helium check valves and pressure regulator systems and disconnects for the Apollo spacecraft; propellant disconnects for Gemini; helium pressure regulators for the Lunar Excursion Module; helium injection check valves for the Saturn S-II; drain and fill valve disconnects, helium pressure control modules and fill modules for the Saturn S-IVB; and other components for the Atlas intercontinental ballastic missiles.

The division was also building four major components for the U. S. Air Force's Titan III space vehicles.

Stratos-Western was the major producer of sonobuoy launch systems and underwater sound source dispensers for the Navy's antisubmarine warfare aircraft.

INDUSTRIAL PRODUCTS

Stratos Division's Industrial Products Branch was manufacturing nationally known products for over 2,000 industrial companies.

Specialized components ranging from speed control transmissions and differential gearing for printing presses, rubber processing equipment, glass making machinery, and radio telescopes to air regulators, relays and volume boosters for paper making machinery were developed by the organization.

Under the brand names Governnaire Pneumatic Controls, Specon Multi-Speed Transmissions and Kendall Pressure Regulators, the Industrial Products Branch was producing equipment for industries including mining, tobacco, textile, paper, printing, chemicals, petroleum, rubber, steel, transportation equipment and metal working machinery.

THE GARRETT CORPORATION

At the close of 1965 The Garrett Corporation could reflect on its 29th year as the culmination of another new era of progress in research, development and manufacture of commercial, military and space systems.

In fact, the year 1965 proved to be the best in Garrett's history. Sales, shipments, plant expansion and production backlog, all showed marked increases over the previous record year 1964. Employment by year-end had risen to more than 10,500 employees representing an addition of more than 800 since January 1, 1965.

Garrett's 1965 organization was composed of seven divisions and two subsidiaries. While the company's activities were widely diversified, Garrett's principal and traditional business continued to be the development and manufacture of subsystems for military and commercial aircraft. Environmental controls, Garrett's forte in the aircraft industry since the first pressurized production aircraft, the B-29, served as the springboard for the company's entry into spacecraft systems.

The highly successful Mercury program with life sustaining Garrett environmental control systems on board established the company's leadership in the field. Garrett engineers were then given a new challenge: to design and build an even more advanced system for Gemini. Even as Gemini established new records in space, Garrett was perfecting systems for the next step, Project Apollo.

Artist's conception of the 400-bed MUST (Medical Units, Self-contained, Transportable) hospital developed by Garrett and built by three of the company's divisions.

Garrett's leadership continued in traditional product lines such as heat transfer, central air data computers, small gas turbines, auxiliary power units, high speed electrical systems and turbo-machinery.

Garrett's AiResearch Manufacturing Division in Phoenix, the world's largest producer of small gas turbine engines, set a new growth record for the year. Less then 10 months after its new turboprop engine, the TPE-331, received certification from the Federal Aviation Agency in March, AiResearch was producing aircraft engines at the rate of 40 per month. By year's end, three prototype counterinsurgency aircraft developed by North American Aviation for the Department of Defense and powered by military versions of the engine were being readied for evaluation by the U. S. Navy early in 1966. An initial order for 257 of the twin engine aircraft was expected to follow a favorable evaluation report.

General aviation too demonstrated ready acceptance for the TPE-331. By year end Aero Commander had placed sizable orders for the engine to power its new Turbo-Commander. Mitsubishi selected it for its new MU-2. Fairchild Hiller, Helio Aircraft and Volpar Incorporated also placed orders for the new turboprop.

In the field of airborne gas turbine auxiliary power units AiResearch Phoenix maintained its leadership with installations aboard the new Boeing 727, the Douglas DC-9, Grumman Gulfstream II, Hawker Siddeley DH125, the BAC One-Eleven, as well as the longer established Lockheed P3A and Convair Dart conversion aircraft.

In other product lines, a new engine-mounted Jet Fuel Starter, capable of starting any of the large jet and turboprop aircraft engines was introduced.

AiResearch Poenix also was continuing refinement of its MUST (Medical Units, Self-Contained, Transportable) field hospital developed for the Army Medical Service. An additional contract for development of a dental surgery and a clinical laboratory was nearing the hardware stage. The 400 bed MUST hospital provides sanitary, air conditioned surroundings for patients and doctors equal to that found in any permanent base hospital. The unit was first demonstrated to military and civil defense groups in 1964.

Achievement in space power also was notable in 1965 with successful operation of turbine and heat exchanger components both in the Rankine cycle and closed gas turbine power system. These power conversion systems, integrated with a reactor or radioisotope heat source, will provide electrical power in space for periods of one to five years for the next generation of manned and unmanned space missions.

Garrett's AiResearch Manufacturing Division in Los Angeles, the company's largest division, continued to be the pace setter for the entire company in 1965. Sales for the division advanced by approximately 20 per cent with resulting increases in production and shipments. In addition to continued success in the field of spacecraft environmental control systems, giant strides were made in related areas such as cryogenic storage of expendables in space. AiResearch's Reactants Supply System (RSS) provided the Gemini fuel cells with oxygen and hydrogen insuring adequate electrical power for long duration missions.

Military and commercial airframe builders continued to be major customers for AiResearch. Garrett-AiResearch components and systems were being used in the entire Boeing transport series, the Convair 880 and 990, Douglas DC-8 and DC-9, Grumman Gulfstream, Sud Caravelle, and Fokker F-28. Military aircraft such as the McDonnell Phantom II, Lockheed F-104 and Republic F-105 were relying heavily on AiResearch-produced systems and components. Other military aircraft in production in 1965, for which AiResearch was a major supplier, included the F-111, A3J, A6A and A7A and C-141.

AiResearch also was heavily engaged in developing systems for future aircraft such as the huge jet transport C-5A and the supersonic transport.

Garrett made significant inroads with new applications of its products in nonaerospace fields. Being developed for delivery in early 1966 was a revolutionary electrical rapid transit propulsion system to be evaluated by the San Francisco Bay Area Rapid Transit District. Garrett's system employs high speed alternating current electrical equipment, a concept previously thought impossible for train propulsion.

AiResearch Los Angeles and Phoenix developed gas turbine and electrical propulsion systems for commuter trains and intercity rail cars. The first gas turbine-propelled rail car was scheduled to be evaluated on the Long Island Railroad in the summer of 1966. In addition to AiResearch gas turbines, this car was to be the first to incorporate lightweight aircraft type air conditioning built by AiResearch.

Other product lines which offered substantial dollar value to Garrett were flight electronics and electromechanical systems for aircraft. A newly developed turbojet engine analyzing system which continually monitors and records vital engine performance during flight was evaluated by the Air

Force in 1965. By year-end AiResearch had received another contract to equip approximately 40 F-4's and F-105's to continue system evaluation.

A commercial version of this system, called Aircraft Integrated Data System, which monitors other aircraft subsystems in addition to primary engines, was developed for airline use.

AiResearch Industrial Division, leading producer of exhaust-driven super-chargers for diesel and gas engines, in 1965 introduced production quantities of turbochargers for light aircraft. These turbochargers not only turbocharge the engine but also provide air for pressurizing the aircraft cabin.

A new low cost turbocharger designed specifically for farm tractors was developed in 1965. These units are now being tested by tractor engine manufacturers.

AiResearch Aviation Service Division continued to be one of the busier facilities at Los Angeles International Airport. Engaged in aircraft modification and maintenance, the division branched into aircraft sales. Distributor franchises for the Grumman Gulfstream I and II, together with the de Havilland 125, caused Aviation Service to expand by adding a new aircraft sales facility at Long Beach Airport.

Garrett's original division, Garrett Supply, set an all time sales record in 1965. New industrial customers and new lines of office furniture added to its 100 Famous Brands of industrial supplies helped set the record pace. Just before year end the division announced major expansion plans and broke ground for a 50,000 square foot building in the Los Angeles area.

Convair-built Atlas booster starts Ranger VIII moonward, 28th consecutive success for the launch vehicle.

In New Jersey, Air Cruisers Division sales continued to be primarily inflatables for the air transport industry. Sales and backlog reached the highest mark in its history. Programs included retrofitting the entire United Airlines fleet with evacuation slides, inflatable floats for helicopters and life rafts for commercial jet airliners. Air Cruisers production for the military included flotation devices for aircraft and missiles and inflatable shelters for field hospitals.

Garrett Manufacturing Limited of Canada reported continued development of new products for the world military and commercial aircraft market. Temperature control systems, solid state static inverters, pneumatic signal generators, aerospace ground support equipment and radio emergency beacons headed the product list.

GENERAL DYNAMICS CORPORATION

CONVAIR DIVISION

Spectacular space launches, a new Atlas flight reliability record, evaluation of a new aircraft, successful flight of a new satellite, and operational status for a high-energy upper stage highlighted the year for the Convair Division of General Dynamics.

Atlas space launch vehicles completed a record 28 consecutive successes for space missions of the Air Force and the National Aeronautics and Space Administration. The 28th consecutive success was the launch of Ranger VIII atop an Atlas-Agena. This launch and the last of the Ranger series, the Ranger IX flight, produced spectacular close-up photos of the surface of the moon. Atlas space launch vehicles also successfully boosted a SNAP nuclear system and Vela nuclear detection satellite payloads into orbit during the year, plus the last of the Project Fire vehicle launches in tests of atmospheric re-entry at moon-to-earth velocities.

Atlas boosters participated in launches for the Nike-Target and ABRES (Advanced Ballistic Re-Entry Systems) programs from the Western Test Range. An Atlas launched a Convair-produced OV1 satellite in a dual pod and a side-mounted scientific passenger pod. The OV1 achieved orbit with all systems performing successfully.

Atlas vehicles were also used during 1965 to launch Centaur high-energy upper stage vehicles for NASA. The second launch of Centaur for the year—the sixth in the Atlas-Centaur series—resulted in the hydrogen-powered upper stage being declared operational by NASA. The AC-6 vehicle performed flawlessly in a full-scale rehearsal for the operational Surveyor flights schedules to soft-land instruments on the moon prior to manned landings. The

Centaur vehicle successfully placed a dynamic model of the Surveyor on a trajectory toward a "paper" moon, simulating operational flights to come in every way except for actual landing on the moon.

The AC-6 launch was the 39th successful Atlas space launch vehicle flight in the last 41 attempts.

Two Convair 600 prototypes made their first flights in 1965 and both were scheduled to receive Federal Aviation Agency certification by the end of the year.

The Convair 600/440 prototype, a blend of Rolls-Royce Dart 10 engines with Convair 240 airframes, made its maiden flight May 20. Central Airlines of Forth Worth, Texas, took delivery of the first 600/240 on September 17, then launched a program of pilot training and route proving with the aircraft.

The Convair 600/440 prototype, which combines the Rolls-Royce Dart engines with either Convair 340 or 440 airframes, made a successful one hour and 30 minute first flight August 20, then started precertification flight testing.

Four airlines, Central, Trans-Texas, Caribair and Hawaiian, had contracted with Convair for a total of 52 Convair 600s by early October. Compared with the piston powered Convair-Liners, the 600s feature a payload increase of up to 2,850 pounds and a cruising speed increase of 50 miles an hour.

On July 28, 1965, the Convair Division successfully concluded a two-year program of design and production of a life support system capable of keeping four men in space for a year with 90-day resupply of certain expendables. The system was produced for the Langley Research Center.

Little Joe II, the solid-fueled booster built by Convair for suborbital space missions, continued its work for the Apollo program in launches of Apollo abort systems at the White Sands, New Mexico, Test Range. The most powerful solid-propelled booster in the U. S. space stable, Little Joe II compiled a record of 3 successes in 4 flights. The 4th flight was partially successful.

During 1965, two divisions of General Dynamics merged under the name Convair. In February, the Convair Division and the Astronautics Division of General Dynamics merged to become the Convair Division under one management. In late September, J. R. Dempsey, president of the division, resigned. Jack L. Bowers, director of electronic systems for General Dynamics and a veteran of more than 19 years in aircraft and space system engineering and management, was named general manager of the Convair Division.

ELECTRONICS DIVISION

During 1965, the Electronics Division of General Dynamics sustained the pattern of growth and profitability begun in 1962 with heavy concentration in communications equipment and systems, aerospace tracking systems, aerospace ground support equipment and antisubmarine warfare devices.

Production of high-frequency single-sideband equipment such as AN/GRC-106 for the Army and AN/WRC-1 for the Navy hit an all-time high. This equipment incorporates unique all-electronic digital tuning techniques developed over a period of several years by the Electronics Division. Development and production were started on a large procurement of AN/MRC-107 Communications Central Equipment to be used by the Tactical Air Command in the 407L Forward Air Control System. Each unit of this equipment is highly mobile and consists of radio transmitters and receivers operated from a gasoline engine-driven generator. The entire system is carried by a jeep and a trailer.

A $45,000,000 contract was received in June from the Army Electronics Command for the design and fabrication of digital subscriber terminals to be used as part of the AUTODIN (Automatic Digital Network) system. AUTODIN is a worldwide digital communication system which will be extended to all branches of the armed forces under the administration of the Defense Communications Agency.

Early in the year, another link in the Air Force chain of global tracking stations was completed at Pretoria, South Africa, under the GLOTRAC tracking station program and was successfully used to track space vehicles on the Eastern Test Range of the Air Force. This station, like previous GLOTRAC stations, provides sensitive electronic tracking and data processing equipment housed in a mobile, air-conditioned van for ease of transportation to a tracking site by air, sea or land. Economical and extremely precise in its metric tracking capability, GLOTRAC is designed to track vehicles more than 23,000 miles into space; determine velocity to better than six inches per second, and pinpoint location to within 100 feet.

The nation's first of three Apollo Instrumentation Ships, the Vanguard, was floated out of the building basin at the General Dynamics Quincy Shipyard on September 9 to begin the final phase of its conversion from a World War II oil tanker to a floating electronic island which will assist in the tracking of astronauts to the moon. The completed ship was to be delivered in February 1966, and ready for participation in the initial phases of the Apollo program in June, 1966. Two other ships, the Redstone and the Mercury, were to follow in succession later in 1966. Work under the contract for these three ships was being performed by four divisions of General Dynamics: Electronics Division, prime contractor with responsibility for complete systems integration; Electric Boat Division, ship construction; Convair Division, large antenna structures; and Stromberg-Carlson Corporation, a subsidiary of General Dynamics, telephone and intercommunication equipment.

Initial prototype quantities of aerospace ground equipment (AGE) were built and delivered to the Air Force in support of the various avionics systems on the F-111 aircraft. This equipment embraces a new approach to electronic testing using a modular configuration with an optimized mixture of manual and automatic testing capabilities. The new concept, which has been dubbed TASC, an acronym for Total Avionics Support Capability, provides the flexibility to make it applicable to all advanced avionics systems on other proposed aircraft as well as to meet the F-111 aircraft requirements.

This advanced aerospace ground equipment is the result of a considerable investment by both the Air Force and General Dynamics in the future of support systems capable of providing dynamic automated testing of advanced avionics equipment. Test stations can be computer-controlled by an inexpensive general purpose digital computer, in the same way that many other routine operations are being controlled today.

In the antisubmarine warfare area, several designs of underwater hydro-acoustic transducers, employing the principle of controlled generation of acoustic energy from the flow of hydraulic fluids under pressure, were delivered to the Navy. In addition, an extensive program covering the development of acoustic arrays, conformal to the shape of a ship's hull, was undertaken.

Designs of terrain following radar equipment intended for fast, low-flying aircraft were completed and successfully flight tested on appropriate aircraft.

A large microelectronic facility was established to permit the adoption of integrated circuits into all types of electronic equipment produced by the Electronics Division and thus achieve more reliable, more compact, and less power-consuming designs.

At year-end, about 4,500 people were employed by the Electronics Division. Nearly 85 per cent were located at the main plant in Rochester, New York, while the remainder were employed in a subsidiary operation in San Diego, California. Heavy concentration on research and development was indicated by the fact that about 1,600, or nearly a third, of the employees were professional people.

POMONA DIVISION

One major tactical missile program went into full production and a new program was born during 1965 at the Pomona Division of General Dynamics.

Redeye, the unique shoulder-fired guided missile designed to protect the infantryman from low-altitude flying enemy aircraft, went into production for the U. S. Army and Marine Corps. The 28-pound missile system was also under consideration for use by many NATO countries and Australia.

The new program was the Standard Missile system, under development for the U. S. Navy. A development and pilot line production contract was awarded to the Pomona Division early in 1965. Standard Missile implements the Navy's concept of a standardized shipboard missile system for defense of the fleet against surface and aerial threats. To the Navy surface-to-air potential, Standard Missile adds increased tactical effectiveness. Primary objective 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 two versions of Standard Missile—extended range and medium range. The principal difference between the two is in the propulsion systems. The extended range version has a separable booster and a sustainer rocket motor. Medium range has an integral dual thrust level rocket motor. Interchangeability of hardware between the two versions is being emphasized in the development program.

Despite a demonstration of technical feasibility, the Mauler weapon system was cancelled because of insufficient funds for continuation of the development program.

Another new contract awarded the Pomona Division was for retrofit and modernization of Terrier/Tartar guided missiles for the Navy. Although eventually to be replaced by Standard Missile, the Terrier and Tartar missiles continued in production. The two missiles now arm 60 ships of the U. S. Navy in addition to ships of France, Italy, the Netherlands, Japan, Australia and Germany. New ships commissioned during the year included the carrier *USS America* (Terrier), the *USS Josephus Daniels* (Terrier) and the *HMAS Perth* (Tartar).

Another technical highlight of the year was the first successful demonstration of the accuracy of supersonic missile guidance against a target illuminated by a laser beam. The flight, conducted as part of a privately sponsored effort of the Pomona Division known as "Operation Hot Spot," resulted in a direct hit. The techniques demonstrated are applicable to interception of both surface and air targets.

Along with rapid advances in laser technology, the test foreshadowed an entirely new series of tactical weapon applications.

All facilities at the Pomona Division previously had been owned by the U. S. Navy and operated by General Dynamics. During 1965, however, a new $2,000,000 engineering building was completed with corporate funds. The new building permits greater expansion of research and development as well as engineering administrative facilities.

CANADAIR LIMITED, A SUBSIDIARY OF GENERAL DYNAMICS

There was great activity in many fields at Canadair during 1965 as its policy of diversification continued under its new president, Frederick R. Kearns, former executive vice president. Kearns succeeded J. Geoffrey Notman, who became chairman of the board, in February.

Rapid development of the company's CL-84 Dynavert tilt-wing V/STOL aircraft continued with the first vertical flight taking place on May 7, considerably ahead of schedule. After a second series of flights in the hover and slow-speed regimes, necessary ground testing took place.

Flight testing resumed in October and transitional flights from the vertical to horizontal were conducted in mid-November, again well ahead of schedule.

In July, the Canadian Government awarded a contract to Canadair to build approximately 125 Northrop F-5 fighters for the Canadian Defence Force, where it will be known as the C5-5, plus the necessary spares and support equipment.

Under development was the CL-215, the first aircraft to be designed specifically as a water bomber to protect valuable forest areas against the ravages of fire. Simplicity of operation and maintainability of this amphibious aircraft are prime factors of its design.

The CL-215, in its water bomber role, can carry 1,440 U. S. gallons and with water tanks removed, there is unobstructed cargo space for loads of 7,800 lbs. Interest in this aircraft has led to additional configurations which enable it to be employed to advantage as a transport or cargo carrier, for crop dusting and spraying, general agriculture, forest fertilizing, air sea rescue or maritime patrol.

Two "stretched" versions of the CL-44 turboprop airliner were sold to Loftleider/Icelandic Airlines, the new version known as the Canadair "400," being 15 feet longer and capable of carrying 189 passengers trans-Atlantic. Upon delivery in March, 1966, Icelandic was to return its two original CL-44s for conversion to the "400" configuration.

Considerable interest was shown by several governments in the CL-41G, a multirole jet aircraft based on the successful CL-41A Tutor pilot trainer. It was developed to perform weapons training, border patrol, light attack, reconnaissance and other tactical missions, while retaining its capability as a primary, basic or proficiency trainer. The 41G can carry up to 3,500 pounds of standard ordnance stores, which can include general-purpose and napalm bombs, machine-gun pods, air-to-surface missiles, clusters of folding-fin aircraft rockets, and extra fuel tanks.

Under development for the Canadian and British Armies was the CL-89 (XC1) short range reconnaissance drone system designed for day and night target acquisition and battlefield surveillance. It is a self-contained mobile system that carries sensor equipment for taking pictures and is recoverable, as it returns and lands by parachute with air bags to cushion ground impact. The drone is then available for further missions. At year-end, the system was completing its firing tests at the Army Yuma Proving Ground, in Arizona.

The company also designed and manufactured a Transportable Control Tower, which can be completely equipped and used as a permanent traffic control center at secondary airfields or in undeveloped areas, as a temporary center at airfields pending installation of permanent equipment, as a temporary center at small airfields whenever an emergency results in heavy traffic, or as a support for the rapid deployment of military forces in small airfields or airstrips.

Canadair was also manufacturing 33 prefabricated airport traffic control tower cabs for the United States Federal Aviation Agency.

The company designed and manufactured a 30-foot dish antenna for the Canadian Government Defence Research Telecommunications Establishment with the capability of tracking artificial earth satellites, aircraft and celestial bodies.

Canadair's Research & Development facility was working on escape systems for flight vehicles, operations research survivability/vulnerability studies, and doing medical research on a venous blood pressure recording system.

GENERAL ELECTRIC COMPANY

DEFENSE ELECTRONICS DIVISION

The General Electric Company's Defense Electronics Division continued to be in 1965 a leading research and development organization as well as a major supplier of electronics to the defense and aerospace market. The major programs included radio guidance for all the U.S. manned orbital flights, both the Mercury and Gemini programs; guidance and fire control for the Polaris fleet ballistic missile; flight controls for the F-4 and F-111 aircraft; advanced radar and sonar detection equipment, and a wide variety of advanced computers.

With headquarters in Utica, N.Y., the division includes the Heavy Military Electronics Department and Radio Guidance Operation in Syracuse, New York; Light Military Electronics Department in Utica and Johnson City, New York; Ordnance Department in Pittsfield, Massachusetts, and the Electronics Laboratory in Syracuse. More than 16,000 persons, including 3,500 college graduates with technical degrees, were employed at the six locations, generally in the Northeast. Research, development and manufacturing facilities covered more than 4,000,000 square feet of floor space.

ELECTRONICS LABORATORY

The Electronics Laboratory was engaged in applied research, advanced development and support activities in electronics and related fields.

Investigation under way at the laboratory included electronic applications of advanced circuits, control and instrumentation, data recording and display and signal detection. Other areas included optoelectronic and microwave devices, solid state materials, guidance techniques and information processing.

The laboratory developed a computed display which converts aircraft instrument readings into simulated landscapes by which a pilot can maneuver his plane. NASA was using the concept to simulate moon landing vehicles.

Work continued on a "learning" computer called BIPAD II which will be the forerunner of machines that can repair themselves without affecting their output. A small laser ranger, mounted like a rifle, was developed at the laboratory. The 30-pound device has an accuracy of plus or minus one foot over a 250-50,000 foot range.

The laboratory also developed low light level television techniques to view objects which are not visible to the human eye and an infrared chemical detection system to determine the presence of certain chemical agents in the atmosphere.

GE designed this 18-pound microelectronic computer, capable of performing more than 16,000 operations a second, for defense and other aerospace uses.

HEAVY MILITARY ELECTRONICS DEPARTMENT

The Heavy Military Electronics Department, which developed the giant BMEWS radar for the Air Force, was working on major equipment for undersea warfare, air defense, missile and space defense, and tactical warfare applications.

The major contracts included the SQS-26 shipboard sonar, the largest in the Navy; mine-locating and experimental sonars; long range search radar; array radars and close support radar.

The Army awarded a contract to the department for production of a mobile radar colled HIPAR (High Power Acquisition Radar). HIPAR will operate in conjunction with the Nike-Hercules antiaircraft missile. The mobile unit will consist of a 43-foot-wide antenna hauled on five semitrailers.

A microminiaturized radar scope with broad air, sea and land applications was also announced. The new radar display, called MIRAGE for microelectronic radar indicator for ground equipment, was assembled under an Air Force contract. It uses less power than a 100-watt light bulb and is as compact as a portable television set. Advanced solid state circuits and construction techniques used in MIRAGE are expected to have broad applications ranging from a tactical radar indicator to a high performance radar indicator for air traffic control.

LIGHT MILITARY ELECTRONICS DEPARTMENT

The Light Military Electronics Department continued to design and manufacture airborne equipment for a variety of mission requirements including detection, countermeasures, navigation and flight control, guidance, computing and data processing.

The department received the first production orders for the F-111 radar, flight control and optical sight. Significant firsts went into the design of the airborne equipment for the revolutionary variable-sweep aircraft now undergoing test flights.

G.E.'s flight control will be used on both the Air Force's F-111A and the Navy's F-111B. The attack radar and optical sight were being evaluated in aircraft and will be installed on the F-111A later. The new flight control system was developed from experience and technical knowledge gained by G.E. in designing and producing flight controls for the F-4 Phantom II, F-3H Demon, F-105 Thunderchief, F-104 Starfighter and F-101 Voodoo.

The attack radar system, designated the AN/APQ 113, is the latest in a long line of radars developed and manufactured by G.E. The attack radar allows the crew of the two-man aircraft to fire at a target without actually seeing it. In addition, it updates the information utilized in the navigation subsystem.

Extensive use has been made of microelectronics and solid state circuitry in the attack radar to conform to the stringent size and weight requirements for the system.

The lead computing optical display set provides accurate gun or missile firing control. The optical display projects the pilot's sight aiming reference on to a combining glass mounted inside the windscreen. The pilot simply holds the aiming pip on the target and fires when he reaches the proper range.

The optical display also presents information required to perform pre-programmed dive bombing maneuvers, navigation to the target and blind landings.

Autopilots for the HS Victoria, a 75-passenger hydrofoil under development, were designed by the department using techniques developed for the high performance aircraft automatic flight controls.

A lightweight, ultrafast microelectronic data processing unit was developed for the computer industry. The 18-pound digital computer, designated A-212, is no larger than an office typewriter. It requires only 750 cubic inches of space. Power requirements are 67 watts.

The A-212 can perform more than 166,000 operations per second. Advanced models of the microelectronic set will have a computational rate of nearly one-half million calculations per second. The A-212 is a solid-state, general purpose digital computer for real-time control and data processing in aerospace systems.

Frequency agility techniques were developed to provide airborne radar systems with improved radar picture fidelity and immunity to countermeasures.

ORDNANCE DEPARTMENT

The major program underway at the General Electric Ordnance Department was inertial guidance and fire control for the Polaris fleet ballistic missile. The Mk2 inertial guidance system and the Mk84 fire control are both second generation systems.

Work was under way on study programs for the Poseidon missile guidance and fire control.

The Ordnance Department gave close industrial support to the Massachusetts Institute of Technology in developing the Mk2 guidance. The guidance package in the Polaris missile itself weighs 80 pounds, the smallest of its type in use in ballistic missiles today. The Mk84 fire control keeps track of constant changes of the Polaris submarine, continuously updating the missile target instructions until the moment of firing. The fire control can simultaneously make ready for firing all 16 missiles aboard a Polaris submarine.

The department was also engaged in research and development work on equipment such as antennas, power drives, underwater ordnance, remote handling and electro-optics.

RADIO GUIDANCE OPERATION

The Radio Guidance Operation produced, designed and developed radio guidance and control systems, missile and space range instrumentation, military computer systems and data transmission systems. G. E. radio guidance systems have been used in all the major U.S. space programs, including Gemini, Mercury, Ranger and Mariner.

RGO, in cooperation with the Air Force and NASA, was working on newer and more precise radio tracking techniques which will considerably enhance the state-of-the-art in guidance and instrumentation technology.

Major installations during the year included impact prediction and range safety computer for the NASA station at Wallops Island, Virginia, and system engineering and peripheral equipment for NASA's computer complex at Merritt Island, Florida. The installations included the GE-600 series computer which is applicable to real time data processing and handling applications.

RGO pioneered in the development of gallium arsenide transmission systems. Tests of the system have shown that it can operate without interference in almost all but the most severe weather. The gallium arsenide beam can be transmitted through a pipe, either straight or curved, with 100 per cent transmission reliability or security.

FLIGHT PROPULSION DIVISION
THE ADVANCED ENGINE
TECHNOLOGY DEPARTMENT

Three new, major jet propulsion systems and an improved V/STOL lift fan system under development at the Advanced Engine and Technology Department were announced in 1965. In June, the 50,000 pounds thrust class General Electric Company turbojet engine proposed for America's Supersonic Transport (SST) was unveiled. Development of the augmented GE4/J5 turbojet for the SST was based on several concepts derived from G.E.'s Mach 2 J79 turbojet, the CJ805 commercial version of the J79, and from the company's Mach 3 turbojet, the J93. Extensive tests of the SST engine components were conducted. G.E. predicted the GE4/J5 could be ready for an SST prototype flight test in three years, and could complete type certification in five years.

The announcement of another new high performance turbojet and a new approach to jet engine development was made by General Electric in 1965. The new GE1 turbojet is in the same thrust class as the well known General Electric J47 engine, but is approximately half the length and one-quarter the volume of the J47. The Building Block Concept, a new propulsion approach used with the GE1, provides for "add-on" components which are mated to the common gas generator to permit the engine to be tailored to different aircraft mission requirements.

In September, a USAF contract for approximately $500,000,000 went to General Electric for turbofan engines to power Lockheed Aircraft Corporation's C-5A heavy logistics transport. The GE1/6 high bypass ratio turbofans for the C-5A will deliver about twice the thrust of current turbofan engines in commercial airline service and will have a fuel consumption significantly lower than present engines. G.E. has already successfully tested a 2/3 scale GE1/6.

Meanwhile, the unique General Electric lift fan system for V/STOL aircraft has been advanced to the point where fans nearly 13 feet in diameter are envisioned. G.E.'s LF2 advanced lift fan system on test developed more lift, more thrust and was lighter in weight than the company's first generation lift fan, the X353-5B used in the Army's XV-5A experimental V/STOL aircraft.

In general, the department was also active in the area of lift cruise, direct thrust and deflected thrust engines for V/STOLs. Within the organization other groups were active in the research and development of hypersonic propulsion to meet future aviation needs.

LARGE JET ENGINE DEPARTMENT

On the morning of October 14, 1965, the USAF North American XB-70 experimental aircraft, powered by six General Electric YJ93 turbojet engines, completed Phase II of flight tests at Edwards Air Force Base, California, by successfully flying at three times the speed of sound.

The YJ93 engine, a lightweight high performance afterburning turbojet manufactured at LJED is in the 30,000 pound thrust class. It was designed for a wide range of flight conditions from sea level static to sustained cruise at Mach 3 at altitudes over 70,000 feet. Each time the aircraft flies it provides the National Aeronautics and Space Administration (NASA) with 14 special basic measurements in supersonic transport research.

While the J93 was achieving initial Mach 3 flight successes, the department was moving ahead with initial production of J79-10 engines for the supersonic USN Phantom II's and J79-17's for the USAF F-4 aircraft. The advanced versions of the J79 develop 17,900 pounds of thrust at takeoff with afterburner, six percent more than the J79-8 and -15 used in the McDonnell F-4 and 13 percent more than the J79-11A used in the Lockheed F-104 Starfighter aircraft.

The J79 engine reached three aviation milestones during the fourth quarter of the year. It marked its two-millionth engine flight hour, the tenth anniversary of the shipment of the first J79 from the Large Jet Engine Department, and the delivery of the six-thousandth J79 to the military.

Nonaviation applications of G.E.'s jet engines included propulsion for high speed surface transportation such as hydrofoils, air cushion vehicles and military patrol gun motorboats, and base or auxiliary power for land-based aircraft catapults, diesel locomotives, and electrical generation units.

A new concept in domestic water transportation, the commercial hydrofoil *Victoria* was launched in July and scheduled to complete its sea trials and begin operation between Seattle, Washington, and Victoria, British Columbia, before the end of the year. The 75-passenger hydrofoil, capable of speeds up to 45 miles-per-hour, is propelled by two LM100 General Electric gas turbines rated at 1,000 horsepower each. The turbines are derivatives of the widely used T58 helicopter and V/STOL engines.

In Las Vegas, Nevada, the world's largest gas turbine-powered ore hauling truck was unveiled at the American Mining Congress exhibit in October. The LM100-powered truck, capable of hauling more than 100 tons of ore, will be used in a 12-month demonstration and evaluation program.

Elsewhere on the marine front, the nation's first Air Cushion Vehicle passenger service was inaugurated on San Francisco Bay. The Bell Aerosystems ACV, employed to speed airline travelers and other passengers between city-center and airport, can skim across both land and water on a thick cushion of air generated by an LM100 gas turbine-powered fan.

Besides the new commercial application of LM100 gas turbines, the Navy launched the G.E. LM1500 gas turbine-powered USS Plainview, and two Patrol Gun Motorboats (P.G.M.-84 and -85) that utilize LM1500's as boost power at high speeds. LM1500 gas turbines are derivatives of the J79 family of commercial and military jet engines that have logged over 3,000,000 engine flight hours.

Three other unique nonaviation applications of jet engines went into service in 1965. The U.S. Marine Corps LM1500-powered aircraft catapult system gained operational status, an LM100 aircraft-type gas turbine was used for the first time as boost power for a West German railroad locomotive, and ten LM1500 gas generators were operated for the first time to produce 100,000 kilowatts of reserve electrical power for the Cincinnati Gas & Electric Company.

SMALL AIRCRAFT ENGINE DEPARTMENT

The growth of small aircraft engines to higher power levels gained new momentum in 1965. The department's J85 afterburning turbojet, the T64 turboshaft/turboprop, and the T58 turboshaft all have growth developments to their credit.

A significant development in the J85 engine program was achieved when a test stand version of the modified J85-13 produced 5,000 pounds of thrust. The J85/J1A advanced turbojet is a proposed growth version of G.E.'s 4,080-pound thrust J85-13. The higher thrust obtained in the J85/J1A resulted from the addition of a compressor stage to increase airflow.

The G.E. J85-powered F-5 Freedom Fighter being deployed around the world under the Military Assistance Program added Canada to a list of allies from Europe and Asia who have chosen the supersonic tactical fighter. Meanwhile, an improved version of the Northrop F-5, powered by two uprated 4,300-pound thrust J85-15 power plants started flight testing during the summer. In a related J85 development, General Electric started delivery of six J85-13 afterburning turbojets to the Fiat Company, Turin, Italy, for the Fiat G91Y tactical fighter prototypes now being built there.

Growth of the T64 turboshaft/turboprop from 2,850 to 3,080 shaft horsepower reached the test stand stage of development during the last twelve months. With preliminary test results at 3,080 shaft horsepower the T64's growth potential to 3,400 shaft horsepower and beyond was initiated. Earlier in the year, the 2,850 shaft horsepower T64 for helicopter and V/STOL aircraft was certificated by the Federal Aviation Agency. The department also negotiated with Ishikawajima-Harima Heavy Industries Company, Ltd., for the manufacture of T64 engines in Japan.

The first shipments of the T58-10, 1,400 shaft horsepower engine, a growth derivative of the T58 power plant for V/STOLs, was made in the second half of the year. Also of significance was the rollout of two T58-powered V/STOL aircraft this year; the Bell Aerosystem's X-22A tri-service research aircraft and the Piasecki 16H-1A compound helicopter. The X-22A utilizes four T58 1,250 shaft horsepower engines and the Piasecki Pathfinder II is powered by one engine.

COMMERCIAL ENGINE DEPARTMENT

The Commercial Engine Department assumed additional responsibilities this year when the business and marketing activities for the CF700 and CJ10 business aircraft jet engines were transferred from the Small Aircraft Engine Department. The shift also included the CT58 turboshafts for Sikorsky S-61 and S-62 helicopters and Boeing-Vertol V-107 helicopters. The transfer was a major step in the consolidation of General Electric's commercial aviation business within the Commercial Engine Department.

With the transfer of the CF700 and CJ610 power plants to CED, a broad scope sales and support program for these engines was undertaken. The company offered a flat price for engine overhaul in addition to an engine loan plan and a newly adopted engine exchange plan. The CJ610 turbojet powers the Aero Commander Jet 1121, Lear Jet and HFB 320 Hansa, and the CF700 engines are used on Pan American's Fan Jet Falcon.

Commercial Engine Department reported progress in achieving the objectives of the G.E. Fleet Leader Program in 1965. Improved TBO's (Time-Between-Overhauls) and increased parts life were noted for its CJ805-3 turbojets in operational service in the

Convair 880 and the CJ805-23 aft-fan version in the Convair 990.

An improved worldwide engineering service for users of G.E. jet engines and a realignment of marketing operations within the company's Flight Propulsion Division were also announced during the year. The marketing realignment streamlined the division's marketing services and strengthened relations with and support of G.E. customers worldwide.

The department's newly acquired commercial helicopter engine, CT58-140-1, was certificated by the Federal Aviation Agency at mid-year. The engine, with a 1,400 shaft horsepower takeoff rating, is a growth version of the CT58-110 engine in service with the major turbine-powered helicopter airlines throughout the world.

MISSILE AND SPACE DIVISION

The General Electric Company's Missile and Space Division, responsible for exploring and applying the technologies associated with missiles and space vehicles, made significant progress in 1965.

The division remained vitally involved in major space programs, capped by its selection by the Air Force as prime contractor for planning, developing and integrating the experiments for the Manned Orbiting Laboratory.

About 18,000 people were employed by the Missile and Space Division, including about 9,500 in the Philadelphia area. Thirty-one percent of all division employees were professional engineers and scientists, compared with 16 percent for the aerospace industry as a whole.

Division headquarters were located at the Valley Forge Space Technology Center 17 miles west of Philadelphia. This facility is the largest center owned and operated by private industry for space research and development. Research, design, development, test and manufacturing activity were under way in about 3,500,000 square feet of floor space at Valley Forge, Philadelphia, Burlington, Vermont; Bay St. Louis, Mississippi; Daytona Beach, Florida; Huntsville, Alabama; and Houston, Texas.

SPACECRAFT DEPARTMENT

The Spacecraft Department, located at Valley Forge, moved ahead with development of unmanned satellites and space systems.

The General Electric gravity gradient stabilization system was one of the department's major success stories of 1965. The Spacecraft Department developed and built gravity gradient systems for GEOS, the Geophysical Observatory Satellite successfully orbited in November. GEOS was the first NASA spacecraft to use gravity gradient stabilization.

The U.S. Air Force also awarded the department a contract to develop and manufacture two Gravity Gradient Test Satellites, and work continued on the development of gravity gradient control and stabilization systems for NASA's Applications Technology Satellites.

The Nimbus weather satellite, a flight-proven earth orbiter that is one of the most complex vehicles ever launched, was another major project. The Spacecraft Department is the major industrial contractor for Nimbus, and also developed the satellite's unique stabilization and control system. Nimbus I was launched in 1964 and two other Nimbus vehicles were in assembly and design stages at the Space Technology Center, to be launched in 1966 and 1967.

NASA's Orbiting Astronomical Observatory also involved extensive development work by the department. G.E. engineers and scientists developed an extremely accurate stabilization and control system with the capability of pointing the orbiting telescope at any position in space within one-tenth second of arc for periods of to 150 minutes.

Growing participation in the development of nuclear power systems was another G.E. accomplishment during the year.

A SNAP 19 Radioisotope Thermoelectric Generator system will augment the primary solar battery power supply aboard Nimbus B. General Electric made plans to build appropriate storage and handling facilities for this and future nuclear power projects.

In October, the Atomic Energy Commission selected G.E. to develop and build the first nuclear power system for operation on the surface of the moon. The system, designated SNAP 27, will use Plutonium 238 as the heat source to produce 50 watts of thermoelectric power. It will provide electric power to send back selected measurements from an experiment package left on the moon by the Apollo astronauts.

G.E. engineers also performed study and design work on a SNAP system for NASA's Surveyor spacecraft, for a military satellite and for larger units in the kilowatt power range intended for manned space vehicles.

Activities during 1965 helped add to the General Electric record of space accomplishments, which include the development and manufacture of all, or a critical or substantial part of, 38 percent of all satellites launched by the United States.

MOL DEPARTMENT

General Electric formed a new department in October to spearhead the company's work on the Air Force's Manned Orbiting Laboratory program. Headquarters for the MOL Department is located at the Valley Forge Space Technology Center.

The Air Force selected the General Electric Company on August 25 to plan and develop the space experiments for the $1.5 billion MOL program. Although the total impact of the MOL award could not immediately be estimated, company officials said the G.E. part of the program should represent a sizable portion of the over-all project.

At the time of the award, the G.E. MOL team totaled more than 300 engineers and supporting personnel but a considerable expansion was expected.

RE-ENTRY SYSTEMS DEPARTMENT

The Re-entry Systems Department, with headquarters in Philadelphia, highlighted its 1965 activities by completing production of the Mark 6 re-entry vehicle for the Air Force Titan II ICBM.

The Titan II is the largest missile re-entry vehicle in the nation's arsenal. The Re-entry Systems Department is responsible for the research, development and production of vehicles and systems which survive re-entry into the earth's atmosphere or entry into the atmosphere of other planets. It also is responsible for support equipment and services for such re-entry systems, for dynamic nuclear power conversion systems, electric propulsion systems and the research and development of undersea systems. The department contains 600,000 square feet of manufacturing, test facilities and offices. About 3,350 people were at work in Philadelphia during 1965, and 1,560 more were employed at other locations throughout the country.

Development of the Biosatellite continued in 1965, resulting in the complete assembly of the first vehicle prototype. This prototype, an exact duplicate of the "flight hardware," was scheduled to begin an extensive round of qualification tests in January, 1966. The Biosatellite, developed for the National Aeronautics and Space Administration's Ames Research Center, will study the effects of long-duration space flight on terrestrial life. The orbital flights will last from three to thirty days and experiments will be conducted on a variety of life forms ranging from amoebas to primates.

Development work continued on the Mark 12 re-entry system which will be used as part of the Air Force Minuteman II weapon system.

A major part of the department's efforts during the year was devoted to the development of a family of test and research re-entry vehicles for the Air Force, including the Nike Zeus test vehicle and the Re-entry Measurement Vehicle. These flight vehicles and other research programs such as CRESS provide new basic data on the phenomenon of re-entry, and lead to future, advanced operation vehicles.

Development continued on the Maneuvering Ballistic Re-entry Vehicle.

Another major area of activity was the study of entry and lander systems for other planets and the basic technologies that are required. This included studies on the Voyager program for NASA's Jet Propulsion Laboratories.

It has also included extensive NASA and company-funded work in the sterilization of spacecraft and their components. One of the greatest technical challenges to the aerospace industry is the development of complete space-vehicle systems that can be thermally sterilized or "cooked" at several hundred degrees for days and then function reliably in space.

Advanced research was carried forward on a variety of "exotic" structural and re-entry materials and their applications. Major materials developments that occurred during the year were:

—Flight testing on the X-15 research aircraft of a series of silicone rubber compounds. This was part of a program to determine whether the aircraft can use re-entry type materials as heat protection for very high speeds. Called ESM (for Elastomeric Shield Material) the material also seems well suited for orbital re-entry and planetary entry.

—Development of a process for permanently treating the surface of metals such as aluminum with a variety of colors. This process appeared to be headed for major commercial application "spun-off" from the space age. Although it was conceived as a method to control space vehicle temperatures, it shows promise of treating building materials and metal bodies.

—Development of a process for electroforming thin pieces of aluminum with optically accurate surfaces. This may provide future mirrors and collectors for spacecraft that combine light weight and accuracy with freedom from magnetic effects.

Continuing research was carried on in biosciences, lasers and special applications of electronics.

Research leading to development of liquid metal

General Electric's electronic computer system provides high speed, accurate and reliable checkout for Apollo equipment.

vapor turbine systems for producing electricity from nuclear power continued, and was highlighted by the successful performance of a two-stage potassium turbine during a 250 hour endurance test.

In 1965, the 100th satellite recovery vehicle produced by the Re-entry Systems Department was successfully recovered from orbit.

MISSISSIPPI TEST SUPPORT DEPARTMENT

The Mississippi Test Support Department, a company operation since 1963, became a department in 1965.

It was formed when NASA determined that industry support should be acquired for the activation and operation of the Mississippi Test Facility, to be built as a proving ground for booster and second stages of Saturn-Apollo space exploration vehicles. These tasks were first assigned to General Electric as an extension of its Apollo support contract, and the company then formed the Mississippi Test Support Operation to accomplish them. MTSD is headquartered at Bay St. Louis, Mississippi. MTF, a facility of NASA's Marshall Space Flight Center in Huntsville, Alabama, is located on a 13,500-acre forest and marshland site in Hancock County, Mississippi.

General Electric, as prime contractor to NASA, provides through its Mississippi Test Support Department activation and operational support in two major areas: plant and test support operations and technical support and technical systems.

During 1965, MTSD assumed responsibility for operating many of the facilities and systems in the test, laboratory and engineering and industrial complexes at the test site, and for the diverse functions required to support its development as the second largest construction project in the nation. Operation of electrical substations, a central heating plant, natural gas, sewage and potable water systems, and a navigation lock, bascule bridge and seven-mile man-made canal system was begun. Associated new responsibilities included operation of specially designed and constructed barges for transport of cryogenic fuels such as liquid hydrogen and liquid oxygen. MTSD also began operation and maintenance of high-pressure gas and cryogenics systems (air, helium, nitrogen, hydrogen) requiring miles of special piping, new welding techniques, fabrication of special valves and creation of intricate warning and monitoring devices.

Simultaneously, personnel of MTSD were engaged in provision of air, surface and water transportation, security services, pest control programs, library, medical, mail, reproduction, food, telephone, radio and facsimile services, as well as custodial. Others were checking out, operating or maintaining complex systems for data acquisition and data reduction; electronics, materials, photographic, instrumentation, acoustical, measurement standards and meteorology laboratories and status monitoring and test warning systems.

Engineers and technicians of MTSD continued to assist NASA and Corps of Engineers personnel in assuring new buildings and structures under construction were completed, equipped, instrumented and ready for beneficial occupancy on schedule.

The Mississippi Test Facility, one of the most important links in the nation's manned lunar landing program, neared operational readiness for initial static tests, scheduled for early 1966, of the S-II-T test model and subsequently of S-II flight stages. Testing of the larger and more powerful (160,000,000 horsepower) booster stages for the Saturn V was scheduled to begin later in 1966 upon completion of the dual-position S-IC test stand, which will tower nearly 40 stories high. The Mississippi Test Support Department had more than 1,400 employees in 1965.

APOLLO SUPPORT DEPARTMENT

The Apollo Support Department, headquartered at Daytona Beach, Florida, kept pace with the fast-moving Apollo moon program during the year.

The department was under contract to NASA to develop acceptance checkout equipment to automatically test subsystems for the Apollo spacecraft, and then to check the mating of the assembled vehicle with its Saturn booster.

The department at year-end had about 2,700 employees at Daytona Beach and another 1,350 worked in Huntsville. There were additionally about 675 in Cocoa Beach and some 500 in Houston.

The department provides engineering support in the areas of reliability and integration, directed at the development of methods, procedures and techniques required to assure a safe and successful mission for the Apollo program.

The department's reliability work included the development of an over-all mathematical model, techniques, and methods for use by NASA for the assurance of mission success and flight safety. ASD was also working in the area of failure mode effects analysis, and on the development of methods for use by NASA in the review of reliability and quality program planning.

ASD's integration work may be defined as assistance to NASA in its efforts to assure the compatibility of the major system elements with each other and with the system objectives. This is basically a problem in communications in the broadest sense. In turn, General Electric is assisting in the development of documentation.

ASD was developing and producing for NASA much of the Apollo hardware, the kind of equipment which is seen in the blockhouses and control centers at Cape Kennedy. For the Command, Service, and Lunar Excursion Modules, this is referred to as ACE-S/C or Acceptance Checkout Equipment-Spacecraft. For the Saturn launch vehicles, it is referred to as ESE, or Electrical Support Equipment. For the checkout of the launch facilities, it is usually referred to generally as Launch Support Equipment, or specifically by the function of the facility with which it is used. This includes such hardware as Propellant Tanking Computer System, Measurements Calibration System, Telemetry Ground Support Equipment, and Radio Frequency Test Equipment.

MISSILE AND ARMAMENT DEPARTMENT

The Missile and Armament Department at Burlington, Vermont, continued in 1965 as the company's manufacturing facility for the production of re-entry vehicles and development of aircraft armament and special weapons.

In addition to its production work on Mark 6 nose cones and aerospace ground equipment for the Atlas, Thor and Titan ballistic missiles, the department was conducting research and development and design activities on materials and equipment for space and satellite programs.

Production of the world's fastest firing guns, the 20 millimeter Vulcan cannon and the 7.62 millimeter Minigun—a six-barrel system capable of firing up to 6,000 rounds a minute—increased in 1965 with the award of several new Army contracts. Pods containing these weapon systems, for attachment to helicopters and Air Force combat aircraft, also were produced.

Contracts also were received for a helicopter grenade launcher which fires more than 200 high-explosive grenades a minute, and for a Minigun system to be mounted on helicopters in units which also contain rocket launchers.

The year's activities also included advanced development work on General Electric's new Thin-Film distillation process for producing potable water from sea or brackish water.

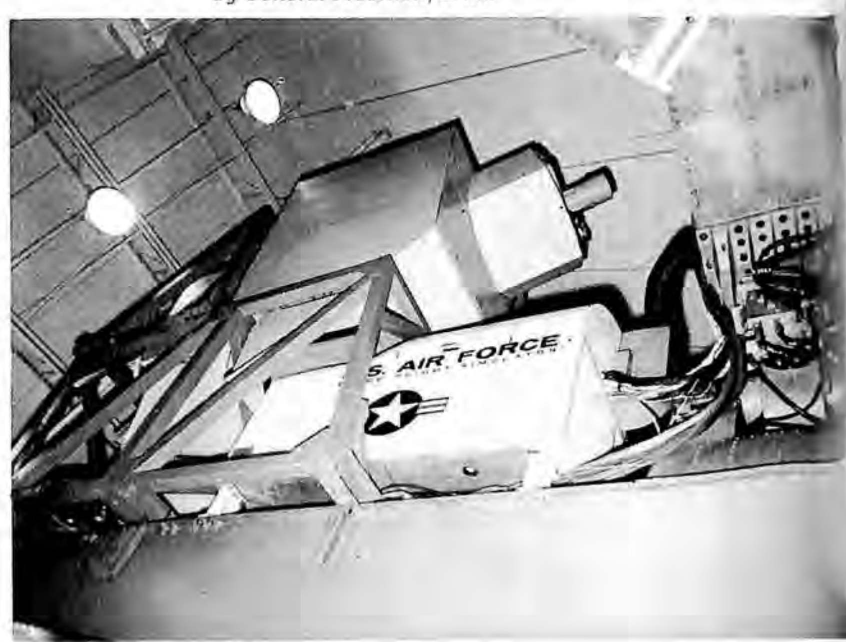
GENERAL PRECISION, INC.

General Precision, Inc. has, through a planned program of selective diversification and selective new-product development, continued during 1965 to establish itself as a major producer of electronic, electromechanical, optical and other precision-made products for the military, government and industry. The company consists of the Aerospace Group in Little Falls, New Jersey; Librascope Group, Glendale, California; and Link Group, Binghamton, New York, and employed at year-end more than 11,000 people in plant space of about 2,500,000 square feet.

AEROSPACE GROUP

Virtually every major aircraft, missile and space vehicle serving the country's national defense and the space program incorporates General Precision Aerospace equipment produced by its Systems, Kearfott and GPL divisions. Products range from inertial navigation and guidance equipment, high-precision components and gyrodynamic devices and Doppler navigation systems to data-handling systems and closed-circuit television for military and general-purpose industrial and educational applications.

The world's largest space mission simulator was built for the USAF by General Precision/Link.



In 1965, under Air Force direction, General Precision Aerospace conducted a flight test program of its new stellar inertial guidance system. The new system is designed to lock on to stars after a missile launch to ascertain the missile's location; it then guides the missile to its target.

Sensitive gyroscopes and actuators produced by Aerospace Group were used in the vital midcourse maneuver of the 1964-65 Mariner IV spacecraft on its trip to Mars and put it right on target.

To maintain its leadership position in its principal fields, the Group organized its Aerospace Research Center. The center, staffed by outstanding scientists, was studying in such areas as lasers, thin films, interplanetary navigation aids, gyro-less inertial systems, celestial tracking techniques, strap-down guidance and optical communications.

LINK GROUP

At the Link Group the 1965 emphasis was on simulation of military aircraft, commercial aircraft and space missions, and it included the less glamorous but equally important automobile driver trainers. These simulators duplicate on the ground, and in a safe environment, the events that occur or will occur in actual flight or on the road.

At Link's Systems Division, the famous "Blue Box" of World War II has been replaced, for example, by highly sophisticated analog and digital computerized simulators for the Apollo and Lem missions, and for the new high-speed military and commercial jet aircraft.

NASA's astronauts will take their first "flight" to the moon long before their actual blast-off from Cape Kennedy. In fact, the Apollo and LEM simulators will permit them to safely, and with remarkable realism, take the trip many times without ever leaving the ground.

Link also built for the Air Force the world's largest space-mission simulator, which was installed at Edwards Air Force Base, California, and which will be used to train Air Force pilots for space flights.

The Group developed a growing business in information storage and retrieval devices, and it was supplying high-accuracy, precision-measurement equipment used in mapping operations and determining missile flight characteristics.

Other Link equipment was in use by NASA to produce lunar and Mars photographs and by the U. S. Weather Bureau to reproduce data acquired by spacecraft for meteorological observation. In this connection, it was Link equipment, to a large degree, that made it possible for photos of the moon to be shown live on TV as the Ranger IX spacecraft plunged toward the lunar surface.

On the other side of the coin, Link was 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 isn't equipped with the company's controls to provide power, speed and accuracy for the steel-making process. Controls are also supplied to the nonmetallic materials manufacturers including producers of packaging and printing materials, paper, plastic fiber and textiles.

LIBRASCOPE GROUP

Computers for command-and-control, antisubmarine-warfare and fire-control systems were part of the product mix that the Librascope Group provided to decision makers during the year, to help solve the problems of gathering, processing and displaying information.

The company was also producing a line of components and peripheral equipment for use in its own computers and data-processing systems and for marketing to other computer manufacturers, the government and industry. Included were magnetic-disc memory systems, woven thin-film memory planes and encoders. Librascope was designing and manufacturing electro-optical instruments for reconnaissance and surveillance systems, for optical tracking and associated instrumentation and for projection systems.

Research and development was being carried out in the fields of basic material structure, electroluminescence, woven thin-film memory planes and infrared and visible-light detection devices.

The family that General Precision, Inc. belongs to also includes other subsidiaries that produce a diversified array of products from photographic and audiovisual equipment at Graflex, Inc., Rochester, New York; to high-intensity light-projecting equipment for theatres and arenas, airport runways and photomechanical reproduction at The Strong Electric Corporation, Toledo, Ohio; to theatre equipment and community-antenna TV systems at National Theatre Supply Company, Tarrytown, New York.

In line with its selective diversification program, changes in defense procurements have been met by the company developing competence in many areas and selectively choosing those areas that promised the greatest opportunities for continued profits and growth. This concept of selective diversification was also carried over into the company's expansion activities.

Most recent of these activities was the purchase by General Precision of the business of the Riverdale, Maryland, plant of the Electronics Division of A.C.F. Industries, Inc. and the leasing of the plant. This operation employed at the end of 1965 over 800 people in the engineering, manufacturing and sale of specialized electronics equipment.

Earlier in the year, General Precision, recognizing the importance of data communications and oceanography, laid the groundwork for its participation in these fields with the acquisition of Tele-Signal Corporation, Hicksville, Long Island and the joint formation with Union Carbide Corporation of Ocean Systems, Inc. In addition, the company made selective affiliations to build a diversified international operation.

In the international field, General Precision joined with leading manufacturers in Japan, Italy and West Germany in the organization of affiliated companies based in those countries. In England, the company holds a majority interest in General Precision Systems, Ltd.

Deliveries were made of Mitsubishi Precision's simulator for the Japanese F-104J aircraft and that company opened a new plant to increase capacity for the development and production of these and other electronic products for the Japanese market. Overseas production of aircraft simulators and auto-driver trainers continued in England.

Recognizing the importance of reliability and the desirability of cost reduction, General Precision launched a company-wide Zero Defects program aimed at improving product quality and performance. The company made use of special television programs, individual company meetings and various communications media to explain the program to the employees with the goal in mind to reduce costs to the taxpayer and improve quality of weapons and systems. The program was successful in indoctrinating all employees to its chief aim, to get the job done right the first time.

THE GYRODYNE COMPANY OF AMERICA, INC.

During 1965, Gyrodyne increased production of QH-50C drone helicopters to approximately double the previous years' rate. The QH-50C is the weapon carrier, and the heart of, the U. S. Navy's Anti-Submarine DASH System. In August 1965, an initial DASH outfitting was delivered to the Japanese Maritime Self Defense Agency under the Military Assistance Program.

Under a separate contract, drone helicopters were delivered to Pt. Mugu, California, to be used as target drones at the Pacific Missile Range.

Further advances in technology were achieved by completion of programs and technical reports on a prototype tilt-float helicopter; tank tests of a gyro-stabilized float system for rough water amphibious helicopters at Stevens Institute of Technology; and a Surface Speed Sensing System for the DASH program.

In addition, prototype model QH-50D vehicles were completed and commenced flight tests at the Naval Air Test Center, Patuxent River, Maryland. The QH-50D was to be phased in during 1966 to replace the QH-50C fleet operational model. It will have improved payload, range and performance.

During the year new construction added approximately 50,000 square feet of factory space. Flight test facilities were expanded and new facilities and equipment were acquired. These additions will result in a higher rate of production and greater efficiency. Total plant space at year-end was more than 200,000 square feet.

HAMILTON STANDARD

Division of United Aircraft Corporation

Progress in space life support work and in the state of propeller art, production of air inlet controls for the General Dynamics F-111 variable-wing aircraft, and the beginning of a 365,000-square-foot plant expansion program highlighted Hamilton Standard's activities in 1965.

Two types of gas management assemblies were being developed for the oxygen–nitrogen life support system on NASA's Biosatellite, the earth-orbiting capsule which will conduct biological experiments on animals and plant life. Development and qualification units of the control for the three-day flight were delivered to General Electric's Re-entry Systems Department, and work continued on the development of the 30-day system.

First deliveries of a preproduction environmental control for the Apollo Lunar Excursion Module (LEM) and related ground support check out equipment were made to Grumman Aircraft. A water-cooled portable life support system designed to sustain the lives of astronauts exploring the lunar surface was delivered to NASA's Manned Spacecraft Center. Hamilton Standard continued to work on advanced life support subsystems for earth-orbiting space stations and prolonged space flights. These included the development of equipment for reclaiming water from urine and wash water for re-use for drinking and eating purposes, the removal of carbon dioxide in air-tight space cabins, and the recovery of oxygen from carbon dioxide.

Three major propeller models were produced for the Lockheed C-130E transport and HC-130H rescue aircraft, the Lockheed P-3A and Grumman S2E subhunters, de Havilland CV-2 Caribou transport and Grumman OV-1 reconnaisance plane. The Buffalo transport, the turbine-powered version of the Caribou being manufactured for the Royal Canadian Air Force, will be equipped with a fourth propeller type, the new 63E60.

Hamilton Standard's advanced propellers underwent extensive flight tests on the Ling-Temco-Vought XC-142A tilt-wing aircraft and were on the Bell Aerosystems X-22A ducted-propeller plane. These military V/STOL aircraft have propellers with similar lightweight, high thrust designs: fiberglass blades and gear boxes attached directly to the propeller. Under Navy-supported programs, development continued on an integral gear box propeller and the tandem-bladed variable camber propeller which employs two blades as one to achieve higher take off and cruise performance.

Entry into the small propeller field resulted in Federal Aviation Agency certification of the 33LF propeller and the start of its production for the Turbo Commander business aircraft. The North American OV-10A counterinsurgency aircraft, which made its first flight in mid-year, is equipped with the same propeller. Hamilton Standard also moved into the marine propeller field as its was awarded a contract to build titanium propellers for the U.S. Navy's Plainview hydrofoil ship.

Hamilton Standard continued manufacturing air inlet controls for the U. S. Air Force F-111A tactical fighter and the Navy "B" version under contract to General Dynamics. The control, a high precision hydromechanical device, automatically moves the inlet's cone-shaped spike to smooth the flow of air passing through the duct to the engine despite sudden changes in aircraft speed, altitude and engine power setting.

Fuel controls were supplied to a variety of gas turbine engines that power commercial and military airplanes and helicopters. The powerplants included the Pratt & Whitney Aircraft J52, JT3D, JT12, JT8, JFTD12 and TF33 engines and the FT4 and FT12 marine turbines; the General Electric J79, T58 and T64 gas turbine engines and the Lycoming T55. The Federal Aviation Agency authorized Pan American Airways to operate the Hamilton Standard fuel control on its Boeing 707's for 6,200 hours between overhaul.

In environmental control activity, contracts were received to develop primary, secondary and air-to-fuel heat exchangers for the air conditioning system on the Anglo-French Concorde supersonic transport and cabin pressure regulating systems for the Boeing 737 short range jetliner. The air conditioning system for the Navy's Ling-Temco-Vought A-7A attack plane passed its qualification tests and went into production. In production were air conditioning units for the Northrop T-38 jet trainer and the F-5A fighter version and the Douglas TA-4E jet trainer, and pressure regulators for the Grumman A-6A and General Dynamics F-111 military aircraft.

Porous plate sublimators for cooling electronics equipment on the Saturn IB and V rocket boosters were qualified and went into production. An advanced heat exchanger, the sublimator rejects heat by exposing heat-carrying water to vacuum's low pressure where it first freezes and then turns to vapor. Developed by Hamilton Standard, the self-regulating device is also being used in the LEM environmental control system and life support back pack for the Apollo moon-landing program.

Hamilton Standard's Electronics Department produced static power supplies for the Army's Shillelagh tank-mounted missile and Northrop T-38 and F-5A aircraft, and automatic stabilization units for several Sikorsky helicopters. It also continued making electronic fuel controls for P&WA industrial gas turbine engines and temperature controls for the Grumman A-6A and Lockheed P-3A aircraft. The autopilot for the Navy's largest hydrofoil ship, the Plainview, was shipped, and a contract was received to produce stabilization augmentation systems for Hiller's FH-1100 four-place commercial helicopter.

Ground support equipment built by Hamilton Standard contributed to NASA's Gemini manned flights and the successful launchings of the Air Force Titan III-C launch vehicle at Cape Kennedy, Florida. This equipment included propellant servicing trailers for the Gemini vehicle's flight controls, electronic checkout equipment for the electrical systems on the Titan III-C's solid fuel rocket boosters, and ground air conditioners for the Titan core vehicle.

Fuel and oxidizer propellant servicing trailers for the S-IVB stage of the Saturn moon rocket were delivered to Cape Kennedy. Ground support equipment in production included test stands for fuel controls, propellers and environmental controls.

One of the leading manufacturers of electron beam welders, Hamilton Standard continued to advance the use of this metalworking technique. A contract was received from NASA to develop and build a hand-held electron beam welder for metal-joining experiments in space. Machines in production included advanced nonvacuum welders for production of tubing and automobile parts and high-powered 25KW equipment.

Two construction projects for handling expansion needs were announced. Erection of a 165,000-square-foot office addition at Hamilton Standard's main plant in Windsor Locks, Connecticut, began in the fall. A modern plant with 200,000 square feet of floor space was to be constructed in Windsor Locks during 1966, and Hamilton Standard planned to move its electronics operations into the new building from the existing plant in Broad Brook, Connecticut.

HARVEY ALUMINUM

Activities at Harvey Aluminum during the year 1965 were highlighted by a major expansion program to more than triple productivity, a record production rate at the primary aluminum reduction facilities, and an increase in the fabrication of mill products in aluminum, titanium, steel alloys, and zirconium for the aerospace industry and related markets.

Harvey Aluminum at year-end was undergoing a major expansion program, including construction of a new aluminum rolling mill in Lewisport, Kentucky; an alumina plant in St. Croix, Virgin Islands; bauxite mining facilities in the Republic of Guinea, Africa; and an aluminum smelting and fabrication complex on the island of Karmoy in Norway.

Large extrusions, complex forgings, impact extrusions, and other wrought aluminum products were produced by Harvey for military aircraft, aerospace vehicles, rockets and missiles, and ground support equipment. Production continued on aluminum components for SATS installations (Short Airfield for Tactical Support). Harvey designed and developed the AM-2 landing mat for the SATS unit, a mat standardized by the Navy and used by the Marine Corps.

Titanium and steel shipment were made for jet engines, jet transports, interceptors, and missiles. Development work was conducted on the use of titanium for the supersonic transport program. The company solidified its position of leadership within the industry as a supplier of titanium and steel extrusions for aerospace applications.

Aerospace programs receiving material produced by the company included the C-141, F-4, F-5A, 727 and 737, COIN, DC-9, Gemini, Polaris A3, and Saturn.

With the extension of structural requirements to serve new advancements in aerospace, Harvey planned to maintain its significant position as a producer of metals for defense and space. For example, the company's extensive research into new metals and alloys produced a new aerospace composite material combining aluminum and steel fibers in a lightweight, high strength form.

A magnetohydrodynamics generator is fired at Hercules Powder's Bacchus, Utah, facility.

HERCULES POWDER COMPANY

A leader in solid propellant rocket technology, Hercules Powder Company increased its position in the defense area during 1965. It was awarded contracts for the development of solid propellant motors for the Poseidon program. Hercules was assigned all of the work on the second stage of this vehicle. Work on the first stage will be performed under a joint venture with Thiokol Chemical Corporation, with Hercules as manager of the joint venture.

Major technological breakthroughs were also achieved in 1965 with the successful flight test of high energy motors for Sprint and Hibex antimissile missiles, and the demonstration of a new booster/sustainer unit with extremely low radar attenuation characteristics.

The company continued to provide propulsion units for Minuteman, Polaris, Honest John and other defense missiles, as well as motors for many and varied space applications such as the precision motors which placed the Nuclear Detection Satellites in orbit during 1965.

In another field of energy, Hercules demonstrated the creation of electrical power from a solid rocket exhaust without the use of conventional turbines, generators, etc. By means of magnetohydrodynamic generation, the research group at Bacchus, Utah, was able to produce 1,500,000 watts of power for one second, using as a conductor the exhaust from a small solid propellant motor. Earlier, working on a research contract for the United States Air Force and in cooperation with MHD Research, Inc., a Hercules subsidiary, the Bacchus group pumped a laser by an explosively driven generator which provided 300,000,000 watts for one ten-thousandths of a second through a special flash lamp. Hercules also demonstrated high-energy pulse power generation from a hybrid motor and the company was perfecting this system.

Heart of the guidance platform in the Gemini spacecraft is the azimuth block, here being adjusted by a Honeywell engineer.

HONEYWELL INC.

MILITARY PRODUCTS GROUP

For Honeywell Inc., 1965 was a year of expansion and diversification of its military and aerospace capabilities. While Honeywell guidance and control equipment was performing on some of the year's most spectacular space shots, preparations were moving forward for production of the most advanced antisubmarine torpedoes in the nation's arsenal. While electronics remained the mainstay of the company's Military Products Group (MPG), significant progress was made in the rapidly developing area of fluid technology. The government continued to be the largest customer for MPG products, but several devices were introduced for the commercial market.

Announced in November 1964 and organized in 1965 was Honeywell's new Systems and Research Division, the fourth division in MPG, with headquarters in Minneapolis. (The other three divisions are Minneapolis Aeronautical, Ordnance and Florida Aeronautical.) Purpose of Systems and Research is to strengthen Honeywell's ability to create and carry out major military and space systems programs. Establishment of the division concentrated in one location the systems programs formerly carried on by several divisions. Systems and Research is responsible for planning, sales and advanced development of avionics, space and weapons systems and for conducting advanced studies and research leading to new technologies and new products.

One of the first and largest projects of the new division was development and manufacture of the Scanner spacecraft under a contract with the Langley Research Center of the National Aeronautics and Space Administration (NASA). Scanner, scheduled for launch in 1966, is to be used in a horizon definition experiment. Electronic equipment aboard the vehicle was designed to take readings of the infrared radiation emitted from the earth's atmosphere.

Under a contract with NASA's Marshall Space Flight Center, Systems and Research engineers and scientists conducted extensive human factors experiments during the summer and fall with two men confined to a plywood cabin representing the type of lunar roving vehicle in which tomorrow's astronauts might drive on the moon. The experiments were aimed at determining cabin configuration that would enable men to perform within the cramped quarters of such a vehicle. More tests were planned for 1966.

At year's end, finishing touches were being put on a new, multimillion-dollar Honeywell electronics production facility near Tampa. Equipment produced at the plant is classified. The 65,000-square-foot plant, built on a 17-acre site, was scheduled to employ some 900 persons and, when in full operation, to add about $5,000,000 in new payrolls for the Tampa Bay area.

Across the bay at the Florida Aeronautical Division in St. Petersburg, Aug. 11 was one of the brightest days of the year. It was the day a Centaur rocket, carrying a Honeywell all-inertial guidance system built in St. Petersburg, successfully launched a dummy Surveyor spacecraft on a simulated trip to the moon. The Florida Aeronautical Division is associate prime contractor on Centaur. Success of the Atlas-Centaur-6 flight qualified the guidance system for journeys into deep space—the first such operational qualification of a launch vehicle guidance system.

The most dramatic space shots of the year were the two-man Gemini flights. Electronic subsystems built by Honeywell provided precision guidance and control during these missions. Two Honeywell divisions build major equipment for Gemini, the first U. S. manned spacecraft to use inertial guidance. The Minneapolis Aeronautical Division supplies the attitude control and maneuver electronics for the Gemini spacecraft and three-axis reference systems for both the Gemini launch vehicle and the Gemini Agena target vehicle. The Florida Aeronautical Division builds the spacecraft's inertial measurement unit.

Shipped to Cape Kennedy in the fall for launching early in 1966 was Apollo spacecraft 009, the first operational model of the three-man spacecraft being readied for a trip to the moon and back within the decade. Honeywell's Minneapolis Aeronautical Division manufactured the stabilization and control system for the spacecraft.

Work at the Ordnance Division, headquartered in the Minneapolis suburb of Hopkins, took on an added dimension in July with the Navy's award of the second-source prime contract to build Mark 46 torpedoes. Intensive efforts began immediately to begin production. Overall program direction and final assembly, testing and checkout of the high-speed, deep-diving antisubmarine missiles will be at Ordnance facilities in the Twin Cities. The Minneapolis Aeronautical Division will build the gyroscope pendulum assembly, heart of the torpedo's electronic guidance system. Two branches of the Ordnance Division also will be involved: the California Ordnance Center at West Covina will build testing and checkout equipment, and the Seattle Development Laboratory will build the transducer.

While the Mark 46 will be the first torpedo actually manufactured by Honeywell, the company is not a newcomer to weapons systems using torpedoes. The Ordnance Division was prime contractor for the ASROC (antisubmarine rocket) missile. In 1965 the ASROC and the Terrier supersonic guided missile weapons systems were combined to give the Navy a new concept in shipboard weaponry. Development contractor of the ASROC portion of the new system was Honeywell's California Ordnance Center.

In January, announcement was made of a contract award to the company's West Coast Ordnance operations for construction of a system to hold the drilling platform steady for Project Mohole, the National Science Foundation program to penetrate the earth's crust at a spot in the Pacific Ocean near Hawaii.

A delicate but durable sonar device manufactured by the Seattle Development Laboratory pinpointed the location of sunken barge loaded with chlorine gas and averted a potential catastrophe at Baton Rouge, Louisiana, in September. The device is called a precision profiling sonar set. It was installed aboard an Army Corps of Engineers vessel to search for the missing bargeload of gas, which had been sunk by Hurricane Betsy in the Mississippi River.

In another Seattle project, production was under way throughout the year on the AN/UCC-1, the first large-scale application of microelectronics to a major Navy communications program. AN/UCC-1 is a system that provides for simultaneous transmission of multiple teletype signals over radio channels to ships or stations.

Early in the year Charles L. Davis, vice president in charge of MPG, predicted that the country's infant fluids technology would mature into a $250-million-a-year business by 1970. Honeywell continued to lead U. S. industry in the manufacture of fluid control systems without moving parts or electronic components. Largest contract of 1965 was for $2,700,000, awarded by the Air Force to Honeywell's Minneapolis Aeronautical Division for advanced development of a fluid jet engine control system.

Among the year's new products with both military and commercial potential was the ALERT, a solid-state, general-purpose digital computer combining speed, flexibility and low cost in a small package. The ALERT is particularly well suited for applications such as aircraft fire control systems, manned space programs, ground and sea-based missile complexes, field command and control, airborne command and control, complex navigation problems and reconnaissance missions. It will be used by NASA in 1966 for energy management computation aboard an X-15 aircraft. The Florida Aeronautical Division developed the ALERT.

(Article on Honeywell Inc. continued on page 125.)

AERODEX, INC.

The year 1965 proved to be a year of many advances for Aerodex, Inc. Tremendous expansion took place when Aerodex acquired a new building with 296,593 sq. ft. of operating space under one roof at the Miami International Airport, adjacent to its present facilities. Employment reached a peak of 3,200. The company retained its enviable reputation as the world's largest aircraft engine overhaul facility by completing over 6,000 of the largest and most complex reciprocating engines in operation under contracts with the U. S. Air Force.

Concurrent with performance under the military contracts, Aerodex also completed overhaul of over 200 various types of engines for airlines, the Federal Aviation Agency and private aircraft operators in its commercial department.

In addition to the manufacturing and operating space, the company added 24,125 sq. ft. of test cell capacity by adding 10 new units to its bank of test cells. Further improvement is manifested in the installation of a Clayton Dynamometer, which offers laboratory type testing under perfectly controlled conditions for engines up to and including 4,000 horsepower. This addition becomes significant when it is recognized as the only such unit in operation east of the Mississippi River commercially operated by an engine overhaul facility.

The complete tooling and implementation of a mechanized production line to modify and recondition exhaust manifold assemblies was accomplished in 1965. Aerodex engineered, manufactured and put into operation completely automatic machines to satisfy requirements and has delivered over 16,000 valves which would otherwise have been lost by rejection. All testing and certification was conducted during this program.

AVCO CORPORATION

AEROSTRUCTURES DIVISION

Avco Aerostructures Division's capabilities as a manufacturer of major airframe components at Nashville, Tenn., are employed primarily for military purposes. However, the division last year began production of the 35-foot wings for Grumman's jet-powered Gulfstream II, a long range corporate aircraft.

The division also manufactures structures and assemblies for space vehicles, rocket boosters, missiles, aircraft and helicopters, aluminum and stainless steel honeycomb panels, thermal control panels and thrust termination tubes for rockets.

ELECTRONICS DIVISION

Avco Electronics Division, located at Cincinnati, Ohio, and Huntsville, Ala., during 1965 supplied improved lightweight man-pack and vehicular communications equipment for test under combat conditions.

A growing family of Avco electronics receivers and decoders is being used on a number of classified space programs. In addition, the division received a contract for research, development and production of the radar segment for a detection and weapons system against ballistic missiles launched from submarines.

The Huntsville facility was enlarged during the year to provide more on-site facilities and capabilities in support of NASA's Marshall Space Flight Center.

One of the most important programs of the division was the production of an infrared countermeasures receiving system for the Air Force F-111 fighter used to detect enemy missiles approaching the aircraft. The division also won a contract for new high frequency radio receiver-transmitters for the F-111.

Electronics provides a variety of communications gear for missiles and space vehicles including command-destruct receivers for destroying rockets and space boosters which stray off course.

EVERETT RESEARCH LABORATORY

Avco Everett Research Laboratory at Everett and Haverhill, Mass., continued reentry studies started for the Air Force more than 10 years ago. From aircraft operating over the Pacific missile range, the division monitored the reentry of ICBM nose cones and also conducted classified research studies necessary for developing the Army's Nike X antimissile defense system, using data obtained from the monitoring work.

The laboratory received an Army contract to develop a superconducting energy-storage device with a 100,000 watt-second capability.

Working with Aerostructures Division, the Everett Research Laboratory is supplying the first magnetohydrodynamic (MHD) generator designed and built for other than experimental purposes to power a hypersonic wind tunnel at the Air Force's Arnold Engineering Development Center.

National Heart Institute awarded the division a contract to study the medical, surgical, technological, economic, legal and social factors which must be considered in the development of artificial hearts. During the year the division also developed a 50-kilowatt, ultraviolet, pulsed gas laser which is believed to have one of the highest power outputs ever achieved.

ORDNANCE DIVISION

Avco Ordnance Division at Richmond, Ind., increased its production rates during 1965 to remain one of the nation's major suppliers of military ammunition. The Division produces conventional or non-nuclear ammunition, air-to-ground and surface-to-surface warheads, fuzes and related materials. Arming and fuzing devices are produced by the division for the Polaris, Minuteman and Titan missiles.

RESEARCH AND DEVELOPMENT DIVISION

Avco Research and Development Division at Wilmington, Lowell and Lawrence, Mass., continued work on heat shields for the Apollo command module and several key contracts for preliminary study phases for the unmanned Voyager scientific exploration of Mars. Avco is studying for NASA the feasibility of two different types of small, lightweight Mars probe vehicles, one to make atmospheric measurements and communicate information back to earth during entry into the Martian atmosphere, the other to negotiate a survivable landing and communicate data back to receiving stations on earth.

The division received a contract to build and operate a boron filament pilot plant at North Wilmington on an experimental basis. Under a NASA contract a program was started to synthesize and evaluate ferrohydrodynamic or highly magnetic fluids.

Other contracts seek ways to improve operational capabilities of future ballistic missile weapons systems in the hostile environments generated by active defense systems.

Early in 1966, the Research and Development Division was divided into two separate divisions: Avco Missile Systems Division and Avco Space Systems Division.

TULSA DIVISION

Avco Tulsa Division at Tulsa, Okla., continued development of an airborne ground surveillance system using company-designed magnetometers for the Air Force.

Working under contracts from both NASA and Air Force, Tulsa designed, developed and assembled space radiation instruments used during last year's globe circling flights of Gemini IV, VI and VII to measure the radiation absorbed by human muscle tissue. Called dosimeters, these instruments contain a special plastic substance with the same radiation absorption characteristics as human tissue.

Tulsa also conducted experiments for NASA to determine damaging effects of the space environment on thermal coatings, optical glass and metal surfaces.

The Tulsa Division was designated the Avco Instrument Division early in 1966.

CHANDLER EVANS, INC. CONTROL SYSTEMS DIVISION OF COLT INDUSTRIES, INC.

The Chandler Evans Control Systems Division of Colt Industries in 1965 continued volume production of TA-2 unitized main fuel controls for gas turbine-powered helicopters. The TA control series is a highly sophisticated yet compact fuel management system for the Lycoming T-53 free turbine engine that is seeing military service on Bell UH-1 Iroquois helicopters in Viet Nam and elsewhere in the world.

An advanced TA-2 control also will be on the new Bell UH-1B HueyCobra, an armed and more powerful version of the UH-1, now in production. The TA control encloses within one housing the main engine fuel control, main fuel pump and free turbine governor. More than 30,000 Chandler Evans main fuel controls have been produced, logging more than 2,000,000 service hours in Army helicopter operations—many thousands of them under jungle combat conditions.

1965 also was Chandler Evans Control Systems Division's ninth consecutive year of production of main fuel pumps for gas turbine applications. To date more than 22,000 of these positive displacement fuel pumps have accumulated more than 28 million service hours on Pratt & Whitney Aircraft and General Electric gas turbine engines for such notable commercial and military aircraft as Boeing 707 commercial transports, B-52 bombers and KC-135 jet tankers; Douglas DC-8 jet transports; Lockheed Starlifter commercial cargo jets, and Northrop F-5

Computer section of a Chandler Evans TA-2 unitized fuel control system for Lycoming T-53 gas turbine engine used in Bell UH-1 helicopters. Integrated fuel control and fuel pump package is produced at West Hartford, Conn., by Chandler Evans Control Systems Division of Colt Industries.

Freedom Fighters. Chandler Evans MFP-90 pumps also are on the Pratt & Whitney Aircraft jet engines that power the General Dynamics' Fort Worth Division F-111 variable-sweep wing fighter aircraft.

For the Continental J69 turbojet engines on the Ryan Firebee drone aircraft for Air Force, Army and Navy use the division produced the MC series of fuel controls.

In the regenerative engine field the division also developed and produced the IC-13 fuel control for a Ford gas turbine truck engine. Like other Chandler Evans fuel controls, it integrates fuel pumping, metering, filtering, pressure regulation and turbine speed governing in a unitized package.

Another industrial control new in 1965 was the Chandler Evans EHSV electrohydraulic servo valve for machine tool and similar control functions.

In still a different aerospace control area the Chandler Evans Control Systems Division in 1965 was actively working on stored gas actuation systems for at least 18 different missile programs, some of which are in production and others of which are in advanced developmental stages.

Other aerospace control components produced by the division during the year included temperature probes, afterburner fuel flow dividers and fuel regulators, hydraulic pumps, de-icing controls, aircraft cabin air temperature systems and related aircraft components.

COOK ELECTRIC COMPANY

Developments from Cook Electric's Tech-Center Division once again played several key roles in the nation's space efforts.

Contributions from the .company's advanced engineering and manufacturing facilities during 1965 were principally in recovery and deceleration systems, satellite instrumentation, communications systems and long-range airborne direction finding systems.

Among the company's most prominent sources of recognition, and certainly one of the most exciting current development areas, was in the field of recoverable capsules.

A contract for the design and manufacture of Mach 20 camera capsules, to be used in the U. S. Air Force's ballistic missile program, capped more than two years of feasibility studies by Cook Electric engineers. This state-of-the-art advance will yield for the first time photography of the activities of multistage boosters and missiles, showing such critical sequences as stage separation, upper stage

Cook Electric Engineer completes assembly of experimental package for Orbiting Astronomical Laboratory. Team of engineers is currently working on second flyable unit in cooperation with University of Wisconsin.

ignition and fuel sloshing. The Mach 20 capsules are expected to make a number of important contributions to space progress.

During the year the company also delivered several Mach 10 recoverable camera capsules for use in the Apollo program.

Cook Electric scientists are also studying the possibilities of obtaining other needed data from astronauts in flight, including biological samples, through the use of recoverable capsules.

The year also featured continued development in the field of parachute technology. Indicative of this progress was a new type "Hyperflo" parachute, the first to perform successfully at hypersonic velocities (Mach 6 and above). Recoveries that would have otherwise been impossible are now being planned and scheduled as a result of this development.

The "Hyperflo" advance further enhanced the company's position of leadership in deceleration technology. Cook Electric decelerators were used in the first successful space recovery, the first full scale ballistic missile nose cone recovery, the first ICBM nose cone recovery, the first full scale ICBM recovery system, and the first recovery of living creatures from space. The company's "Paraloon" was the first inflatable device for stabilization, deceleration and flotation.

In 1965, as in previous years, Cook Electric biomedical recorders were constant companions to U.S. astronauts in flight. These units have proven to be highly reliable recorders of vital data on the physiological condition of astronauts during flight. Measurements include their every heartbeat, respiratory data, blood pressure and temperature.

In one of the most significant advances of the year, Cook Electric engineers, in cooperation with the University of Wisconsin, completed the first experimental package for the Orbiting Astronomical Laboratory (OAO). Although the first launch was ill-fated due to a battery breakdown in the vehicle itself, the program is continuing, and hopes remain high that the OAO will make significant contributions in man's attempt to learn more about his environment through space explorations. The Cook-Wisconsin team is currently at work on a second OAO package.

The company's success on the OAO project gave rise to a contract with Northwestern University for the design and fabrication of an ultraviolet spectrograph to be used in photographing star fields and stellar emissions from aboard Apollo manned spacecraft. This joint industry/university project for the National Aeronautics and Space Administration is expected to yield information that cannot be discerned from the earth's surface, another major advance toward increasing understanding of the universe. Models of the spectrograph have been delivered, and a working prototype is scheduled for completion in September, 1966.

In another highlight of 1965, the company was awarded two major contracts for the production of airborne direction-finding-tracker systems, to be installed in HC-130 aircraft operated by the U. S. Air Force's Air Rescue Service and the Space Systems Division. These advanced systems are capable of picking up signals from several thousand miles away from space vehicles, and from several hundred miles from sources at the earth's surface. They are designed for tracking space vehicles during their return, thus hastening recovery of the astronauts. These direction-finding-tracker systems are used in the Gemini and Apollo manned space programs.

In the field of audio systems, the company completed major contracts for installations at the Army's White Sands Missile Range, NASA's Goddard Space Flight Center, and the Air Force Eastern Test Range.

In related activities over the year, the company's Inland Testing Laboratories continued high levels of product evaluations, many for use in the space/defense programs, and activities continued in the fields of electronic warfare, nucleonics and undersea warfare.

Work intensified in the field of radar and guided missile electronic countermeasures.

GENERAL DYNAMICS CORP.

FORT WORTH DIVISION

Principal effort of the Fort Worth Division of General Dynamics Corp. was devoted to the development and production of the F-111.

At the end of 1965, eleven developmental F-111s were undergoing flight test. Eight Air Force versions and three Navy versions had made a total of 320 flights for a total of 459 hours with 98 of the flights at supersonic speed.

The variable-sweep wing concept, which represents a giant step in the history of aerodynamics, has proved its validity without question. The wing system itself has worked perfectly from the first test flights, and even in its current stage of development, the F-111 is one of the most versatile aircraft ever built.

In April the Department of Defense announced approval of a letter contract covering initial procurement of 431 F-111 aircraft. This includes 389 for the United States Air Force, 24 for the United States Navy and 18 for the Royal Australian Air Force. The Department of Defense announcement said that this fixed-price incentive-fee contract covering multi-year procurement is expected, when definitized, to exceed $1,500,000,000. Funds totaling $99,000,000 were obligated during 1965 to initiate the procurement of the first 69 production aircraft and long lead time work on the remainder.

Twenty-two research and development aircraft will be flying by the end of 1966. Even though the research, development, test and evaluation program continues into 1968, tooling and other facilities for the production run are currently being aligned at the Fort Worth division. The first production aircraft is scheduled for delivery to the Air Force in early 1967.

In December the Air Force was directed to proceed with the development of a reconnaissance version, the RF-111A. This aircraft will require a minimum of configuration changes, but will be equipped with special systems for all-weather and night reconnaissance operations. Approximately $12,000,000 was authorized for the initial development program, but no decision has been made as to when production will be initiated.

In the same month the Department of Defense announced that it would ask Congress for authorization for the development, production and deployment of a bomber version of the aircraft to be known as the FB-111.

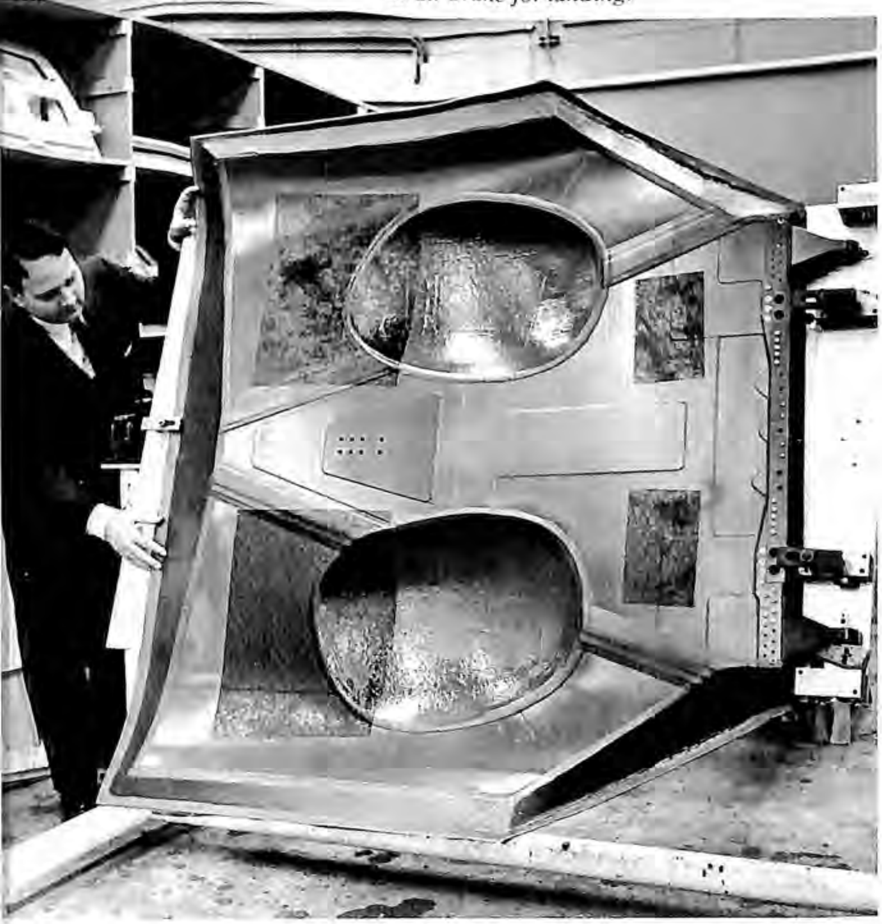
The British Government also has an option to order F-111s.

Other manufacturing programs in the plant include building aft sections for General Dynamics' Atlas space launch vehicle. Also in the space field, the Fort Worth plant is building components for Centaur, high energy space vehicles being developed for the National Aeronautics and Space Administration by the Convair Division of General Dynamics. The Fort Worth plant also modified B-57 bombers into RB-57F reconnaissance aircraft.

B. F. GOODRICH COMPANY

Significant aerospace product developments by B. F. Goodrich Company in 1965 included the production and successful hydrostatic testing of the largest segmented glass filament wound rocket motor case ever manufactured. The 50-foot long, 13-foot diameter fiberglass rocket case was completed at the filament winding plant of Goodrich's Aerospace and Defense Products division at Akron, Ohio, under subcontract to Thiokol Chemical Corporation for the U. S. Air Force. The case required more than 20,000 pounds of glass filament and resin.

Landing gear door of F-111 tactical fighter is fabricated from four different densities of honeycomb core bonded together with special Plastilock adhesives developed by B. F. Goodrich. Door also serves as air brake for landing.



Goodrich also delivered to the U. S. Navy a prototype sonar bow dome for sea trials and developed a space-saving, foldable aircraft tire. Designed for "the next generation of aircraft," the self-folding tire was developed jointly with the Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio. Advantage of the tire is that it takes up only one-half to three-quarters as much space in the wheel well of an aircraft with the landing gear retracted but unfolds to standard size for takeoffs and landings. The development is a result of a new molding process which permits folding of the sidewalls of the tire under the tread which has a circumference only slightly larger than that of the wheel on which it is mounted. When the landing gear is lowered, the tire is automatically inflated and expands to its proper size.

The company's foldable tire is the second development in this area following radically new tires developed for the supersonic XB-70 aircraft. In addition to its tire research and development, Goodrich has also supplied tires for all the large commercial jet aircraft.

A revolutionary liquid-cooled brake has satisfactorily completed certification tests installed on a Boeing 727 airliner as required by the Federal Aviation Agency for commercial airline service. Described as a "giant step in aviation progress," the new brake is scheduled to go into regular passenger service during 1966. It employs circulating fluid to absorb heat and carries it away from the brake, wheel and tire assembly thus preventing heat build-up on the braking surfaces. The new brake operates up to 1,500 degrees cooler on the lining surfaces than conventional brakes on jet liners, thereby helping to increase aircraft safety. The cooler operating system results in improved life of the brakes, wheels and tires.

Aerospace and Defense Products division has also developed a forced-air cooling system for brakes designed primarily for use on short-haul jets which make frequent landings. A special axle-mounted electric fan blows on the brakes to speed the cooling process between landings.

Goodrich has produced several dynamic, high-performance adhesives including four different Plastilock systems measuring as thin as 8,000ths of an inch for the variable-sweep wing USAF/Navy F-111 tactical fighter. The adhesives are used on the aircraft's wings, fuselage, tail and outer skin to resist damage from temperatures at supersonic speeds and from fuel, water, sonic fatigue and internal pressure. Because of their thinness and lightness, the adhesives help to keep the weight of the aircraft to a minimum.

Special wheels and brakes have been designed and built to deliver higher torque without fade and to permit fast, chatter-free stops for the F-111, the XB-70 and other military aircraft as well as for larger commercial jet aircraft such as the Boeing 707-320, 720 and 727. In the general aviation market, Goodrich expanded its dealer organization by more than 100 outlets and added to its product line tires, deicing systems, and accessories for several new models.

GOODYEAR AEROSPACE CORPORATION

Operational evaluation of the Subroc anti-submarine missile, for which Goodyear Aerospace Corporation is prime contractor, was successfully completed in 1965 and the U. S. Navy began deploying the potent weapon in its growing fleet of nuclear-powered attack submarines.

The addition of Subroc to the Navy anti-submarine warfare inventory gives U. S. hunter-killer submarines a weapon capable of striking hostile submarines with a nuclear punch at long range. The company continued production of Subroc in its Akron, Ohio facility.

SUBROC missile built by Goodyear Aerospace Corporation hangs from crane during loading aboard submarine for Pacific tests. Missile is fired through conventional torpedo tube and travels through water and air to reach objective.

Goodyear Aerospace Corporation engineer examines canister assembly that will be used to orbit a 100-foot diameter PAGEOS inflatable satellite developed by Goodyear. Satellite is to be packed inside canister for release once vehicle attains orbit.

This country's most advanced sidelooking radar system, developed for the reconnaissance version of the McDonnell Phantom II airplane, also attained operational status and was used for the first time in Southeast Asia. The radar units enable aircraft to survey and record on film wide areas of terrain.

Among significant new programs started during the year, Goodyear Aerospace, a subsidiary of The Goodyear Tire & Rubber Company, began development and production of transporters for the Air Force Minuteman missiles and initiated production of air transportable photo processing and printing modules for use in tandem with reconnaissance aircraft.

The company also revealed that it had developed and is producing a new lightweight, non-metallic armor plate which has been providing excellent protection for Army helicopter and reconnaissance crews in Vietnam. The armor consists of a ceramic facing material which shatters the projectile and a fiber glass backing which prevents penetration.

In electronics, Goodyear Aerospace continued to be a major supplier of tactical flight and weapons systems trainers and radar classroom trainers for the

U. S. Navy, electronic countermeasures and radar interpretation devices.

The company fabricated a 140-foot diameter radome and erected it at Clear, Alaska to house a giant BMEWS (Ballistic Missile Early Warning System) antenna, also built by Goodyear Aerospace and scheduled for erection in 1966. It was the sixth radome and antenna combination produced by the company for the BMEWS program.

Production continued on a wide range of plastic canopies and radomes for military and commercial aircraft and on the fiber glass filament wound rocket motor cases for the Navy Polaris A-3 missile.

In space-oriented activities, Goodyear Aerospace built and delivered to the National Aeronautics and Space Administration the prototype STEM (Stay Time Extension Module) for possible use in future moon exploration and began production of launching canisters for the Pageos satellite.

Project Gemini astronauts carried with them Goodyear Aerospace-developed Ballutes (balloon-parachutes) as part of their safety equipment and the company developed flotation balloons for righting the three-man Project Apollo spacecraft after splashdown. Work was initiated on several other deceleration and recovery device programs, including the Air Force PRIME program.

Late in the year, Loren A. Murphy, a 40-year Goodyear veteran, succeeded retiring T. A. Knowles as president of Goodyear Aerospace Corporation.

Grumman Ag-Cat is utilized for crop dusting, spraying, seeding and a host of other utility jobs.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION

In 1965, the 36-year-old Grumman Corporation enjoyed a record year. Gross sales were up 42 percent over 1964, and net income nearly doubled.

It was also a year of substantial expansion for the company. Close to 750,000 square feet of new area was occupied or under construction, and new machinery purchases enhanced manufacturing capabilities. In addition to expansion at Bethpage, New York, headquarters, 100 acres of land in Savannah, Georgia, were acquired and manufacturing facilities at Stuart, Florida, were substantially increased.

During 1965 the company produced 149 military aircraft, 20 Gulfstream I's and 76 Ag-Cats.

Grumman's military aircraft line extended its highly successful operational record as no less than seven different models performed their various missions in Vietnamese combat areas. They are: A-6A Intruder all-weather attack bomber; E-2A Hawkeye

C-2A Greyhound was developed by Grumman to meet U. S. Navy requirements for an improved utility transport to deliver cargo and personnel to and from aircraft carriers at sea.

Twin-turboprop Grumman Gulfstream I is specifically designed for the utility and business aircraft market.

and E1B Tracer AEW aircraft; S-2E Tracker ASW aircraft; HU-16 Albatross air/sea rescue aircraft; OV-1 Mohawk, observation/reconnaissance aircraft; and the C-1A Trader, carrier on board delivery aircraft.

The EA-6A, electronic countermeasures version of the Intruder, became operational with the Marine Corps in December and the C-2A Greyhound, a high-performance replacement for the C-1A COD aircraft, made its initial flight.

The first flight of the F-111B (Navy version of the tactical fighter) was also successfully completed, ahead of schedule, in 1965. Subsequently, the aircraft proved its sustained low-level supersonic flight capability and exceeded the Mach 2 speed range.

The company's commercial aircraft programs recorded a successful year in 1965.

Sales of the turboprop Gulfstream I corporate transport reached the 165 mark at the end of the year. The prototype of the Gulfstream II, a swept-wing, twin-jet version of the Gulfstream I, was under construction and scheduled to fly in mid-'66. This aircraft will carry 10 passangers over 3,600 statute miles at speeds up to 585 miles per hour. By year-end, Grumman had received 40 firm orders for the Gulfstream II.

Seventy-six Ag-Cat crop dusters were built during 1965, bringing the total to over 400. A new model, the Super Ag-Cat, received FAA certification during the year, and its larger engine, increased fuel capacity, and beefed-up construction afford higher performance.

Grumman's first Orbiting Astronomical Observatory, a 3,900-lb. earth-orbiting stellar research satellite, was completed and delivered to Cape Kennedy for launch during the first quarter of 1966.

The Lunar Excursion Module for the Apollo spacecraft represented the company's largest single contract. The first ground test models were produced, and the first flight test model went into the flight hardware outfitting phase.

A continuing and extensive study program in Apollo extension systems was also underway throughout 1965.

Grumman laid the keel for its second ocean-going hydrofoil vessel in 1965. The 56-ton, 90-passenger, 50-knot craft, named Dolphin, was scheduled for launch in the summer of 1966. The Dolphin followed the HS Denison, already operational with the Navy at Point Mugu, California.

Another hydrofoil design program for the construction of a patrol gunboat (PGH) neared completion by the end of the year.

Further activity in undersea studies, especially in the manufacture of submersible vehicles, was being organized by Grumman as the year ended.

The Grumman Gulfstream II is the twin-jet, swept-wing successor to the Gulfstream I, and is scheduled to make its first flight in mid-1966.

INTERNATIONAL BUSINESS MACHINES CORPORATION

FEDERAL SYSTEMS DIVISION

From the floor of the ocean to the far reaches of space, IBM equipment and know-how helped make history during record-shattering 1965.

Examples of the use of IBM equipment included:

The first manned Gemini spacecraft, Gemini 3, was guided in orbit on March 23 by its 59-pound computer built by the IBM Federal Systems Division.

The powerful Real Time Computer Complex, designed and implemented by IBM for NASA's Mission Control Center, Houston, first went operational on June 3 supporting the flight of Gemini 4 and the "walk in space."

Saturn I flew its tenth perfect flight on July 30, a flight that also marked the 54th consecutive time an IBM ASC-15 space computer had guided a rocket successfully.

The first Saturn IB instrument unit, assembled in IBM's new Huntsville facility, was mated to the booster on the huge Saturn pad at Kennedy Space Center on Dec. 1.

IBM computers at NASA's Houston control center and in both spacecraft aided U.S. astronauts to the precise and historic rendezvous of Gemini 7 and Gemini 6 on Dec. 15.

During the year, to meet the growing needs in the Federal Government's space and defense programs and to focus the company's capabilities in these areas, the IBM Federal Systems Division, headquartered in Rockville, Maryland, was reshaped by President Bob O. Evans to concentrate on three areas of advanced technology for Government customers—aircraft, space, and information handling systems. The Federal Systems Division is responsible for supplying IBM advanced information systems and technologies to U.S. aerospace and defense agencies and their prime suppliers.

A new operating center, the Space Systems Center, was established in Bethesda, Maryland, as part of the FSD change. This center, whose general manager is FSD Vice President Arthur E. Cooper, will be responsible for the division's programs in space, which include the specially-built IBM data processor for the NASA Orbiting Astronomical Observatory satellite due for launch in 1966; the on-board digital computer and data adapter in NASA's Saturn IB and Saturn V moon rockets; and space station systems and research including studies for the NASA Manned Orbital Research Laboratory (MORL), USAF Manned Orbiting Laboratory (MOL) and NASA Orbiting Research Laboratory (ORL).

The Space Systems Center is also responsible for the IBM systems—computers and astronaut cockpit instruments—in Gemini spacecraft and their integration with other elements of Gemini guidance and ground control systems, and development and fabrication of instrument units for the NASA Saturn IB and Saturn V launch vehicles—IBM's biggest space contract. The instrument units, containing up to 57 subsystems, are the control centers of these rockets that will send U.S. astronauts on lunar flights. The instrument units are being assembled at the division's facility in Huntsville, Alabama.

The Federal Systems Center is the FSD group that has been located in Bethesda, Maryland, but with a new name. This center will add new emphasis to its development and implementation of ground-based systems for command, marine, intelligence, space operations support and management information handling. The center, headed by Bruce G. Oldfield, FSD vice president and general manager, includes an engineering laboratory for design and development of specialized systems equipment, e.g., communications, display, console and similar devices needed for total information systems.

Projects for the Federal Systems Center in 1965 included an \$80 million award from NASA to continue development and systems management responsibility for the Real Time Computer Complex, heart of the Mission Control Center at NASA's Manned Spacecraft Center, Houston; studies of new automatic data systems for U.S. Army forces in the field; and development of a new Navy cost information system, called "Bluestreak," to help Department of Defense planners do a better job of assessing how much defense per dollar the U.S. is buying.

Additional Federal Systems Center projects were a new computation system for NASA's Goddard Space Flight Center, providing, in effect, special and complex mathematics and computer instructions needed for computing orbits and attitudes of the scientific satellites Goddard launches (e.g., TIROS), and continued development of an intelligence data handling system for the Department of Defense, involving preparation of special files of data and processing techniques for a sophisticated information retrieval and correlation system.

During the year IBM engineers from this center demonstrated an experimental electronic communications unit that can do both time division switching and frequency division multiplexing—operations that ordinarily require separate pieces of equipment.

The unit, called ISAM for Integrated Switching and Multiplexing, is a refrigerator-size system developed by IBM for the Air Force's Rome Air Development Center.

An experimental radio-telephone that can handle hundreds of conversations at once was announced in June at the Federal Systems Center. The battery-operated VHF transceiver permits many calls to be transmitted on the same channel simultaneously by assigning each its own code.

The Federal Systems Center will investigate digital receiver design techniques under terms of an \$80,000 contract awarded by the U.S. Air Force Rome Air Development Center in the summer. FSC will explore those analog functions of communications receivers that can be performed better by a digital computer or by a special digital device.

IBM continued to win significant laser awards, among them a \$49,565 contract to develop laser arrays from NASA's Marshall Space Flight Center. The primary goal is obtaining increased light output power at room temperature as compared with single lasers. Several schemes of phasing and coupling diode lasers are being explored.

The third FSD operating component—the Electronics Systems Center, Owego, New York—concentrates on advanced systems for aircraft, including military helicopters, transports, fighters and bombers. This facility will also be responsible for FSD manufacturing and for developing advanced computers for space and defense applications. John B. Jackson is FSD vice president and general manager of this center.

During the year, IBM began, with Eastern Airlines, to develop a new system to improve plane maintenance and make flying safer. A Whisperjet on regular runs was equipped with some 40 sensing devices that feed a continuous record of operational data to on-board data-gathering equipment. These data are processed later on an IBM 7074 in Eastern's Miami headquarters, to analyze flight conditions, especially as they affect maintenance. One goal is to develop a computer that could go aboard airliners to process operations data during flight.

This center, under a 1965 contract with NASA's Kennedy Space Center, is also exploring the possibility of replacing portions of the heavy umbilicals on launch towers with a laser communications system. The demonstration system will use eight tiny lasers to replace 112 wires, including two voice links.

An aerospace computer memory drum about the size of a baseball was developed by engineers at the IBM Electronics Systems Center. It is seven times smaller but holds four times more information than existing memories of its kind. It is designed to store and then give information to computers that guide missiles, rockets, or aircraft to their targets. The 2 1/2 pound device is highly reliable because it has only one moving part—a small cylinder on which data is stored magnetically.

IBM planned to consolidate most of the local facilities of the Federal Systems Division into one building at Gaithersburg, Maryland. Ground was broken in 1965 for a new, two-level building scheduled for completion in 1966.

KAISER AEROSPACE & ELECTRONICS CORPORATION

Kaiser Aerospace & Electronics Corporation had a backlog of orders of \$29,100,000 at December 31, 1965, compared with \$24,545,000 at the end of 1964.

The business of Kaiser Aerospace & Electronics consists primarily of the production of solid fuel rocket motor nozzles and aircraft structural components by the aerospace division and development and manufacture of the Kaiser FLITE-PATH system of navigational aids for airplane pilots by the electronics division.

At its San Leandro plant, the company is a leader in the production of nozzles for major military missile programs. Quality of the workmanship was attested by the U. S. Air Force in November when it presented the San Leandro plant its Zero Defects Achievement Award.

In 1965 volume production was started at the company's ultramodern 40,400-square-foot numerical control plant for machining of large aircraft forgings at San Leandro. Parts now being machined include a number of complex components for such aircraft as the General Dynamics F-111.

The rate of production of the airborne Kaiser FLITE-PATH system and associated Kaiser Radar Data Converter was more than doubled in 1965 at the Palo Alto, California, plant. This all-weather system, which utilizes a TV-type display simulating real world conditions for the pilot, is the only one of its kind being produced in volume for the military. While production is presently for the Grumman A-6A airplane, the company is developing similar systems for other military aircraft of the latest design and several deliveries were made in 1965 of systems to be used in the Navy's F-111B. In addition, a new system designed at the company's Palo Alto plant for use in light aircraft, both military and civilian, is nearing the production stage.

Construction of a 72,000-square-foot building adjacent to the company's Palo Alto development laboratory was started in 1965. This new building, scheduled for completion in 1966, is required for the expanded electronics manufacturing operations.

In 1965, Kaiser-Cox Corporation was organized for the purpose of marketing community antenna television (CATV) equipment. The new company, owned equally by Kaiser Aerospace & Electronics and Cox Broadcasting Corporation, started operations on November 1, 1965.

PIPER AIRCRAFT CORPORATION

1965 was a good year for the Piper Aircraft Corporation. Increased dollar and unit volume tell only part of Piper's growth story which is bolstered by the young philosophy of its president, pioneer aircraft builder William T. Piper, now in his 86th year.

"It's not enough just to build fine airplanes," Mr. Piper says. "We must have more airports, service facilities, trained personnel, increased production, and continuing programs of education for the public and the people in our industry."

William T. Piper, Sr., president, and William T. Piper, Jr., executive vice president, Piper Aircraft Corporation, are shown looking at a production line of Piper aircraft.

Putting Mr. Piper's words into goals has led to greatly increased production space at both the Lock Haven, Pennsylvania, and Vero Beach, Florida, plants, a cooperative airport building program with the U. S. Jaycees, a "Work and Fly" program for high school graduates, increased service training here and abroad, and increased local and national advertising directed at the non-flying public.

In 1965, Piper announced a $4.5-million capital expenditures program which will double production space at Vero Beach by mid-1966 and add 133,000 square feet of production space at Lock Haven.

Vero Beach is expected to reach 20 Cherokees a day by late 1966 in the new spaces, more than double its eight-a-day average in 1965. New spaces at Lock Haven will be used to produce the Navajo, Piper's entry into the medium twin field. This new turbocharged, six-to-eight place executive aircraft is expected to be marketed for less than $100,000.

Long an advocate of teaching people to fly, Mr. Piper established a "Work and Fly" program for selected high school graduates who do not have finances to pay for flight training.

"This is not a give-away program," Mr. Piper says. A portion of production jobs have been reserved for this group and they have the opportunity to learn to fly in new Piper aircraft at greatly reduced rates. While thousands have learned to fly at Piper over the years through this system, it was the first time the company had set up a specific program for high school graduates.

Piper extended its emphasis on learning to fly to its national advertising in major consumer magazines with its continued offer of a $5 Special Introductory Flight Lesson which it originated several years ago. Plans were also made to extend this advertising to the dealer level through local newspapers in 1966.

With representation in 91 countries of the free world, a stronger program was placed into effect for export sales which now account for approximately 25 percent of Piper's total production. In recognition of Piper's efforts and the amount of dollars returned through mounting export sales, President Johnson awarded the company the Presidential Export "E" Award in 1965.

Piper's "Quality Dealer" program got into full stride during 1965. This program is designed to assist present dealers and to attract the best possible new aircraft dealers to Piper and features backup and information programs from the company in all areas of a dealership.

Special sales training programs for dealers and their personnel, as well as added service training, were instituted.

In addition to its airframe, engine and systems training programs, Piper began an AutoPilot Specialists School and a program of certifying Piper autopilot centers as an added feature to its Certified Service Centers which have been providing service to customers for several years.

A third service school was added to those in operation at Lock Haven and Vero Beach. Piper's wholly owned European subsidiary in Geneva, Switzerland, Piper Aircraft International, now has a service school which has now helped train service personnel from most countries of Europe and Africa. In addition, the school is open to Government officials and participation has been excellent.

There were other high points in 1965 for Piper as well as one low point. A strike by production workers in the fall idled the Lock Haven plant for seven weeks and slowed production at Vero Beach.

Max Conrad, 61 year old trans-oceanic ferry pilot, established a new world's non-stop distance record of 7,868 miles with a Twin Comanche which he landed at St. Petersburg, Florida, on December 26th after a 56.8 hour flight from Capetown, South Africa.

In November, Piper delivered its 3000th Cherokee and in December, its 4000th twin, an Aztec C which went to Southern Newspapers in Montgomery, Alabama.

For the third year in a row, a Piper won the All-Women's Transcontinental Air Race, more commonly known as the Powder Puff Derby, with Cherokees placing first, second and third. Eight out of the first ten places were taken by Pipers which bettered the 1964 score of the first seven out of ten.

Pipers finished first, second and eighth in the Women's International Air Race.

Jim Clark, winner of the 1965 Indianapolis "500," joined the ranks of well-known racing drivers who fly their own Pipers.

Many flying clubs and major flying schools switched to the Cherokee.

The peripatetic Mr. Piper practices what he preaches about airport building. Not only does he travel about 100,000 miles a year speaking to groups interested in acquiring airports but he built one on Mustang Island near Corpus Christi, Texas, where he has an interest in a real estate development.

Working with the U. S. Jaycees, Mr. Piper has helped promote a national program to interest communities in building airports, aerial marking and flying clubs for Jaycees.

SUNDSTRAND AVIATION DIVISION OF SUNDSTRAND CORPORATION

During 1965, Sundstrand Aviation continued to hold its commanding position in the Constant Speed Drive industry. The development by Sundstrand of the Axial Gear Differential/Constant Speed Drive (AGD/CSD)—first introduced in 1963—represented a significant advancement over the hydraulic differential type CSD being offered until then. It provides greater reliability, lighter weight, and longer life for aircraft electrical systems.

AGD Constant Speed Drives currently in production for military applications at Sundstrand Aviation include those for the F-111, F-4B/C, the SAAB J-37, the A-7A, and the C-141. Commercial versions of the AGD drive now on production contract include the Boeing 737 and the Douglas DC-9 and DC-8 60 Series.

In order to respond to the demands of new product development and the substantial increase in business for existing lines, Sundstrand Aviation has recently announced that a new engineering campus will be built in Rockford, Illinois. This ultramodern multimillion dollar site will combine the research, development, engineering, sales, and administrative functions of both Sundstrand Aviation in Rockford and in Denver, Colorado. It is scheduled for completion in early 1967. Although the new building will house all engineering functions formerly conducted in Denver, the Colorado manufacturing plant will continue to produce parts for the Aviation and other Sundstrand Divisions.

Sundstrand's long experience in hydraulics in reflected in the engine driven hydraulic pumps and motors being offered for aircraft applications. Sundstrand Aviation hydraulic pumps have been selected for the Lockheed SST and are being proposed for a number of other new, or planned, planes.

A great deal of enthusiasm has been shown by potential customers for the Hydrostatic Transmissions designed and developed by Sundstrand for both on and off the road applications. Extensive testing is being conducted in this product area and a wide range of application is predicted. Testing of the Sundstrand DMT has been conducted on both track and wheel vehicles with remarkable success.

During 1965, Sundstrand Aviation also continued development testing on the primary and secondary power sources for the new Mark 48 torpedo. In addition, work continued on the development of miniature Missile Power Units (MPU) designed to provide electrical power for brief time intervals on various rockets.

Another variety of airborne device, an air data computer with the potential of decreasing altitude separation and reducing the pilot's workload on commercial jet airliners, was introduced by Honeywell's Minneapolis Aeronautical Division. The division sold several of the compact, modular computers to American Airlines for use aboard Boeing 727 jet transports.

Engineers at the Minneapolis Aeronautical Division designed a commercial device called an RF (for radio frequency) probe. Purpose of the portable, self-contained trouble-shooting instrument is to detect latent defects in all types of electronic equipment. The probe spots intermittent electronic faults that characteristically emit RF energy.

HUGHES AIRCRAFT COMPANY

The successful launch of the Early Bird communications satellite April 6 marked the major news event of the year for Hughes Aircraft Company, which built the synchronous satellite at its space systems division for the Communications Satellite Corporation.

Early Bird, an advanced version of the previously successful Syncoms 2 and 3, achieved its difficult "stationary" orbit 22,300 miles over the Atlantic at the equator, started operating right on schedule and continued to operate "loud and clear" throughout the year without any faults or breakdowns.

When Comsat inaugurated commercial operations between the U.S. and Europe in June, Early Bird provided 240 two-way telephone channels 24 hours a day, linking 85 percent of the world's telephones.

Comsat Corporation asked approval of the Federal Communications Commission October 19 to buy four super Early Bird-type satellites from Hughes for about $11,730,000, with an option for purchase of additional satellites. The new Comsat satellites would be larger, more powerful and more versatile than the Early Bird in orbit. They will be used to support the Apollo program of landing astronauts on the moon as well as for other commercial service.

All three U.S. television networks, Canada and European TV nets used Early Bird for coverage of news and special events, some in color. In October, the satellite was used for two-way coverage of Pope Paul's historic visit to the United States.

The Early Bird success stimulated ABC-TV and CBS-TV to award Hughes feasibility study contracts regarding the use of proposed giant satellites capable of carrying national TV programming to provide wider and better U.S. coverage.

Meanwhile, Early Bird's older brothers, Syncom 2, launched July 1963, and Syncom 3, launched August 1964, continued to operate over the Indian Ocean and Pacific Ocean, respectively, compiling new space communications records.

Early in 1965, both Syncoms were used by the Army Satellite Communications Agency (SATCOM) to complete the world's longest telephone call through space satellites—a 17,000-mile double-hop between New Jersey and Ethiopia the long way around the earth.

In March, Syncom 2, hovering over the Indian Ocean, made more space history by carrying the voices of Gemini 3 astronauts Virgil Grissom and John Young to NASA space control centers in the U.S. as their capsule orbited the world.

Hughes Aircraft continued research on its TWT, a Traveling Wave Tube (in jar) that amplifies space signals from a whisper to a shout.

Another far-reaching experiment, started in 1964 and continued throughout 1965, used Syncom 3 for two-way teletype transmission from Camp Roberts, California to a Pan American aircraft flying the Pacific, the first transmission of information via satellite to and from a commercial airplane. Syncom 3 did the trick from its roost over the intersection of the equator and the International Dateline, where it also had carried live telecasts of the 1964 Tokyo Olympics.

In January, Sen. J. William Fulbright (D., Ark.)

disclosed that Hughes Aircraft Company would build a communications satellite earth station in Arkansas and operate it as a space communications research terminal. During the year, ground was broken and construction started on the ground station, which will include an 85-foot-dish antenna with supporting buildings. It will be financed and operated by Hughes.

The company's space systems division continued work on the Surveyor spacecraft which NASA planned to launch in 1966 for a soft-landing on the moon as a forerunner of the Apollo man-on-the-moon program. Under direction of NASA's Jet Propulsion Laboratory, Hughes was building seven Surveyors designed to land gently on the moon and send back information and television pictures to make the eventual manned landing safer for the astronauts.

Another Hughes contribution to the space age came from the company's microwave tube division which built a unique metal-and-ceramic traveling wave tube (TWT) that was described by The New York Times as the "critical component" in the transmitter of the Mariner 4 spacecraft as it sent back photos of Mars last July. Other Hughes TWT's had been used successfully aboard both Syncoms and Early Bird and were scheduled for launch on at least eight future space shots, including the Apollo man-on-the-moon vehicle.

Hughes continued development of the Navy's Phoenix missile system for the F-111B Navy interceptor. Early in 1965, the Phoenix successfully completed its first airborne test when an inert missile with the same external configuration, weight and center of gravity as a complete Phoenix was ejected from an A3A launching aircraft and maintained a correct, stable attitude during an unpowered descent over the Pacific off Point Mugu, California. Hughes is prime contractor to the Navy's Bureau of Weapons for the entire Phoenix system, which consists of the missile itself, an advanced radar and missile control system, and the missile-bomb launcher.

On a single day (May 1), the Lockheed-built USAF all-weather fighter interceptor YF-12A, which carries the Hughes ASG-18 armament control system and the Hughes AIM-47A missile, set seven world flight records for speed and altitude at Edwards Air Force Base, California. The aircraft can fly at more than 2,000 miles an hour and reach altitudes of more than 70,000 feet.

The Hughes HS-100 Aided Visual Attack System, a versatile airborne fire control system that includes a laser ranger, underwent tests aboard F-4C Phantoms at Eglin AFB, Florida, where USAF pilots agreed that "the laser has shown great potential in this feasibility program and future systems probably will include lasers." The system is designed to permit tactical aircraft pilots to attack ground targets from extremely low altitudes with great accuracy and with no danger from blast to pilot or plane.

In September, the Army announced that it had successfully fired the developmental model of its new supersonic antitank missile, the TOW, scoring center hits on tank-sized targets more than a mile away. TOW, which stands for Tube-launched, Optically-tracked, Wire-guided missile, is being developed by Hughes at its Culver City, California, headquarters facility under direction of the Army Missile Command to provide a major boost in firepower for infantry units by combining a powerful warhead with high accuracy at both close and long ranges. In October, the Army awarded Hughes a \$4,178,655 contract for research on the use of TOW missiles on helicopters.

Early in the year, scientists at Hughes Research Laboratories at Malibu, California, where the first operating laser was developed in May, 1960, achieved continuous operation of a ruby laser at room temperature, a breakthrough that led a Hughes executive to predict that communications between satellite and satellite, distant space stations and earth, and man-in-space and earth may someday ride the narrow, concentrated light beams of lasers.

The company's research labs also were awarded a \$192,000 NASA contract to develop a device that will sense the mass of an object at a distance by detecting its gravitational field. The goal of the 16-month research program is to develop a small, lightweight, rugged sensor that can be carried on lunar orbiters to measure the mass distribution of the moon and used on deep space probes to measure the mass of asteroids.

Hughes space systems division engineers made rapid strides on water electrolysis rocket engines for future communications satellites. The new control system, one of four company inventions that possibly could save more than \$2 billion for an eventual global satellite communications network, uses water for fuel and extends the possible control life span for satellites from only a few years to as much as 20 years.

At NASA's Manned Spacecraft Center in Houston, a special version of the Hughes automatic circuit tester called FACT (Flexible Automatic Circuit Tester) was being used to simulate voltage outputs and to validate wiring.

In February, Lawrence A. Hyland, Hughes Aircraft's vice president and general manager, announced sweeping promotions in the company's executive alignment "to meet more effectively the responsibilities of management in a business which has greatly expanded in scope, diversification and complexity in the last few years."

Hyland appointed Dr. Allen E. Puckett as executive vice president, sharing that rank with Roy E. Wendahl. John H. Richardson was named senior vice president and succeeded Dr. Puckett as executive of the aerospace group. C. Harper Brubaker, executive of the company's ground systems group in Fullerton, California, also was promoted to senior vice president.

John W. Black, vice president, became assistant aerospace group executive, succeeding Richardson, and named as new vice presidents were William F. Eicher, Dr. Fred P. Adler, Dr. Nicholas Yaru, Dr. Malcolm R. Currie and Dr. George F. Smith. Robert S. Killough was appointed secretary of the company. Lance P. Johnson was named manager of the company's microelectronics division at Newport Beach in addition to his roles as manager of the electronic products and industrial systems division.

During 1965 total company employment at all divisions rose slightly from about 24,000 to 25,300. Some of the increase resulted from a campaign to recruit 1,000 scientists and engineers during the calendar year for work on a wide variety of space and defense contracts in four aerospace group divisions. The company's gross income exceeded $400,000,000 for the tenth consecutive year.

HUGHES TOOL COMPANY

AIRCRAFT DIVISION

The biggest news of 1965 at Hughes Tool Company's Aircraft Division was the award of a $14,966,964 Army contract to build 714 light observation helicopters during a three-year period.

The Hughes pact emerged after stiff competition with Fairchild-Hiller Corporation of Palo Alto, California, to provide a reliable, easily maintainable turbine-powered aircraft. The Army required that it be capable of performing the primary tactical mission of visual observation, target acquisition, battlefield reconnaissance and command control.

The Hughes Army helicopter is basically a four-seater but is capable of transporting a five-man fire power team plus pilot.,

The first aircraft under the contract, which was expected eventually to total at least 4,000 helicopters, was scheduled for delivery in the summer of 1966. The Army program caused Hughes Tool Company to double its helicopter work force.

The light observation helicopter (LOH) was designated the YOH-6A by the Army. It is 400 pounds (30 percent) lighter than the competitive ship in the final competition. Its empty weight is 1,070 pounds and it can lift a useful load in excess of that, thus becoming the first light helicopter to be able to lift more than its own weight. The LOH, powered by a 250-horsepower Allison T-63 jet engine, achieved an unofficial world speed record for light helicopters of 170 miles an hour; it cruises at 145 and it has attained a true air speed of more than 160 miles an hour. The YOH-6A has a sustained rate of climb of 2,200 feet a minute at full gross weight and is capable of hovering out of ground effect at 6,000 feet on a 95-degree day.

Before winning the Army LOH contract, Hughes announced plans to produce a five-seat luxury "executive" version of the military air helicopter which, the company claimed, will provide "much faster portal-to-portal travel" than a 200-mile-an-hour twin engine airplane.

In addition the company said it would market a utility model of the same executive aircraft that will carry seven in "work" conditions. The "500" executive model will sell for about $69,500 while its "workhorse" twin sister would be priced at $65,000.

The difference in price between the commercial "500," the "500" Utility and the military versions is chiefly accounted for by the fact that the military craft contracted for does not include the engine, the electronics or the luxury interior and other equipment on the commercial model.

The "500" is regarded by Hughes as "an economic breakthrough in that any other commercial turbine powered helicopter planned or in production costs 50 percent to 150 percent more per seat." Flight at 150 miles an hour within a 450-mile radius direct to heliports or landing points atop or adjacent to departure and destination is the outstanding feature of the "500" models.

Below, the commercial version of Hughes Tool Aircraft Division's OH-6A, above. The "500" is a five-place executive helicopter.

Early in 1965, Hughes' research "Hot Cycle" jet helicopter made its first public flight at the Culver City plant's airstrip.

One of the principal attributes of helicopters of this jet propulsion type is the simplicity of the rotor drive system which eliminates all heavy gear boxes and complex mechanical drive components. The mechanical simplicity and lightweight features permit it to lift loads more than twice its empty weight. Present day helicopters have a useful load roughly equal to their own empty weight.

The helicopter rotor is propelled by ducting the high energy gasses from a turbojet engine to the rotor tips where they are exhausted. Conventional helicopters are powered by drive shafts similar to those on automobiles which are much heavier than the pneumatic system used on the Hot Cycle.

Obvious military uses will include highly versatile and economical transports carrying heavy cargo or passenger loads into areas now considered inaccessible to conventional aircraft. The helicopter's hovering ability and high speed of about 300 miles an hour could be employed to advantage in antisubmarine warfare.

The Hot Cycle helicopter, or XV-9A, generally resembles many other helicopters in outward appearance except for a jet housing on each side of the fuselage, louvered openings at the tip ends of its three rotor blades and the lack of a tail rotor, since there is no shaft torque to counteract. The power plant consists of two General Electric YT64 gas generators. The rotor is 55 feet in diameter.

The test flights culminated more than four years of development by Hughes. The feasibility of the Hot Cycle rotor system was proven on the company's whirl stand in 1962 under a program sponsored jointly by the Army, Navy, Air Force and Hughes Tool. Advanced ground tests were completed in June, 1965.

The Hot Cycle system had its genesis in Hero's turbine some 2,000 years ago in Alexandria. A gas generator, consisting of a kettle of water heated by a fire underneath produced gas (steam) which was ducted into a sphere and out through two jets directed to produce rotation.

One of the most important military jobs undertaken by Hughes Tool during the year was to arm the Navy with its fastest gun system, the 20 millimeter Mark 4 Gun Pod with Mark 11 gun.

The firm received an initial contract to produce for the Bureau of Naval Weapons $9,568,350 worth of aerial gun systems, described as "the most versatile and advanced ever developed for the Navy."

Each Mark 4 gun system consists of three external pods each of which contains a self-powered, twin-barreled 20 millimeter aerial cannon, the Mark 11 gun. Each pod is hung from the fuselage or wing of an attack aircraft in the same manner as that employed for external fuel tanks and bombs.

Rate of pod fire, which is 4,200 rounds a minute, allows the pilot of an attack jet aircraft to lay down quickly and at high speeds a devastating concentration of firepower with a minimum of exposure time to enemy fire. A standard system of three pods can fire at a rate of 12,600 rounds a minute on a pinpoint target. The total projective energy is 5,000 horsepower per gun during firing.

The pod system is designed to be compatible with a variety of Navy and Marine attack aircraft, and the gun pod can be installed on a number of other military aircraft. Quick installation or removal of pods gives the military commander the option of ordering an aircraft on an air-to-ground mission or putting it up quickly on observation missions without armament. Each gun pod can be attached to an aircraft in about three minutes, removed in just one minute.

The Mark 4 gun system, with its Mark 11 gun mounted in a supersonic gun pod, is reminiscent of "Old West" small arms. It works on a revolver principle, but its large single cylinder feeds two barrels which fire simultaneously at 70 rounds a second.

ITT FEDERAL LABORATORIES

ITT Federal Laboratories, headquartered in Nutley, New Jersey, is comprised of major technological centers encompassing avionics, communications (including space), aerospace and the physical sciences. It provides to the military and industry a "total service" capability in advanced research, development, manufacture and service. The company is a major segment of the U. S. Defense-Space Group of International Telephone and Telegraph Corporation, a world leader in telecommunications and electronics.

During 1965, ITTFL completed the transfer of its complete aerospace capability to its San Fernando, California, facility, combining the missiles and space systems activity formerly at Nutley with the existing California operations, with specializations in tracking and instrumentation, satellite systems, reconnaissance, ranging instrumentation, missile systems, space guidance and control, fuzing and electro-optical technology. This integration of aerospace activity within ITTFL and resultant combination of technologies in common engineering areas places ITTFL-San Fernando as a first-tier supplier of a broad range of aerospace equipments and subsystems. Principal technical disciplines in the expanded operation include aerospace systems (satellite, electronic and electro-optical), reconnaissance, electro-optics, astrionics, and tracking and instrumentation.

At year-end, the aerospace operations in California included 75,000 square feet devoted to research, development and pilot-plant production. Adjacent to this facility is another member of ITT's defense-space group, Industrial Products Division, with an additional 75,000 square feet of manufacturing support.

Development activity at ITTFL-San Fernando resulted in several significant achievements for the military and space agencies during the year. The first group of a complement of ITT-developed star trackers was provided to NASA for use in upcoming lunar orbiting programs. The star tracker, which responds only to the light from the star Canopus, provides roll attitude reference data to control systems in the unmanned spacecraft to keep it positioned correctly for taking sharp, close-up photographs of the moon's surface during its entire flight. Also developed for NASA was an optical tracking and ranging system which will provide future orbiting space vehicles with the necessary angle, range and rate information to accomplish space rendezvous and docking operations. This development was a direct contribution from advancements made in electro-optics research during the past few years.

In the area of tracking and instrumentation, ITTFL introduced an extremely accurate and stable tracking and telemetry receiver for use on existing and advanced space programs. The receiver provides automatic antenna following of telemetry and beacon transmitter signals emanating from manned or unmanned spacecraft. The receiver accommodates voice, T.V. or data reception and performs a tracking function as well. Also developed for the military was a telemetry receiver capable of providing ground stations with higher quality reception of voice, T.V. and data signals from orbiting spacecraft and space probes. The advanced signal combining techniques employed in this highly sensitive receiver provide the space agencies the opportunity to collect more useful space data over a broader range of frequencies and at greater distances in space.

A portable automatic calibration tracker, designated PACT, was developed and delivered to the Goddard Space Flight Center. This unit provides optical calibration for radar and deep-space tracking antennas. After manual siting of the moving target is accomplished, the ITT unit provides tracking data for automatic positioning of the ground station radar antenna.

Two other programs involving deliverable equipment centered around a space-borne transponder and an infrared telescope. The coherent space-borne transponder is to be employed in orbiting spacecraft and space probes to provide both control and data telemetry, as well as tracking information to ground stations. This equipment forms an integral part of the U. S. Army's orbiting geodetic satellite manufactured in ITTFL/SF, which is providing more accurate long-range mapping data than heretofore available. The infrared telescope—a 20-inch telescope radiometer—was developed for NASA's Langley Research Center. A significant characteristic of this unit is a set of multiple sensors which allow alternate detection of a broad range of the visible/infrared spectrum. This ITT unit, which can provide a tracking function as well, finds application in such areas as determining the spectral content of shock waves surrounding a re-entering spacecraft.

KAMAN AIRCRAFT CORPORATION

Production continued during 1965 on Kaman's two major helicopter programs, the UH-2 Seasprite, fleet utility helicopter for the Navy, and the HH-43 Huskie, utility/rescue helicopter for the Air Force.

Operating at Air Force bases in the United States and overseas as well as with foreign governments, the Huskie extended its reputation for outstanding safety and its record of availability for the most difficult missions. Making rescues of downed airmen in enemy-held territory in both North and South Viet Nam, the Huskie has been credited with more than 400 pickups.

The all-weather Seasprite made numerous rescues at sea and demonstrated the importance of foul-weather, nighttime, and extended range operations. In the fall, the company tested a twin turbine version of the Seasprite and continued flight test of a compound version of the UH-2.

The Nuclear Division made new and extensive additions to both its staff and facilities. Production of intercommunication equipment and instruments continues from the Instruments Division. SEA (Science Engineering Associates) was successful in winning important new ocean engineering business and anticipated further expansion of business.

AirKaman was highly successful in sales of the new Lear Jet for which it is distributor in eleven Northeastern states. Sales of Beechcraft airplanes for business and private use increased along with service to general aviation and business as fixed base operator at Bradley Field, Windsor Locks, Connecticut. AirKaman established a new sales organization and was opening sales offices for principal Eastern cities.

For the first six months of the year Kaman's sales were $25,000,000 and employment stood at 2,500 at the end of the six month period.

KOLLSMAN INSTRUMENT CORPORATION

Developments in the highly competitive aerospace field during 1965 underscored Kollsman Instrument's strength in two significant areas: production performance and technical excellence. Proven performance enabled the company to secure substantial follow-on programs. Superior technical resources led to successful bids on important new programs and the development of a wide variety of advanced aerospace products.

Activities of 1965 encompassed a broad range of programs in avionics, space and advanced technology.

AVIONICS DIVISION

Overall business activity within the Avionics Division in 1965 was an acknowledgment of the company's position in the design and production of airborne instrumentation.

Activity in the commercial jet aircraft market was one of the primary reasons for strong business levels. The two main airframe suppliers, Boeing and Douglas, produced jet aircraft far in excess of their earlier 1965 forecast. The continuing high volume of airline business stimulated their buying policies to the extent that they have purchased more aircraft equipment than ever before.

The KIFIS system continued to be a very strong seller with wide acceptance among airline and airframe customers. New equipment was also developed which provided opportunities for the Avionics Division to capture a large market position in the commercial jet business.

During 1965, the Avionics Division received orders for new products in all areas of the division. The most significant item among these was Boeing Aircraft's decision to select Kollsman as the supplier for the Air Data Computer on the 737 twin-engine jet. Of special importance was the fact that this air data computer program provided a means by which Kollsman can increase its market position and compete on a number of other air data computer requirements expected to develop in the commercial aviation area in the next five years.

In addition, the division was highly successful in obtaining new orders for servo pneumatic altimeters for commercial applications. This new development, which provides for an extremely accurate altimetry measurement over a wide altitude range, was being produced for American Airlines, TWA, United Air Lines, Eastern, Avianca, National and the Federal Aviation Agency. It was expected that in 1966 many other domestic and foreign carriers would place large orders with Kollsman for this altimeter.

KOLLSMAN MOTOR CORPORATION

Kollsman Motor Corporation orders received in 1965 were the highest recorded since the subsidiary was established in 1959. Many of these orders were for advanced designs, requiring engineering and tooling on multiyear procurements.

Follow-on production contracts received by the subsidiary during the year were significant. Additional production contracts for instrumentation for the TFX supersonic tactical fighter and the McDonnell "Phantom" aircraft were received late in 1965.

SPACE DIVISION

In 1965, the Space Division realized one of its primary management goals by substantially increasing its backlog and volume. Expectations of the Apollo/Lunar Excursion Module program materialized with the receipt of a $43,000,000 contract for the design and manufacture of Apollo/Lunar Excursion Module Navigation Optical Subsystems. This, coupled with the prior Apollo contracts, brought the total Apollo/Lunar Excursion Module contract to more than $50,000,000. During the year, initial deliveries of the Apollo Optical Subsystems, e.g., automatic tracking sextant, scanning telescope and alignment optical telescope, were made. In addition, initial delivery of associated ground support equipment was accomplished.

Other NASA and Air Force contracts originating in 1965 offered significant business potential. Included were the Space Sextants and Stadimeters used on the Gemini flights; Sextant and Stadimeter assist the astronaut in manually navigating his space craft. These relatively inexpensive, lightweight, high performance instruments are likely to become standard equipment on future manned flights, particularly for abort operations where they can provide all necessary navigation information for safe return to earth. The first successful operation of the sextant was accomplished during the Gemini 4 flight in June, 1965.

Extension of prior technology was also represented by receipt of a contract for the optical astronomy package for Apollo Extension Systems. This is a study to investigate the feasibility and merit of adapting the Goddard Experiment Package into an optical astronomy unit for early missions on the lunar surface. The lunar surface, due to the absence of atmosphere, offers great potential for astronomical observations.

The Lunar Survey Viewfinder, another new NASA study contract, enables the astronaut to observe and study particular aspects of the lunar surface. The system is directly applicable not only to the Apollo Command Molule, but also to the Lunar Excursion Module and other manned spacecraft.

SYSTEMS MANAGEMENT DIVISION

The United States Air Force AN/USQ-28 Geodetic and Photo Mapping System continued to contribute to the growth of the Systems Management Division. During 1965, the first three systems were tested and accepted by the Air Force and were being installed in an RC-135A aircraft for flight testing. The flight test program was scheduled for the early part of 1966.

In addition to the systems capabilities and knowledge developed from the AN/USQ-28, the Systems Management Division developed the Geocon IV Mapping Camera Lens. This lens combines high resolution and color correction necessary for reconnaissance with the distortion-free characteristics demanded by aerial mapping. Its application beyond the original system is far reaching, with operational capability of such precision permitting its use in photography by vehicles ranging from low flying aircraft to future lunar and planetary explorations.

The skills developed by the Systems Management Division allowed the company to gain a strong foothold in the field of intelligence and reconnaissance and should permit continued growth of the Systems Management Division. This was evidenced in the last month of the year by an award to the division by the Army Engineering Research and Development laboratories for a study program for the Automation of Airborne Profile Recorder Data Reduction.

CORPORATE TECHNOLOGY CENTER

The company's research and engineering capabilities, reorganized in 1965 into the Corporate Technology Center, made dynamic strides in the development of new products and the application of new technologies.

A new model of Kollsman's data display system was developed by the Corporate Technology Center in 1965 and was received enthusiastically in both the commercial and military markets. The new display system, designated Delphic II, has as one of its major features the capability to provide four-color display from a single projector; four colors with one projector is an exclusive Kollsman capability. Commercial enthusiasm over this was evidenced by CBS' selection of the Kollsman Delphic II display to provide a "scoop" in the graphic telecast of the Gemini 6 and 7 launches, rendezevous and splash down. Also during the year the fifty projectors constituting the Alaska Air Command Display System went operational at mid-year. In addition, Kollsman received a contract from Link for the LEM Trainer Display System.

Kollsman CTC broadened its activity in laser systems and an optical radar system for search and detection was delivered to the Navy. Kollsman's previously successful weapon fire simulator was followed by the development of airborne weapon simulator capable of withstanding an aircraft environment. NASA's space exploration program received a boost through the successful completion of the laser beam pointing study which led directly to the optical technology satellite study for NASA.

KOLLSMAN SEMICONDUCTOR ELEMENTS

Kollsman, with its continuing growth, has become a leading independent supplier of crystal and fabricated silicon to the semiconductor industry. To meet further increases in product demand, its production capacity was gradually being supplemented. Equipment additions will not only improve the division's competitive position, but will also further support its already-recognized entrance into the epitaxial field.

KOLLSMAN SYSTEM-TECHNIK

A milestone in the German subsidiary's growth in 1965 was the occupancy of the new 60,000 square foot plant in Munich-Allach. The consolidation of all company facilities under one roof resulted in further rationalization of production, quality control and administration.

The company succeeded in becoming one of the leading European manufacturers of aviation equipment. The sales and production program encompassed a wide range of airborne instruments, systems, computers, recorders and components.

The company's 1965 products were to be found on the equipment list of all major European commercial and military aircraft projects. NATO Airforces and airframe manufacturers were entrusting to the company the solution of future developments of aviation systems and instruments.

KOLLSMAN INSTRUMENT LIMITED

The year was one of change in the British aircraft industry, with the cancellation of all the major military aircraft projects. Kollsman's British subsidiary overcame this economic letdown by consolidating its position, succeeding in fulfilling its program of planned expansion, and by obtaining a larger proportion of available work.

During the latter part of the year, Kollsman Instrument Limited received a major contract for the development and supply of vital flight instruments for the Concorde supersonic transport. The Concorde is a high performance supersonic transport under joint manufacture by Sud Aviation and the British Aircraft Corporation.

Earlier in the year, KIL had received contracts for standby altimeters for the Concorde.

The British subsidiary was very active in development of new products. Significant among these was the Crash Recorder Transducer, for both civil and military application. KIL received the two largest orders for these transducers to be placed in the United Kingdom.

Another product development which offered long term potential was the MK-28 Counter Pointer Altimeter. Early in the year, KIL received a development contract for the MK-28, a modified form of the MC-3 Altimeter. It was the intention of the British Government to apply this type of altimeter to most of the United Kingdom military aircraft, and production contracts were expected in 1966.

The Lear Jet facility at Wichita, Kansas

LEAR JET CORPORATION

The year 1965 was marked by one milestone after another for Lear Jet Corporation.

Following three initial deliveries to corporate owners late in 1964, the company's production lines were readied at the outset of the new year to ultimately complete 10 Lear Jet Model 23 aircraft per month.

By June this goal was reached and maintained, and at year-end some 80 Lear Jets were in corporate service around the world, more than any other business jet.

Keeping pace with increasing demands for the eight-place, 570 mile-per-hour Lear Jet, a second major facility expansion was completed in May, 1965, bringing total company floor space in Wichita, Kansas, to approximately 250,000 square feet. Still another expansion program was launched late in the year, adding 40,000 more square feet of plant area.

Employment, which on January 1 stood at 1,291, exceeded 2,300 12 months later, an increase of some 1,000 persons.

On April 17, the first Lear Jet to fly the Atlantic Ocean landed in Frankfurt, West Germany, completing what was described as a "perfect" crossing. Lear Jet D-IHAQ covered the 5,577 miles from Wichita in 10 hours and 17 minutes flying time, an average of 540 miles per hour at 41,000 feet altitude.

More than 10 Lear Jets flew transatlantic on delivery flights to European owners or in service for United States operators conducting business abroad. President William P. Lear, Sr., flew Lear Jet N803LJ to Europe with six persons on board on an August/September business and pleasure trip.

On May 21, Lear Jet N1965L was flown from Low Angeles to New York and back to Los Angeles in a total of 10 hours and 22 minutes flying time, establishing three world speed records in the business jet category.

On October 12, two new Lear Jet aircraft were formally announced: the Lear Liner Model 40 and the Lear Jet Model 24.

The Lear Liner, set to fly about mid-1967, will be offered in two basic configurations, seating up to 28 passengers for commercial airlines, and in a corporate version with a wide variety of seating arrangements.

Powered by twin fuselage-mounted Rolls-Royce Spey Junior fanjet engines, the Lear Liner will have a high cruising speed of 560 miles per hour at 45,000 feet flying altitude, and will operate from fields in the 5,000-foot category.

The Lear Jet Model 24, a growth version of the Model 23 which remained in active production, was expected to receive FAA certification early in 1966—the first under new FAR 25 requirements, which succeeded the old CAR 4b criteria.

By end of 1965 Lear Jets in corporate service had accumulated well over 18,000 flying hours, equal to some 9,000,000 miles.

In other company activities, the firm's Industrial Division in February was dissolved into two new operating divisions—Avionics, which like the Aircraft Division, has headquarters in Wichita, and Stereo Division, with offices in Detroit, Michigan.

Producing a growing line of airborne electronics equipment, not only for the Lear Jet but for the general aviation industry, the Avionics Division was pioneering advanced navigation/communications equipment, including the Model FC-110 Automatic Flight Control System.

Stereo Division activities embraced manufacture and marketing of eight-track stereophonic tape player systems for automobiles, homes, boats, and aircraft, as well as the compact cartridge units accepted by this equipment.

The company late in 1965 announced still a fourth operating division, the Actuator Division, with headquarters in Cleveland, Ohio.

Total sales for the fiscal year 1966, ending April 30, were forecast at about $85,000,000.

LEAR SIEGLER, INC.

Maintaining its position among the leaders in the aerospace industry, Lear Siegler, Inc. (LSI) continued its broad participation in almost all of the major Department of Defense and NASA programs involving aerospacecraft and missiles, as well as commercial airline markets. An excellent example of LSI's strong position in the field of manned aircraft was the fact that the company's aerospace operations entered the new fiscal year on July 1, 1965, with the highest backlog in its history.

Several realignments of executive talent occurred during the past year. In the interest of obtaining maximum and most effective use of the available management team, these changes in responsibility were promotions from within LSI, rather than the addition of new personnel.

K. Robert Hahn, a corporate vice president and former president of the Power Equipment Division, joined the headquarters group, with responsibilities for long range planning and supervision of certain major LSI divisions. His position at the Power Equipment Division was filled by Andrew F. Haiduck. Lloyd G. Hallamore, president of the Electronic Instrumentation Division, assumed executive responsibility for the Astronics Division, formerly headed by Haiduck. During the fiscal year James V. Bitner was named president of the Instrument Division. He formerly served as executive vice president of this largest LSI division. David Gerstein, who had served as executive vice president of the Data and Controls Division, was named president of the division.

Former Commander-in-Chief of the North American Air Defense Command, General John K. Gerhart (USAF Ret.), joined the staff of LSI, serving as assistant to the president. He is primarily responsible for long range planning of new product development.

During the year, LSI continued its major program of diversification and augmentation of product lines within existing divisional operations. While this expansion was primarily in the consumer/commercial market area, the company did enter the rapidly expanding field of computer programming by establishing a new and completely independent organization called Information Systems Company.

ASTRONICS DIVISION

One month after its first public demonstration in the United States, the LSI All-Weather Landing System (AWLS) performed flawlessly during additional demonstration flights in January at Patterson Field near Dayton, Ohio, and Dulles International Airport at Washington, D.C. Conducted for more than 200 high ranking military, government and aviation officials, the flights displayed the LSI system's capability in aligning the Caravelle jetliner with the runway, controlling its speed and attitude during the landing approach and landing the aircraft without the pilot's touching the controls. A total of 28 completely automatic landings were made during the demonstrations. At year-end ninety LSI automatic landing systems had been sold for use by nine European airlines and Alitalia Airlines was scheduled to place the system in late in 1965.

Delivery of the first production model of the Astronics-developed dual automatic flight control system for the Navy's new A-7A aircraft was made in mid-year. In addition to conforming to the program's low maintainability requirements, the light attack aircraft's automatic flight control system includes control augmentation and dual transducer stick steering. Designed for safety, as well as capability and maintainability, the system allows the pilot to preflight the system in less than two minutes and receive an automatic "go, no go" indication during flight.

Also in the field of automatic flight control systems, Astronics continued production of AFCS units for the Q2C target drone and DSN-50 ASW drone helicopter.

Programs completed or in progress at the end of 1965 at the division included: development of a fail operational dual servo system, a wheel force sensor research and development program for the USAF, application of field effect transistors for use in automatic flight control systems, design and development of digital circuitry for autopilot applications and the development of a squeeze bearing device utilizing piezoelectric principles for advanced North Seeking Gyro systems.

DATA AND CONTROLS DIVISION

During the year the Data and Controls Division of Lear Siegler, Inc., took a big step into the rapidly expanding field of electronic information gathering and processing with the development of its LSI-8000 Data Processing System. Recognition of this new LSI capability came in the form of a contract from the Army for data processing equipment to be installed at the White Sands Missile Range.

In aerospace systems work, R&D efforts were concentrated on development of specialized power conditioning equipment involving ultrahigh reliability, high voltage techniques and high efficiency design. As a result, the Data and Controls Division provided the radiation hardened static inverter for the SNAP-10A. Placed in polar orbit on April 3 aboard an Agena spacecraft, the LSI static inverter was designed to function properly in space for a period of three years without serious degradation of output, voltage or frequency tolerance maintainability.

The division was also selected to provide the high power static inverter and converter for the STAFF (Stellar Acquisition Flight Feasibility) system. In reality, the inverter/converter is a central power conditioning system which supplies 400cps power to the gyro wheel and multilevel DC power for various torques. Although the first flight was terminated by missile malfunction, the system provided sufficient power for telemetry transmission even after the Polaris A-1 has been destroyed and the system exposed to the salt water.

In addition to these power devices, the division continued production in such areas as autopilot systems, servo amplifiers for radar and antenna control systems and precision voltage radar power supplies. The division also delivered a revolutionary new underseas instrumentation device to the Naval Electronics Laboratory. Called the Sonodiver, the unit is designed to accurately measure ambient noise and temperature to provide valuable information in the little-known area of "inner space."

INSTRUMENT DIVISION

During 1965, the Instrument Division, largest of LSI's aerospace divisions, placed increasing emphasis upon the total systems approach while maintaining its strong position in the aerospace market as a supplier of subsystems and components.

Marking a first in the aerospace industry was the fabrication and testing of a truly low-cost inertial guidance system for tactical missiles. The low-cost system was achieved through the utilization of conventional ball bearing gyros with the latest state-of-the-art electronic circuitry. Demonstrated at the Holloman Air Force Base rocket sled test facility, the system performed well within the accuracy requirements for currently planned tactical missiles.

Also related to the inertial guidance field was LSI's development of a new suspension technique for accelerometers and gyros called squeeze film bearing. This frictionless, air suspension method provides better than best evaluated inertial quality accelerometers and the division obtained a contract to further develop a gyro utilizing this technique.

One of the most interesting projects during the year concerned the role of LSI in the Gemini program. Ten important LSI instruments, including the pilot's primary flight director-attitude indicator, performed perfectly during the history making flights. This demonstrated performance contributed to the award of a contract for the Lunar Exploratory Module (LEM) Attitude Display System. Consisting of two Flight Director Indicators and a Gimbal Angle Sequence Transformation Assembly per vehicle, the system will incorporate such firsts as LSI-developed thin-film microcircuits, servoed dual meters and electroluminescent lighting.

Pioneering efforts in the development of electroluminescent instrument lighting and display systems, the division recorded two significant breakthroughs with the development of a high-contrast lamp, making electroluminescent displays readable in daylight; and a unique switching method for display of digital inputs utilizing silicon controlled rectifiers.

Development of the Geocentric Vertical Reference, designated GVR-10, was also completed and a production contract was received for this highly accurate vertical gyro for use in aircraft terrain avoidance, fire control and bombing systems.

LASER SYSTEMS CENTER

Laser hardware in 1965 was in an evolutionary period and several contracts in this fast changing field led to interesting technical developments. Flight-testing of a clear air turbulence detection system using LSI-developed laser transmitting and receiving equipment was started during the year by the University of Michigan. The hardware represented the first flying laser rangefinder or airborne laser radar system. An improved version of the system was also delivered to the National Aeronautics and Space Administration in mid-year for extensive flight tests and evaluation.

Although not an airborne application, the ability of the laser to weld many dissimilar metals and to work in extremely small areas is of great interest to electronic and aerospace industries. Several contracts were received for delivery of metalworking systems. LSI developed and delivered a Q-switch laser system which produces a gigawatt (1,000,000) of pulsed peak power. Now in operation at a major aerospace firm, the device incorporating uranyl-doped glass Q-switch elements and resonant reflectors has a high degree of reliability.

In another aerospace related application, the Laser Systems Center received a contract from the Naval Ordnance Laboratory for a laser shadowgraph system which will replace a conventional arc-gap or spark illuminating device. The brightness and illuminating properties of the laser were expected to provide increases in the yield of data from ballistic model flight test.

ELECTRONIC INSTRUMENTATION DIVISION

For a number of years LSI's Electronic Instrumentation Division has been among the leaders in the design and manufacture of video systems and instrumentation and control systems for the country's aerospace programs. During the year the division's major projects included work on such programs as Saturn, Titan and Apollo.

In addition to major instrumentation and control systems work for NASA's Marshall Space Flight Center and the Mississippi Test Facility, the division received awards for several important video systems installations. They included operational television systems for two launch pads at Cape Kennedy, ground surveillance television systems for the Mississippi Test Facility and Sky Screen Range Safety television vans for the Atlantic Missile Range.

The division achieved a technical breakthrough during the year through exploration of military and space applications for a pulsed laser as a light source and ranging device for use with its television cameras. Initial experiments performed in 1965 with ultra short flashes from a green laser provided by LSI's Laser Systems Center and an Electronic Instrumentation Division camera equipped with an electronic shutter demonstrated the principle of Range Selective Imaging. As a result, this technique holds promise of extending vision during operations in poor weather and underwater or where backlighting can improve target detection.

POWER EQUIPMENT DIVISION

LSI systems and components which produce or harness power, whether it be electrical, hydraulic, pneumatic or electromechanical, are manufactured by the Power Equipment Division. While this equipment is for the most part in well-established product areas, such as electric power and systems equipment for the Series 60 DC-8 and fuel boost pumps, generators, starters and starter-generators for Army, Air Force and Navy aircraft, the division was also making significant contributions in 1965 to the nation's missile and space programs. This participation in aerospace programs ranged from test point couplings for the Apollo program to hydraulic power packages for the Agena and studies to devise procedures to analyze all brushless type alternater designs and select the optimum configuration through computer programming.

Major research and development projects undertaken by the division during the year resulted in significant progress in over-all advancements in the general field of power control equipment. A number of improvements were incorporated in magnetic particle clutch designs to extend reliability of these units and in turn the servos and other equipment in which they are used. A new concept in seals for couplings used in systems handling liquid oxygen and hydrogen will extend the applicability of couplings for spacecraft and ground support equipment. Also, in what can be classified as a technical breakthrough, there was the development of a technique whereby the output signal of a single AC generator can be partially converted to an other than the base generator frequency. This eliminates objectional characteristics and makes it practical to operate equipment requiring different frequencies from the same power source.

Notable programs in progress at year-end at the Power Equipment Division included newly developed DC starter-generators and static voltage regulators for the Army OH-6A (LOH) helicopter;

the design and manufacture of a servo actuator for NASA's Multi-Mission Module; lube and scavenge pumps, also for the OH-6A; and the design, development and fabrication of a 22.5 kilowatt solid state generator for NASA to be used with induction brazing tools.

LEAR SIEGLER SERVICE, INC.
(A Wholly Owned Subsidiary of LSI)

An increasingly important LSI product in recent years has been the manpower capability offered by Lear Siegler Service, Inc. During 1965, LSSI maintained its position as one of the nation's leading service organizations while at the same time expanding its operations into certain new activities which will contribute to future growth.

For the fifth consecutive year, the LSI subsidiary received a contract for aircraft and aerospace systems maintenance during fiscal 1966 at more than 45 U. S. Air Force installations throughout the world. In addition to providing substantial cost savings, the efficiency of this service system results in numerous other advantages to the Air Force. The savings are accomplished by way of LSSI's field team concept of taking skilled men to the operational site, rather than the expensive process of moving the work to the men.

A significant step toward further diversification was taken by LSSI with the formation of a new organization, Information Systems Company. To provide a base for the new company, LSI acquired all assets of Computermat, Inc., a subsidiary of the Matrix Corporation.

LING-TEMCO-VOUGHT, INC.

Under "Project Redeployment" in January, 1965, Ling-Temco-Vought consolidated 11 divisions into 3 subsidiaries: LTV Aerospace Corporation, LTV Electrosystems, Inc., and Ling Altec, Inc. A further reorganization in July absorbed the 3 remaining divisions imto 2 of the subsidiaries—LTV Military Electronics Division and LTV Continental Electronics Division into LTV Aerospace Corporation, and LTV University Division into Ling Altec, Inc.

Outstanding for its variety of engineering and scientific skills, Ling-Temco-Vought at year-end numbered among its 17,000 employees more than 5,000 in the engineer-scientist-technical categories. Activities at the giant Dallas-based electronic/aerospace company extended from outer space to the ocean depths and ranged from space vehicles, aircraft, missiles and land vehicles to super-power transmitters, guidance and control systems, display systems, power vibration equipment and high fidelity speaker systems for the home or the concert hall.

LTV Aerospace's Vought Aeronautics Division was selected to build the Navy's new light attack aircraft, the A-7A Corsair II, placing the company in a leading position in the aircraft business with 2 major programs, the A-7A and the tri-service XC-142A vertical takeoff and landing transport aircraft, the nation's largest V/STOL in flight status. In addition, work continued on new flight vehicles for the future, including advanced V/STOL designs.

In the space field a major program of the Astronautics Division was launch vehicles. These included Scout, a low-cost, 4-stage rocket used by NASA and the military services for a variety of space tasks. First solid-fueled rocket to place payloads in orbit, Scout used LTV-supplied launchers, blockhouse equipment and other support items. The booster was scheduled as launch vehicle for the Italian Project San Marco, and it was used in British and French experiments.

Ling-Temco-Vought met another engineering challenge in the space field with the production of its Modular Maneuvering Unit (MMU), a compact device which transports an astronaut outside the spacecraft and makes possible research toward the assembly, repair and servicing of vehicles in space. To be used by NASA and the Air Force, the MMU will see service in a Gemini astronaut's 1966 walk in space. The program was expanded in 1965 under Air Force and company sponsorship.

Huge fuel and oxidizer containers for the first stage of the massive Saturn rocket were being fabricated by LTV. Nine of these containers, each more than 62 feet long, provide 850,000 pounds of fuel for Saturn's powerful first stage engines.

Among 1965 study projects at LTV Aerospace were orbital launch operations, advanced lunar transportation systems, remote man-machine control system evaluation investigation of space repair techniques, solar flares, high temperature materials research, spacecraft attitude control work, advanced instrumentation and display systems and advanced military space systems such as anti-intercontinental ballistic missile and satellite interception systems.

Engineering capability produced LTV's Manned Aerospace Flight Simulator, used for study and training by the nation's astronauts in both Gemini and Apollo programs, and by the company for its own space projects.

LTV's Military Electronics Division passed the $25,000,000 mark in production of actuators for the

Minuteman intercontinental ballistic missile. The division extended its controls work under a $2,000,000 contract to develop and produce fluid injection valves for the Titan III first stage rocket engines.

The work of this division also included microcircuitry, laser technology, ground support and checkout equipment, guidance systems, radar and communications systems, antennas and other projects vital to the nation's space and defense programs.

The Display Systems Plant of Military Electronics continued to supply to defense and space agency establishments its Iconorama system which displays up-to-the-minute data on the location of space vehicles and aircraft.

Engineers of the LTV Continental Eelectronics Division maintained the company's lead in the fields of super-power radar and radio transmission systems. This division produced the Ballistic Missile Early Warning System transmitters which keep constant vigil against enemy attack: the world's most powerful radio installations at Cutler, Maine, which communicate at great distances with submarines under the sea; the Voice of America's powerful transmitters penetrating Eastern Europe and Asia; and the 30,000,000-watt pencil beam radar systems operating at White Sands.

Range Systems Division supplied target drones and drone service to the Navy. The division completed negotiations for a 3-year contract expected to exceed $2,500,000 in the first year for administration and management services at NASA's new Merritt Island launch area.

Operating units outside the Dallas area also made substantial progress.

LTV Electrosystems, Inc., at Greenville, Texas, developed, integrated and installed highly advanced electronic systems for airborne applications. This unit provides aircraft modifications and depot level aircraft maintenance.

Michigan Division at Detroit continued its work as prime contractor for the Army's new Lance battlefield missile. It has started development of the new XM-561, a 6-wheeled, articulated vehicle based on the company's Gama Goat, and capable of traversing rough terrain heretofore impossible for wheeled vehicles.

Kentron Hawaii, Ltd., an LTV Aerospace Corporation division based in Honolulu, operated tracking stations for the nation's space programs.

LTV Ling Altec, Inc., at Anaheim, California, continued to engineer and manufacture powerful vibration and testing equipment for the nation's aerospace programs. It also produced top quality high fidelity electronics available, recording and studio broadcast equipment, theater and concert hall sound systems and specialized public address systems.

LTV University Division at Oklahoma City again ranked as one of the major producers of loudspeakers and sound casting equipment in the nation.

A broad range of programs was undertaken at the Research Center to keep Ling-Temco-Vought in the forefront of the aerospace industry. Studies range from closed ecological systems to propulsion systems for tomorrow's interplanetary vehicles.

Aerospace work and research continued in such areas as electronics, communications and controls, propulsion techniques, micrometeoroid hazards, gamma ray and X-radiation measurement, heat resistant graphite and ceramic materials, fuel cells and other energy sources, laser applications, acoustics and hypervelocity flight phenomena.

LOCKHEED AIRCRAFT CORPORATION

Victory in the Air Force's highly significant C-5 heavy logistics system competition was a major highlight in Lockheed's manned aircraft achievements in 1965, a year that also saw the diversified company push ahead in fields of space, missiles, propulsion, electronics, and ocean systems work. In the year's first nine months, sales of $1.28 billion were 9 percent above those reported for the same 1964 period.

The C-5 contract, first to be awarded under the Department of Defense's new packaged procurement concept, called for creation and lifetime support of 58 of the 350-ton transports. The Air Force also has options for additional quantities.

Lockheed's C-5A will be the world's largest airplane: 236 feet long, 62 feet 8 inches tall at the tail, with a wing span of 222 feet 10.9 inches. Projected payload is 265,000 pounds over transcontinental distances or 100,000 pounds over 5,500 nautical miles. Its four fanjet engines will have 40,000 pounds of thrust each. Besides the 2,342 square foot cargo compartment, it will have an upper deck that accommodates 95 persons, including two six-man flight crews. High flotation landing gear will permit operation from relatively short, semi-prepared landing strips. First flight will be in 1968.

C-141 production was being built up as StarLifters began transoceanic MATS service on both coasts, including regular cargo and personnel schedules to Southeast Asia in support of American commitments in Viet Nam. The C-141 para-dropped 70,195 pounds, the heaviest parachute delivery a single airplane has made in one flight, and became the first jet transport to drop paratroopers.

C-130 deliveries passed the 850 mark, and a 29th model—the HC-130H—joined the USAF Air Rescue Service. Saudi Arabia became the 13th nation to purchase the Hercules. More than 200 Hercules helped airlift troops to the Dominican Republic. They joined Lockheed-built StarLifters, P-2H Neptunes, P-3A Orions, EC-121 Constellations, and F-104 Starfighters in Viet Nam action.

Lockheed stepped up production of the JetStar executive transport to meet increased demands, and proposed a 17-passenger "station wagon" version of the 550-mile-per-hour craft.

Another Lockheed airplane, the titanium YF-12A interceptor, set 9 world speed and altitude records, including straightaway speed of 2,062 miles per hour, closed course speed of 1,688 miles per hour, and a sustained altitude of 80,000 feet. Also of titanium, the SR-71 reconnaissance aircraft was scheduled to join the Strategic Air Command at Beale AFB, California.

A completely different concept, the XH-51A compound rigid rotor vehicle, set a new speed-altitude record for rotary wing aircraft—263 miles per hour at 12,000 feet. Lockheed was one of two finalists in the Army's advanced aerial fire support system competition with a proposal built around the rigid rotor's built-in stability. Deliveries of P-3A antisubmarine patrol planes to the Navy continued, and the propjet sub hunters received new electronic localizing equipment. At year-end, air forces of 14 nations operated about 2,000 Starfighters, many of them manufactured under license at factories in Canada, Japan, Italy, Germany, Belgium, and Holland.

The Federal Aviation Agency awarded Lockheed a contract to proceed with Phase II-C of the supersonic transport program, continuing the airframe competition with Boeing. The contract covered design refinement, prototype tooling development, fabrication of mockups and structural elements, and proposals for a follow-up program to build and test two preproduction aircraft.

In space work, Lockheed delivered Agena target vehicles to Cape Kennedy for orbital rendezvous and docking missions with NASA's Gemini spacecraft. And an Agena D-Thor combination thrust the second OGO satellite into polar orbit for new space experiments.

As Polaris A3 production continued, Lockheed completed the contract definition phase of the C3 Poseidon, a new fleet ballistic missile with double the A3's payload. The company fired its third 156-inch solid propellant rocket motor, exerting 3,000,000 pounds of thrust, and tested a hot gas valve directional control system.

In electronics, Lockheed proposed a 3-D radar design that would provide range, azimuth, and altitude information simultaneously using separate radar beams, each with its own feed horn and receiver. Another electronics innovation was a patented optical correlator that stretches short radar energy bursts into long pulses needed to reach distant targets, then compresses the return signals to original form.

Expanding its oceanographic interest and capabilities, Lockheed opened a new marine laboratory at San Diego, launched the world's largest high speed hydrofoil—an ASW research tool—and began building a research submarine that will carry a 7,000 pound payload, dive 6000 feet, and remain underwater 12 hours. Manned by a crew of two, the 50-ton deep submergence vessel will accommodate two additional observers. Lockheed delivered to the Navy a computerized coordinated tactics trainer that poses, and solves, problems for all elements involved in antisubmarine warfare exercises.

Other significant 1965 accomplishments included:

Regular weightless flight above 100,000 feet for aerospace pilot trainees in NF-104 Starfighters equipped with rocket boosters; completion of a new bioastronautics manned environmental facility and a new cryogenics test facility in California; start of construction on a whirl tower at the Lockheed Rye Canyon Research Laboratory to test rotor blades up to 110 feet in diameter at tip speeds up to 500 miles an hour; dedication of the Lockheed Georgia Research Laboratory; and start of construction of the world's largest privately owned subsonic wind tunnel, also in Georgia.

Other accomplishments were lease of the deactivated Chennault AFB, Louisiana, as an aircraft maintenance base, with subsequent USAF award to maintain and modify F-101 interceptors; contracts to install Lockheed advanced flight data recording systems on MATS C-133 transports and maintenance data collection and analysis systems aboard Trans World Airlines' DC-9 fleet; development of a new waterjet propulsion system that could double the speed of ocean vessels; and demonstration of a research craft with retractable skis that would permit landing craft speeds of 70 miles per hour.

Lockheed started pilot production of metal and oxide microparticles after a metallurgy breakthrough that provides extremely fine powders applicable to magnetic memory and switching devices, polishing agents, bearings, alloys, and conductors.

The company completed for the State of California a study on use of computers to handle, with the systems approach, the growing flow of information among government branches.

Among other highlights of 1965 were:

A successful bid to purchase Lockheed-operated USAF nuclear laboratories in Georgia.

Company-funded construction of two Model 286 rigid rotor helicopters for FAA certification and military demonstrations.

Doubling to more than 800 the number of personnel supporting company activities at the NASA Manned Spacecraft Center after award of a follow-on contract to supply Apollo engineering services, and formation of Houston Aerospace Systems by Lockheed Electronics Company.

Purchase by Continental Air Services, a Continental Airlines subsidiary, of two Lockheed L382B propjet transports. Continental planned to operate the commercial Hercules in Southeast Asia.

Addition of waterfront property to Lockheed Shipbuilding and Construction Company for a new way following $48 million Navy award for two more landing platform docks.

Introduction of Lockwood, made by a process that hardens, strengthens, and beautifies wood impregnated with plastic that is irradiated to change the molecular structure.

Lockheed's board of directors in March elected A. Carl Kotchian to the reestablished position of executive vice president. M. Carl Haddon succeeded him as group vice president. In October, Lloyd M. Bentsen, Jr., president of Lincoln Liberty Life Insurance Company of Houston, became a member of the board. He succeeded Harry L. Dunn, who retired after 21 years as an active director, but will continue to advise Lockheed as an honorary director.

At year-end, Lockheed had about 78,000 employees at nine operating companies, associated bases, and offices. Company facilities covered more than 21,800,000 square feet of floor space in manufacturing plants, research centers, laboratories, test sites, service bases, satellite tracking stations, offices, affiliates, and subsidiaries in 32 states, two outlying U. S. territories, three British colonies, and 26 nations throughout the world.

LOCKHEED MISSILES & SPACE COMPANY

The government's first vessel for research and development of methods to recover mineral wealth from under the ocean began sea tests in February. Lockheed Missiles and Space Company was cooperating in this Bureau of Mines (Department of Interior) program with International Minerals & Chemicals Corporation and Merritt-Chapman & Scott Corporation. Each of the 3 companies was providing funds, program leadership, engineering manpower for research and development, scientific knowledge and physical facilities for the project. Ocean-floor deposits of phosphorite, black sands and manganese are early targets of the program; Lockheed was developing machinery and methods for recovering these minerals from the continental shelf. The first sea-going laboratory, originally a freight boat provided by the Army, was followed later in the year by a second operational research craft, a converted Navy vessel. Both were based at the Department of Interior's oceanographic facility at Tiburon, California.

The project definition phase of a competitive study for development and production of solid motors for the powerful Poseidon C3 missile was completed by Lockheed M&SC and was under evaluation by the Navy. The study, undertaken in March, was awarded to Lockheed, with Hercules Powder Company and Thiokol Chemical Company as associate subcontractors for the design, development and prototype fabrication of the first stage motor. Hercules will cooperate on the second stage motor as well. Prime contractor for the Polaris missile system, Lockheed managed development of the highly successful Polaris A1, A2 and A3, which will eventually equip 41 Fleet Ballistic Missile submarines. With a range of 2,500 nautical miles, the A3, scheduled for 28 of the 41 submarines, completed its first full year of operation with the fleet. Poseidon C3 will have double the payload of the advanced A3. The Polaris submarines will require only minor modification to carry the larger Poseidon C3.

A software "model" of the battle tank of the 1970's was announced in March by Lockheed as part of a 1965 study contract conducted for the Army Materiel Command for a new tank concept. The computer analysis of optimum tank design was based on 3 major factors of firepower, mobility and survivability with an overall guideline of cost effectiveness. Lockheed's Main Battle Tank study involved no hardware, but concentrated on design and systems analysis with refinement of computer simulation techniques in evaluating design.

A special research submarine which can take a 7,000-pound payload more than a mile beneath the ocean's surface was under construction by April at

Lockheed Sunnyvale. Capable of remaining submerged up to 12 hours and providing full life support for the 2-man crew for 48 hours, the *Deep Quest* is a 50-ton versatile research test bed, destined for a variety of missions to test components and materials needed for exploration and exploitation of the untapped riches of the sea. Scheduled to be operational in late 1966, *Deep Quest* will further Lockheed's deep submergence research and development program and ocean mining efforts.

Developments and applications in the techniques of powdered metallurgy for aerospace purposes were revealed by Lockheed at the International Powder Metallurgy conference in June. Not only had new materials been utilized, but methods were developed for reduction in powder particle size to submicron dimensions, and new means devised for compaction and consolidation of the powders. The largest amount of metal powders in aerospace work has been in high performance massive structural components. Spectacular successes were cited in unusual materials such as silver-infiltrated tungsten, used in power plant systems for rockets and missiles.

Lockspray-Gold, a process which keeps out infrared radiation and ultra violet, but still permits visible light to penetrate, was announced in August at Lockheed M&SC. A coating on the helmet of Gemini IV astronaut Edward H. White protected him from harmful radiation during his walk in space. Later Gemini craft will have a coating of the gold sprayed over the interior surface of the adapter section; the spray helps keep the equipment at operating temperatures. Lightweight "roll up" antennas on spacecraft were also coated with Lockspray-Gold, the electrical conductivity of the gold resulting in excellent radio frequency radiation.

A Lockheed study undertaken for the State of California blueprinted a statewide information system which, once fully operational, will save the state and local governments as much as $400,000,000 a year. The program disclosed in September began with development of a conceptual design by Lockheed's Research & Development Division, of organizing, simplifying and making readily accessible the flood of information flowing between state, country, city, industry, citizen and the federal government. The Lockheed system provides for a federation of state and local computer centers tied together by an Information Central and operating within a framework of compatibility rules so they can work together yet retain local autonomy. Information Central comprises a statewide data network and switching facilities, plus a central electronic index of the information stored in the files of participating computer centers.

Workhorse of the nation's space program, the Lockheed Agena series of space vehicles played an important role in the nation's space program, and was scheduled to fulfill a great many unmanned space requirements through 1970. Agena has an integral, liquid-fueled rocket engine built by Bell Aerosystems Company, which propels the vehicle to orbital speed and is capable of being restarted in space. Agena was first to return capsules from space with successful sea and midair recoveries, first to be placed in the difficult polar orbit, first to attain a nearly circular orbit, first to change and maintain its attitude on orbit, and first to restart in space. Agena was participating, or scheduled for participation in such programs as Ranger, Mariner, Nimbus, Echo II, OAO, OGO and Gemini.

The Agena selected for the Gemini program is the most advanced version of the series. Capable of being maneuvered from the Gemini spacecraft or from earth, the unmanned Agena satellite will be mated with the Gemini in the rendezvous and docking maneuver. The Agena can be restarted after docking is achieved, permitting the coupled Gemini Agena to perform a variety of maneuvers.

THE MARQUARDT CORPORATION

The Marquardt Corporation's activities during 1965 reflected the company's continuing objectives in the advancement of airbreathing propulsion technology as well as its expansion of product and customer mix. A decade ago, Marquardt was almost wholly recognized as a developer of ramjet propulsion systems; at the end of 1965 almost half of its activity was represented by space-oriented equipment contracts. The latter programs included rocketry, composite engines and hypersonic propulsion systems.

Marquardt's two major programs in the area of advanced airbreathing propulsion related to research and development of the Supersonic Combustion Ramjet (Scramjet) and low altitude chemical propulsion systems for the Air Force.

In conjuction with its newly acquired subsidiary, General Applied Science Laboratories, Marquardt completed testing of a flight-weight Scramjet thrust chamber. Effort continued in the areas of manufacturing and experimental hardware testing. The Scramjet's thrust chamber design presents many features which are new to ramjet technology, and its long life expectancy represents a considerable

Artist's conception of a test vehicle for the Scramjet being developed by Marquardt.

advance over regeneratively cooled rocket chamber technology.

The Scramjet represents a return to the classic simplicity of the "flying stovepipe," Marquardt's subsonic ramjet of 1945. The Scramjet uses to full advantage the inherently simple fixed geometry design of the ramjet for hypersonic acceleration and cruise performance. The engine performs most efficiently at flight speeds exceeding Mach 6 and altitudes above 50,000 feet. Its range capability expands rapidly as its speed increases. Potential applications for space, military, and commerical uses include hypersonic cruise aircraft, recoverable launch vehicles, and defense and tactical missile systems.

Combustion performance of the Scramjet, tested at Cornell Aeronautical Laboratories and at the Marquardt Research Field Laboratory, disclosed dramatic performance of the dual mode combustor. A small scale engine was demonstrated at the General Applied Science Laboratories in which thrust was measured successfully.

Significant progress in supersonic combustion technology resulted from the work sponsored by the Air Force Aero Propulsion Laboratory with Marquardt-Van Nuys, in conjunction with General Applied Science Laboratories and Navy-sponsored efforts at the Applied Physics Laboratory of Johns Hopkins University. Marquardt's 1965 effort was directed development of a modular Scramjet flight test vehicle.

Other Marquardt activity in airbreathing propulsion technology included continued production of the 16 1/2-inch diameter ramjet engine for the Army Redhead-Roadrunner target missile. Under contract to the Columbus Division of North American Aviation, Marquardt was designing an advanced 19-inch ramjet aimed at extending the target missile's range and altitude capabilities. A series of flight evaluation tests of the Redhead-Roadrunner during 1965 demonstrated complete reliability in the performance of the Marquardt ramjets and fuel controls.

Marquardt's major efforts in space equipment programs were represented by the company's development of the 100-pound thrust reaction control rocket engines for NASA's Project Apollo Service Module, under contract to the North American Aviation's Space and Information Systems Division, and development of the reaction control system for the Apollo Lunar Excursion Module (LEM), under contract to Grumman Aircraft Engineering Corporation.

Development on the service module engines was essentially completed, and preliminary flight rating testing and production engine acceptance testing were under way.

Successful testing of the LEM propellant system and thrust chamber assembly in a configuration geometrically similar to the LEM reaction control flight system marked a major milepost in the LEM program. Marquardt extended its reaction control rocket and propellant systems testing capability with the establishment of new remote testing facilities at Magic Mountain, a site approximately 30 miles north of the company's Van Nuys plant.

At Magic Mountain, Marquardt was testing reaction control engines, propellant systems, and advanced high energy fuels, including fluorine based propellants. The combined Marquardt test facility capability provides a broad range of testing aerospace systems, components, and fuels from sea level to above 185,000 feet.

Other space equipment activity at Marquardt included production of a 100-pound thrust rocket engine for velocity control guidance of the Lunar Orbiter, under contract to the Boeing Company. The initial engine, identical to the Apollo reaction control engine, was delivered for ground testing during the year. Marquardt was also conducting a study for North American on advanced reaction control systems for the extended Apollo mission. Under a NASA contract, the company was developing a space power unit and a waste management system for extended space missions and Lunar explorations. The space power unit is a small reciprocating engine using hypergolic fuels, which can provide efficient shaft power for electrical, hydraulic and mechanical requirements in space vehicles or lunar bases.

At Marquardt's Pomona, California facility, which represents the company's major activities in electronics, a complete air defense simulation system was being produced for the Japanese Air Self Defense Force (JASDF) for use in conjunction with Japan's BADGE network. Marquardt-Pomona also provided the T-10 trainers and associated equipment which simulate B-52 bomber navigation and bombing exercises for installation at Strategic Air Command and Air Training Command bases. The company's electronics operations were continuing company-sponsored research toward diversifying applications of its multichannel memory (MCM) technology. This technology, which is basic to the land mass simulation portion of the T-10 trainer, appears to have application in missile penetration path analysis, site-selection for ground-to-air missiles, and high-density storage of permanent data. Development also continued on VueMarq, a unique wide-angle optical viewing device which has application to both training and operational equipment.

During 1965, Marquardt combined its advanced research operations between its central research organization, ASTRO, and its subsidiary, General Applied Science Laboratories. The new Science and Technology Group is responsible for advanced research programs in such areas as supersonic combustion, aerothermodynamics, slurry fuels, advanced airbreathing propulsion, electrical propulsion, facilities design, electronic instruments, hydro-acoustical equipment, Doppler navigation, re-entry physics, associative memory systems, weapons guidance electronics, military training equipment, and special purpose television devices.

Marquardt's Ogden, Utah, facilities successfully achieved diversification from ramjet production to the manufacture of specialized aerospace products. The Ogden operation is associated with the production of components and subassemblies for such programs as Polaris, NERVA, Phoenix, Titan, Poseidon, Gemini, Apollo, Phoebus, Saturn, F-4B and F-4C aircraft, and many others. Ramjet engines for the Redhead/Roadrunner were being produced at this facility.

At year-end 1965, Marquardt employed approximately 2,500 personnel, with operations at Van Nuys and Pomona, California; Ogden, Utah; and Westbury, New York; and district offices in Washington, D.C.; Dayton, Ohio; Houston, Texas; and Huntsville, Alabama.

MARTIN COMPANY

BALTIMORE DIVISION

Principal activities of the Baltimore Division in 1965 centered about four major product lines: Gemini launch vehicles, spacecraft, nuclear power supplies and aircraft, the latter in three areas; modification, fabrication and new design.

By far the largest division program was production, assembly and test of the 90-foot modified Titan II launch vehicles, under contract to the Air Force System Command's Space Systems Division, for NASA's two-man Gemini program.

With successful launch of the second and final unmanned rocket on January 19, the Gemini program moved into high gear with five manned launches, including the historic Gemini 7/6 rendezvous in December.

The rocket for the GT-8 rendezvous and docking mission completed its factory tests by mid-November. Vehicles for GT-9, 10 and 11 were in final assembly or vertical test by year's end. The final launch vehicle for the program, No. 12 was due to begin final assembly in 1966.

Two other space programs were prominent in Baltimore Division activities during 1965. One was the country's first maneuverable reentry spacecraft, the SV-5D "PRIME" (Precision Recovery Including Maneuvering Entry) lifting body program. Construction of four relatively small (6-1/2 by 4 feet) flight vehicles was started, aiming for first flight late in 1966 on the Western Test Range as part of the Air Force's START (Spacecraft Technology and Advanced Reentry Test) Program.

These lifting body vehicles, the result of six years of Martin design and wind tunnel testing, will demonstrate the maneuverability of lifting bodies from hypersonic velocities on leaving orbit down through Mach 2 speeds on recovery.

A larger manned version of the SV-5 was being considered by the Air Force to demonstrate maneuverability of such a craft from Mach 2 down to conventional landing speeds.

Another spacecraft area saw completion on conceptual design studies for NASA's Langley Research Center of an interplanetary, or deep space, meteoroid detection satellite. The mission of such a craft would take it out to the asteroid belt, 100,000,000 miles from the earth.

Nuclear activity of the Baltimore Division included installation on June 21, 1965 of the first commercial use of a SNAP (Systems for Nuclear Auxiliary Power) radioisotopic generator in an offshore oil rig in the Gulf of Mexico near Morgan City, Lousiana.

Martin's RIAS group celebrated its 10th anniversary with dedication of its new laboratory at Relay, Maryland.

It was the fifth pioneering terrestrial application of a SNAP generator, all of them designed and built by Martin. The other four—a buoy, a lighthouse, a weather barge, and an ocean bottom navigational beacon—began their second year of operation.

Another SNAP, powering an unmanned weather station at the North Pole, completed its assigned task and was returned to Baltimore for refurbishment and possible new use. A seventh terrestrial SNAP, powering a weather station at Minna Bluff near the South Pole, continued successful operation.

Three Martin-built SNAP generators continued furnishing electrical power to orbiting satellites of the Department of Defense, and work was started under AEC contract on a pair of fueled generators designed for NASA's advanced Nimbus-B weather satellite.

Martin Nuclear engineers also completed conceptual design of a Terrestrial Unattended Reactor Power System (TURPS) for the Army. It would combine some of the features of SNAP generators (no moving parts) and the larger reactor power systems.

Delivery of the reactor containment vessel and outfitting of the world's first floating nuclear power station, the MH-1A for the Army, proceeded on schedule.

More than 90 aircraft rolled through the hanger doors of Martin-Baltimore's Aircraft Modification Center during the year, including KC-135's, B-57's in several configurations and an SP-5B Martin Marlin Seaplane which had a jet installed in its tail for Navy evaluation.

Aircraft fabrication work at Baltimore under subcontract to other airplane manufacturers included components of the A6 for Grumman, the F-4 for McDonnell, C-130 and C-141 for Lockheed, the Chinook helicopter for Boeing Vertol and the Iroquois, or UH-1 "Huey" helicopter for Bell.

New design effort was concentrated on VTOL and STOL tactical fighters, ASW and small cargo aircraft.

Three separate real-time, 7-day flights to the moon and back were simulated in Martin-Baltimore's lunar mission simulator. Pilots from the Air Force's Aerospace Research Pilot's School at Edwards AFB "flew" the missions as part of a NASA Headquarters study of crew performance and pilot reliability.

Three space qualified zero-reaction space power tools were delivered to the Air Force Aero Propulsion Laboratory at Wright-Patterson AFB, including the first scheduled for actual use in space aboard the Gemini 8 mission early in 1966.

Under a NASA Manned Spacecraft Center contract, the division produced a complete toolbox including prototypes of power tools, dead-blow hammer, automatic saws, restraining devices and personnel operating work lights.

A 10-foot lunar rock coring drill also was developed for NASA-Houston and was under evaluation at year's end.

Extensive reaearch in ablative reentry materials, HF antenna, fluidics, solar panel power distribution systems and processes for handling exotic metals needed for future flight regimes was conducted by the division during the year.

One highly sophisticated project completed in September and delivered to the Aeronautical Systems Division of the Air Force Systems Command at Wright-Patterson was a 1/3 scale model of a section of an aerospacecraft. It involved development of new techniques in the handling and forming of second generation columbium and other super alloy metals. The work was done under the Air Force's ADCEP (Advanced Structural Concept and Evaluation Program).

During 1965, the division received the Small Business Administration's Special Aerospace Award for its critical parts subcontract program on the Gemini launch vehicle.

The Air Force's "Achievement Award" for significant contributions in reducing costs through improved worker performance in the Martin originated Zero Defects program was presented to the Baltimore Division.

Baltimore employees also were honored by the Treasury Department for 96 per cent participation in the U. S. Savings Bond Program, highest percentage of participation in the aerospace industry.

ORLANDO DIVISION

Martin's Orlando Division continued its emphasis and investment in programs and facilities aimed at broadening its tactical missile, electronics and communications systems capabilities.

Major 1965 contracts included the Army's Pershing ballistic missile system; the Army's Sprint antimissile missile; Rada, telephone-type tactical radio communications system; and the Bullpup air-to-surface missile.

More than $8 million was invested during 1963-65 in research facilities, including a new $2 million guidance systems development laboratory scheduled for completion in early 1966. Other research facilities included a high-temperature high-velocity ablative material test complex, which uses large solid-rocket motors as a gas generator, and an extensive armament research and test center.

In research, areas of major interest during the year included guidance and control, ablative and protective coatings, structures, materials, and payloads. Extensive research went into lasers and their application, inertial reference systems, millimeter and submillimeter. waves, fluidics, radar, communications, and advanced warhead fabrication.

Production continued during 1965 on the Army's Pershing surface-to-surface ballistic missile system, deployed in Europe with the U. S. Seventh Army and with the Federal Republic of Germany within the framework of NATO. All battalions originally scheduled to be equipped with Pershing had been activated by the end of the year.

A continuing series of annual practice test firings from off-range sites in southeastern Utah into White Sands Missile Range, New Mexico, began during the year. These exercises, designed to maintain troop proficiency in handling the 400-mile-range Pershing missile, included firings by American and German units from Europe as well as those headquartered in the U. S., since there are no range facilities in Europe to provide desired flight data.

Work began at Martin-Orlando early in the year on an $18,615,000 Army contract for improved Pershing ground support equipment. The work involved design, development, and fabrication of prototypes of an improved programmer test station.

The Sprint missile, one of the major components being developed for the Army's Nike-X missile defense system, was being developed by Martin's Orlando Division as subcontractor to the Bell Telephone Laboratories. Sprint will be one of two interceptor missiles used in the Nike-X system. The other is the long-range Zeus, which is nearly twice the length of the Sprint, has three stages and is capable of operating at extended range. Both are designed to kill not only ICBM warheads, but also those of submarine launched intermediate range ballistic missiles. Sprint will significantly increase the capabilities of the Nike-X system by broadening its range of operation. Intercepts will be possible not only at long ranges but also at relatively short ranges. In addition, through use of Sprint and new radars, the Nike-X system will be able to engage numerous targets simultaneously.

Components of the Sprint, including its motors and its "pop-up" launching system, were successfully tested. The missile configuration and body materials were put through extensive testing. In addition, models of the missile were placed in the searing blast of rocket motors to simulate flight shock and temperature.

Martin-Orlando was also developing an advanced battlefield communications system that combines the ease of dial telephone-type operation with the mobility of the vehicular radio. The system, called RADA (Random Access Discrete Address), would handle voice, teletype, facsimile, and data transmission and reception within an Army combat division without the use of heavy, fixed switching centers or vulnerable cabling.

The initial phase of the contract, underway at year-end, called for demonstration of techniques to be used in a RADA system. Later phases, to be entered after the Army approves the techniques, require feasibility demonstrations and fabrication of models of the basic equipment to be used in RADA.

All the capabilities of wired dial telephone systems, and more, are planned as integral to RADA. It would provide for priority service among selected subscribers, conference calls, and area warning. Further, RADA would provide complete privacy of communications between sender and receiver. It is designed to be extremely portable, and adaptable to all military vehicles. RADA would operate on either vehicular battery power or internal battery power.

RADA is a radio system in which simultaneous transmissions can occur within a common frequency band without mutual interference. This is because the form of the transmission is such that it can be directed exclusively to the receiver to whom it is addressed. It uses pulse position modulation within its assigned frequency band.

The subscriber set has the features of a portable touch-tone telephone. This equipment automatically selects an available frequency within the alloted band and broadcasts the address of the called party.

If connection cannot be made because of the range of propagation phenomena, the user set automatically shifts to another frequency band and calls a repeater unit to extend the search for the called party. The process can be repeated through several repeaters until the search has covered the entire division area. Computer techniques enable this process to be carried out in a matter of seconds. Similar random access techniques are being proposed to provide the answers to communication problems for other military services.

Research and development to advance the state of the art in electronic air defense continued effort at the Orlando Division.

Martin developed and produced this nation's first electronic fire distribution system for guided missiles—the Missile Master—installing 10 of them at major U. S. metropolitan centers. Before the last Missile Master was in place, a smaller, transistorized system performing many of the same display, surveillance and data exchange functions was already on the drawing board. The first of these new systems, called BIRDiE (Battery Integration and Radar Display Equipment) was installed in 1961 at Turner Air Force Base, near Albany, Georgia. Nineteen were produced, including a training system for the Army Air Defense School at Fort Bliss, Texas.

As the sophistication of air defense technology and packaging techniques advanced during the past few years, system modifications were engineered and introduced into both BIRDiE and Missile Master. This work continued through 1965.

BIRDiE processes and distributes target information about manned aircraft to guided missile batteries and coordinates Nike Hercules and Nike Ajax (and, with modifications, the low-altitude Hawk) missile fire. It can be operated independently in its own area or as part of an overall air defense netowrk. Efficiency of BIRDiE is underscored when compared statistically with Missile Master. BIRDiE occupies 97 percent less space, uses 95 percent less power, and requires 80 percent fewer operating personnel.

The Bullpup air-to-surface missile, developed and produced by Martin Company, was operational with Navy, Marine, and Air Force squadrons throughout the world. Three versions of Bullpup were designed and built by the Orlando division: A, B, and Nuclear Bullpup. Public announcements by Department of Defense agencies indicate that Bullpup was performing with great tactical success in the Viet Nam action.

Martin-Orlando's 1965 Bullpup effort was centered on development and production of ground handling equipment, aircraft-installed equipment, aerospace ground equipment, and trainers.

DENVER DIVISION

Highlighting the Denver Division's accomplishments during 1965 were the successful Titan III flights. Martin-Denver. is systems integrator for the Air Force Titan III Standard Space Launch System program. This division also builds the Titan III main airframe.

Titan III-A, the three-stage version of the vehicle, flew twice from Cape Kennedy, and both flights established new U. S. space records.

On February 11, a Titan III-A placed a payload into an orbit ranging from 1,502 to 1,506 nautical miles. It was the most circular orbit ever achieved; eccentricity was only 0.0005.

The second Titan III-A flight, on May 6, also was flawless. Transtage, the space propulsion vehicle developed for Titan III, gave an unprecedented demonstration of space maneuver capabilities, including four in-space starts and stops.

Titan III-C, which flew its maiden mission from Cape Kennedy on June 18, was the most powerful U. S. rocket ever launched until that time. Its twin-motor solid propellant booster stage generated 2,400,000 pounds of thrust. Titan III-C was the first U. S. booster to use true parallel staging, and the first million-pound-class rocket to utilize all-storable propellants. The rocket's second stage was the most powerful ever ignited in space, and its 21,000-pound payload (exclusive of vehicle proper) was the heaviest ever orbited.

Earlier in the year, the Department of Defense announced program go-ahead for Titan III-B, a two-stage version for use with Agena, Centaur, Transtage and other upper stages.

On August 25, President Johnson announced the decision to proceed with the Air Force Manned Orbiting Laboratory program and confirmed Titan III as the MOL program booster.

While Titan III comprised most of the division's business during 1965, the Titan II ICBM program remained a major Martin Company product. Operational at 54 complexes in Arizona, Kansas and Arkansas, Titan II was employed successfully in crew training launchings from Vandenberg AFB, California. Production of Titan II continued at Martin-Denver to replace missiles utilized in the Western Test Range operations.

Research programs were conducted in the areas of high energy rate forming, propulsion and pressurization system development, zero-gravity phenomena in liquid fuels, liquid hydrogen and fluorine applications, inertial controls development, space rendezvous and docking, and acoustic environmental effects.

CANAVERAL DIVISION

The Canaveral Division, Martin Company's flight test and launch operations arm, chalked up its 180th countdown and launch since its establishment in 1958 with the successful launching of GT-5.

In 1965 the division moved from weapons systems development to space flight with two launching programs: the modified Air Force Titan II booster for NASA's manned Gemini missions; and the Air Force Titan III Standard Space Launch System, most powerful space booster in the nation's inventory.

During the year, 7 Gemini-Titan II launch vehicles and 5 Air Force Titan III Standard Space Launch vehicles were erected, checked out and launched by Canaveral Division personnel.

The division also completed construction of a sprawling spaceport for the Titan III, called the Integrate-Transfer-Launch (ITL) facility. Consisting of two launch stands, seven missile assembly and handling areas, and a unique 10.5-mile railroad, the $180 million ITL is designed to handle 30 or more Titan III launchings annually.

With crews on the scene since 1951, Martin was the oldest continuous aerospace tenant at the Cape. Since 1951, the company has test flown eleven separate missile and space systems and activated eleven launch facilities. The programs conducted by the division since its inception include Matador, Mace-B, Viking, Vanguard, Pershing and the Titan family of vehicles—Titan I, Titan II, Gemini-Titan II, Titan III-A, and Titan III-C.

RESEARCH INSTITUTE FOR ADVANCED STUDIES (RIAS)

The Research Institute for Advanced Studies conducts basic research in materials, physics, and biosciences. A division of Martin Company, RIAS scientists pursue fundamental research, but they are not required to apply their investigations to immediately marketable products. Results of RIAS research are published freely in the leading scientific journals and in symposium papers, within the constraints of national security.

In 1965, RIAS scientists published more than 100 papers in scientific journals and presented 110 papers and lectures at professional meetings and universities throughout the world.

Martin's basic research center celebrated it's tenth year with the dedication of its new $1,200,000 laboratory facilities in Relay, Maryland, three miles southwest of Baltimore City. The new building, set in 29 acres of scenic countryside, provides 43,000 square feet of space. About half of this space is devoted to laboratories; the remainder consists of offices, seminar rooms, a library, and administrative and shop areas. Dr. Homer E. Newell, NASA Associate Administrator, dedicated the facilities formally on July 22, 1965.

A month before the formal dedication, RIAS hosted a two-day international symposium on the environment-sensitive mechanical behavior of materials. Co-sponsored by the U. S. Army Research Office at Durham and the Physical Metallurgy Committee of the AIME, the conference brought together some 100 metallurgists, ceramics scientists and plastics specialists from United Kingdom, Canada, South Africa, and the United States. The conference centered on materials exposed to corrosive atmospheres, vacuum, light, electricity and liquid metals. Discussions following presentations of papers pointed up the complexity of problems facing materials researchers and concluded in the realization that even the most promising new theories do not fully explain the environment-related failure mechanisms for all materials.

The RIAS materials group also began an expansion program to include studies of ceramics and refractory metals. By alloying various ceramics, the group sought new information that may lead to controlling dislocations, the atom-sized defects that eventually cause fracture.

The institute's physics department continued its work in solid state physics, chemical physics and space physics. New knowledge gained in solid state research on a group of salts, called alkali halides, shows promise for new light-seeking devices and high-temperature rectifiers and has led to the initiation of new studies of piezoelectric crystals.

Chemical physicists evolved new techniques for predicting various characteristics of complex molecules and conducted theoretical studies toward developing equations for the flow of ionized solutions through porous membranes.

The space physics section, investigating the properties of incoming primary cosmic radiation from space, worked on the development of a balloon experiment to measure the high-altitude charge and energy spectrum of the medium and heavy components of this radiation.

Bioscience research at RIAS encompassed photosynthesis and microbiology. The photosynthesis staff, which examines the processes whereby living plants convert sun light into energy, continued efforts to isolate the light-sensitive chemicals involved in the conversion and to determine the effects of light intensity on plant growth.

RIAS microbiologists are studying chemisynthetic bacteria, which may be useful in sustaining astronauts on extended space flights, and they are developing instruments for detecting life in space.

Approximately two-thirds of the 1965 work at RIAS was carried out under basic research contracts with the Air Force, Army, Navy, NASA, ARPA, AEC, NIH and Department of Interior's Office of Saline Water. The remaining support came from Martin Company.

McDONNELL AIRCRAFT CORPORATION

McDonnell attained major milestones in its two leading product lines during 1965.

In the Gemini spacecraft program, the three-orbit flight of astronauts Virgil I. (Gus) Grissom and John W. Young on March 23 made history as the first mission on which a spacecraft was maneuvered in orbit and piloted during reentry. Then came the four-day mission of James A. McDivitt and Edward H. White II on June 3–7, with its spectacular 21-minute walk in space. The longest space flight on record was achieved by Astronauts Frank Borman and James Lovell in December for a full two weeks in Gemini 7, and on December 15 Gemini 7 and Gemini 6 successfully made the first space rendezvous. These flights set the stage for even more dramatic missions to follow in the Gemini series and moved the nation's program for landing men on the moon nearer to its goal.

The initial successes in the manned Gemini program were achieved after only two unmanned test launches, attesting to both the soundness of design and the reliability of the spacecraft. Gemini was designed as a work horse for space. It demonstrated the capability of being launched on schedule with less than the original estimated time between launches and it proved an overall maturity of design that has already yielded much scientific data valuable to our national space program.

Midway during the Gemini V flight, President Johnson announced on August 25 that he had ordered the Air Force to proceed immediately with the development of a Manned Orbiting Laboratory (MOL). This project was of great importance to McDonnell in that MOL will consist of a Gemini B spacecraft which McDonnell will design and build, and a pressured cylindrical laboratory about the size of a small house trailer in which astronauts may stay aloft for a period of up to 30 days. The space pilots will remain in the Gemini B until the orbit is established, and they will then move through a hatch in the spacecraft heat shield into the laboratory to perform predetermined experiments. At the completion of their mission, the astronauts will move back into Gemini B for the return trip to earth.

McDonnell has been working on Gemini B for more than three years and has been under contract with Space Systems Division of the Air Force for more than a year. An additional contract for a seven-month definition phase on Gemini B was received on September 1.

The other major line of business for McDonnell–the F-4 Phantom aircraft–reached a milestone on July 7 when the 1,000th Phantom was delivered to the armed services. Confidence by the military in the Phantom was justified by its performance in Viet Nam action. Reports from operational squadrons revealed that the Phantom was doing a highly effective job as an interceptor with the Navy and Air Force and as a fighter-bomber with the Marines and Air Force. The year 1965 marked the deployment of Air Force F-4Cs to Alaska, Okinawa, the Philippines, and Viet Nam, the first deliveries of Air Force RF-4C and Marine Corps RF-4B reconnaissance Phantoms to operational squadrons, and the first overseas deployments of the RF-4C to France and the United Kingdom.

Increased funding for the Phantom was planned under the fiscal 1966 budget.

MENASCO MANUFACTURING COMPANY

During 1965 Menasco won a large portion of the new landing gear market, made substantial development of its organization and acquired facilities to enable the company to meet its program commitments and to earn a satisfactory return for its stockholders. The company's backlog, second highest in its history, was excellent in terms of size, composition and growth potential.

Menasco invested or committed, during fiscal 1965, more than $1,000,000 for new machinery and equipment in continuation of a company program to modernize its equipment, balance and enlarge its capacity to take maximum advantage of market opportunities. New construction included an addition to the Texas plant and new facilities added to the Burbank complex.

Under 1965 contracts Menasco was participating in the following programs: the Bell UH1B helicopter; Boeing Minuteman shock isolation; Boeing 707-120-320, 720 aircraft and the CH46A helicopter; Collins antenna systems for missile sites; Douglas DC-9 and Saturn; General Dynamics-Grumman

F-111A and F-111B; General Dynamics Centaur; Lockheed C-130, C-141, P3A and JetStar; McDonnell F-4K; North American Apollo; Northrop T-38; Westinghouse MK-17 and MK-21 liquid spring.

During the year 1965, the company successfully completed, within a constricted time frame, the initial portion of its program to develop and manufacture shock isolators for the Minuteman Wing VI launch control centers and launch control equipment buildings. The company established a major new facility for the critical testing requirements of these products.

New products were developed within the scope of Menasco's capability and experience. Some of these included: an automatic mechanism for acquisition and tie-down of shipborne helicopters; shock isolators suitable for railroad use; space docking mechanisms; and devices for underwater applications under the company's pressure vessel work.

NORDEN DIVISION OF UNITED AIRCRAFT CORPORATION

Design, development and production of advanced airborne radar systems constituted the major activity of United Aircraft's Norden Division during 1965. Principal product was search and track radar for Grumman's A6A Intruder jet bomber. The carrier-based Intruder, whose mission is low-level penetration, entered squadron service in Viet Nam during the year.

Using Norden radar, the Intruder's two-man crew can seek out targets obscured by weather or darkness. The pilots "see" targets and geographical features by means of cockpit viewing screens which provide a visual representation of the ground and air below and in front of the aircraft. Accompanying Norden computer equipment provides the crew with continuous flight data. Norden also delivered to the Navy ground test equipment to support its radar systems.

An outgrowth of the A-6A radar was a terrain-following radar Norden began developing for use in the Navy's integrated helicopter avionics system (IHAS). The new radar, lighter than its predecessor, will automatically maintain a predetermined clearance altitude, or permit the helicopter to fly in the "nap of the earth," regardless of weather conditions. Its first application will be in the Marine Corps' Sikorsky CH-53A heavy assault helicopter. The IHAS radar is adaptable to other types of helicopters, as well as fixed-wing aircraft.

Another of the electronics firm's products, a contact analog display system, went into operation during the year on Polaris submarines. Norden's "Conalog" system provides a moving pictorial pathway for the helmsman, and shows on a 19-inch screen information such as roll, pitch, heading, speed, and surface and bottom positions. Conalog also was chosen for use on new nuclear-powered attack class submarines. Norden designed similar systems for fixed wing aircraft and helicopters.

A Norden simplified inertial guidance system (SIGS) performed perfectly during a flight test aboard a Sergeant missile in August. The test demonstrated the feasibility of low-cost guidance systems for tactical missiles. SIGS was designed, developed, and built by Norden under contract to the Applied Physics Laboratory of Johns Hopkins University, which provided supervision and systems integration for the Navy Bureau of Weapons.

Norden's system work was supported by a variety of precision components for both in-house use and for sale to other avionics firms. The division was producing high performance gyros for the inertial sensor portion of the LEM backup guidance system. The LEM gyros were being built in cooperation with United Aircraft Corporate Systems Center, developers of inertial sensor assemblies for the LEM abort guidance system.

Norden continued production of pressure ratio indicating systems, which give a pilot of a jet aircraft climb and cruise power information and monitor jet engine performance during flight. The devices are in use on F-111 aircraft, Mirage fighters, B-58 bombers and Sud Super Caravelles.

Norden gas pressure systems are part of the navigation equipment of advanced Terrier and Tartar supersonic missiles, the antiaircraft shields for Navy carriers, cruisers, and frigates. These systems sense changes in gas pressure and channel energy into electrical output to guide the missiles.

The division at year-end was one of the world's leading producers of encoders, or analog-to-digital converters. These devices, which translate flight data into the language of computers, were incorporated in major aircraft, weapons, missile and space programs. Norden Gray code encoders positioned the giant wings of Pegasus satellites which were launched into space during the year to measure the presence of meteoroids.

Norden continued work during 1965 on an Air Force contract to devise new methods of employing computers to speed the design and layout of microminiaturized integrated circuits. The project developed methods of analyzing new circuit designs by computer programs, thus assuring the quality of circuit performance prior to committing designs to tooling.

Norden stepped up its output of specialized microminiaturized circuitry during the year. The first circuits developed by the master-dice, or breadboard, technique, were delivered to North American's Autonetics Division for use in ships inertial navigation equipment (SINS) for Polaris submarines. The circuits, Inductosyn preamplifiers, were the initial microminiaturization applications to SINS equipment. Another Norden circuit, a sense amplifier, was fabricated to interrogate the high-speed magnetic memory core of the Apollo moon vehicle's guidance computer.

NORTH AMERICAN AVIATION, INC.

The year 1965 saw the achievement of significant technical advances in all the principal fields of company endeavor. The XB-70 underwent numerous flight tests that went far in proving out the sweeping aeronautical advances designed into it. The OV-10A counterinsurgency aircraft was completed and flown within a very demanding schedule. Both the F-1 and J-2 rocket engines were test-fired for full duration in the clusters of five that will be used in the first and second stages of the Saturn V lunar-launch vehicle. The low-thrust space engines for maneuvering the Gemini two-man capsule operated successfully in orbital flights. The microminiaturized guidance and control system of the Minuteman II ICBM performed flawlessly on all flights. In the first space flight of a nuclear reactor, the SNAP 10A operated in orbit for 43 days. Flight testing of space capsules was undertaken in preparation for the first Apollo earth-orbital manned flight.

In preparing for new markets, as well as staying abreast of current ones, North American devoted increasing effort to research. The company's research and development study contracts continued to grow in number. At the same time, 1965 saw still another increase in company-sponsored independent research and development work.

North American operated in close teamwork with thousands of subcontractors and suppliers. During the year the company placed purchase orders with over 16,000 firms, in nearly all of the 50 states and in a number of foreign countries.

AIRCRAFT

North American was developing or manufacturing a variety of major products ranging from component parts up to entire systems for accomplishing extensive defense or space missions. In aircraft, the XB-70 vehicle No. 1 was paced toward its design cruise speed of Mach 3, or three times the speed of sound, while vehicle No. 2 entered flight test. The XB-70 made longer sustained flights at supersonic speed than any other known aircraft and was providing the nation with invaluable data on advanced flight. As the only flying aircraft in the size and performance class of the planned supersonic transport, it was contributing vitally to this forthcoming advance in civilian aeronautics.

Production continued on the Navy's most advanced tactical reconnaissance aircraft, the RA-5 Vigilante. It is operated in connection with the Integrated Operations Intelligence Center System (also manufactered by North American) for processing, storing, disseminating, and displaying intelligence data for command purposes on aircraft carriers.

The first prototype OV-10A light armed reconnaissance aircraft was completed and flown approximately 10 weeks ahead of the contract schedule. This propeller-driven airplane was specially designed for a large variety of close support missions and anti-guerrilla operations.

Modification work continued on F-100 fighters for United States and French air forces, and on a large number of T-28's for improved counterinsurgency operations.

The first production T-2B twin jet trainer for the Navy was completed and flown during the year.

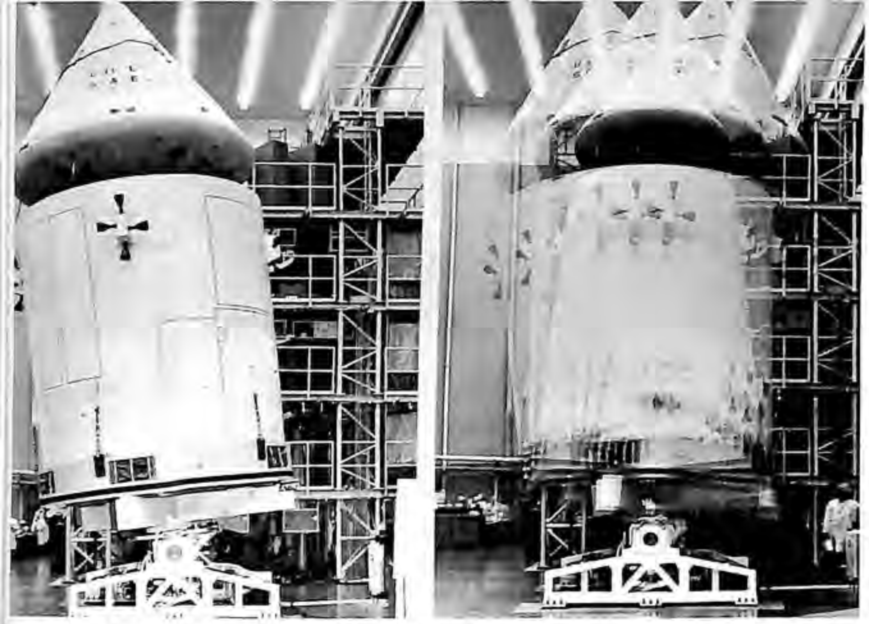
The company was building horizontal stabilizers for the Douglas DC-9 shorthaul commercial transport, and was performing certain tooling and engineering work for both the DC-8 and DC-9.

The T-39 military aircraft program was completed in 1965 after delivery of 191 utility trainers to the Air Force and Navy over a four-year period. In addition, a substantial number of Sabreliner executive transports were sold to private companies and other customers. The excellent flight record of the aircraft during two years of commercial operations enabled the company to double the airplane's warranty period from 12 to 24 months.

ROCKET ENGINES

While continuing to provide the major portion of the propulsion for U. S. space flights, North American was testing still more powerful engines for the Apollo moon mission.

Production of Thor and Atlas engines for the



Apollo spacecraft gets "rock 'n roll" treatment on the "polarity checker" at North American's Space and Information Systems Division.

space program continued and the advanced MA-5 Atlas engine system consistently launched successful space flights without failure. These included the Ranger photographic missions to the moon, the Mariner probes to Venus and Mars, and the orbiting of the SNAP 10A reactor.

The H-1, first engine designed especially for space flight, performed well in 10 out of 10 Saturn I launches, in which eight of the engines are clustered in the first stage. Deliveries of a more powerful version were scheduled to mid-1966.

The F-1, most powerful liquid-fuel engine known, was successfully fired for full duration in the five-unit cluster that will be used to launch the Apollo lunar flights. These spectacular firings generated 7,500,000 pounds of thrust—the most ever produced at one time.

Five J-2 rocket engines, using liquid hydrogen fuel for improved performance, will be clustered to propel the second stage of the Saturn V lunar launch vehicle. During the year, the J-2 was cluster-fired for full duration with a test S-II stage, under simulated space conditions. A single J-2 was also test-fired under such conditions with the Saturn V upper stage. Deliveries continued throughout the year.

Low-thrust engines, designed and built by North American for controlling and guiding manned spacecraft, were used on all the Gemini manned orbital flights, and enabled the U.S. to achieve "firsts" in space maneuvering and rendezvous. Company-built attitude control engines operated perfectly in four flights of the upper stage of the Titan II space booster.

Production continued on solid-propellant motors for the airborne Sparrow, Shrike, and Sidewinder missiles. The company was also producing launch boosters for the Army's Redhead/Roadrunner target missile and for the Navy's KD2U-1 target drone, as well as gas generators for the Navy's Tartar and Terrier missiles, and various igniters and turbine starters. A solid propellant motor was being developed for the Phoenix missile, for use with the Navy's new F-111B fighter aircraft.

ELECTRONICS

During the year, the company's position in the field of microelectronics moved from the design and experimentation phase into advanced testing and production.

The guidance and control system for the Minuteman II intercontinental ballistic missile successfully completed all its 13 flight tests. The first major use of microelectronics in an operational system, this equipment was being installed at Air Force bases. Due in large part to the improved guidance and control system, Minuteman II's greater accuracy, payload, range, and reliability make it from four to eight times more effective than Minuteman I. Production of this advanced system was expected to continue for some time.

In its work on the Minuteman I program, completed in 1965, North American met or surpassed contractual goals for accuracy, reliability, and weight. In virtually all electronic components, a 100-to-1 reliability improvement was achieved. To further improve performance of Minuteman II, the company was designing and developing a post-boost control system for directing the reentry vehicle after burnout of the missile's engines.

Deliveries continued on the Ship's Inertial Navigation Systems for both the United States and British Polaris submarines. The Navy was also using company-built SINS in attack and guided missile submarines, range tracking ships, and aircraft carriers, including the world's largest. North American was studying a more advanced autonavigation system for nuclear submarines that would be armed with the improved Poseidon missile.

The Air Force was evaluating North American's N16 all-microminiaturized autonavigator for possible use in various weapon systems.

The company's D26 series of computers entered advanced development. This family of high-speed, versatile data processing equipment was expected to find application in high-performance defense and space systems.

The XR45 multimode radar, first microminiaturized airborne radar system, completed initial flight tests and provided improved performance for supersonic attack aircraft.

ATOMIC ENERGY

In its 20th year of atomic work, North American provided the first nuclear reactor operated in space, and continued to perform research and development in advanced reactors for central power and water desalination.

Launched into orbit April 3, the company-built SNAP 10A nuclear reactor met all objectives during its 43 days of uninterrupted, flawless performance. The test demonstrated that nuclear reactors can be integrated into typical spacecraft to provide electrical power for observation and weather satellites, orbiting laboratories, electrical propulsion, and earth communication.

The experimental SNAP 8 reactor, an advanced version of the SNAP 10A, was operated continously for 209 days, completing a longer run and demonstrating better operational reliability than any other known nuclear reactor of its type.

In the field of central station power, the company-built, organic-moderated reactor at Piqua, Ohio, performed exceptionally well in its second year of commercial operation. The reactor proved highly responsive to increasing or decreasing power demands and permitted continual reductions in operation costs.

During the year North American made progress on two advanced reactor concepts. One is a heavy water-moderated, organic-cooled reactor (HWOCR) being developed for the AEC jointly with Combustion Engineering, Inc. This type promises low fuel cycle costs and large capacities up to 3,000 megawatts. The HWOCR is a leading candidate for central station power as well as for use in large-scale water desalination. Component development work continued in the program for an HWOCR in Spain. The other advanced concept is the sodium-cooled fast breeder reactor, which offers great potential both for low energy costs and improved fuel utilization in the long range.

SPACE ACTIVITIES

North American's share of responsibility in the Apollo program was on the schedule established to place Americans on the moon by 1970, and successful equipment tests during the year gave every reason for confidence that the target date would be met.

Test versions of the Apollo command module were used successfully in three launchings of the Pegasus micrometeoroid detector, NASA's largest instrumented satellite. The launch escape system worked well in its tests, including one unplanned emergency when the command module was pulled to safety. Structural testing was also advanced on the service module housing most of the electronic equipment for the mission, and on the adapter for carrying the lunar excursion module, which will take two of the astronauts to the surface of the moon and back to the orbiting spacecraft.

Advanced testing was proceeding on Saturn V's S-II second stage. A flightweight version was delivered to NASA's Mississippi Test Facility for combined testing of all subsystems.

The first Apollo manned space flight was scheduled for 1966.

PROJECTS

The last of the low-altitude versions of the Redhead/Roadrunner target missile under the initial order from the Army were delivered for operational use in the field. They will be used to simulate high performance aircraft and missiles for target practice by Army Air Defense Command missile batteries.

Flight tests began on the Hornet advanced air-to-surface missile, which is guided to its target by an electro-optical system. The company was also doing research and development work for the Navy on two other proposed missiles using an electro-optical guidance system: the Walleye glide bomb and the Condor air-launch guided missile.

The company completed and successfully demonstrated a pump for use in an artificial heart that may be developed under auspices of the National Heart Institute. Eight pumps were delivered and additional research was being performed on other components.

The company continued to build large-scale, ground-based antennas for satellite tracking and other space requirements. Two 30-foot antennas were delivered to Sylvania Electric and a 40-foot unit was being built.

The "Hoverbuggy" VTOL simulator was rolled out at North American's Los Angeles Division during 1965.

North American's extensive studies of life support systems for bases or stations in space led to a contract with the U.S. Public Health Service for reclaiming sewage water and growing algae for animal feed at a pilot plant in California.

Using advanced engineering and management techniques, the company completed a blueprint for a study of California's transportation requirements over the next 50 years.

At year-end, total employment at North American's divisions—Autonetics, Atomics International, Columbus, Los Angeles, Rocketdyne, Science Center, Space and Information Systems—was approximately 100,000. Total floor area amounted to about 23,000,000 square feet.

NORTHROP CORPORATION

World events of 1965 confirmed Northrop's often stated view that the challenge of limited or conventional warfare demands the use of advanced technologies normally associated with space and missile projects. Northrop has long devoted particular attention to the characteristics of limited war and hence was able to meet many of the tactical needs of that type of conflict.

At the close of the year the world requirement for the Northrop F-5 tactical fighter appeared to be increasing. A squadron of 12 F-5A's was deployed to Viet Nam by the U. S. Air Force for an extensive series of combat assignments. Object of the mission was to obtain information to be used in developing concepts, procedures, tactics, and techniques for the employment of the F-5 in combat, according to the Department of Defense.

The supersonic fighter had also been chosen, either through independent purchases or via the U. S. Military Assistance Program (MAP), for use in nine allied countries. Canada selected the F-5 after an extensive evaluation of 14 types of aircraft. In Spain, Northrop signed a license agreement with Construcciones Aeronauticas, S. A., for production of F-5s for the Spanish Air Force. The first of 64 F-5's scheduled for delivery to Norway during 1966–67 was flown in June.

The Department of Defense stated that the MAP order will total about 700 aircraft. Nations announced as F-5 recipients included Iran, Korea, Greece, the Philippines, Nationalist China, and Turkey. Five other countries in Europe and the Far East were actively considering the F-5 at year end.

An improved version of the F-5, designated the F5-15, evoked considerable interest within the U. S. Air Force. The F5-15 is a modification of the standard F-5A that provides additional thrust, a shorter runway roll, and greater climbing capability. New General Electric J85-15 jet engines produce 4,300 pounds of thrust compared to 4,080 pounds for earlier F-5 engines.

Northrop delivered its 600th T-38 to the Air Force Air Training Command in 1965. This airplane has achieved important reductions in ATC maintenance costs. In one month, some 400 T-38's were flown a record total of 24,669 hours and in so doing recorded a new mark of only 11.8 maintenance man-hours per flight hour. Both achievements established new records for supersonic military aircraft.

The T-38 had been used as a space-flight readiness trainer for NASA astronauts since early 1964. In mid-1965, when a new group of scientist-astronauts was named, the Air Force announced that four selectees requiring flight training would receive 120 hours of training in T-38's.

The German government announced its intention to purchase a quantity of T-38's for use in training German Air Force pilots in the United States.

Northrop Norair continued to manufacture outer wings and aft fuselages for Boeing 707 and 720 series commercial airliners. This work was being done under follow-on orders to a contract originally awarded to Northrop by Boeing about ten years ago. Another long and successful contract with Boeing was completed earlier in 1965 when Northrop delivered the 820th aft fuselage and outer wing sets for the C-135, KC-135, and RC-135 aircraft.

Plotting from a Northrop Vigicon information display projector system make a weird pattern on the wall.

The experimental, wingless, M2-F2 lifting body research vehicle was completed at Northrop Norair under contract to NASA and delivered to the agency in June. A second vehicle in the program, the HL-10, was near completion as the year ended. The configuration of the second vehicle was created at NASA's Langley Research Center; the first at Ames. Both will be employed in an extensive flight test program at Edwards AFB to gain knowledge in the art of controlling future manned space vehicles in the earth's atmosphere during the critical terminal approach and landing phase.

During the year Northrop's Space Laboratories (NSL) designed and delivered two earth-orbiting satellites to the Air Force. These spacecraft, the OV2-1 and OV2-3, were launched as "bonus" payloads on USAF Titan IIIC boosters from Cape Kennedy. NSL performed this work for the Air Force Office of Aerospace Research.

Under contract to Rice University, Houston, Texas, NSL designed and constructed a "pre-prototype" model of a 140-pound satellite for possible future application to a NASA study of auroral radiation and other near-earth phenomena.

Continued NSL efforts in the area of life sciences included activation of a "bioclean" room to support investigations in microbiology, installation of a new 100-foot lunar gravity simulator that has provided biomechanical and physiological data indicating the best rates for man's future work on the moon, and development of a space suit that provides protection from the stresses of acceleration, thermal extremes, and atmospheric decompression while permitting man to perform useful tasks.

NSL support activities included technical assistance to the Army's NIKE-X project office; engineering and operational support to the Jet Propulsion Laboratory (JPL) on Rangers VII, VIII and IX during their development and subsequent successful TV coverage of the moon's surface; partial support of JPL during the Mariner IV photographic mission to Mars; engineering support on space programs at NASA's Ames Research Center, and operation and maintenance of a JPL propulsion test facility at the Edwards Test Station.

Northrop Nortronics also played a part in 1965's Ranger and Mariner successes. As on previous Ranger moon shots, Nortronics provided the sun and earth sensors, central computer and sequencer, and other attitude control systems and equipment which guided Rangers VIII and IX on their lunar photo missions. Nortronics also assisted the Jet Propulsion Laboratory in developing the spacecraft attitude control system which kept Mariner IV steady on its course throughout its 350,000,000-mile journey to Mars.

Northrop Ventura space recovery and landing systems have successfully returned to earth every astronaut sent into space by the United States. This effort included all of the Project Mercury flights and all of the Project Gemini flights to date. Northrop systems were scheduled for use in the remaining Gemini missions and work was going forward in preparation for their use in the various missions of the Apollo moon program.

In tests of the Apollo equipment, the Northrop system provided successful escape from simulated rocket failures on the launch pad, at 20 miles' altitude, and at very high altitude. In one case the dummy "astronaut" escaped unscathed despite actual total disintegration of the rocket.

Negotiations neared completion with the National Aeronautics and Space Administration in 1965 for application of the Cloverleaf controllable gliding parachute to the nation's space flight programs. The Cloverleaf, conceived originally under an Air Force precision aerial delivery program, demonstrated the ability to glide nearly two feet horizontally for each foot of vertical descent. It was expected to lead to precision recovery of manned and unmanned space vehicles on land instead of water.

Years of work in developing concepts for advanced tactical missiles resulted in Northrop Norair's selection by the Navy in 1965 to compete in the contract definition phase of the Condor missile system. Condor will be a short-range air-to-surface missile carrying a high-explosive warhead.

An important new business opportunity was created in June with Northrop's selection as prime management and engineering support contractor for the Navy's Deep Submergence Systems Project (DSSP), a five-year multimillion-dollar program of underwater research and development. As systems engineering support contractor, Northrop Nortronics will assist the Navy's Special Projects Office in the management, integration, and coordination of all phases of the deep submergence program. Nortronics will help establish criteria for the design of all systems, train personnel, and analyze performance and missions.

Under another Navy contract, Northrop Ventura started work on the development of an interim ASCAC (Anti-Submarine Contract Analysis Center) system. The purpose of the center is to provide rapid and accurate identification of contacts made by anti-submarine surface ships and aircraft.

An important innovation in the shipping industry was the development of automated, centralized ship control systems which will help reduce costs of ship construction and operation. Northrop Nortronics, at its Marine Equipment Department (MED), near Boston, is a pioneer in this burgeoning technology. MED was awarded a contract for and was designing and producing centralized marine control and instrumentation equipment for six Grace Line cargo ships.

Page Communications Engineers, Northrop's worldwide communications subsidiary, received renewal of several military contracts. Work included operation and maintenance of the backbone of the communications system in Southeast Asia, initially designed and installed by Page for the United States Department of Defense. In Viet Nam, for the U. S. Army, Page was also performing around-the-clock operation and maintenance of extensive Page-designed-and-installed communications systems linking major combat facilities. In Europe the company furnished the Army with Page-designed test equipment used to monitor communication-system performance during operation.

In other military work Page was performing operation and maintenance services on a U. S. Air Force microwave system in the United Kingdom. Similar services are being supplied by the company on satellite tracking facilities in New York state and on underseas cable terminals connecting key areas in the Far East.

In the commercial field Page was awarded contracts to operate and maintain the commercial troposcatter telephone system it had installed in the Bahama Islands. For the Imperial Government of Ethiopia, as part of a nationwide communications updating and improvement program, Page was constructing three medium-wave radio broadcast stations to operate in conjunction with existing broadcast-communications facilities. Other commercial contracts were obtained for various communications systems in Libya, Samoa, and Hawaii.

In the area of research and development, Page designed and was testing a low-cost, high-performance transportable satellite communications ground terminal which is attracting national and international attention. The excellent performance capabilities proved in the model are significant in view of the worldwide market potential of the broad new field of satellite communications.

Astro Technology Corporation, formerly a wholly owned subsidiary of Page, became the Astro Technology Division of Page in 1965. The new division, located at Mountain View, California, received a contract from the Naval Ordnance Test Station to furnish an integrated computing system that enables faster, more accurate processing of target position data for the Nike-Ajax antiaircraft missile.

In the growing field of information systems Northrop Nortronics developed several information display systems having a wide range of applications in command and control. Known as Vigicon systems, they comprise all the equipment necessary to assemble data (from many different types of communications sources), to process data (using converters, analyzers, and computers), and to present it in various types of graphic display as rapidly as information is received.

Nortronics' Vigicon systems are capable of charting such events as the orbit of a spacecraft, the trajectory of a missile, the deployment of military forces (including aircraft, ships, and troops), and the path of a torpedo in the sea. The division installed a large-screen, theater-type Vigicon system at NASA's Goddard Space Flight Center for analysis of all future space missions, including those in Gemini and Apollo programs.

Northrop, through the Nortronics Division's Precision Products Department (PPD), located near Boston, has acquired an estimated 30 percent of the nation's competitive market for gyroscopes. Business acquired by PPD in 1965 included an emergency detection gyro package and basic sensor for the automatic flight control system of NASA's Saturn rocket booster; auxiliary gyros for the Minuteman II inertial guidance system, and an inertial reference integrating gyro for the Polaris missile inertial guidance platform.

PPD has also established itself as the leader in the design and fabrication of precise gyro test equipment. Initially manufactured for the department's own use and for the Navy, this and other test equipment are now being supplied to NASA and Air Force facilities.

To keep pace with increasing Air Force and Army armament and advanced weapon requirements, Northrop Nortronics expanded its ordnance facility to include capability for design, development, and fabrication. For the Air Force, ordnance engineers are developing an advanced air-to-ground, rapid-firing weapon; a special-purpose rocket system which can be launched laterally from high-performance aircraft, and special dispensing tanks to be suspended from aircraft wings for a variety of missions.

At its Marine Equipment Department in Massachusetts, Nortronics produced M-6 helicopter armament systems for use in the Army's UH-1B helicopters. The helicopter gunner uses a hand-directed sight to pinpoint a target and, through a servo system, directs the machine guns to fire on that target.

A multipurpose armament pod designed and manufactured by Northrop Norair was successfully integrated into the air-to-ground tactical pilot training programs of selected allied nations. The company also fulfilled a contract to produce a quantity of pods for U. S. Air Force evaluation.

On October 1, 1965 Northrop acquired the Amcel Propulsion Company of Asheville, North Carolina, from the Celanese Corporation of America. Now known as Northrop Carolina, Inc., the company develops and produces chemicals, explosives, ordnance, and rocket propulsion devices for the Department of Defense and NASA.

Northrop Ventura designed a new low-cost jet-powered target aircraft, the NV-105, to fill the gap between low speed and supersonic targets now in service with the Army and Navy. Using off-the-shelf components and techniques developed in earlier Northrop programs, the NV-105 will be capable of speeds up to 400 knots at altitudes from sea level to 40,000 feet. Its purpose is to provide low-cost realistic training for military gunnery and antiaircraft missile crews.

In the field of navigation and guidance systems, engineers at Northrop Nortronics produced a compact "suitcase navigator"—weighing less than 60 pounds—that comes close to providing instant navigation for high-performance military aircraft.

Modified versions of the Nortronics Mark IV shipboard inertial navigation system (SINS) were being installed aboard Air Force Eastern Test Range tracking ships to assure precise stabilization of tracking radar. Although much smaller and lighter than other operational SINS, the advanced inertial systems have complete navigational capability and will serve as backup units to the primary systems.

The Nortronics Division's experience in stellar-inertial navigation will also be applied to range ship tracking during Apollo missions. Star trackers now being developed for the National Range Division will provide highly accurate celestial "fixes" which will be used to monitor the accuracy of SINS systems and to provide angle information for calibration of tracking radar.

During the year, successful ground-based demonstrations were made of Northrop Nortronics' automatic tracking subsystem to be used in the Airborne Lightweight Optical Tracking System (ALOTS) being developed for the Air Force. The purpose of ALOTS is to provide high-altitude photo coverage of launches from Cape Kennedy. In its first operational test, the system's optical sensor pinpointed the launch and early flight phases of a Gemini manned space mission with complete success.

Under a Bureau of Ships contract, Nortronics began designing and producing digital checkout systems for 26 new destroyer escort vessels intended primarily for antisubmarine-warfare operation. Designated TEAMS (Test Evaluation and Monitoring Systems), Northrop's equipment will provide direct operational monitoring of critical shipboard electronic systems, including long-range sonar, fire control, navigation radar, and search radar. TEAMS will be an advanced version of the Polaris DATICO system produced by Northrop and will feature increased checkout speed and even higher reliability.

PACIFIC AIRMOTIVE CORPORATION

A rapid increase in Pacific Airmotive Corporation's participation in the general aviation field took place during 1965. The company, already established as the largest distributor of Cessna aircraft in the world, acquired Business Aircraft Distributors in Oakland, the Cessna wholesaler for northern California and western Nevada. Augmented by the southern California and Baja California territories of PAC's Airflite, Inc., subsidiary, the retail organization being serviced at year-end by Pacific Airmotive included 33 dealers.

A Cessna dealership was established at Palm Springs Municipal Airport. The completion of a new building in October provided Pacific Airmotive-Palm Springs, Inc., with 30,000 square feet of space, including a passenger terminal, pilot lounge, flight school, maintenance hangar, aircraft parts facility and Cessna aircraft display room.

With the purchase of the buildings and equipment of Aero Sales & Service, Pacific Airmotive expanded its Air Oasis Cessna dealership facilities on Fresno-Chandler Municipal Airport. Company operated Cessna dealerships totaled six and, in addition to Palm Springs and Fresno, they were located at San Diego, Riverside, Long Beach and Burbank.

As the exclusive conversion agency for the Allison-Convair modification program, Pacific Airmotive's Aircraft Division converted a total of 20 Convair aircraft to Allison turboprop power during the year for corporate customers, airlines and the Air Force. The performance of the converted aircraft for airline use proved highly successful.

The first Fan Jet Falcon to arrive in the United States touched down at Burbank in June for interior installation and other modifications by Pacific Airmotive Corporation. The company is the agent/distributor for the Fan Jet Falcon with Pan American World Airways Business Jets Division, and was supplying technical assistance, service and spar parts support to Falcon owners at the company's Aircraft & Engineering Center on Lockheed Airport and at its Westchester County Airport facility in New York, where operations were begun in September. Orders were received for 57 Falcons and post factory installations were in progress on several of the French-built jets.

The Avionics Department at Pacific Airmotive's Aircraft & Engineering Center, offering a complete service to aircraft owners including electronic engineering and installation capability, was enlarged during the year by the addition of the instrument repair shop that formerly was located at the Oakland Branch.

Certifications of the PAC-designed windshield rain repellent system for Convair 880/990, DC-8, BAC-111, Jetstar and Fan Jet Falcon aircraft were received during 1965. The PAC system was also certificated on the Gulfstream, Electra, Convair 240/340/440, Allison-Convair, DC-6 and DC-7. Under license to The Boeing Company, Pacific Airmotive is the only U.S. aircraft maintenance company authorized to design, manufacture and install the windshield rain repellent systems on aircraft other than those of Boeing manufacture. Airline fleets retrofitted with the PAC rain repellent system during the year included those operated by TWA, Frontier, Braniff, KLM, Cathay Pacific and TIA.

Pacific Airmotive reactivated its facility on Santa Monica Airport to accommodate the DC-6B cargo conversion program initiated in March under license to Douglas Aircraft Company. The first group of DC-6B's were being modified to include a passenger-cargo convertible interior.

During 1965, the company experienced a 35 percent increase over the previous year in total engine overhaul volume. A contract signed with The Flying Tiger Line provided for exclusive overhaul and repair of the carrier's Rolls-Royce Tyne turboprop engines by PAC covering a period of five years. Overhaul of R3350 engines reached record levels during the year.

New agreements were signed by Pacific Airmotive to represent Goodyear Tire & Rubber Company (Aviation Products Division); General Electric Company (Aerospace Motor & Generator Division and Specialty Control Department); Gill Electric Manufacturing Corporation; Aero Products Research, Inc.; Zep Aero; Jeppesen & Company; and Airborne Manufacturing Company in the distribution of their products through the Aviation Products Division's network of 11 branches and sales offices.

To service the expanding aviation market in the Southwest, two new warehousing branches were established. The new branches located in Dallas, Texas, and Phoenix, Arizona, were supplying local inventories to airline and general aviation customers.

In March, under agreement with The Flying Tiger Line, parts provisioning was begun to meet the maintenance requirements of the carrier's Boeing 707-320C freighters. A similar contract was signed with Pacific Southwest Airlines for the spare parts support of its Boeing 727's and with the West German Air Force to supply airframe spares for its F-86 aircraft.

PHILCO CORPORATION—
A Subsidiary of Ford Motor Company

AERONUTRONIC DIVISION

Aeronutronic Division of Philco Corporation, a subsidiary of Ford Motor Company, ended 1965 with a new all-time high in backlog and looked forward to one of the most successful years in its 10-year history.

The Newport Beach, California, aerospace firm was engaged during the year in research, development, test and manufacture of weapon systems, including fuzes and seekers; re-entry systems, including planetary landing capsules and penetration aids; reconnaissance and intelligence systems, and its associated radar; and antiweapon systems.

Aeronutronic was established by Ford Motor Company in July, 1956, when Ford formed Aeronutronic Systems, Inc., a subsidiary. In July, 1959, it was merged into Ford as Aeronutronic Division. On July 1, 1963, Aeronutronic was merged into Philco Corporation, adding the systems and research capabilities of Aeronutronic to Philco and permitting better coordination of Ford's over-all space and defense activities. Aeronutronic is one of five Philco defense, space and industrial electronics divisions.

The Philco Aeronutronic facility at Newport Beach, California.

Principal components of Aeronutronic Division are several program areas—which act as an extension of the General Manager's office. They are: Tactical Weapon Systems Programs, Re-Entry and Space Systems Programs, and Reconnaissance and Electromechanical Programs.

Tactical Weapon Systems Programs is responsible for two major programs: The Shillelagh surface-to-surface guided missile system, and Chaparral, an adaptation of Philco's Sidewinder air-to-air missile system to an interim antiaircraft role for the Army for forward battle areas. Shillelagh, Aeronutronic's largest single program, is an extremely accurate fully-guided tactical missile planned as the main armament of the Sheridan armored reconnaissance airborne assault vehicle. Aeronutronic is also adapting the weapon system to the M60, the principal U. S. tank. In 1965, Aeronutronic placed Shillelagh in quantity production at a government-owned, company-equipped plant in Lawndale, California, near Los Angeles International Airport.

Chaparral is designed to defend against low-flying aircraft. Earlier called Sidewinder SAM (for Surface-to-Air Missile), Chaparral consists of the Sidewinder 1-C missiles mounted on a modified machine gun mount, with the total system mounted on the M548 vehicle for mobility.

Re-Entry and Space Systems Programs developed and manufactured decoys that at year-end were operationally deployed on U. S. ballistic missiles. They are designed to confuse enemy missile defense. Under a multimillion dollar contract, Aeronutronic was conducting an Air Force program to evaluate impact and radar fuze problems for advanced re-entry vehicles. In the fall of 1965, Aeronutronic was awarded a $30-million contract by the Air Force Ballistic Systems Division to carry out a program for expanding U. S. reentry systems technology. In a re-entry measurements program (RMP), Aeronutronic was developing and manufacturing a series of experimental payloads and a standardized space vehicle or bus. The various experiments are being flown on the standard buses down the Pacific Missile Range, lofted by Atlas boosters launched at Vandenberg AFB.

In the area of space, Aeronutronic was studying and establishing requirements and preliminary design for an Automated Biological Laboratory (ABL) for the National Aeronautics and Space Administration. ABL, as a part of Project Voyager, may be landed on Mars to detect the presence or absence of life there. Also for NASA, Aeronutronic was developing a lunar penetrometer, which Apollo astronauts would use for verifying final site selection prior to setting down on the lunar surface.

Aeronutronic's Reconnaissance and Electromechanical Programs conducts business in three general areas: reconnaissance systems, drone radars, and propulsion products. In the area of reconnaissance photography, Aeronutronic was conducting an experimental program to determine practicality of taking long-range photographs of areas at an oblique angle which would make possible aerial reconnaissance of areas without over-flight.

Aeronutronic was conducting a major propulsion product program for the manufacture for Aerojet of valves which, by emitting hot gases, prevent roll of the second stage rocket engine of Minuteman II.

A strong supporting research capability was maintained by Aeronutronic. The Applied Research Laboratories conducted applied research in materials' structures and processing, solid-state physics, radiation physics, gasdynamics and plasma physics, energy conversion, biosciences, data processing and communications, and advanced weapons guidance systems.

Employment at Aeronutronic at year-end was approximately 3,700.

PNEUMO DYNAMICS CORPORATION

Commercial and military aerospace activities at both the Cleveland Pneumatic Tool (CPT) subsidiary and National Water Lift (NWL) Division of Pneumo Dynamics Corporation were at considerably higher levels in 1965 than in 1964, not only in terms of new business, but also in follow-on orders from previous contracts.

With the receipt of a contract late in the year to supply a quantity of nose and main landing gears for the new Douglas DC-9, Cleveland Pneumatic Tool kept intact its record of supplying gears for every model of the Douglas transport series since the DC-4. In addition, CPT, which has supplied landing gears for all variations of the Boeing 707 transport, was selected to produce this equipment for the new Boeing 737 twin-jet craft.

Among the smaller feeder-type transports and executive-type aircraft, the subsidiary was producing landing gears for the twin-engine Lear Jet and the Grumman Gulfstream II.

National Water Lift was participating in the Boeing 727 and Douglas DC-9 programs with its flight control assemblies and was selected to design and develop aileron and elevator primary flight control actuators for the Boeing 737.

In military aircraft, CPT was supplying landing gears for the Lockheed C141A Starlifter, the Grumman A-6A, EA-6A, and C-2A, the North American T-2B and OV-10A, and both Navy and Air Force versions of the McDonnell F-4 series. CPT was also fabricating wing flap tracks for the C-141A and spare parts for at least 22 models of military aircraft. NWL was producing flight controls for the Lockheed C-130 and C-141A and components for various models of the General Electric J79 jet engine.

Both organizations were actively engaged in proposals in connection with the Lockheed C-5A, with CPT vying for the landing gear system and NWL for flight and engine controls.

A major development of 1965 was the contract to retrofit all C-130 aircraft with Pneumo's System for Take-off Weight (STOW), which measures the gross weight and the center of gravity of the aircraft. It was developed by NWL's Instrumentation and Control Operation.

NWL continued to supply valves and other components for the Gemini program, as it did previously for the Mercury project. The division was participating in the Apollo, Surveyor, and Lunar Orbiter programs and supplied two units for the Astronaut Manuevering Unit. In addition, the Dual Axis Rate Transducer (DART), which was developed by the Instrumentation and Control Operàtion, was being adapted for missile and space applications.

Cleveland Pneumatic Tool, with its in-house capability for making both plastic and metal nozzle components, has become a major supplier of nozzles for the Minuteman II and Scout programs. CPT also manufactures large fuel line components for the Saturn Booster and structural rings ranging from five to 17 feet feet in diameter for the Agena and Apollo projects.

In the aerospace ground equipment area, CPT continued to supply shock isolator systems for the Minuteman program and large ventilation blast valves for Minuteman launch sites.

During 1965, NWL completed construction of an addition doubling its floor space and started construction at I&C which will triple its floor space. The machinery modernization program which got under way at CPT in 1964 reached a peak in 1965 with the installation of several new profiling machines and numerical control machine tools.

PRATT & WHITNEY AIRCRAFT

DIVISION OF UNITED AIRCRAFT CORPORATION

Pratt & Whitney Aircraft's 40th anniversary year in 1965 was a record period for commercial jet aircraft orders.

Domestic and foreign airlines ordered over 580 aircraft with Pratt & Whitney Aircraft engines, more than doubling the previous peak of 227 in 1964. In the decade since the first U. S. commercial jetliners were ordered in October, 1955, more than 1,540 transports powered by Pratt & Whitney Aircraft engines have been ordered by 80 airlines. These represented 5,120 installed engines.

The 18,000-pound-thrust JT3D, the world's most widely used turbofan engine, is the powerplant for most of the long-range Boeing 707 and Douglas DC-8 transports. Another Pratt & Whitney Aircraft turbofan, the company-financed JT8D with full-length duct, also has found wide acceptance. It powers short-to-medium-range aircraft such as the three-engine Boeing 727, and the twin-engine Boeing 737, Douglas DC-9, and Sud Aviation Super Caravelle 10B and 10R.

Delta Air Lines received the first twin-engine DC-9 September 18, prior to scheduled service in December. The 737 rollout was scheduled for late 1966. Its JT8D engines had, by the end of 1965, accumulated over 2,700,000 hours in the 727's and Super Caravelles which began service early in 1964.

The JT8D was also being used under a Swedish license program whereby Svenska Flygmotor is developing an afterburner version for the SAAB JA-37 Viggen supersonic multipurpose combat aircraft.

The TF30, the world's first afterburning turbofan and the powerplant for the revolutionary Air Force-Navy F-111 twin-engine supersonic fighter, successfully completed its military qualification test. This test, the most grueling and demanding ever undergone by an aircraft engine, called for successful completion of two separate 150-hour tests, one of which included 12 1/2 hours of full power operation at Mach 1.2 speed at sea level. The TF30 is in the 20,000-pound-thrust class.

The variable sweep wing F-111 built by General Dynamics, with Grumman as the principal subcontractor, folded its wings in a flight test January 7. The Air Force F-111A aircraft, designed for Mach 2.5 speed, was flown at speeds beyond Mach 2 during the year. The F-111B Navy version made its first flight in May.

A non-afterburning version of the TF30 powers the single-engine Navy A-7A attack aircraft built by Ling-Temco-Vought. This Corsair II plane flew for the first time September 27.

A basic version of the engine, begun as a company-financed project, was designated the JTF10. Under the French designation, TF106, this engine was being developed in France by Societe Nationale d'Etude et de Construction de Moteurs d'Avia-

Pratt & Whitney personnel inspect a completed 38,000 pound thrust J58 engine.

tion (SNECMA) for the Dassault Mirage III-V, a supersonic vertical-lift tactical figher.

Development work continued on the J58 turbojet used in the twin-engine, 2,000-mile-an-hour Lockheed YF-12A advanced interceptor and SR-71 strategic reconnaissance aircraft. The J58, with afterburner, is in the 30,000-pound-thrust class. President Johnson first revealed the existence of the Mach 3 YF-12A in 1964, describing it as the world's fastest operational aircraft.

Secretary of the Air Force Eugene M. Zuckert commended Pratt & Whitney Aircraft division of United Aircraft for its role in establishing new aircraft speed and altitude records with the YF-12A aircraft on May 1.

Two crewmen, Colonel Robert L. Stephens and Lieutenant Colonel Daniel Andre, received the Air Foundation's Thompson Trophy, one of aviation's highest honors, for having reached a straightaway speed of 2,062 miles an hour at Edwards Air Force Base, California, eclipsing a Soviet Union record of 1,665.8 miles an hour.

On the same day, the YF-12A set these records for: speed over a closed circuit, 1,688 miles an hour; speed over a 500-kilometer circuit, 1,642 miles an hour; speed with 1,000 and 2,000 kilogram payloads, 1,688 miles an hour; and sustained altitude in horizontal flight, 80,000 feet.

The Lockheed C-141 StarLifter, a logistics jet transport powered by four TF33 (JT3D) engines, each developing 21,500 pounds of thrust, became operational in the Military Air Transport Service in 1965. Lockheed is offering a commercial version of the plane.

Government support ended for the JTF14 engine design proposed for the new C-5A logistics transport to be built by Lockheed, but the experimental program for this turbofan engine, formerly designated the STF200, continued during the year. The engine had been run for the first time in April, 1964, as a company-financed program.

Under a two-year Air Force contract, work began on an advanced air-breathing engine for a demonstrator program as part of the exploration for an Advanced Manned Strategic Aircraft (AMSA). The engine to be developed is the JTF16, a scaled-down version of the JTF14.

In August, a contract extending through the calendar year 1966 was entered into with the Federal Aviation Agency. This contract called for the design, fabrication and test of three experimental supersonic transport demonstrator engines. Pratt & Whitney Aircraft's entry in the SST engine competition is the JTF17, a turbofan with duct heating.

The SST development work, as well as the continued development of the J58 turbojet engine, was conducted at the division's Florida Research and Development Center.

Pratt & Whitney Aircraft engines continued to demonstrate their stamina and dependability in a wide variety of aircraft. The J57 powers the B-52 bomber, KC-135 tanker-transport and C-135A transport, all made by Boeing; the North American F-100, McDonnell F-101, Convair F-102, LTV F-8 and Douglas F-6 and A-3. The TF33 turbofan is the engine for the Boeing C-135B and B-52H missile platform bomber.

The larger J75 powers the Republic F-105 and the Convair F-106. The J52 is the powerplant for the Douglas A-4E, the Grumman A-6A, and the North American Hound Dog missile. The small J60 (JT12) powers the North American T-39, known as the Sabreliner commercially, the North American T-2B, and the Lockheed C-140, commercially known as the JetStar. A free turbine version of the J60, the JFTD12, powers the Sikorsky S-64 Skycrane helicopter.

Reliable performance of the engines was reflected in the lengthening times between overhaul (TBO). The JT4 commercial version of the J75 reached a TBO of 6,600 hours, the highest for any engine under FAA regulations; the JT3D turbofan reached 6,100 hours by October and the JT8D 3,400 hours. All began with an 800-hour TBO. Total military and commercial operating time of all the division's jet engines exceeded 80,000,000 hours.

The last production model of the J57, the famed turbojet engine which brought supersonic flight to military aircraft and the jet age to U. S. commercial aviation, was shipped June 24. The J57, which won the 1952 Collier Trophy, was the first engine to reach 10,000 pounds of thrust. The first J57 was shipped June 3, 1951, and installed on the first Boeing B-52 bomber. Full-scale production began in 1953 and more than 21,000 were produced.

In the continuing effort to extend the life of its jet engines, Pratt & Whitney Aircraft's Advanced Material Research and Development Laboratory developed a new cast turbine material. Jet engine vanes and blades of nickel-base alloys produced by the new technique showed markedly improved ductility and greater resistance to the effect of high temperatures, thus opening the way to even more powerful and efficient engines in a supersonic age.

The 15,000-pound-thrust RL10 developed at the Pratt & Whitney Aircraft Florida Research and Development Center was the nation's first flight-proven rocket engine using high-energy liquid hydrogen for fuel. During the year it achieved a perfect flight record in the Saturn I program, with 36 engines, six per vehicle, operating flawlessly on the second stage of the Saturn booster. Twin RL10's also powered the second stage of the Atlas-Centaur booster on test flights in preparation for sending the Surveyor spacecraft to the moon to gather information prior to manned exploration of the lunar surface. A total of 44 RL10 engines had been fired successfully in space by the end of 1965. Work on an advanced RL10 continues under contract to NASA.

The Florida Research and Development Center won the annual Nelson P. Jackson 1965 Aerospace Award for "demonstrating the technical feasibility of liquid hydrogen as the next high energy fuel for extending the horizon of space exploration."

In another move to extend space exploration, the division was delivering production fuel cell powerplants on a regular basis to the Space and Information Systems division of North American Aviation, principal contractor to the Manned Spacecraft Center of the National Aeronautics and Space Administration, for the Apollo spacecraft intended to land Americans on the moon.

The PC3A-2 fuel cell powerplant, which will provide on-board electrical power and drinking water for the Apollo astronauts, successfully completed the first phase of its rigid qualification test, including the 400 hours required for a two-week round trip mission to the moon. Each unit generated more than 360 kilowatt hours of energy during the tests. The total endurance test, including non-operating periods of exposure to cold, high humidity and acceleration testing, lasted 1,700 hours.

Three units designed and developed by Pratt & Whitney Aircraft, each producing between 563 and 1,420 watts, will be installed in the Apollo command and service module.

A slightly modified model of the Apollo PC3A-2 was operated continuously in a vacuum chamber for more than 1,500 hours at elevated electrical loads required by some of the Air Force's contemplated Manned Orbiting Laboratory (MOL) missions.

After a review of mission requirements, NASA announced April 5 that the Apollo lunar excursion module (LEM) being built by Grumman would use batteries for on-board electrical power instead of fuel cells, resulting in the end of development work on the LEM fuel cell. LEM is the vehicle intended to leave the Apollo spacecraft to land men on the moon and then return the astronauts to the mother ship for the return to earth.

The division also was working under gas industry contracts to develop fuel cells that can use natural gas and air and it had a contract with the Army Signal Corps to develop a portable unit that uses gasoline.

Additional non-aviation applications for jet engines were found by the division's Turbo-Power & Marine department. This department has sold industrial and marine units totaling in excess of a million horsepower since the program began in 1960 with the successful application of a modified jet engine to the natural gas transmission industry.

The world's largest gas turbine generating unit driven by eight Pratt & Whitney Aircraft GG4 (J75) engines began operating in November at the Public Service Electric and Gas Company's installation at Sewaren, New Jersey. The new generator, which includes four Worthington Corporation free turbines, provides 121,000 kilowatts of electricity during peak periods of electrical demand.

On September 7, the Navy's Military Sea Transportation Service (MSTS) awarded a seven-year contract to American Export Isbrandtsen Lines and the Sun Shipbuilding and Dry Dock Company to build and operate a 25-knot, "roll-on, roll-off" ship powered by two Pratt & Whitney Aircraft FT4 (J75) marine gas turbines, each developing 20,000 horsepower. This will be the first use of Pratt & Whitney Aircraft aviation-type gas turbine engines as the primary source of power in a shipboard application. The swigt, 672,foot-long ship, first of its kind, should be operational late in 1967. She will have a cargo capacity of 7,000 tons—for heavy tanks, cargo trucks, trailers and other vehicles rolling on or off on their own wheels over access ramps—and an endurance range of 6,000 miles at top speed.

The FT4 marine turbojet was developed jointly by the division and the Navy's Bureau of Ships in work begun in 1961. Extensive tests were conducted at the Naval Boiler and Turbine Laboratory in Philadelphia and at the Pratt & Whitney Aircraft facilities in East Hartford, Connecticut.

The lightweight, compact marine powerplant also has been chosen by the U. S. Coast Guard to supply boost power for its high endurance cutter, the *Hamilton*, under construction at Avondale Shipyards in New Orleans. It will be the primary powerplant for a deHavilland Royal Canadian Navy hydrofoil. The gas generator portion of the FT4, with power turbines furnished by Stal-Laval of Sweden, will provide boost power for two Royal Danish Navy frigates.

One FT12 (JT12) free turbine unit developing up to 3,400 horsepower was being tested in a Navy LCM-8 (Landing Craft, Mechanized). Another FT12 was providing power for a 53-foot experimental planing boat sponsored by United Aircraft to serve as a test and development platform for gas turbines, propellers, gears, controls, navigation equipment and items manufactured by various divisions of the corporation. Speeds of 55 miles an hour were attained in preliminary tests.

There were at year-end more than 30 Pratt & Whitney Aircraft turbopower and marine units in operation to pump natural gas, provide peak electricity, and to extract helium. The Dow Chemical Company also ordered three FT4's for production of both electric power and steam at its Pittsburg, California, chemical complex. The installation there, scheduled for mid-1966, will mark the first time P&WA jet engines have been used for primary, or base load, electrical power production.

Field service operating experience on the installed units in industry and marine applications exceeded 210,000 hours at year-end.

The Pratt & Whitney Aircraft ST6, produced by United Aircraft of Canada, has been operating in the 33-foot, high speed Norwegian-built cabin cruiser, *Rimfakse*, since 1963. It was selected in 1965 by the Royal Canadian Navy for use on its newest hydrofoil vessel, along with an FT4. It was evaluated by the U. S. Army in an amphibious supply vehicle. The U. S. Navy Bureau of Ships approved the ST6 after a 1,000-hour endurance test. The approval marked the first time a gas turbine engine of this power class, 445 shaft horsepower, met such Bureau of Ships requirements. Navy diesel fuel was used in the tests.

The small ST6 is the marine version of the PT6 turbine engine. This FAA-certificated engine, first operated in 1959, was in full production during 1965 by United Aircraft of Canada for more than ten aircraft and helicopter programs, including the twin-engine Beech King Air. The PT6 turboprop engine develops 578 equivalent shaft horsepower and weighs 270 pounds; the turboshaft model develops 550 shaft horsepower and weighs 245 pounds.

On July 1, the Atomic Energy Commission announced that because of reduced budget authorization for the SNAP-50/SPUR program, the Government-owned Connecticut Advanced Nuclear Engineering Laboratory (CANEL), operated by Pratt & Whitney Aircraft in Middletown, Connecticut, would be closed. Earlier, engineers completed a year of successful test running of a molten lithium lubricating bearing of the prototype size required in development of a SNAP-50/SPUR nuclear space powerplant. The engineers also had successfully operated an engineering-sized lithium-columbium alloy heat transfer system for 10,000 hours, or 14 months. The system was run at 2,000 degrees Fahrenheit and at a power level of 5,000 kilowatts, an endurance test comparable to running a motor car 500,000 miles without any maintenance whatever. Dr. Glenn T. Seaborg, chairman of the AEC, commended Pratt & Whitney Aircraft for its outstanding contributions to AEC programs and assured the company that the closing of CANEL in no way reflected on management or technical performance. The 1,200 employees at CANEL were reassigned within the corporation.

Construction began during the year on new office and factory buildings, adding nearly a million square feet to the existing 4,800,000 square feet of engineering, manufacturing and office space in East Hartford.

Employment at the end of 1965 was 45,000.

RADIO CORPORATION OF AMERICA

DEFENSE ELECTRONIC PRODUCTS

The Radio Corporation of America is one of the world's most broadly based enterprises devoted entirely to electronics. RCA has pioneered in many areas of electronics, communications, and space sciences, from microminiaturized electronic components to enormous space surveillance systems. The Defense Electronic Products activity is comprised of five separate divisions specializing in a variety of areas vital to national defense and space technology.

AEROSPACE SYSTEMS DIVISION

Aerospace Systems Division at Burlington, Massachusetts, through its diversified talents and comprehensive systems engineering capabilities, contributed significantly to the state of the art during 1965 by means of Government and company-sponsored studies and field support of major aerospace systems and reliable products.

RCA provided assistance on overall systems and hardware engineering on the electronic subsystems to support Grumman's successful proposal for LEM on the Apollo Program. At year-end, ASD was under contract to Grumman to supply the Rendezvous Radar, Transponder and Landing Radar, together with radar ground support equipment, for the LEM vehicle. The Communications subsystem consists of S-Band Steerable Antenna, Erectable Antenna, Transceiver Assembly, Power Amplifier Assembly, and Duplexer Assembly, as well as a Premodulation Processor Assembly, VHF Transceiver Assembly, and Audio Center Assembly. RCA was also working on a Grumman contract for the Attitude Translation and Control Assembly (ATCA) and the Descent Engine Control Assembly (DECA). ATCA provides the timing and sequencing signals for firing the jets for attitude and translation control as well as the automatic turn signals for the gimballed descent engine. DECA will control the descent engine of LEM throughout the power descent to the moon, turning the engine on and off and controlling the intensity and direction of its thrust. Its mission complete with the touchdown on the moon, the DECA will be left behind with the remainder of the LEM descent stage.

In 1965, ASD was under contract to the Army Missile Command for the Land Combat Support System (LCSS) program. This included all studies, investigations, design, engineering fabrication, modifications, and test equipment which will provide complete maintenance capability for the TOW, Lance and Shillelagh Missile Systems. Depot Installation Maintenance Automatic Test Equipment (DIMATE), developed by RCA for the Army Electronics Command and installed at Tobyhanna, was designed to determine the feasibility of automatic test systems capable of "trouble-shooting" assemblies of Army electronic systems. It can reduce conventional testing time by as much as 75 percent.

Under Air Force contract, RCA/ASD is developing the AN/TSQ-47 system for the U. S. Air Force. The AN/TSQ-47 is an Air Traffic Control/Communications System for use by the Air Force Communications Service Mobile Squadrons to support advanced air bases in a tactical employment, newly acquired air bases under combat conditions, temporary replacement or supplement to a fixed facility, and training, and mobility exercises.

The AN/APN-155 Low Level Altimeter was developed under contract for McDonnell Aircraft Corporation and qualified for use in the F4C high performance jet aircraft. It has been a highly successful solid state equipment which was put into production this year, and its excellent acceptance has resulted in follow-on orders to the original procurement.

The Radio Corporation of America is currently conducting research programs on laser devices at the Aerospace Systems Division. ASD performed a Laser Design Concept Study for the U. S. Navy. In this study, a high-energy, short-pulse laser system employing frustrated total internal reflection isolators was investigated. ASD was awarded a contract by the U. S. Army for the design, fabrication and testing of a quantity of Laser Rangefinder systems. Under contract to the Naval Air Development Center, ASD is developing for delivery a Blue-Green Laser Transceiver Unit.

ASD is also doing development work for the Air Force on the AN/FSR-2 Optical Tracking System.

ASTRO-ELECTRONICS DIVISION

Astro-Electronics Division, near Princeton, New Jersey, has achieved a unique place in the field of space science for the design and fabrication of long-life un-

The compact, 12-pound tape recorder which records data aboard the Gemini spacecraft was built by RCA's Communications Systems Division.

manned spacecraft. This division has become a leader in the development of weather satellites, communications satellites, scientific satellites, lunar and interplanetary spacecraft systems. AED has achieved an enviable record of successful spacecraft such as Relay I, Relay II, TIROS II, TIROS VI, TIROS VII and TIROS VIII. Known as the RCA Space Center, its environmental testing facilities rank among the most extensive in the industry.

AED 1965 systems competence covered the design, fabrication, integration, and test of complete spacecraft, such as TIROS and Relay, as well as major subsystems for spacecraft such as Ranger, Lunar Orbiter, Nimbus, Apollo, OGO and others. Space-qualified and flight-proven subsystems designed and built by the division encompassed power supplies, communications, television, data storage, command and control, and stabilization. In addition, AED designed and built complete ground stations and specialized ground-station subsystems.

A new experimental wheel-mode satellite, TIROS IX, was launched early in 1965. In the wheel mode the satellite "rolls" around its polar orbit permitting complete coverage of the earth every day. TIROS X, launched in mid-1965, was the first standard configuration TIROS sent into polar orbit. In addition, AED was a co-contractor for the Nimbus Advanced Weather Satellite Program.

Ranger VIII and Ranger IX, launched in early 1965, were the second and third successful steps toward the selection of a manned lunar landing site. AED did the design, fabrication, and test of the TV payload and ground equipment for these space exploration efforts.

COMMUNICATIONS SYSTEMS DIVISION

Communications Systems Division has its principal facilities located in Camden, New Jersey; New York City; and Tucson, Arizona. Each of these comprehensive facilities consists of a complete engineering organization capable of effective project management and comprehensive systems and product engineering through all phases of design, development, and manufacturing.

A major 1965 effort involved the AN/TRC-97, designed for the U. S. Marine Corps, a solid-state, highly mobile radio relay terminal providing tunable microwave, diffraction, or tropospheric scatter communications in the military band of 4,400 to 5,000 megacycles. With minimal size, weight, and power requirements, it delivers full duplex multichannel voice, data, or teletype communications over paths ranging from 1 to 100 nautical miles.

The AN/PRC-25 Tactical FM Radio Set, a most sophisticated equipment, was being produced for the U. S. Army as well as international customers. It is a battery operated man-pack FM Receiver/Transmitter which provides two-way voice communications over distances up to 10 miles. The equipment is completely transistorized.

An advanced microelectronic radio set, AN/PRC-62, was developed for the Army. This system is a single sideband (SSB) radio set designed for use by combat support units of company, battalion, brigade and divisions. The basic radio set, capable of being transported and operated by a single man, consists of a receiver-transmitter unit with its lightweight rechargeable battery power source, antenna and handset.

Being built for the Navy was the AN/ARC-104 Microelectronics HF SSB Radio Set, a long range, high frequency, single sideband communications set. The design of this advanced integrated electronics set features maximum use of the most advanced microelectronic circuits and techniques.

CSD was awarded a $10 million contract in July, 1965, by The Boeing Company to supply electronic operational equipment and maintenance ground equipment for the modernization of Minuteman I system to Minuteman II system.

Automatic Digital Network (AUTODIN), a vital link in the U. S. Air Force worldwide logistics-data communications network, is the world's largest and most advanced operational data communications system. Under contract to Western Union, RCA designed, developed, produced, programmed, and installed the automatic digital message switching and circuit-switching equipments and magnetic tape subscriber terminals for AUTODIN/ComLogNet. The 1965 AUTODIN contract represented the third major enhancement and expansion of that network.

MISSILE AND SURFACE RADAR DIVISION

The Missile and Surface Radar Division is located on a 433-acre tract at Moorestown, New Jersey. Here is where the highly advanced radar net, BMEWS, was designed, developed and manufactured for installation at three widely separated sites in the Western Hemisphere.

From the installation of the first precision monopulse tracking radar, the XN-1 at Patrick Air Force Base in 1957, the Missile and Surface Radar Division has designed and produced a family of 70 such radars of ever-increasing sophistication and capability; they are installed at locations around the globe, both on land and at sea. The standard RCA

The RCA Missile and Surface Radar Division outfitted and managed the instrumented American Mariner for the Downrange Antimissile Measurement Program.

AN/FPS-16, and its transportable version, the AN/MPS-25, are precision C-Band Instrumentation Radars procured through BuWeps for the Air Force, Army, Navy and NASA, and are ideally suited for assuring range safety and for tracking rockets, missiles, nosecones, boosters, tankage assemblies, instrument packages, debris, earth orbiting satellites, and space vehicles. The AN/FPQ-6 instrumentation radar and its air transportable version, the AN/TPQ-18, represent a major forward stride in the detection, acquisition and precise continuous measurement of the position of missiles and space vehicles in flight. A major contract was awarded by NASA in March of 1965 to RCA for AN/FPQ-6 radars.

RCA's successful implementation of TRADEX led to the award of contracts on PRESS by Lincoln Laboratories. These contracts provided for the implementation of an airborne optics control system, consisting of multiple station keeping and acquisition radars for a remote South Pacific site, and a PRESS control center, comprising consoles, displays and switching.

Under the Apollo Reentry Ships Program, M&SRD was developing the first precision tracking radar to use integrated circuits for all tracking functions. This instrument is known as Compact All-Purpose Range Instrument "CAPRI."

The first major real-time ground support system for space missions to use integrated circuits was to be installed on the Eastern Test Range in 1966 by M&SRD. The system will enable flight scientists to select and call up various telemetry data from space vehicles while they are in flight down the Eastern Test Range. More than 30,000 integrated circuits are used in this equipment providing a 10 to 1 reduction in space, weight and power requirements over conventional circuitry. A continuing program of research led to miniaturization of radar components and M&SRD also made substantial advances in phased array, radar tracking and techniques.

RCA also developed a high performance tactical radar, UPS-1, for use by the Marine Corps, Air Force, Army and Navy. It is packaged in lightweight units, suitable for transportation and operation in the assault phases of amphibious operations. RCA was working during the year on contracts for this equipment for U. S. as well as foreign government requirements.

M&SRD was being funded for SAM-D, a large-scale study and development program to formulate advanced air defense systems for field armies of the future.

WEST COAST DIVISION

In September, 1965, RCA established a new West Coast Division made up of the Van Nuys, California, facilities and Aviation Equipment Department in Los Angeles, California.

The West Coast Division received a contract from NASA's Marshall Space Flight Center for the production of a number of ground computer systems to be used for the checkout and launch of the Saturn IB and Saturn V launch vehicles. Over $20,000,000 in contracts were awarded to WCD in 1965 by NASA on this program. The Saturn V rocket is the launch vehicle for the Apollo manned lunar mission. The computer system includes the RCA 110A computer, conventional input-output equipment, digital and analog stimulus and measuring equipment, and high-speed data communications equipment.

WCD's data handling capabilities included the RCA 110A Computer, a general-purpose digital computer capable of automatic monitoring and control. By virtue of its Series 4100 Real-Time Data Processor and Teletype Data Exchange, WCD is a principal contributor to RCA's overall capability in digital communications and message switching. The RCA 4102 Data Processing System is a complete transistorized general-purpose digital computer system economically providing excellent performance in both data processing and real-time applications.

The problem of displaying computer data to personnel in easily understood, quickly assimilated form has been the subject of intensive development by West Coast Division engineers for many years. Display technology has been advanced in such basic products as Saturn data link and analog displays, Rome Air Development (RADC) displays, and Models 6050/6051 Video Data displays. Major emphasis has been in the command and control application and management control application.

In the area of command and control application, WCD contributed complete display systems to the NASA Saturn SI and SIB programs.

In addition to the significant amount of experience gained by WCD in incorporating status-monitoring and fault-location provisions in Atlas and Talos launch control and checkout equipment, the display requirements met for the Ballistic Missile Early Warning System (BMEWS) have advanced the state-of-the-art.

RCA-WCD also gained considerable experience in electronic warfare systems as they relate to hostile threats to ground-based, shipborne, airborne, re-entry and orbital military vehicles, and in electronic countermeasures techniques and operational equipment based upon the requirements of these vehicles. This background included contracts with three of the military services. Study programs in the areas of satellite survivability and re-entry vehicle penetration aids also resulted in valuable experience in advanced countermeasures techniques.

The Aviation Equipment Department is devoted to the development, design and manufacture of electronic flight aids for aircraft. Its customers include most of the free world's commercial airlines, feeder airlines, business aircraft, and some military aircraft. All products have FAA certification. They are flight tested through long cycles of operation under actual flight conditions, as well as being thoroughly laboratory tested. Products include: Weather Radar Systems, Transponders, and Airborne Distance Measuring Equipment.

ROCKWELL-STANDARD CORPORATION

AERO COMMANDER DIVISION

A highlight of the year for the Aero Commander Division of Rockwell-Standard Corporation was its entry into the single-engine aircraft field with two models. First of the new aircraft, shown at a press conference on July 12, was a 4-place, high-wing craft designated the Aero Commander-100. The plane, originally developed by the Volaircraft Corporation, grosses 2,250 pounds, has a maximum cruising speed of 142 miles per hour and a range of more than 600 statute miles.

The company announced that marketing headquarters for the Aero Commander-100 would be in Aliquippa, Pennsylvania. Dealer franchises were being offered to selected distributors of the twin-engine Aero Commander line, but the new franchises were not intended to be limited to existing Commander distributors.

Plans called for production of about 180 Aero Commander-100's in 1965, with production expanded in 1966 to a minimum of 500 aircraft.

The second of the single engine planes was developed and certified by Meyers Aircraft Company. A 4-place, low-wing craft with speeds above 200 miles per hour and range of more than 1,300 miles, it was designated Aero Commander-200.

Marketing headquarters for the 200 model were located in Tecumseh, Michigan. At the end of 1965, Rockwell was producing 8 planes a month. The company augmented production facilities for the 100 and 200 with a new facility, in Albany, Georgia. The Albany plant was started in 1964 and by mid-year 1965 was producing tail sections for piston and propjet Aero Commanders. Located adjacent to the Albany Airport on 347 acres of land known as Rockwell Industrial Park, the plant has more than 200,000 square feet of floor space devoted to the support of Rockwell-Standard aircraft production plants in Bethany, Oklahoma, and in Aliquippa and Tecumseh. The latter two facilities were designated the Tecumseh and Aliquippa Divisions of Aero Commander, Inc.

Aero Commander's 1965 line included the Aero Commander B, the Grand Commander, the Pressurized Grand Commander, the propjet Turbo Commander and the Jet Commander. The company estimated 1965 production of about 45 Jet Commanders and 48–50 Turbo Commanders; 91 production positions had been assigned for the latter plane.

In 1965, the company added another facility next to Aero's existing sales/service hangar at Bethany. The $500,000 facility has 34,440 square feet of floor space and 77,000 square feet of ramp space. It was to be used for expansion of customer service operations and production flight test.

In 1965, Rockwell-Standard announced its intention to expand further in the aviation field and predicted that Aero Commander sales would reach the $100,000,000 level "in the very near future."

ROHR CORPORATION

Growing volume of aircraft production accompanied by increasing product diversification and advances in manufacturing technology kept activity at a high level at Rohr Corporation plants during 1965.

The company's utilization of numerically controlled equipment and conveyorized assembly operations grew substantially during the year, with consequent increases in production efficiency.

While the company's two divisions, Antenna and Space Products, were active and successful in their respective fields, the bulk of Rohr's business volume continued to result from subcontract production of major structural assemblies for multi-engine aircraft. The company at year-end was participating in every major, multi-engine transport aircraft program in production, both military and civilian.

Turbine engine power plant assemblies, including engine build-up and sheet metal components, remained a basic Rohr specialty. These were being produced by Rohr for Boeing's 707, 720, 727 and 737 series of jetliners; Lockheed's C-130 and C-141 logistics transports, P-3A Navy patrol aircraft and JetStar military-executive transport; Douglas' DC-8 and DC-9 jet airliners, and Grumman's Gulfstream II business jet.

In addition to the power plant assemblies, Rohr's aircraft production included fuselage sections, stabilizers, elevators, thrust reversers, struts, ailerons, landing gear pods and doors, cargo doors, wing-to-body fairings, flight and ground spoilers, wing joint fittings, and many other items.

Installation of a Propulsion Components Test Facility at the Chula Vista plant during the year allowed acceleration of the company's research programs aimed at meeting the requirements of the next generation of turbine engines, particularly in the area of thrust reversal equipment and other "hot end" structures.

Increasing demand for adhesive bonded structures, both honeycomb sandwich and metal-to-metal, led to expansion of bonding facilities at the Riverside plant, including installation of a fifth production autoclave with an inside working diameter of 15 feet and a length of 35 feet. The second Rohr autoclave of this size, the unit is capable of handling the extremely large assemblies associated with new and anticipated aerospace programs.

Meanwhile, the Rohr Antenna Division completed the erection phase on its 210-foot diameter tracking antenna at the Goldstone Deep Space Station in the Mojave Desert. Designed, fabricated and erected by Rohr for NASA and the Jet Propulsion Laboratory, this largest and most precise antenna of its kind was scheduled to go into operation as a part of NASA's Deep Space Instrumentation Facility early in 1966.

Other Antenna Division projects included troposcatter antennas for communications between ground stations, microwave relay antennas, ground-mounted for shipboard radar antennas, steerable antennas for satellite communications, rotating radomes for optical telescopes and a 36-foot diameter high precision radiotelescope and rotating radome.

In still another diversified area, Rohr's Space Products Division participated in several large solid rocket motor programs in the course of the year.

As a major subcontractor to the companies participating in Air Force Space Systems Division's Large Solid Rocket Motor Feasibility Program, Rohr fabricated hardware for virtually all of the major test firings.

Rohr built laminated, ablative nozzles of varying sizes, and provided insulation and other major components used in the firings of 20 large solid propellant rocket motors without a failure of a Rohr component.

Rohr's primary 1965 customers in the space products field were the Lockheed Propulsion Company, Thiokol Chemical Corporation and the United Technology Center.

The Space Products Division also developed capability in fabrication of fiberglass structures, including filament would pressure vessels and a variety of flat and contoured panels.

In order to cope with the size and varied configurations of solid rocket motor hardware, the Space Products Division was equipped with some of the largest special purpose turning machines, hydroclaves and handling equipment in the industry.

Development of this equipment was accomplished largely in-plant, with new machine designs and adaptations accomplished by Rohr engineers. Similarly, at the Chula Vista plant Rohr developed a number of its own machines during the year, both special milling machines and such equipment as a numerically controlled riveting machine. Control systems also were developed by Rohr personnel to meet specific conditions and requirements.

RYAN AERONAUTICAL COMPANY

Ryan Aeronautical Company's XV-5A lift-fan aircraft, its jet-powered Firebee target missile programs, space and earth electronics and a newly developed waterborne target system constituted the San Diego firm's major areas of advance during 1965.

The Ryan XV-5A compiled nearly 100 hours of flight time at Edwards Air Force Base as the year ended and Phase II flight tests concluded.

Formal acceptance of the aircraft by the Army in January was followed by an expanded flight test program that was to include 250 flights, more than 90 vertical takeoffs and landings and 125 conversions from conventional flight to VTOL or VTOL to conventional mode. The XV-5A was being developed under contract to the Army Aviation Materiel Laboratories, Ft. Eustis, Virginia.

Ryan's active interest in V/STOL concepts was also represented in the tri-service XC-142A transport, built by the combined team of LTV-Hiller-Ryan. The first two of five models built for Army, Navy and Air Force use were delivered to Edwards Air Force Base in mid-1965 for operational evaluation.

Firebee target missile programs continued to serve as one of Ryan's primary production programs through 1965. Built for use by all the services in weapons system evaluation and ground-to-air and air-to-air exercises, the jet-powered Firebee served as the primary target vehicle for Springboard–65, conducted in the Caribbean Sea during the first three months of the year. Ryan provided contract field services at Roosevelt Roads, San Juan, Puerto Rico, to assume responsibility for operational maintenance and control of Firebees.

Army Air Defense Command programs at White Sands and McGregor Firing Ranges in New Mexico continued to use the 600-mile-an-hour Firebee targets throughout the year. The addition of Ryan-developed Towbee aerial targets, used in conjunction with Firebees, extended Ryan capabilities well beyond previous levels. Fitted onto the wing-tips of Firebee vehicles at launch, the Towbee targets are streamed out in flight and serve as primary targets for Nike and Hawk missile crews.

Permanent launch and control facilities for Firebee operations at McGregor Range were established in conjunction with the Army's training programs there.

Within the area of Firebee activity, but reflecting significant advance, was the evolution of Ryan's multipurpose Firebee for the Army, designated the MQM-34D. Offering weapons delivery, surveillance or target vehicle capabilities, the expanded application Firebee was given slightly extended wingspan and a thrust boost to accommodate a 1,000 pound payload capacity.

Firebee target missiles played the lead role in the Air Defense Command's biennial William Tell Weapons Meet at Tyndall Air Force Base, Florida. Fighter-Interceptor squadrons based throughout the U. S., in Canada, Alaska and Europe competed in the nine-day aerial weapons meet, which closed as the most successful event of its kind ever held.

In August, the Navy Bureau of Weapons announced the award of a contract to Ryan to develop a growth version Firebee, designated XBQM-34E, whose capabilities will include supersonic regimes. Wind tunnel testing and developmental advances were experienced during 1965 with flight and static test models scheduled for delivery in early 1967.

Shortened wings, longer, slimmer fuselage plus a 140-pound engine boost are supersonic features of the Firebee II. The new breed Firebee will carry a jettisonable fuel pod which can be discarded in flight following completion of subsonic missions. Assuming its supersonic configuration, it will then offer speeds up to 1,000 miles per hour.

Under areas related to Space Electronics, Ryan continued intense work schedules during 1965 on development of its radar landing system for use in the Lunar Excursion Module. Under contract to Radio Corporation of America, the Ryan-built system will guide man's Apollo landing on the moon. A prototype of this system was built and was being flight tested in late 1965, with modifications and continued test work scheduled for the balance of the year.

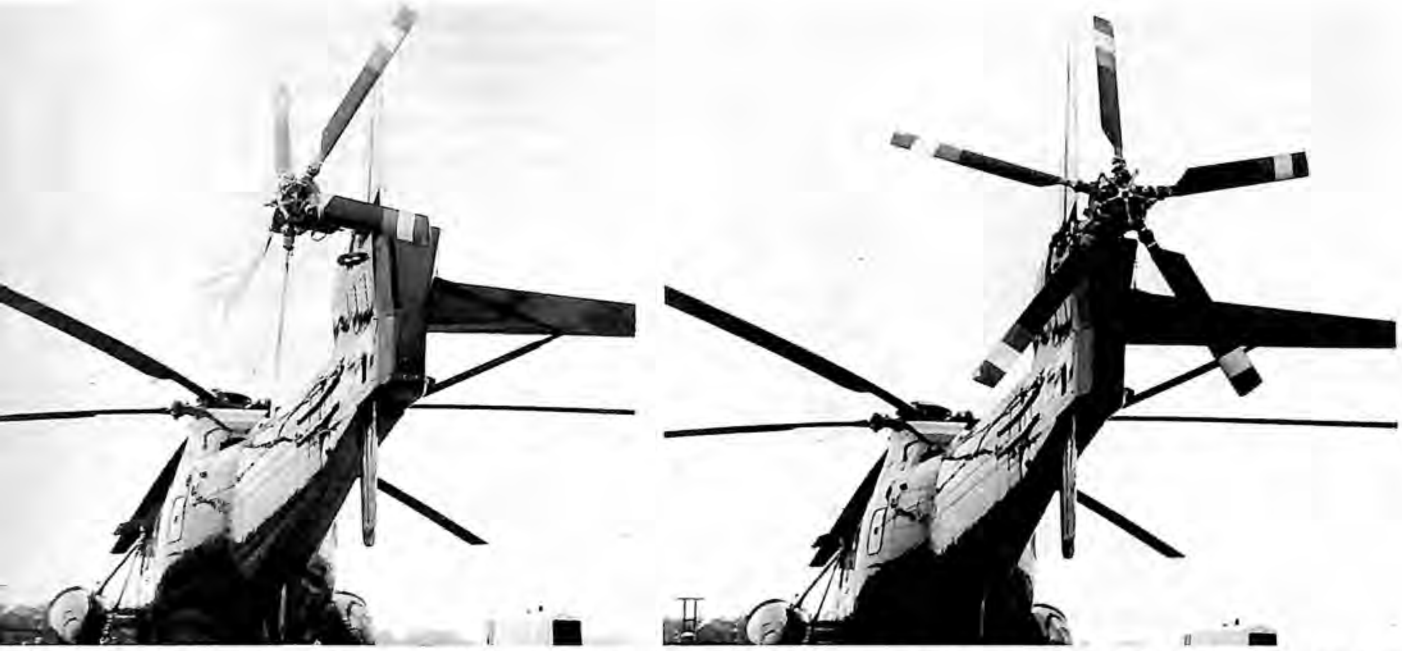
Ryan was also serving as prime subcontractor for the system which will soft-land Surveyor on the moon and, in addition to the landing radar systems, was providing solar substructures for use as a space vehicle component in collecting the sun's energy.

Ryan space altimeters for altitude measurements continued at a strong pace during the year. Demonstrated capabilities of this sytem included the Mariner IV vehicle program in 1965 in which measurement accuracy of 100 feet in an altitude measurement of 310 miles was registered.

Ryan produced the first waterborne, remote-controlled target boat ever used by the Navy in early 1965, delivering a number of its Firefish systems to units in the Atlantic and Pacific Fleets. Design and production of Firefish came after Navy destroyers were attacked by North Viet Nam PT-boats in the Gulf of Tonkin. Remote-controlled, the Firefish target boats attain 30 knots and perform the full range of evasive maneuvers which hostile craft might be expected to use.

SIKORSKY AIRCRAFT
Division of
United Aircraft Corporation

The start of full-scale production of the new Ma-



Sikorsky's new Rotoprop, which can change spin axis in flight, serves as either a helicopter tail rotor (left) or as a pusher propeller for VTOL's (right).

rine Corps CH-53A heavy assault helicopter, further proving of the S-64 Skycrane (including establishment of new world altitude records), and continued delivery of SH-3A antisubmarine helicopters to the Navy, CH-3C transports to the Air Force and HH-52A search and rescue craft to the Coast Guard were indicative of an active year for Sikorsky Aircraft and its products during 1965.

In addition, the United Aircraft Corporation Division revealed its revolutionary new Rotoprop tail rotor-propeller, conducted significant flight operations with its S-61F compound helicopter, and became a finalist in the Army competition for a new advanced aerial fire support system (AAFSS).

Flight delivery of three S-61N's to Greenland and another to England brought to 20 the number of twin-turbine aircraft of the type in commercial operation in this country and abroad. Continued production of the piston-powered S-58 transport, first flown in 1954 and in operation during 1965 in more than 30 countries, was guaranteed with receipt of additional orders for delivery to Military Defense Assistance Program countries.

In a move to increase its long-range search and rescue capability while retiring some older fixed-wing aircraft, the Coast Guard selected the S-61R in the configuration currently being delivered to the Air Force as the CH-3C. With the Air Force, the CH-3C had been delivered to six major commands. Its missions included long range rescue, drone retrieval, space hardware and astronaut recovery at the Cape Kennedy launch sites, mapping and personnel and cargo transportation.

After a year of intensive testing and naval preliminary evaluation at the Stratford plant, Sikorsky prepared CH-53As for demonstration at Naval Air Test Center, Patuxent River, Maryland, at the end of the year. In early 1966, Board of Inspection and Survey trials were to begin at Patuxent River, to be followed in the spring by the Fleet Introduction Program at Santa Ana, California.

As its proposal for the Army AAFSS, Sikorsky chose a compound helicopter with a fixed wing and a Rotoprop, a device designed to serve as a conventional antitorque tail rotor in the helicopter mode and as a pusher propeller at high speed. The Rotoprop was proved successful during flight tests conducted with an S-61 on which a test installation of the device was used.

Configured as a test vehicle for a joint Army-Navy Research and Development project, the compound S-61F was aided toward high speeds by addition of two Pratt & Whitney J60 engines mounted outboard of the fuselage. Before wings were installed, the S-61F reached 242 miles an hour, believed to be the fastest a helicopter was ever flown without wings. Wings were added later and the flight test program continued.

Greenlandair, established to provide helicopter passenger transportation among towns and settlements in Greenland on a year-round basis, began operation with its S-61N's in June, covering more than 2,000 miles of routes from its headquarters in Godthaab. In England, International Helicopters, Ltd., formed by British European Airways and Okanagan

Helicopters to provide helicopter support for the offshore oil exploration activities of Shell Exploration, Ltd., made ready to transport men from the mainland to oil drilling rigs in the North Sea.

Concluding a two-year period of evaluation at Fort Benning, Georgia and other areas of the South, Army CH-54A Skycranes set three world altitude records. The new records included: carrying 11,000 pounds to 21,250 feet; 4,400 pounds to 27,500 feet; and 2,200 pounds to 29,300 feet. The CH-54A also carried 90 persons, including 87 combat equipped troops in a detachable van attached to the fuselage, believed to be the largest number ever flown at once in a helicopter. In Exercises Air Assault I and II, Skycranes carried loads including 20,000-pound armored personnel carriers, 155 millimeter howitzers, bridge sections, road graders and other heavy cargo. In September, the first CH-54A's of the 478th Transportation Company, Heavy Lift, arrived for duty in South Viet Nam. The company is a supporting unit of the First Cavalry Division, Airmobile.

SOLAR

A Division of International Harvester Company

Pioneering work in the development and manufacture of advanced aerospace components and systems, the introduction of a new gas turbine self-contained starter for jet propulsion engines plus the development of a new gas turbine-powered ground air conditioning system for business jets highlighted recent activities at Solar.

Significant achievements were made in several Solar manufacturing specialties such as electron beam welding, high temperature brazing and diffusion bonding. Continued research into the problems associated with forming and joining of materials such as beryllium, tungsten and molybdenum and their alloys made these materials available for use in space and nuclear projects.

Solar's experience in the design and production of lightweight, high strength structures led to several spacecraft antenna fabrication contracts including those for the Apollo and its Lunar Excursion Module. Many of the concepts employed in this work were developed by Solar engineers. The small, extremely lightweight antennas were fabricated from foil-gage metals such as Rene 41. To assemble the antennas Solar developed miniature spot welders to join each mode of the structure prior to brazing of the entire unit. Continuing activity in thin foil technology included investigation of materials systems and corollary development of forming and joining techniques necessary to produce advanced, lightweight, high strength sandwich-type structures for operation under extremes of temperature and structural loads.

Other activity in specialized structures included further work in the development of all-metal honeycomb for such uses as insulation, turbine blade tip seals and structural applications. One of the most interesting recent applications for all-metal honeycomb has been in energy absorption systems. With a coefficient of restitution of nearly zero, the structure has the ability to absorb large shock loads and can be used in aerospace applications where it is desirable to soften impact.

Solar continued to be heavily involved in the development and fabrication of propellant lines and fuel pressurization subsystems for space boosters and upper stage vehicles. Production continued at a steady pace on boundary layer control systems for the F4 Phantom II jet fighter. Solar also manufactured the air extraction system which is used for pressurization, air conditioning and other purposes on the B-70 triple sonic aircraft.

Volume production of the giant F-1 tube-and-shell heat exchangers for the Saturn V/SIC booster led Solar's heat exchanger activities. Other types either in production or development stages included plate and fin heat exchangers, space radiators and cold plates for specialized aerospace applications.

Clean room facilities at Solar were upgraded to include hydraulic level cleaning. They had previously been an approved source for pneumatic cleaning of aerospace components and systems.

As one of the worlds largest subcontractors of jet engine components, Solar was engaged in the fabrication of prototype components for advanced engines being developed by major aircraft engine firms—including engines with a thrust-to-weight ratio in excess of 20—in addition to the manufacture of components for current production engines.

Major emphasis was given to the development of protective coatings for new refractory materials systems, and research is being conducted with beryllium-beryllium oxide, molybdenum-alumina and tungsten-zirconia.

In the small gas turbine field, Solar received a development contract for a new gas turbine self-contained starter for aircraft jet engines and built prototypes for evaluation. The units are complete gas turbine engines which mount directly on main propulsion engines for cranking. Weighing only 75 pounds and producing 140 horsepower, they operate on fuel from the aircraft, and offer starting at one-half to one-eighth the cost of other types of starting systems. The gas turbine starter can be used with engines as the J57, J75, J79, TF30 and TF33.

During 1965, Solar announced a new integrated auxiliary power and ground air conditioning system for business jets and small commercial aircraft. Powered by a Titan gas turbine, the new system provides up to 25 kilowatts of either A.C. or D.C. electrical power concurrently with up to four tons of air conditioning or 100,000 BTU/hour of heating. Various models of the system were purchased for installation in JetStar, Falcon, F-27 and FH-227 aircraft. Increasing demand for the Titan turbine as a helicopter auxiliary power unit resulted in increased production during the year. The Titan gas turbine, available in ratings of 80 to 105 horsepower is used in every major U. S. military cargo helicopter program.

Use of 1,100 horsepower Saturn gas turbines in two National Aeronautics and Space Administration installations increased Solar's involvement in the nation's space efforts. The world's first gas turbine-powered towboat will be used to move missile stage and cryogenic tanker barges at NASA's Mississippi Test Operations. Four Saturn gas turbine generator sets will supply electrical power at an advanced spacecraft tracking station in the Mojave Desert. Solar gas turbine generator systems either in development or production stages have outputs of 10, 20/30, 45/60, 100/150, 200, and 750 kilowatts.

SPERRY RAND CORPORATION

Major Sperry divisions of Sperry Rand throughout the nation continued to develop and produce vital aerospace systems for military and commercial use during 1965.

On Long Island, the Sperry Gyroscope Company Division, a pioneer in the design and development of systems using microcircuits, was awarded several significant contracts for equipment based on these advanced design techniques.

One of these systems, the integrated light attack avionics system (ILAAS), was termed one of the largest potential avionics contracts of the decade. At the end of the year, Sperry was in contract negotiation for this system which will, for the first time, link together navigation, flight control, communications, weapons delivery, and displays. First installation was scheduled for the Navy's A-7 attack aircraft under development by LTV.

Design studies for a similar type of system for the General Dynamics F-111, designated the Mark II avionics, continued and at year-end the Air Force narrowed the competition down to three firms. Sperry was selected as one of the companies to continue its development work on this system which will integrate navigation, communications and weapons delivery.

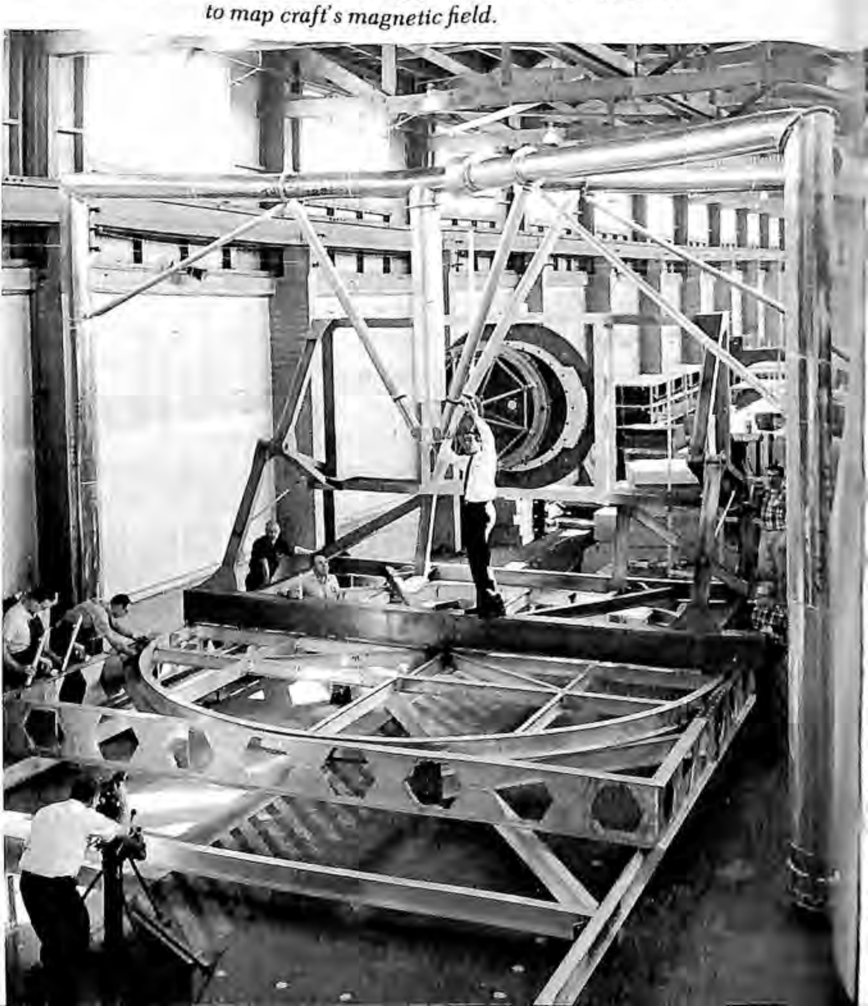
For helicopters, Sperry had underway an intensive development program in the field of vertical and horizontal displays. This equipment has a potential beyond the helicopter market and is applicable for future vertical takeoff and landing aircraft as well.

Cockpit windshield displays which present the pilot with all pertinent landing data including an outline of the runway, airspeed, altitude and the relative position of the aircraft were developed during the year and received extensive in-flight testing. Called HUD (head-up display), the system was extremely well received by military and commercial pilots participating in the test program.

Sperry's Loran navigation systems continued in production and development of the advanced Loran-D for tactical use proceeded toward joint Army-Air Force field tests scheduled for 1966. This system will enable ground and air forces to operate from the same exact position, thus enabling aircraft to locate ground targets within yards.

During the year deliveries began of the first microcircuited production Loran-C to the Air Force. This equipment, the AN/ARN-78 navigation receiver, is the first solid state airborne receiver to enter the Air

Engineers at Sperry Utah place test model of Mariner IV in device to map craft's magnetic field.



Force inventory. It has five times the reliability of any comparable receiver, is less than one-third the weight, and is less than one-third the size of comparable non-microcircuited systems.

In the commercial field, development continued on the SGN-10 inertial navigation system which Pan American Airways ordered for its jet fleet. This system is a complex of sensors and an airborne computer which enables the pilot to navigate without the help of sources outside the aircraft. Late in the year, a system was installed in a Boeing 707 as part of the test program and it performed well on oversea flights. SGN-10 systems were also ordered by Germany and Great Britain for evaluation.

Among other airborne equipment in production at year-end were: airborne radars for the Douglas C-133, Lockheed C-130, Boeing KC-135 and a variety of other aircraft and radar altimeters for numerous aircraft including the Boeing B-52, Lockheed C-130 and C-141.

For the space effort, NASA awarded Sperry a significant contract during 1965 to provide engineering support services for the Goddard Space Flight Center's Test and Evaluation Division. Sperry's responsibility includes the management programming operation and maintenance of the data collection and analysis system.

Also in the missile and space field, the Navy ordered from Sperry the first instrumentation radars to use microcircuits. They will be used for precision tracking of missiles and aircraft at the Pacific Missile Range.

Meanwhile, Sperry's space programs under way at the Long Island facility continued in the development and production of critical navigational equipment for both the Apollo and LEM lunar vehicles, the Lunar Orbiter, and space guidance systems. Several advanced study projects for the national space program were also being conducted.

Sperry Gyroscope Company Division also continued to advance the state-of-the-art in laser and infrared technology in its Electro-Optics group; manage the critical navigation system for the Navy's Polaris submarine program; moved into the field of deep submergence with important contracts including one to give the bathyscaph Trieste extended capabilities, and another for the design and construction of the instrument and control system for NR-1, a nuclear powered, deep-diving research craft; and continued to produce sophisticated radars for shipboard and ground use.

Sperry's international operations are conducted by Sperry Gyroscope Company, Ltd,, London; Sperry Gyroscope Ottawa, Ltd.; Sperry Gyroscope Company of Canada, Ltd.; and Sperry Europe Continental Company.

Another significant step in the space effort was a major NASA contract award which established the Sperry Rand Space Support Division in Huntsville, Alabama. This contract provided for support services which include evaluation and qualification testing, pilot manufacturing, process evaluation, facilities engineering, and design and evaluation of guidance and control systems. Sperry constructed its own facilities in Huntsville during the year to house this operation.

The Sperry Phoenix Company Division in Phoenix, Arizona, continued as a major aerospace contributor in 1965 and construction was begun on a new facility which would increase the size of the plant by 50 percent. Employment at Phoenix was expected to nearly double during 1966.

Sperry Phoenix was manufacturing or developing flight control systems for the Douglas DC-8 and DC-9; Boeing 727 and 737; Lockheed JetStar and C-130; Grumman A-6A and E-2, AO-1, and Gulfstream II; deHavilland CV-1; Fanjet Falcon; Hawker Siddeley DH-125; HFB-320 Hansa; and Bell UH-1B.

The division's compass systems were aboard the Douglas DC-8 and DC-9; Boeing 707 and 727; Lockheed C-130, C-141, JetStar, and F-104; General Dynamics F-111; Grumman OV-1 and Gulfstream I; Bell UH-1B; deHavilland DH-125; and over 20 light business twin-engine aircraft.

In addition, Sperry Phoenix designed and developed integrated instruments for the Douglas DC-8 and DC-9; Boeing 707; Grumman Gulfstream I; and Lockheed JetStar; turbine vibration indicators for jet engines; re-entry vehicle autopilots; and the emergency communications and homing beacons used on the Gemini and Apollo space vehicles.

During the year United Air Lines became the first U. S. carrier to fully qualify for new landing minimum which will reduce weather-caused delays and cancellations. The qualification, made with equipment which includes the Sperry SP-30 automatic pilot, permits jetliners to land with cloud ceilings of 100 feet and forward visibility of one-quarter mile.

The Sperry Microwave Electronics Company Division in Gainesville, Florida, acquired significant contracts in the field of ground checkout equipment for aircraft and missile systems during the year. Included was checkout equipment to test preflight operational readiness of missile beacon transponders, and flight line checkout equipment for the terrain-following radar of the Navy's LTV A-7A. The division was already producing similar checkout equipment for the Air Force's McDonnell RF-4C.

Sperry Semiconductor Division in Norwalk, Connecticut, continued as a major supplier of microcircuits to the electronics industry and during the year completed the installation of a multimillion dollar production facility to increase its output several fold.

Sperry Piedmont Company Division in Charlottesville, Virginia, while more widely known for its efforts in the area of marine equipment, made further inroads into the space field during 1965 with the completion of a major portion of the instrumentation for the Eastern Test Range at Patrick Air Force Base, Florida. The Sperry Piedmont equipment is part of the Missile Control Center at the Range.

At the Sperry Rand Research Center in Sudbury, Massachusetts, solid state scientists developed the application of a new insulating material to silicon during the year. This process promises a greater production yield of more electrically stable microcircuits, and a corresponding slash in the size and cost of microcircuited equipment such as air and spaceborne computers. In addition, atmospheric physicists have employed unique radiometric techniques in studies aimed at development of advanced warning systems to detect clear air turbulence areas ahead. In other areas display and computer scientists are working on new methods for transmitting wide-band pictures over narrow-band voice channels.

Diversity of products for use in all parts of the world and in space applications was "Progress Report 1965" from Sperry Utah. The year saw Sperry-produced Sergeant missiles continue to play an active role in defense with U. S. Army forces in the U. S., in Europe, and in the Pacific area. Army's Sergeant, in addition to its role in defense, carried a Navy experimental guidance system "piggyback" in tests at White Sands Missile Range in the spring. In September, approximately 800 West German troops participated in firings of the Sergeant at the Outer Hebrides Islands, Great Britain.

"SCAMP III" markings seen earlier in the year on rows of packing boxes on Sperry's shipping docks were only a hint that a team of 30 Sperry engineers and technicians and their families were going on a year's temporary duty in Europe to work with U. S. Army and West German troops updating Sperry Utah-produced Sergeant missile systems deployed with NATO forces there.

In 1965, the world had its first television report from the vicinity of Mars. Jet Propulsion Laboratory's Mariner IV spacecraft had been prepared in part for its journey by being passenger aboard a magnetically "dead" aluminum and plastic frame produced by Sperry. Called the Magnetometer Mapping Fixture, the device permitted precise measurement of Mariner's own magnetic field before its historic flight.

For use in Viet Nam, the Army Weapons Command in October placed an order with Sperry Utah for the production of more than 1,000 helicopter machine-gun mounts. The mounts will permit the addition of machine-gun fire power aboard the UH-1D Iroquois and the CH-47 Chinook helicopters for protection during troop carrier missions and the evacuation of the wounded.

One of the unique products of 1965 was the Army Tank Gunfire Simulator. Developed by the Army's Tank-Automotive Center, the simulator is a stainless-steel tube which clamps to the tank gun-barrel. A mixture of oxygen and propane injected into the tube is ignited electrically to simulate the explosion, muzzle-flash, and smokeplume of a live round of ammunition. Sperry Utah will deliver more than 400 of the simulators for use in training of Army tank crews and supporting infantry.

Scheduled to "go on the air" in 1966 was another Sperry Utah product: the Operational Television System for the manned spacecraft operations building at NASA's Kennedy Space Center at Merritt Island, Florida. The new system comprises television cameras, monitors, and remote control equipment which will permit viewing of astronauts and their spacecraft during simulated space flight training operations.

Bearing a striking resemblance to missiles, the main Sperry Utah product line was a 1965 newcomer to the company's production scene, the Air Force's TDU-9/B Supersonic Tow Target. The TDU-9/B is the latest member of the Air Force's family of supersonic aerial targets used for weapon system validation, combat aircrew training, and evaluation of air-to-air tactics. The 170-pound target is carried to the firing range clamped to a heavy duty reel launcher that is externally mounted to a supersonic fighter interceptor. In the intercept area, the pilot plays-out the target on a steel "fishline" which can be extended to any length up to nine miles.

The 151-inch missile-shaped target simulates a variety of targets electronically and reports to a ground station "miss-distance" information of the weapons fired, the Sidewinder, the Falcon, and the Genie Rocket. Reel-in of the 170-pound target is accomplished prior to landing the tow aircraft.

A prototype model of the Sperry produced TDU-9/B was on display for the first time at William Tell 65, the USAF World-Wide Fighter Interceptor Weapons Meet held at Tyndall Air Force Base, Florida. The first production model of the TDU-9/B was scheduled for completion in December, 1965.

The efforts of nearly 2,000 Sperry employees in the Salt Lake and Clearfield Freeport Center plants showed prominently in the hardware produced by the company. But "Progress Report 65" included advances in the "silent activities" that support the product show.

Since 1957 the company has received six major safety awards for man-hours worked without lost-time accidents. Included in this record was a one year-long stretch of nearly 8,000,000 man-hours, and two others of more than 7,000,000 man-hours each. In the year 1965, Sperry employees worked 2,200,000 man-hours without a lost-time accident.

The company's Value Engineering seminars continued to attract representatives of government, the military services, and industry. More than 600 persons participated in the week-long Value Engineering sessions to find new ways of improving the product and reducing its cost. Application of advanced Value Engineering and other cost savings techniques at Sperry effected more than $2,300,000 defense contract cost reductions within a 6-month period.

In 1965, approximately 300 employees participated in the company-sponsored, 100 percent tuition refund program. More than 2,700 employees have participated in this self-improvement program over the last nine years.

The year 1965 proved to be a year of growth and achievement for Sperry's UNIVAC Division.

UNIVAC's year of progress began in January with delivery of a $2,000,000 real-time reservations system to Northwest Airlines and was climaxed in December by a $39,000,000 order from United Airlines, for the design, assembly and installation of a powerful real-time, on-line reservations, operations and management data processing system.

It was also a year in which UNIVAC strengthened its technological position in the realm of space and missile guidance:

In February, a UNIVAC Athena Computer at Vandenberg AFB, California, successfully completed its 100th guidance mission, logging over 14,000 hours of faultless service.

Throughout the year, UNIVAC 490's in NASA Manned Space Flight Center and UNIVAC 1218's in tracking stations all over the world kept unerring second-by-second check on every aspect of Gemini space flights.

In February, NASA placed an order for a $2,600,000 UNIVAC 1108 Computer which, when delivered, will be the fastest and most powerful single system to be added to the space agency's complex of large-scale scientific computers.

In July, orders for forty UNIVAC 1230 computers (value $13,400,000) were announced for NASA's Apollo moon program.

The practice of pioneering new and unusual uses for UNIVAC computers continued unabated in 1965. Some of the standouts included: a computer program that enables the Canadian House of Parliament to automatically set type in French and English for its daily record of debates; a highly successful 5 month test conducted in conjunction with New York City Police Department to apprehend drivers of stolen cars with aid of a UNIVAC 490 Computer; supplying the computing elements (UNIVAC 1218) for Lincoln Laboratory's experimental portable satellite.

Sustaining an environment for growth by planning and building for the future was a high-priority activity for UNIVAC in 1965. The division introduced an impressive array of new products that will be the mainstay of its business in the years ahead: the UNIVAC 1001 Card Controller; the UNIVAC 1005 Data Processing System; the flexible and versatile UNIVAC 490 Real-Time Modular Series; and the "super computer," the UNIVAC 1108 II Multi-Processor System.

These systems as well as several significant advances in basic research computer technology and production techniques were providing UNIVAC with prime resources for continued growth. Added to these assets were a lengthening roster of major operating installations and a record of demonstrated leadership in all areas pertaining to the design and application of electronic data processing systems.

THIOKOL CHEMICAL CORPORATION

Thiokol Chemical Corporation scored a number of important achievements in both solid and liquid rocket engines during 1965.

In big boosters, Thiokol successfully fired, in February at Brunswick, Georgia, a 156-inch diameter, 100-foot solid-fueled rocket engine. The largest motor fired to that time, it generated 3,000,000 pounds of thrust during a 70 second burn time.

In other big booster developments, the largest segmented fiberglass 156-inch motor case was successfully hydrotested at more than 1,000 pounds per square inch internal pressure at Wasatch Division, which also began the winding of another 156-inch plastic case slated for firing in early 1966.

In addition, the largest submerged gimbaled nozzle ever built was successfully fired during the static firing of an Air Force Minuteman first stage solid propellant rocket test motor.

Steering systems for solid propellant rockets were demonstrated by the successful static test firing of a rocket motor using a new submerged nozzle employing chamber-bleed hot gas injection thrust vector control (TVC). This achievement was made possible by the development of a pintle valve that permits flow of secondary gases into the side of the submerged nozzle.

In October, Thiokol successfully test fired the 300th Minuteman Stage I solid propellant motor as part of a reliability improvement qualification program. In the same month the Navy Special Projects section awarded the first stage development of Poseidon to the Hercules-Thiokol team.

In space-solids developments, Thiokol's Elkton Division completed qualification of the solid retro motors for the Surveyor program. Elkton retro rockets also continued to return payloads from orbit in the Gemini and Discoverer programs. An advanced Surveyor main retro rocket, containing a new high energy beryllium solid propellant, was also successfully test fired. Other new propellants, which demonstrated the potential of beryllium to deliver increased ballistic performance, were also produced by Thiokol in a company-funded facility at Wasatch and successfully fired in large motors as part of the Air Force Adobe program.

Other achievements included completion of the flight verification tests for the Castor II motor and the first successful flight of Athena utilizing the Thiokol XM-33 rocket engine.

In liquid engine achievements for space, Thiokol's Reaction Motors Division completed qualification of the vernier engines for attitude control of Surveyor. Altitude simulation tests were also completed on the OF_2 engine at Arnold Engineering Development Center. RMD wound up the year by receiving the development, test and qualification contract program for the NASA C-1 "common" engine.

Achievements in the tactical category were made in both the liquid and solid areas. Continued production of Bullpup B raised to nearly 40,000 the total of prepackaged liquid rocket engines produced by RMD. As for solids, Thiokol continued its production of Minuteman, Sergeant, Pershing and Subroc motors.

In sounding rockets, Thiokol's Astromet Division provided Nike-Tomahawks for the probing of the atmosphere in shoots from Wallops Island, Ft. Churchill, Canada and Barotonga Island in the South Pacific.

Other milestones reached were the 30,000th rocket firing at Elkton; the 10,000th motor for Nike-Hercules delivered by Longhorn; and production of the 100,000,000th pound of PBAA propellant.

In the broad area of advancements in technology, Thiokol demonstrated a restartable solid propellant rocket motor, comprised of wafers of propellant interspaced with thermal barriers; continued its development work on air-ducted rocket motor engines; conducted significant work in wide temperature range propellants; demonstrated new mastic insulation as part of the 156-inch firing at Brunswick, Georgia; continued work on high energy propellants and air launch propulsion studies; conducted acoustical laboratory studies for limited warfare; and completed a study of seat catapult systems.

TRW INC.

TRW Inc. (formerly Thompson Ramo Wooldridge Inc.) increased both it's pace and stature in its role as a major contributor to the aircraft, missile and space fields in 1965 in the areas of systems engineering and technical assistance of missile and satellite programs, research and development of subsystems and components, study contracts on a variety of aerospace projects, and continuing production of components for manned aircraft engine programs.

TRW's Tapco plant built the nozzle for Aerojet-General's 260-inch rocket motor, successfully fired during the year.

A case in point was the TRW Systems operation (formerly Space Technology Laboratories). Where Systems was previously active only in missile and space work, the 1965 range of interests of this group expanded to encompass antisubmarine warfare, scientific instruments, and systems engineering and systems management of non-defense and non-space projects.

Hand in hand with its overall expansion program, TRW Systems initiated plans to add 500,000 square feet of manufacturing and engineering facilities in California, Texas and Washington, D. C. by the end of 1966.

Mariner IV's central computer and sequencer, built by TRW, helped the spacecraft sense its way on its historic fly-by of Mars. The company also built the thermal control equipment which maintained temperatures inside the spacecraft within limits tolerable to its electronics, and developed the guidance equations for the lift-off phase of the launch.

TRW negotiated a contract with NASA for increased responsibilities for mission and trajectory analysis in the Apollo/Gemini space programs. In another area of the Apollo program, the company began feasibility studies for an engine for controlling the movements of man and machine while on the surface of the moon.

The team of TRW, Douglas Aircraft and RCA was one of three selected by Jet Propulsion Laboratory to conduct studies on the Voyager spacecraft, a large, unmanned scientific payload to explore Mars. TRW also won a contract to study the feasibility of a spacecraft to probe the planets Jupiter and Pluto.

A six months' study program was completed and submitted to the Communications Satellite Corporation in which TRW proposed a commercial satellite system that offered a gravity-stabilized design to provide 100 percent communications service on 1,200 channels linking five continents. TRW zener diodes, high-Q Varicaps and transistors were used on Comsat's Early Bird Satellite, launched early in the year.

The Titan III-C Air Force booster which made its maiden flight in June was equipped with TRW's 120-inch nozzles. TRW's largest product, a composite plastic ablative nozzle measuring more than 15 feet in diameter at its widest ends, standing 20 feet high, and weighing over 17 tons, was completed and shipped to Aerojet General's Dade County, Florida facility. It was mated to Aerojet's giant 260-inch solid fuel engine and successfully static-test fired. In 140 fiery seconds, the huge motor consumed over 1,600,000 pounds of propellant and generated more than 3,000,000 pounds of thrust, the greatest total impulsive force ever achieved in a solid fuel engine.

Another significant delivery scheduled for 1966 is a 156-inch nozzle produced by a new TRW-developed manufacturing process. Production continued in 1965 in the area of nozzles and composite structures for the Minuteman, Polaris, Titan III-C, LEM, and S-IVB programs.

In support of a Pratt & Whitney Aircraft metallurgical development, TRW produced precision castings having a new grain structure that should extend the life of jet engines and open the way to more powerful and efficient engines for military and commercial applications.

TRW received contracts from NASA's Lewis Research Center to develop improved high-temperature alloys for more efficient gas turbine engines; one involving the production of cobalt-base alloys for stator vanes and another for nickel-base alloys for turbine buckets.

The Navy awarded TRW a contract to develop the main gear box for its DASH helicopter. The craft was scheduled for its first test flight in 1966, the first flight application of TRW's new roller gear drive.

A 1965 award of considerable significance involved the production of the complete propulsion system for an advanced version of the Mark 46 antisubmarine killer torpedo. TRW is the principal subcontractor to Honeywell, Inc. for this torpedo, which can be launched from air or surface craft, dive to a preset depth, travel in wide circles and, using sophisticated devices, seek out and destroy enemy subs. The company also continued to maintain its position as a major supplier of control rod mechanisms for the Navy's nuclear submarine fleet.

Production of jet engine parts and fuel pumps continued to be the production mainstay of TRW's Equipment Group operation. Substantial demand for components for commercial jetliners and increased procurement for military fighter aircraft boosted the company's manufacturing schedules. Important new aircraft pump orders in house included a contract from McDonnell Aircraft for double-ender fuel booster pumps to be used on the British version of the Phantom II multipurpose fighter (F-4K) and an order from Grumman for plug-in booster pumps for the Gulfstream II executive aircraft.

Rohr Aircraft placed a firm order with TRW for delivery of pneumatic actuators that are to be used by Rohr to demonstrate performance of a movable thrust nozzle on a VTOL aircraft. This represented the company's first sale of such actuator equipment, the know-how for which was licensed from the Plessey Company in England.

Additional variety in new business came to TRW in the form of an order from Union Carbide Corporation for a roller drive speed increaser for use on a medical centrifuge that ultimately will be used in conducting virus disease research for the National Institute of Health.

TRW's ordnance program continued to gather momentum in accordance with the company's long-range plans for that group. Award of an Army contract to make 18,000 M-79 grenade launchers combined with Browning sporting rifle production to create the desired balance between military and commercial work that has proved to be so beneficial to the company in the past.

UNITED AIRCRAFT CORPORATION

United Aircraft Corporation strengthened its hand in its traditional spheres of flight, made significant advances in rocketry and space technology, and continued to diversify into non-aeronautical lines throughout 1965.

The corporation provided the power for front-line military aircraft, achieved record sales of jet engines to airlines, and began producing new helicopters. In the space realm, it made important contributions to preparations for the manned moon shot, and its liquid-fueled rocket engines and solid-propellant boosters delivered power for successful orbital flights of NASA and Air Force rockets. Meanwhile, United Aircraft's research and development teams pressed ahead with a broad range of forward programs on the frontiers of technology.

In May the corporation added its seventh operating unit with the formation of the Vector division. Located in Trevose, Pennsylvania, Vector is a designer and manufacturer of telemetry equipment. It had previously functioned as a department of the Norden division since February, 1964, when United Aircraft acquired the assets and business of the former Vector Manufacturing Company.

During the year, United Aircraft enbarked on new construction that will add more than 1,500,000 square feet of floor space to facilities of Pratt & Whitney Aircraft, Hamilton Standard, and Vector divisions.

Because each division operates autonomously, reports of the company's technical and manufacturing activities for the year are reported separately under the names of the divisions. They are Pratt & Whitney Aircraft, jet and rocket engines, military and industrial powerplants, fuel cells; Hamilton Standard, propellers, electronics, accessories for spacecraft and aircraft, controls; Sikorsky Aircraft, helicopters, flying cranes, and other advanced vertical-lift vehicles; Norden, guidance, navigation, radar, and other electronic systems; United Technology Center, solid-propellant boosters and advanced space propulsion systems; Vector, telemetry; United Aircraft Corporate Systems Center, systems design and development.

United Aircraft Research Laboratories accelerated its materials research in advanced filaments and composites under contracts with the Air Force, Navy, NASA, and company sponsorship. It began marketing high-strength, continuous boron filaments, and it intensified its work on other promising fibers, such as silicon carbide, preparing on a laboratory scale fibers of high strength and stiffness.

A controlled solidification process patented by United Aircraft for direct production of whiskers embedded in the matrix yielded a promising new whisker-reinforced columbium alloy for high-temperature structural uses.

With Air Force support, the Research Laboratories went to work on supersonic combustion ramjets as part of its continuing interest in hypersonic air-breathing propulsion and rocket research.

From the labs' physics research came a significant new technique for producing a very high-temperature plasma of extreme purity. It involves the irradiation by a high-energy laser pulse of a single solid particle suspended in a vacuum by electrostatic fields. The development could result in important new knowledge applicable to efforts to achieve controlled fusion.

United Aircraft stepped up its level of activity substantially in 1965. In 1964, the last full year for which figures were available, the corporation reported net income of $29,084,040 on sales of $1,235,918,321, with unfilled orders totaling $1,200,-000,000. For the first half of 1965, net income was $21,152,649 on sales of $665,194,677. Approximately 70,000 persons were on the corporation's payroll as of October 31, 1965.

UNITED AIRCRAFT CORPORATE SYSTEMS CENTER
Division of United Aircraft Corporation

United Aircraft Corporate Systems Center moved ahead on several technological fronts during the year in its role of tying together the work of United Aircraft's divisions in systems projects calling for such a multipronged approach.

The center was set up in 1961 to manage, develop, and produce complex space, missile, military, and other systems and to serve as the management organization for major interdivisional systems efforts involving United Aircraft's other divisions. It also seeks to bring forth new products and subsystems not clearly falling within the province of any other division.

During the year, the center carried out a number of government- and corporate-funded study, design, and development projects in such spheres as space, guidance, weather, data processing, communications, transportation, and weapons.

One example of the interdivisional approach to projects managed by Corporate Systems Center was a high-speed experimental planing boat launched during 1965 in the Gulf of Mexico. Under the center's direction, the 53-foot vessel was built as a test and development platform for gas turbines, propellers, gears, controls, navigational equipment, and other products manufactured by divisions of United Aircraft. Pratt & Whitney Aircraft provided the boat's gas turbine drive, based on an aircraft-type jet modified for marine use. Hamilton Standard developed the titanium propeller.

Another interdivisional project involving Corporate Systems Center was the Air Force's Titan III-C rocket, launched successfully on its first test flights in 1965. The rocket's two solid-propellant boosters, developed by United Technology Center, are fastened to the liquid-fueled core vehicle by attachment structures designed by Corporate Systems Center and built by Sikorsky Aircraft.

Space and missile guidance remained a prime area of interest for the Corporate Systems Center, which made progress during the year in fulfilling its most significant contract: design and development of the inertial sensor assemblies for the abort guidance system of the Project Apollo lunar excursion module.

The center received a contract for continuance of its work as systems contractor for the Air Force 433L system, a program to modernize weather data collection and forecasting in support of military aviation. As part of this work, the center developed in 1965 an electronic digital-to-voice system that "talks" to pilots in a recorded human voice to give them weather information in flight. The system comprises film sound tracks on a rotating drum and a light-and-photocell arrangement, controlled electronically, which picks out the proper combination of words and phrases to reflect current weather conditions around an airfield.

The Corporate Systems Center also prepared detailed concepts for high-speed, lightweight passenger trains designed around aerodynamic principles and powered by aircraft-type turbine engines.

UNITED TECHNOLOGY CENTER

Division of United Aircraft Corporation

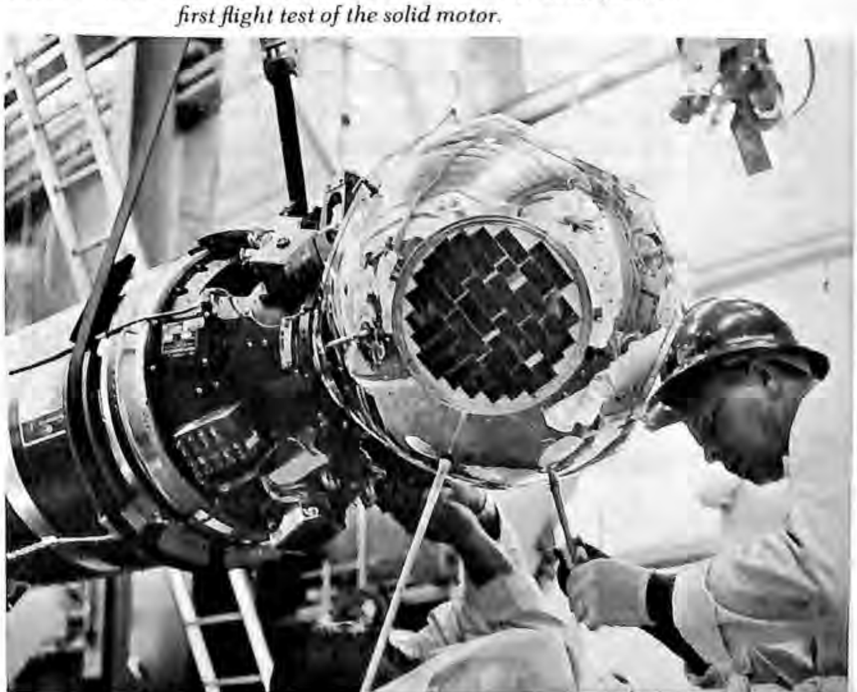
Fully successful first flights of the nation's most powerful solid-propellant rocket in flight status and of one of the highest performance small solid rockets highlighted 1965 activities at United Technology Center.

Pairs of the 1,200,000 pound thrust boosters which UTC produces for the Air Force Titan III-C space launch vehicle performed perfectly in the Titan III-C's first two flight tests, June 18 and October 15, from Cape Kennedy. The 86-foot tall, 250-ton boosters were produced in segments at UTC's Coyote, California, Development, Processing, and Test Center and shipped to Cape Kennedy by train. Each of the big, steel-encased rockets contained about 420,000 pounds of aluminized PBAN propellant and was equipped with a liquid injection TVC system. They provided more than 2.5 million pounds of thrust as the booster stage of the Titan III-C.

As the year ended, the company was studying development of other 120-inch-diameter, solid booster configurations to provide smaller and greater amounts of thrust for other possible versions of the Titan III.

UTC's FW-4S motor, developed and qualified in less than a year as an improved fourth-stage motor for the Scout space launch vehicle, proved its high performance in flights aboard a Scout and a Thor. The new motor, with a mass fraction believed to be the highest of any operational solid rocket, can increase the Scout's polar orbit capability by about 25 percent.

Technicians mate SECOR satellite to UTC's FW-4S motor prior to first flight test of the solid motor.



Other 1965 highlights for the United Aircraft Corporation division included: continued development and static test-firing of hybrid rocket engines; successful static firing of a new upper-stage, storable liquid-propellant engine with the highest efficiency of any known liquid rocket of comparable size; and laboratory demonstration that hybrid rocket motors can provide an efficient power source for tremendous bursts of electricity by means of magnetohydrodynamics (MHD).

UTC, with headquarters in Sunnyvale, California, maintains facilities that include one of the largest test stands in the nation for the static firing of large solid rockets and a new large mixing station, put into operation in 1965, which increases the company's solid-propellant production capacity to about 6,000,000 pounds a month.

VECTOR

Division of United Aircraft Corporation

Vector became United Aircraft's seventh operating division in May, 1965, and in September broke ground for a new 185,000-square-foot plant adjacent to its main facility in Trevose, Pennsylvania.

Vector, organized in 1956, designs and manufactures analog and digital telemetry systems. It became part of United Aircraft in 1964 when the corporation acquired the assets and business of the Vector Manufacturing Company. Before it became a full division of United, it functioned as a department of the corporation's Norden division.

Vector produces telemetry equipment for use in aircraft, missiles, satellites, manned spacecraft, and missile test-range communication systems. It also applies its telemetry capability to the medical field, developing patent-monitoring systems that simultaneously check the heart, respiration, temperature, and other physiological functions of patients undergoing intensive hospital care.

The year saw Vector make significant progress in its transition from a producer of standard telemetry components to a totally integrated producer of all microelectronic equipment and systems.

Initial production of a radiation-hardened missile telemetry system for the Defense Atomic Support Agency established the division as a primary source of such systems. The nuclear radiation levels specified for the system, which includes both airborne transmitting and ground receiving equipment, were highest under which electronic equipment has been required to perform. A ground-based data acquisition system was delivered to NASA for use in the manned space flight program. Production was undertaken under a contract for 50,000 transistors for use in relay equipment for community antenna TV systems being installed throughout the country.

WESTINGHOUSE ELECTRIC CORPORATION

Westinghouse pushed to completion the Guantanamo Naval Base sea water conversion and electrical power plants early in 1965, well ahead of schedule. Begun in 1964, this major undertaking put into operation a sea water conversion plant just 5 1/2 months after receipt of the Government order. The first unit of the power plant provided electricity less than 5 months later, in mid-December, 1964. A conversion plant at Point Loma, California, was dismantled, transported and reassembled at Guantanamo Bay. Two additional units designed and constructed by Westinghouse were added; they offered a total capacity of 2,250,000 gallons per day of potable water produced by "flash evaporator" technique. The Guantanamo installation was the 30th Westinghouse water conversion plant in operation or on order throughout the world, with a total daily production of 14,000,000 gallons of fresh water for public water supplies, industrial and electric power plants.

Pennsylvania's coal research board, sparked by the Guantanamo achievement, contracted with Westinghouse engineers for a study to convert acid mine waters into a major source of future public water supplies. Results of the research, announced in August, detailed the feasibility of building a plant which will produce 5,000,000 gallons of water daily, plus electrical power as a by-product, for only 33.3 cents per 1,000 gallons. This cost compares favorably with suburban residential rates ranging from 43 cents to over $1 per 1,000 gallons. The process is a refinement of the desalination method in operation at Guantanamo which not only converts sea water into fresh water but generates electricity as well. The study was the first phase of a 3-part research program preceding construction of a field plant capable of a 5,000,000 gallon daily production. The new process, which uses coal as fuel, was financed solely by contributions from Pennsylvania's coal industry. Second and third phases involved construction of a small operating pilot plant in the Westinghouse Laboratory at Lester, Pennsylvania, and the 1966 construction of the first field plant in Pennsylvania's coal region.

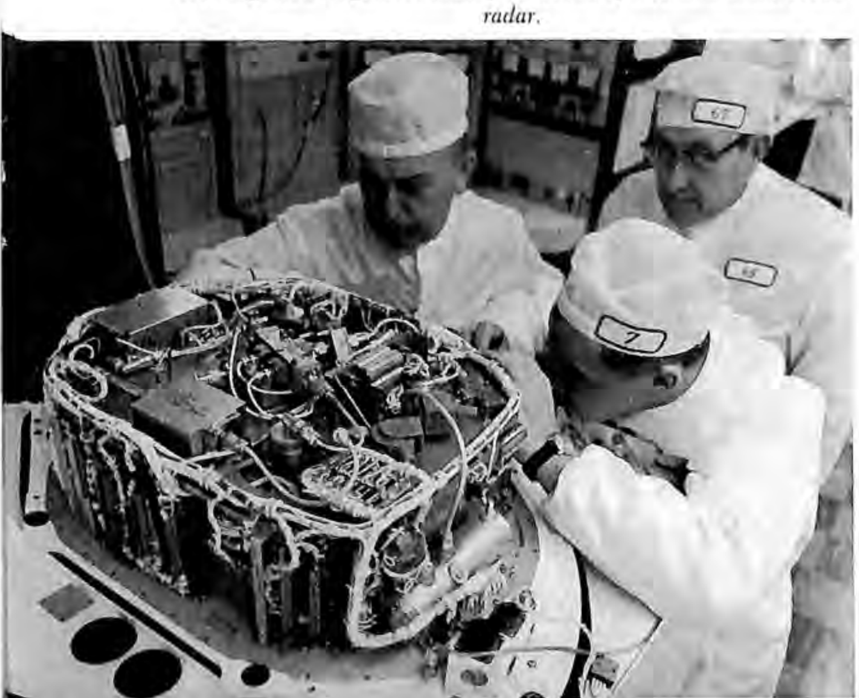
New laser technology studies were disclosed in

January and March by Westinghouse Defense and Space Center and Research Laboratories.

The first was development of a system with which engineers can vary the time duration of a high power laser's pulse of light. The system, which produces and can repeat a smooth or "spikeless" pulse of light, promised to make possible investigation of previously unexplored areas of laser technology. Concentrating on the pulsed laser, Westinghouse engineers used a ruby rod as light source in which chromium atoms were excited or charged to a high energy level. When the laser was discharged very quickly, these atoms gave up their energy, dropped back to their normal state and in doing so, emitted an intense pulse of light, the waves of which were all in one direction. The capability of isolating a single pulse of a few billionths or several thousandths of a second, and repeating the selected pulse at will, made possible the exercise of more precise control in an experiment or application. Scientists heretofore were limited to experiments of either short pulse or long pulse laser beams, and they were difficult to duplicate. The variable pulse laser system paved the way for step-by-step studies to achieve a complete understanding of such mechanisms in a wide range of pulse levels.

The March announcement revealed development by Westinghouse research scientists of a new laser material that automatically generates extremely sharp and powerful individual pulses of laser light. Known as giant-spike operation, it increases immensely the peak power of a laser beam and is useful for such important laser applications as ranging or distance measurement and reconnaissance, or radar-like detection of objects at a distance. Giant-spike operation was achieved by means of complicated optical apparatus placed outside the laser itself, apparatus necessary to force the laser to emit one short, powerful laser pulse, or spike. Otherwise, the pulse of light normally emitted would consist of a complex array of separate shorter pulses, occurring at unpredictable instants, lengthening the overall laser bursts and lowering its average power level. Using a new kind of glass laser material, the Westinghouse Research Laboratories were able to produce such giant spikes of energy within the laser rod itself. The material was a neodymium glass with a slight but critical modification: the addition of a small amount of uranyl (a form of uranium) ions which, acting as a timer, eliminated the random spikes of light and induced one powerful burst.

Westinghouse engineers make final check of a Gemini rendezvous radar.



California Institute of Technology contracted with Westinghouse Sunnyvale, early in the year for construction of the first of several 130-foot radio telescope dish antennas for the Owens Valley Radio Observatory. The antennas, mobile on wheels along rails and capable of use in a variety of patterns, are larger than most residential building lots. They will make the Navy sponsored observatory extremely flexible for studies ranging from investigations of the surfaces, atmospheres and temperatures of the planets to the size and shape of the universe.

Among several Westinghouse developments in radar during 1965, the Navy detailed in January operating capabilities of the side-looking airborne AN/APD-7, deployed aboard the RA-5C Vigilante. Operating from high or low altitudes, slicing through darkest night or heaviest cloud cover and photographing enemy territory on either side miles away from the flight path of the plane, the advanced AN/APD-7 is the first truly operational version of the side-looking radar. Part of the Integrated Operational Intelligence System, it makes a continuous photographic record of land areas along the flight path with minimum likelihood of detection.

Westinghouse Aerospace Division announced in February that it had flight tested the AN/AWG-10 multimission interceptor weapons control system. This unique and versatile radar system features improved range and tracking ability, terrain avoidance and mapping, and reduces both aircraft turnaround time and the number of maintenance personnel. The AN/AWG-10 Missile Control System was contracted by the Bureau of Naval Weapons for Westinghouse design, development, fabrication, integration and maintenance.

The Navy tackled the problem of radically reducing the weight of heavy electronic equipment with a mid-year contract for action by the surface division of Westinghouse Defense and Space Center. Test case for the experiment was the 3,000-pound AN/UPS-1 radar with a 70 percent weight-reduction-potential. Westinghouse affirmed the possibility of realizing this revolutionary project by advanced engineering and microelectronics. Not only will the resulting radar be sharply reduced in volume, but it will be more reliable and have a longer operating life.

The Gemini Rendezvous Radar and Evaluation Pod, companion units of a radar system developed by Westinghouse Aerospace Division, joined NASA's program in mid-1965. The system, tested by Gemini 5 and used to achieve the Gemini 7/6 rendezvous, will aid an early 1966 Gemini mission in hunting-out, rendezvous and docking with an unmanned Agena rocket. It provides the astronauts with information on the direction of the Agena, its distance from the Gemini, and the speed at which it is moving toward or away from the spacecraft. The rendezvous radar and pod were contracted by McDonnell Aircraft Corporation, prime contractor to NASA for the Gemini spacecraft.

Among other Westinghouse projects in the space program, the magnetic equipment department at the Homewood plant in Pittsburgh constructed a 4-ton cryogenic "supermagnet" rated at about 500,000 times the average magnetic field strength of the earth. It was to be used in studies at NASA's Lewis Research Center. Scientists there expected to reach the high magnetic rating by using liquid neon to cool the magnet to 410 degrees below zero Fahrenheit.

NASA awarded the aerospace division a contract in April to produce one of the experimental packages aboard a satellite that will help pave the way for future unmanned orbital laboratories. Westinghouse will provide the environmental measurement experiment package and build power supplies and a telemetry encoder to relay its information back to earth. The experiment will yield information on solar cell damage, thermal coatings and the analysis of energetic particle fluxes, essential for designing equipment and developing techniques for the unmanned orbital laboratories.

A mobile ultrasonic cleaning system housed in a 30-foot trailer, for last-minute cleaning of space capsules, was scheduled to be rolled out on the Wallops Island launch pad in 1966.

The Westinghouse system, delivered in May, is to play a critical role in NASA's series of experiments to determine what happens to liquids in space, since contamination of the capsule walls could change the basic properties of the liquid and affect information relayed to scientists back on earth. The 3 basic units of the ultrasonic cleaning system include equipment which cleans the capsule by use of sound waves, a powerful spraying device and a dryer.

The first simulator capable of testing the compatibility of individual components in spacecraft electric power systems was completed in July by Westinghouse aerospace electrical division. Heretofore tested individually with scant attention to their compatibility with each other and with the total system, various components and their effects on a complete system can be verified by the simulator. The complete condition of the system is displayed on the control console through lights and meters.

Westinghouse research engineers developed an experimental system that recovers life-giving oxygen from the waste products exhaled in breathing. The oxygen is generated by a fuel cell fed water vapor and carbon dioxide. With the duration of space missions increasing to more than a month, the need for generating oxygen in flight from compounds and waste rather than carrying it along is of growing significance.

One tiny electronic package developed for aerospace purposes by Westinghouse Defense and Space Center may prove to be equally valuable for infantrymen, counterinsurgency forces, or airborne observers directing ground troops. The 5-inch command and control receiver was made to evaluate new uses of molecular electronic components in aerospace equipment. Constructed almost entirely from fingernail-sized electronic components provided by the company's molecular electronics division, it displays 8 tiny lights which can be illuminated in various combinations to denote certain commands. When radio silence is not necessary, the unit can receive voice commands as well. A leader would control the lights by means of a transmitter.

To fulfill Department of Defense requirements calling for multiple sources of integrated circuits for major military electronics systems, Westinghouse and Raytheon Company signed a dual-source agreement early in 1965. Integrated circuits, also called molecular electronics, integrate into tiny solid blocks of material the functions ordinarily performed by an entire assembly of electronic components. Under the agreement, Raytheon became a second source manufacturing and supplying a line of integrated circuits made heretofore only by Westinghouse. Westinghouse molecular electronics division furnished certain equipment and technological capability to insure exact electrical interchangeability.

Westinghouse completed a major expansion program in March, doubling facilities at its nuclear fuel fabrication plant at Cheswick, Pennsylvania. The expansion was necessary to enable the company to keep pace with the growing demand for commercial nuclear fuel for the increasing number of generating stations throughout the world.

May contracts, totaling approximately $34,000,000 to power 26 Navy destroyer-escort vessels, constituted one of the largest marine equipment orders to an American company since World War II. Westinghouse marine headquarters plant in Sunnyvale was constructing all equipment except the generators, provided by its East Pittsburgh division. Deliveries, started late in 1965, were to continue through 1967. Each ship will have a main propulsion steam turbine, reduction gear to drive it, and the associated condenser and air ejector; 3 750-kilowatt turbine-generator sets to supply electrical needs; and 4 forced draft blowers pouring air into 2 steam boilers. Construction of the ships was divided between Todd Shipyards Corporation in Seattle and its yard in San Pedro; Avondale Shipyards, Inc., New Orleans; and Lockheed Shipbuilding and Construction Company in Seattle.

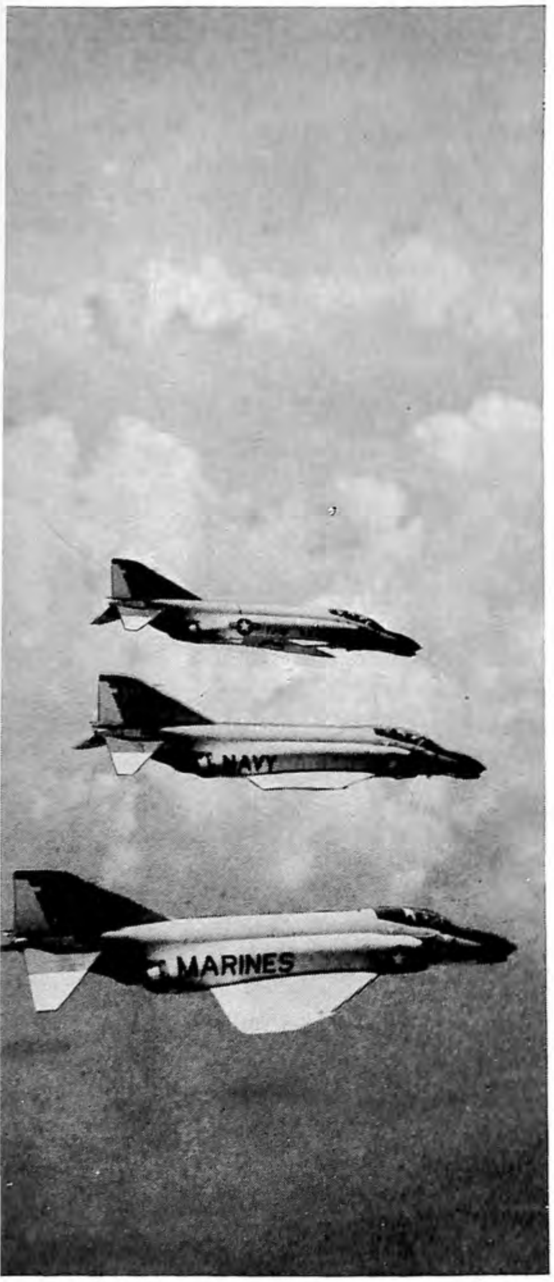
A Westinghouse demonstration test for the Air Force in late June proved that giant ballistic missiles can be "cold eject launched" before firing. In cold ejection, the first stage propulsion engine starts up only after the missile has been popped out of its silo in "peashooter" style. The ejection gas generated for cold launch by small solid propellant rocket motors boosted the dummy missile about 150 feet aloft. Engineers from the missile launching and handling department, Sunnyvale, demonstrated the technique; technical direction for the program was provided by the Air Force's Rocket Propulsion Laboratory.

The development for the Navy of a small thermoelectric generator, capable of operating for a year untouched by human hands, was announced in July. The 100-watt generator and associated equipment were designed and later built by Westinghouse aerospace electrical division, for use, unattended, on a 40-foot buoy which will process oceanographic and meterological information for oceanographers, weather forecasters and the fishing industry.

A Westinghouse Defense and Space Center program that had saved the taxpayers thousands of dollars on manufacture of equipment for the government was disclosed at mid-year. The surface division alone had accrued savings of more than $192,000 under the program in the first 6 months of 1965 under Error Free Performance (EFP) program, which shifts emphasis from eliminating defects in equipment to eliminating the causes of defects. A team of manufacturing and engineering experts investigate every defect reported to discover the cause of the error. They can thus locate and correct faulty equipment, working methods or other elements which contributed to the error.

Among international programs undertaken in 1965 was a Royal Australian Air Force contract for 2 radar systems to be produced in conjunction with 2 British firms. Westinghouse Defense and Space Center was building the radar portions; Plessey Radar Limited was prime contractor for the system; and Marconi Limited was to provide the computers. Composed of an inflatable antenna and lightweight electronic equipment, the entire radar can be parachuted into inaccessible areas and set up in a few hours. The new radar system will improve the RAAF's capability in obtaining early warning information, surveillance of aircraft movements and control of interception. At the same time, it will reduce the number of operational personnel required by earlier systems.

Under a technical exchange agreement with the French Office of Undersea Research, the Westinghouse-constructed *Deepstar-4000*, first of a family of deep-diving submersibles, began testing in the last quarter of 1965. Designed by a French undersea research group headed by Captain Jacques-Yves Cousteau, the 9-ton *Deepstar* dives to a depth of 4,000 feet for periods up to 24 hours, travels under its own battery power at underwater speeds up to 3 knots, and carries a crew of 3 men. Its hull, which houses crew, operational equipment and instruments, was fabricated by the Westinghouse Marine Division, Sunnyvale. Surrounding the hull is a hydrodynamicallyshaped fairing containing equipment for propulsion, lighting, controls, photography and sample collection. Two Westinghouse electric motors (one on each side of the hull) operate under high pressure while flooded with fresh or salt water. The deep sea research vehicle is a key element in the world-wide diving service of Westinghouse Underseas Division's charter facilities program.


NAVY
MARINES

NOW Precision Low Level Airdrops Without Ground Aids

Official USAF photo

Sperry's Radar Navigation System...

AN/APN-161 ... makes possible precision cargo/troop airdrops without ground aids. This system has successfully completed USAF Tactical Air Command operational tests in a C-130. Employing very high resolution Ka-band (34,000 mc) radar, the system uses small tactical targets (bridges, buildings, natural terrain) to update present position. Tracking cross-hairs can be manually adjusted by the navigator for correction of dead reckoning errors. Corrections are automatically fed to the pilot by a horizontal situation indicator. "Distance to go" is monitored through the run, and the "Green Light" comes on automatically. The technique demonstrated by the Sperry AN/APN-161 subsystem is an answer to precision low level airdrops.

RADIATION DIVISION, Sperry Gyroscope Company, Great Neck, New York

SPERRY

DIVISION OF SPERRY RAND CORPORATION

FROM AERONUTRONIC . . .

PRODUCTS FOR SPACE AND DEFENSE

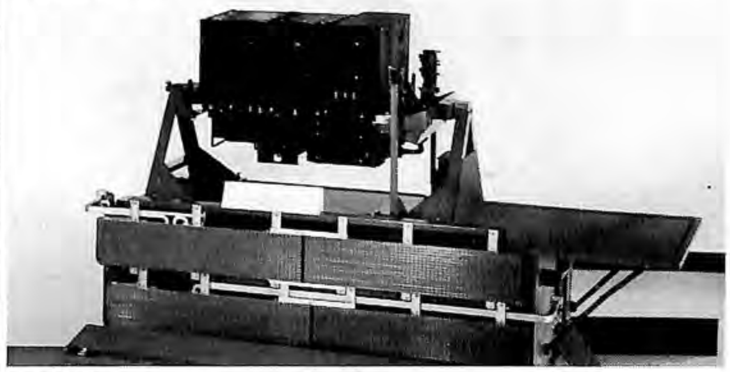
Aeronutronic currently has 85 prime contracts with the Department of Defense and National Aeronautics and Space Administration. Among major programs are...

SHILLELAGH Aeronutronic's single largest program is the development and manufacture of the U. S. Army surface-to-surface guided missile system, Shillelagh, a bold new achievement in weaponry for Army armor units. Shillelagh is a tank-fired guided missile that has achieved unprecedented reliabilities and accuracies during its development test program. Shillelagh is now in high-volume production.

CHAPARRAL During 1965 Aeronutronic was awarded a major prime contract for developing the Chaparral forward area interim air defense system, adaptation of the heat-seeking Sidewinder air-to-air guided missile to this new anti-aircraft ground-to-air role. Chaparral is completely mobile, mounted on a full-tracked modified Army cargo vehicle. It will be used by front-line forces for protection against low and medium altitude enemy aircraft.

ABL The answer to one of man's most intriguing questions, "Is there life on Mars?" may one day be found through use of an automated biological laboratory (ABL) which Aeronutronic is studying under contract with the National Aeronautics and Space Administration. ABL will be a fully-automated and miniaturized biology laboratory. capable of performing a number of biological experiments in the surface of Mars in a search for life on that planet.

RMP The Re-Entry Measurements Program (RMP), a major U. S. Air Force effort to extend U. S. re-entry technology, was awarded to Aeronutronic late in 1965, emphasizing the Newport Beach center's major role as a developer of re-entry systems for U.S. intercontinental ballistic missiles (ICBM's). Other major re-entry programs include one to test improved ICBM warhead fuzing and arming techniques, and another to develop apparatus for "piggyback" carrying of additional payloads on large space launch vehicles.



RADAR Aeronutronic engineers are developing airborne radar systems that give unusually high resolution, permitting radar aerial reconnaissance of areas during all kinds of weather, day or night. The radars are light weight and may be mounted in small, front-line reconnaissance aircraft. They offer the highest resolution per pound of any radars.

RESEARCH As an investment in future growth, Aeronutronic operates an Applied Research Laboratories in support of its technical programs. With a staff of more than 200, the laboratories conduct fundamental investigations into areas such as materials, chemistry, biosciences and physics.

AERONUTRONIC

A DIVISION OF PHILCO CORPORATION/A SUBSIDIARY OF FORD MOTOR COMPANY

FORD ROAD/NEWPORT BEACH, CALIFORNIA

What you can expect from General Precision.

STELLAR INERTIAL GUIDANCE SYSTEM (STINGS)—This high-precision guidance system for missiles recently completed a successful series of stellar acquisition feasibility flights (STAFF) for the U.S. Air Force. It uses the stars to update the inertial guidance system. (Top)

MINIATURE DOPPLER RADAR NAVIGATION SYSTEM—For airborne navigation. Provides altitude and flight parameters with highest precision. Perfect for all fixed-wing, helicopter and VTOL aircraft. (Middle)

PRECISION COMPONENTS—New gyroscopes under development promise performance equal to conventional gyros priced 2 to 3 times higher. Will be used in low-cost inertial system now being developed. (Bottom)

The most advanced aerospace electronic technologies.

General Precision offers a primary source of experience for programs involving technological teamwork at the highest levels—from miniature space age components to world-wide information systems.

Our total capability involves all phases of advanced research, development and production to meet virtually any precision electronic requirement.

How do your present needs fit in with our ability to serve you in these specialized areas?

- Navigation, guidance & control
- Simulation & training
- Weapons control
- Data processing
- Digital information systems, including
- Command and control, and
- Communications equipment

Some of the achievements and capabilities of our three Groups are shown here. For details on any part of our work, write to General Precision Inc., Tarrytown, New York.

AEROSPACE GROUP

A leading developer and manufacturer of aerospace navigation, guidance and control systems, and precision components.

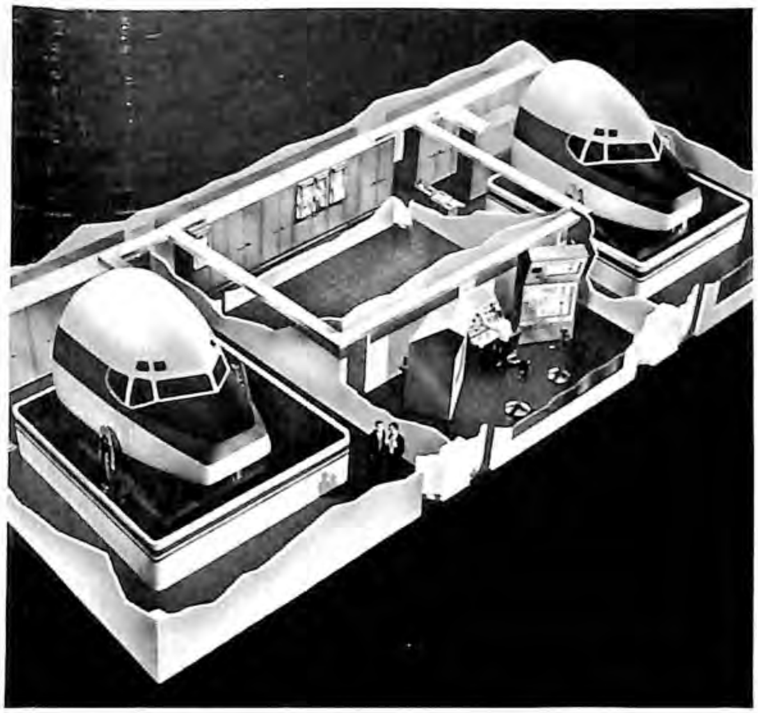
NAVIGATION, GUIDANCE & CONTROL SYSTEMS

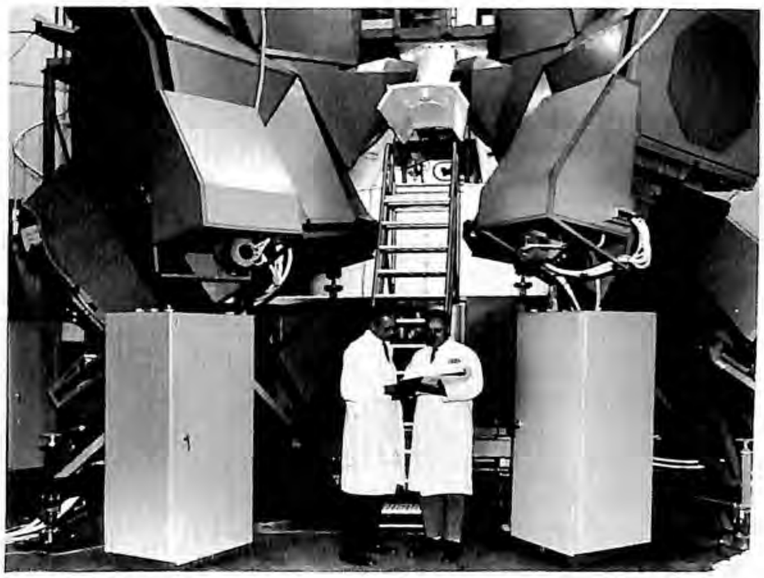
AIRBORNE NAVIGATION COMPUTERS—DIGITAL, ANALOG & HYBRID

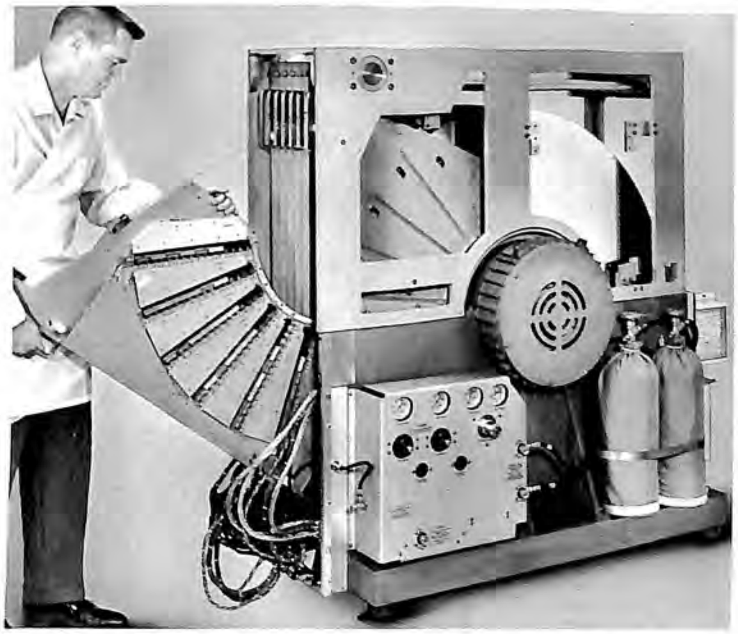
GYROSCOPES, PLATFORMS, ACCELEROMETERS, SERVOS

PACKAGED HYDRAULIC & ELECTROMECHANICAL CONTROL SYSTEMS FOR AIRCRAFT & MISSILES

INFORMATION HANDLING & DATA DISPLAY SYSTEMS, CLOSED CIRCUIT TELEVISION







COMMERCIAL AIRLINE SIMULATORS—The twin cockpits of this 707 jet simulator can be driven singly or simultaneously by a Link GP-4 high-capacity digital computer. One GP-4 can also drive two different aircraft simulators such as supersonic transport and DC-8-61. (Top)

APOLLO MISSION SIMULATORS—The primary training systems for moon astronauts, they will simulate the entire mission including launch, rendezvous, docking, re-entry and earth landing. (Bottom)

WEAPON CONTROL SYSTEM FOR SUBROC — Librascope manufactures computing and data display system for launching and directing flight path of this advanced anti-submarine missile. (Top)

MASS MEMORY SYSTEM—Can store over 300 million bits of information. Used in large data processing systems such as giant Librascope AN/FYQ-11 in Air Force Command-and-Control Center at the Pentagon. (Bottom)

LINK GROUP

Link is the pioneer and foremost producer of digital and analog flight simulation systems. No other name in the world is so well known in aircraft and space vehicle simulation and training.

MILITARY & COMMERCIAL AIRCRAFT AND SPACE VEHICLE SIMULATORS

VISUAL SYSTEMS

RADAR LAND MASS SIMULATORS

DATA STORAGE & RETRIEVAL SYSTEMS

EXPLOSIVE ORDNANCE AND ACTUATING DEVICES

LIBRASCOPE GROUP

Librascope is the recognized leader in anti-submarine warfare weapon control systems. This Group has advanced capability in digital computers and large-scale data processing systems.

WEAPON CONTROL SYSTEMS

LARGE-SCALE DATA PROCESSING SYSTEMS

MEMORY SYSTEMS, ENCODERS & OTHER DIGITAL EQUIPMENT FOR COMPUTERS & DATA PROCESSING SYSTEMS

PRECISION OPTICAL SYSTEMS

GOVERNMENT RESEARCH & DEVELOPMENT

Research and development on aerospace systems of all types constituted the major portion of the funds expended on all government R&D during the year, which amounted to $15.961 billion (fiscal year 1966). Expenditures at approximately the same level were contemplated for fiscal 1967, with aerospace R&D again accounting for most of the effort. The enormous range of government R&D projects precludes even a catalog listing, but this section contains the research and development highlights of 1965 in those agencies primarily concerned with aerospace work. Additional detail on unclassified projects is supplied in the resumes of the individual companies in the Aerospace Industry section, and in the Reference Section.

ATOMIC ENERGY COMMISSION

In June, 1965, the Atomic Energy Commission realigned its organization to put all space related research and development under one director of a new Division of Space Nuclear Systems. The division has two main elements: the Space Nuclear Propulsion Office, the joint AEC-NASA office responsible for space nuclear rockets and isotopic thrusters; and the Space Electric Power Office, which directs nuclear electric power and propulsion projects.

During 1965, AEC made substantial progress in developing the technology for nuclear rocket propulsion systems for space missions. The second of the series of NERVA experimental power reactors—NRX-A3—was successfully operated through three power cycles in April and May.

In December, AEC completed plans for the first NERVA Reactor/Engine System Test to obtain information applicable to an actual flight engine system. The NRX/EST comprises a flight-type reactor mounted in an up-firing position on a test car modified to accommodate a close-coupled turbopump, and a regeneratively cooled nozzle with a bleed port through which hot gas is ducted to drive the turbine. The engine system test series was to be followed in 1966 by ground-based experimental engine tests in a down-firing test stand.

During 1965, a series of KIWI-sized but higher powered reactors, designated Phoebus, were being fabricated for ground testing. In June, the first of the series of experiments was conducted with Phoebus 1A. The reactor was run at full power and temperature for about 10-1/2 minutes.

Work also progressed during 1965 on development of fuel elements, materials, hardware and facilities for a new, larger-diameter and higher-powered Phoebus 2.

AEC continued its effort on development of isotopic thruster systems, low thrust rocket engines using the thermal energy generated by isotope decay to heat hydrogen or other propellants to high temperatures prior to explusion through a nozzle to produce thrust.

A historic step was the April 3 launch of Snapshot 1, involving a test of the SNAP-10A reactor. The 500-watt reactor was started up after the spacecraft was in stable orbit at 800 miles altitude, and it operated for 43 days, producing more than 500,000 watt-hours of electricity. Another SNAP 10A reactor was put through ground test throughout most of the year, operating under simulated space conditions. By year-end, it had operated continuously for 343 days.

Research with the SNAP-8 reactor continued in 1965. On April 15, the first experimental reactor of the series completed its scheduled program and was shut down. During this program, the reactor operated at or above 400 thermal kilowatts and 1,300 degrees Fahrenheit coolant outlet temperature for 366 days. The SNAP-8 Developmental Reactor was in fabrication during the year and was expected to be in operation by the spring of 1966.

In February, two SNAP-19 generators were delivered to NASA for tests based on Nimbus-B weather satellite specifications. The 25-watt SNAP-11 thermoelectric generator, originally developed for the Surveyor program, was scheduled to start tests in mid-1966. The SNAP 50/SPUR program to develop a 300 to 1,000 kilowatt nuclear electric space power plant was terminated in June.

AEC was working on two advanced space reactor concepts. The Medium Power Reactor Experiment was exploring the feasibility of a direct cycle, boiling potassium, fast reactor to develop large amounts of electrical power for space use. During 1965, mockup experiments were conducted to obtain data necessary for the design of the reactor and its facility. The Advanced High Temperature Gas Cooled Reactor, being developed for AEC by a contractor, was aimed at developing and demonstrating refractory metal reactor technology for use in an inert gas-cooled reactor system capable of generating electric power in space.

AEC continued its work with the USAF on the Nuclear Detection Satellite program. In mid-July, a third pair of AEC-instrumented NDS (Vela) were launched in tandem by an Atlas-Agena booster. At year-end, AEC was preparing instrumentation incorporating a number of improvements based on past experience, with a launch planned for 1966.

DEPARTMENT OF DEFENSE

Highlights of the major R&D programs of the Department of Defense are contained in the resumes of the individual military services which follow. In addition, DOD was spending almost $200,000,000 on exploratory development projects directed by the Advanced Research Projects Agency. Foremost of these projects was Defender, concerned with the development of scientific and technical knowledge needed for the design of U. S. defenses against ballistic missiles and for assessment of U. S. ballistic missile systems' abilities to penetrate to their targets. About half of the $128,000,000 funding (fiscal year) was to go into the study of missile re-entry phenomena, including full-scale experiments in the Pacific. ARPA also continued its effort on Project Vela, designed to obtain an improved capability for detection of nuclear explosions, both underground and at high altitudes.

AIR FORCE

During 1965 the Air Force Systems Command, under the direction of General B. A. Schriever, continued to advance aerospace technology and its timely application to qualitatively superior aerospace systems for the Air Force. Significant progress was achieved in aeronautical, ballistic, space and electronic activities with several programs being completed and others started.

The last of 800 Martin-built Minuteman I ICBMs became operational on June 30, as the Ballistic Systems Division (BSD) officially turned over a fifth wing to the Strategic Air Command (SAC) at Warren AFB, Wyo.

A month earlier, the Air Force had announced its plans to eventually replace the Minuteman I with the larger, more powerful Minuteman II. At year-end, BSD was directing this "Minuteman Force Modernization" with three squadrons of Minuteman II under construction at Grand Forks AFB, North Dakota, and an additional squadron authorized at Malmstrom AFB, Montana. The larger thrust of the new ICBM model will significantly increase its range over the 6,300 miles for Minuteman I.

During the year, the USAF continued its effort on the Advanced Ballistic Re-Entry System (ABRES), identified as the Department of Defense program for advanced re-entry techniques and devices. Through ABRES, DOD intended to develop an understanding of re-entry phenomena and to establish the mili-

ABRES vehicle, a research tool in a program aimed at development of more effective ICBM nose cones, is readied for launch aboard Atlas.

The Titan III-C, man-rated launch vehicle with more than 2,400,000 pounds of liftoff thrust, made three flights in 1965.

tary worth and feasibility of advanced re-entry concepts. To carry out the flight test program, ABRES employs the Atlas and Athena test vehicles. The Athena missile, launch complex and instrumentation tie-in between Green River, Utah, and the White Sands Missile Range was in use throughout the year.

On September 15, the Air Force announced the awarding of a contract to develop "Burner II," a low-cost upper stage for placing small and medium-size payloads in orbit. The solid stage will go atop Thor standard launch vehicles and will be adaptable for use with Atlas and Titan boosters.

Systems Command made notable contributions toward the nation's space programs during 1965. On June 18, the first Titan III-C, built by Martin Company, was successfully launched from Cape Kennedy to become the Free World's mightiest space booster launched to date. Six times more powerful than the Atlas which carried the Mercury astronauts, Tital III-C developed 2.4 million pounds of liftoff thrust and placed a 21,000-pound payload into a 100-mile circular orbit. Tow other launches, on October 15 and December 15, were successful in the boost phase but failed to achieve the desired orbit. Space Systems Division (SSD) manages the program to develop the Titan III-C as the Air Force's SLV-5 (Standard Launch Vehicle.)

The newly completed Titan III Integrate-Transfer-Launch (ITL) facility at Cape Kennedy was used for the first time in the December launch. The ITL facility will enable the Air Force to launch several space missions in a minimum of time. Use of the Vertical Integration Building (VIB) and Solid Motor Assembly Building (SMAB) will sharply reduce on-pad time and allow for rapid follow-on launches.

An Air Force Atlas-Agena (General Dynamics-Lockheed) space booster launched the third in a series of twin nuclear detection satellites in the Vela program for the DOD Advanced Research Projects Agency on July 20. The satellites were launched from Cape Kennedy into approximately 60,000 nautical-mile circular orbits ranging nearly 150 degrees apart.

In April a cesium contact ion engine was teamed with the Atomic Energy Commission's SNAP-10A nuclear reactor power supply aboard an Air Force Agena spacecraft launched over the Air Force Western Test Range (AFWTR).

Looking toward the future, Systems Command was working on a fourfold spacecraft research program to develop unmanned test vehicles capable of maneuvering to a precision recovery site after reentering from orbit. The Spacecraft Technology and Advanced Re-entry Tests (START) program includes rocket-launched hypersonic flight tests of unmanned lifting body reentry vehicles and aircraft-dropped transonic/subsonic flight tests of a larger vehicle of similar design.

On February 23, the fifth successful flight in the Aerothermodynanic/elastic Structural Systems Environmental Test (ASSET) program was completed. A total of six nonmaneuverable lifting body re-entry vehicles, built by McDonnell Aircraft Corporation, were launched by Thor boosters (SLV-2) over the Air Force Eastern Test Range (AFETR) during the program.

On August 25, President Lyndon B. Johnson directed the DOD to go ahead with a $1.5 billion development of a Manned Orbiting Laboratory (MOL) to find out how useful military man might be in space. Six days later, General Schriever was named to head the MOL program in addition to his duties as Systems Command commander. Brigadier Generals Harry L. Evans and Russell A. Berg were named vice director and deputy, respectively. Later in the year, Douglas Aircraft Company and General Electric Company were selected as principal MOL contractors.

The Systems Command maintained its close support of National Aeronautics and Space Administration (NASA) projects with Air Force facilities, hardware, and people employed in support of NASA programs. On March 23, a modified Air Force Titan II space booster launched the first two-man Gemini spacecraft into earth orbit. Later in the year, Titan II boosters successfully launched four other manned McDonnell-built Gemini spacecraft. Tracking of NASA space launches was assisted by the National Range Division's (NRD) global tracking facilities.

The command's continuing biomedical research provided an essential element of support to the national space program. For example, on October 4, the Aerospace Medical Division (AMD) began the longest space cabin atmosphere experiment it had ever conducted. Four volunteer air crewmen spent 68 days in a space cabin simulator 30 feet long and nine feet in diameter, breathing an atmosphere of 70 percent oxygen and 30 percent helium. The quartet remained at a simulated 27,000-foot altitude for eight weeks.

Several milestones were attained during the year in the development of advanced aeronautical systems. The delta wing North American XB-70A flew at triple sonic speed for the first time on October 14. The six-engine jet's top speed was 2,000 miles per hour at 70,000 feet, preliminary reports indicated. On earlier flights, the XB-70 had weighed more than 500,000 pounds at take-off, which at that time made it the heaviest aircraft ever to become airborne.

The General Dynamics F-111A demonstrated swept wing and supersonic flight early in 1965. The supersonic fighter was being developed under the management of Aeronautical Systems Division for both the Air Force and the Navy. The first official flight test of the two-man F-111A was successfully conducted at the Air Force Flight Test Center, Edwards AFB, California on May 11. Testing was also scheduled to be conducted at the Air Proving Ground Center, Eglin AFB, Florida, on the fighter's avionics and weapon delivery systems.

The first operational squadron of Military Air Transport Service received the Air Force's newest operational all-jet cargo aircraft, the Lockheed C-141 Starlifter, in early 1965.

Secretary of Defense Robert S. McNamara directed the Air Force on September 30 to proceed immediately to develop and produce a revolutionary new transport—the C-5A. The gross weight of the C-5A will be nearly 350 tons, twice that of our largest military cargo plane. It will be able to carry loads of a quarter million pounds 3,200 miles. Lockheed was assigned prime contractor responsibility.

On a speed run at Edwards AFB, on May 1, 1965, the Lockheed YF-12A long-range interceptor claimed nine world records. It flew 2,070 miles per hour over a straight course and reached an absolute sustained altitude of 80,257 feet. The Federal Aeronautique Internationale certified the records.

Captain Joe Engle flew more than 53 miles into space on June 29 to join Lieutenant Colonels Robert M. White and Robert Rushworth as Air Force X-15 pilots holding astronaut wings.

Systems Command was developing two aircraft, the Vought-Hiller-Ryan XC-142A and the Curtiss-Wright X-19A as part of a cooperative tri-service program to produce a new family of experimental vertical takeoff and landing aircraft. The XC-142A, first vertical short takeoff and landing aircraft to be flown and also the largest, made its first conversion flight in January. Operational evaluation started during the summer at Edwards AFB with two test aircraft.

Electronic Systems Division turned over the first Backup Interceptor Control (BUIC) facility at North Truro, Massachusetts, to the Air Defense Command on September 1. BUIC will take over in case Semi-Automatic Ground Environment (SAGE) direction centers become inoperative.

Among 1965 accomplishments of Research and Technology Division's laboratories was the first successful demonstration of internal thrust from a supersonic combustion ramjet (Scramjet) engine. General Schriever pointed out to the 4th Symposium on Advanced Propulsion Concepts in April that a research airplane capable of achieving orbital speeds could result from this study. Scramjets differ from conventional engines in that they have moving parts only in the fuel feed system and produce thrust by burning fuel in a supersonic air stream.

Since superior aerospace systems are dependent upon strong, technically competent laboratories, Systems Command continued to place major emphasis on further strengthening of its in-house laboratories. For example, the Air Force Avionics Laboratory was operating an "electronic shooting gallery," which provides a versatile test ground for airborne reconnaissance devices.

The Air Force Aero-Propulsion Laboratory acquired a high vacuum test chamber that simulates space environment and altitudes up to 990,000 feet. It will be used to test liquid metal system components such as space radiators and solar reflectors. The Aero-Propulsion Laboratory was testing a full size, honeycomb structure for possible use in space.

A new facility at the Air Force Rocket Propulsion Laboratory was enabling the Air Force to study the adverse effects of space environment on rockets and associated equipment.

In January, Systems Command announced that a lightweight "pulse motor" containing 40 solid propellant wafers performed perfectly in a demonstration for the Air Force Rocket Propulsion Laboratory. The test represented a major advance in solid motor thrust control technology, in that a lightweight solid propellant motor, impulse-controllable on command, can give a high degree of mission flexibility.

The Air Force Avionics Laboratory's Electro-Optical Surveillance Special Test Facility at Cloudcroft, New Mexico, went into operation on February 19. The facility operates the largest satellite tracking electro-optical telescope in the United States.

The Air Force Weapons Laboratory at Kirtland AFB, New Mexico, put into operation during the year an ultra-high-speed scientific computer than can add, subtract, and multiply 3,000,000 times a second.

The formation in January of a new Air Force Contract Management Division (AFCMD) ranked among the top management actions of the year. The AFCMD is responsible for DOD contract management activities in plants assigned to the Air Force under the DOD National Plant Cognizance program. In coordinating military and civilian scientific and industrial efforts of the U. S. toward the development of aerospace weapon systems, the Systems Command directs the expenditure of about 31 percent of the Air Force budget, or about 6.1 cents of each Federal tax dollar. The command administers almost 47,000 contracts having a face value of about $53.5 billion.

On September 17, the Air Force Systems Command was awarded the General Thomas D. White USAF Space Trophy for the "most outstanding contribution to the nation's progress in aerospace during 1964." Systems Command was cited for "penetrating the frontiers of space and space technology through the successful development of reliable space launch boosters."

On October 19, General Schriever named Brigadier General Henry B. Kucheman, Jr., deputy for limited war with Aeronautical Systems Division—focal point for all Systems Command limited war actions. It was one of three actions taken to provide quick reaction to operational requirements from Southeast Asia and other areas. General Kucheman will have total accountability of Systems Command research, development, test and evaluation in addition to an effective communications net tying together all of the command's divisions and centers in responding to limited war needs.

The Air Force selected 17 contractors to receive the first semiannual Achievement Awards approved in its Industrial Zero Defects program with Major General G. F. Keeling, Systems Command's deputy chief of staff for Procurement and Production, making the first presentation on October 25.

ARMY

A large part of the Army's 1965 research and development effort was concentrated on the versatile helicopter, which was proving itself in operational use in Viet Nam. Statistics gathered over 800,000 sorties indicated the probabilities that a helicopter will be hit by ground fire only once in every 400 sorties, knocked down by ground fire once in roughly 8,000 sorties, and totally lost only once in over 16,000 sorties.

A significant step in Army helicopter development came in May when a long competitive design competition ended with a contract award for production of a new light observation helicopter. Hughes Tool Company's aircraft division was selected to build the OH-6A, a true forward area helicopter designed for utmost mechanical simplicity and ease of maintenance. The OH-6A will perform the primary tactical missions of visual observation, target acquisition, battlefield reconnaissance and command/control. Turbine-powered, the OH-6A has a maximum speed of 130 knots, climbs at 2,120 feet per minute, has a service ceiling of 18,700 feet and a hover ceiling of 5,000 feet. With a range of 308 nautical miles, it cruises at 120 knots. The Army expected to receive production quantities of the helicopter by June, 1966.

Another milestone in the Army's new approach to materiel development is the Advanced Aerial Fire Support System (AAFSS), in developmental status during 1965. The AAFSS is an integral system which combines an aerial vehicle, its weapons and ground support equipment. The vehicle is a new compound helicopter with cruise speeds of better than 200 knots, more than 50 percent faster than any Army operational helicopter and twice as fast as the armed helicopters deployed in Viet Nam. AAFSS will support troop-carrying helicopter formations and provide discrete suppressive fire in landing zones. In combat, the 2-man crew of the AAFSS will employ a variety of weapons: machine guns, grenades, rockets and antitank missiles. The 1,500-pound weapon load can be carried on missions involving a radius of action of more than 100 nautical miles. Far superior from systems analysis and cost effectiveness standpoints, the AAFSS was not scheduled to reach Army inventory until after 1970, but it was expected that initial hardware funding would be included in the fiscal 1967 budget.

Three years of research, development and test, aided by significant advances of helicopter capabilities, resulted in a new concept of tactical mobility, the Airmobile Division. Substituting air vehicles for trucks, tanks and artillery, the unique unit has 434 aircraft, all but 6 of them helicopters, which can transport at one time one-third of the division. The 1st Cavalry Division (Airmobile) can react immediately to threats over wide expanses and varied terrain. With speed, surprise and general effectiveness previously unavailable, manpower and firepower can be applied quickly in the most critical areas of battle. Following a mid-year authorization, the division was formed from existing units and was proving its value in Viet Nam.

Nike-X missile defense system development and testing continued with the awarding of a further $221,216,696 contract to the Western Electric Company, prime contractor for the system. The contract, announced in September, covered work on the system from October 1965, to the end of September 1966, and included testing of the Nike-X equipment at White Sands Missile Range and on the Pacific island of Kwajalein. The Nike-X system is being developed as a defense aginst intercontinental ballistic missiles and submarine-launched missiles. The only antimissile missile system in advanced development by the United States, it is a high priority Department of Defense research and development project. The system includes the Multifunction Array Radar (MAR) for target acquisition, discrimination, tracking and interceptor missile tracking; the Missile Site Radar (MSR) for target tracking and missile tracking; the Zeus missile for long range intercepts; and for short range intercepts, the high-acceleration Sprint missile. The cost-plus-incentive fee contract funds were divided among several thousand firms in nearly every state of the union which furnish goods and services for the Nike-X development program. Bell Systems Laboratories is responsible for the design and development of the system.

An advanced version of the Zeus antimissile missile was funded in September by a $21,580,464 Army development contract to Western Electric. The new Zeus will have longer range than the earlier interceptor missile of the Nike-X system. Designated DM15X2, the extended-range Zeus will be similar in configuration, but slightly longer and heavier. It will have 2 solid-propellant motors and carry a nuclear warhead. Like the earlier Zeus, it will be guided in flight by ground-based radars in conjunction with high-speed computers, and will have the capability of intercepting intercontinental and submarine-launched ballistic missile warheads outside the earth's atmosphere. Douglas Aircraft Corporation, airframe subcontractor on the original Zeus missile, will develop the improved version.

The Sprint missile was successfully test-fired in guided flight during November, from an operational-type underground cell. Sprint, short-range interceptor of the Nike-X missile system, was ejected from its underground cell at the White Sands Missile Range by a gas-driven piston, and the first stage motor ignited after the missile was in the air. Both solid-propellant motors were fired during the test and Sprint was directed in flight by ground-based radars and computers, although not fired at an actual target. It carried instrumentation instead of a warhead in the nose section. Sprint was the first Army missile to use this "pop-up" launching technique. In

The Army continued research on the "hot cycle" pure jet helicopter. In flight status was the Hughes XV-9A test bed, built for Army Transportation Research Command.

the Nike-X system, the high-acceleration Sprint would be used to intercept targets once they have penetrated the earth's atmosphere. The missile is being developed by the Martin Company and by Hercules Powder Company.

All test objectives were met by the Lance ballistic missile in its first test firing. During March, Lance was fired from a nontactical launcher by a crew from Ling-Temco-Vought, prime contractor for the missile. Lance is a mobile battlefield missile and weapon system. With its launcher, an essential feature of the system, and a self-propelled tracked vehicle, the entire unit is self-contained and self-sustaining. The lightweight launcher and missile can be removed from the tracked vehicle and transported by helicopter or dropped by parachute. For ground mobility, the missile, mounted on the launcher, can be moved into position or towed across country by any available light vehicle.

Lance is designed to furnish fire support, nuclear or conventional, to infantry, armored and mechanized divisions, complementing division tube artillery and extending support capability. It will replace the Honest John and Little John missiles. First Army missile to use prepackaged, storable liquid propellants, it is designed for greater range and accuracy than the weapons it will replace. First successful developmental firing of the LANCE from a tactical version of its launcher, took place during July at White Sands. System development work continued at the Michigan Army Missile Plant near Detroit.

Engineering and design for an adaptation of the Shillelagh missile system were begun with a $1,296,000 May contract to Philco's Aeronutronic Division. The system, particularly effective at long range, will replace the present 105-millimeter gun in the M60 tank. Total amount of the cost-plus-incentive-fee contract was $3,580,000, to be funded over a 2-year period. This will cover incorporation of the Shillelagh missile subsystem components into the tank, and procurement of components and missiles for test and evaluation. The Shillelagh armament system comprises a 152-millimeter gun/launcher, gun mount, conventional gun-fired ammunition, the Shillelagh missile, and necessary fire control elements. The system will go into production for the General Sheridan tank. Application of Shillelagh to the M60 tank will result in a new turret of reduced silhouette, improved ballistic protection and a major improvement in firepower. Turrets and guns removed from the M60 tanks will be retro-fitted with Shillelagh and installed on M48 tanks to replace the 90-millimeter gun.

Two versions of a new Medium Antitank Weapon (MAW) were successfully fired at Redstone Arsenal in June. Designed as a shoulder-fired missile system for use against tanks and other armored vehicles, the MAW will be light and portable enough to be carried by one soldier. It is to be used by infantrymen at the platoon level as a defensive and assault weapon. One version, the Directional Control Medium Antitank Weapon (DC-MAW), will feature a self-contained guidance system which enables the missile to fly along the line-of-sight established by the gunner. The DC-MAW is being developed by the Research and Development Directorate of the Army Missile Command at Redstone. Another concept of MAW, under development at McDonnell Aircraft, uses fine connecting wires between the launcher and the missile guidance system. One of the 2 versions is to be selected by the Army for further development. The Army Materiel Command has responsibility for management of the MAW project.

Research and development of a self-propelled HAWK missile system were under way in August with the awarding of a $1,600,000 Army contract to Raytheon Company. The Hawk (Homing-All-The-Way-Killer) is to be deployed in forward combat areas. Mounted on an XM-548 full-tracked vehicle, the supersonic air-defense guided missile will give the self-propelled Hawk platoon greater mobility and flexibility, and reduce the number of vehicles required by present Hawk units. A self-propelled Hawk platoon will include 3 self-propelled launchers, each mounted with 3 missiles, and 2 ground support equipment items—a continuous-wave acquisition radar for target interception and a high-power illuminator for target tracking and illumination—both towed by the launchers. The assault command console for fire control of the platoon can be carried on one of the launchers or mounted on a trailer and towed by the third launcher. A similar firing unit in the earlier Hawk organization (with the same number of missiles on the launcher as the new concept provides) requires 6 2-1/2-ton trucks. The missiles are transported on pallets and placed on the launcher at the firing site. Under the new concept, self-propelled Hawks will carry ready-to-fire missiles right on the launcher. HAWK is a 16-foot solid-propellant missile that can search out and destroy high-performance aircraft or air-breathing guided missiles from treetop level to medium altitude.

Center hits were scored by TOW during September test firings. A developmental model of the Army's newest antitank missile struck tank-sized tar-

A modified Army UH-1D, built by Bell, was equipped with two free turbine engines for a flight program to test the concept of a twin-turbine power plant in a medium-size helicopter.

gets at a mile's distance during the test. The name TOW is derived from its description—Tube launched, Optically tracked, Wire guided. Under development for attack of hard point targets such as tanks and gun emplacements, TOW is guided in flight by means of a 2-wire link between launcher and missile. 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 moving target, the gunner simply aligns the cross hairs of this telescopic sight on the target, and launches the missile, which automatically flies along his line of sight. With TOW, the gunner does not have to estimate range to target, speed of target, or angle between the course of the target and his weapon. He needs only to keep the cross hairs of his sight on the target while tracking it. 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 or on a variety of ground vehicles. Data obtained from the September firings will be used to refine the final design of the missile system. Prime contractor for TOW is Hughes Aircraft, with warhead development under the Army Munitions Command, Picatinny Arsenal, New Jersey.

The Chaparral air defense weapon system achieved successful guided firings in October. Under development at the China Lake Naval Ordnance Test Station, Chaparral is designed to protect forward area Army forces against low altitude air attack. The weapons system incorporates a modified Army self-propelled vehicle (XM-548) as a mount for launching the Navy-developed Sidewinder 1-C missile, slightly modified for the surface-to-air application and using an infrared guidance system. Cost and development time are reduced to a minimum by maximum use of existing missiles and "off-the-shelf" support equipment. The Army Missile Command at Redstone has technical direction of the program; Philco's Aeronutronic Division is responsible for the Chaparral system and for development of the missile launcher turret. Prime contractor for the missile is the China Lake Naval Ordnance Test Station.

NAVY

One of the highlights of the 54th year of Naval Aviation was completion of a design competition for a new light attack Navy aircraft. A contract was awarded to Ling-Temco-Vought for a new and improved version of the company's F-8E Crusader, designated A-7A. The VAL was developed at the Dallas plant to replace the smaller A-4E Skyhawk, fleet attack bomber. Named Corsair II, the A-7A has a fixed wing and is subsonic, employing a modified version of the Pratt & Whitney TF-30 engine without afterburner. Design improvements give it doubled range and allow substantially greater payloads. Longer range allows the plane greater time on station in close support of troops. After conducting a study of the entire structure of its air-strike system, the Navy ordered development of the A-7A. In the face of an increasingly important limited war role, the Navy required a more versatile aircraft with greater nonnuclear capability. The Corsair II made its first flight at the Ling-Temco-Vought plant in September, 26 days ahead of schedule.

Development of the F-111B multipurpose all-weather fighter advanced during the year and in May, the Navy version of the former TFX made its first flight at the Grumman plant, Peconic River, New York, successfully demonstrating variable wing sweep and low speed handling capabilities. Designed to fly supersonic speed at sea level and to Mach 2.5 at altitude, the F-111B has a crew of 2 seated side-by-side in a unique protective module. Two Pratt & Whitney TF-30 turbofan jet engines with afterburners power the all-weather fighter from low level to 60,000 feet; on transoceanic laps without refueling; and to any point in the world within a day. Special features include the variable sweep wing; maximum structural integrity; high reliability; safety of operation; ease of maintenance; and minimum need of logistic support. The F-111B is designed to carry both conventional and nuclear weapons, including the latest air-to-air and air-to-ground missiles and rockets. Its conventional fire power is that of 5 World War II Flying Fortresses. Amenable to short runways of less than 3,000 feet, the plane has great versatility. It can perform such combat missions as interdiction of enemy supply lines; close support of ground forces; combat patrol; and nuclear strikes. The F-111B outstrips the best operational fighter of any service; it is faster at any altitude; has more than twice the range; carries more than twice the maximum payload. It has greater effectiveness in weapons delivery; better penetrability against sophisticated enemy defenses; shorter takeoff and landing distances. The F-111B is able to change the sweep of its wings in flight from a virtually straight position of 16 degrees, to a sharply swept configuration of 72.5 degrees, or any angle between.

The Phoenix Missile System, together with its launch plane, constitutes the F-111B/Phoenix Weapons System. The Navy-developed missile system consists of the missile, XAIM-54A, the Advanced Radar and Missile Control System, AN/AWG-9, and the Missile/Bomb Launcher, MAU-48A. Maintaining air superiority over beachhead landings, over the Navy's fleets, and in antiairwarfare, will be the mission of the Phoenix Missile System. It will have an all-weather capability of locking onto an enemy aircraft and launching the Phoenix Missile, which then takes over and intercepts the target. Data from the radar is processed by a solid-state, high-speed digital computer and displayed to the missile control officer on a 10-inch cathode-ray tube and a 5-inch multimode storage tube. The radar antenna, a planer array representing a significant advance in antenna design, is the largest broad-band, circular antenna ever built and has high aperture efficiency affording increased radar range. The XAIM-54A is a long-range, high-performance missile with a solid propellant motor. Missile design innovations provide a mission effectiveness never before attained, with substantial increase in range, payload, speed and accuracy. The complete missile unit, assembled in sections, can be broken down into its component modules for easy shipboard checkout and handling with minimum maintenance problems. Built-in self-test features permit rapid system testing and isolation of faults to replace modules.

Hughes Aircraft Company is prime contractor to the Navy for the Phoenix Missile System as the long-range armament of the F-111B. Major subcontractors to Hughes are Litton Systems, Inc. for the computer controls and displays, and Rocketdyne for the rocket engine. The Phoenix successfully completed its first airborne test in 1965. An inert missile with the same external configuration, weight and center of gravity as the complete Phoenix was ejected from an A-3A Sky Warrior over the Navy's Pacific Missile Range, It maintained a correct stable attitude during an unpowered descent.

A new carrier-on-board delivery (COD) aircraft began test flights in 1965. The Grumman C-2A will improve fleet logistics by faster delivery of priority aircraft parts, supplies and personnel from shore bases to carriers at sea. The longer range COD aircraft is the first to be specially designed for hauling jet engines and helicopter rotor blades, too costly and bulky to be stocked at sea. The twin-engine turbo-prop carries a maximum payload of 15,000 pounds of cargo or 40 passengers. It can fly 1,300 nautical miles at speeds over 300 miles per hour with a 5-ton load.

As part of a program for development of an aircraft specifically designed for air support of counterinsurgency and limited war operations, the Navy selected North American Aviation to build the OV-10A (COIN), airborne equivalent of the jeep. This aircraft, which made its first flight in July, can perform peacetime emergency functions including

The tri-service X22A V/STOL craft built by Bell Aerosystems under Navy cognizance, rolled out May 25.

disaster relief, medical missions or riot control, as well as military missions covering light armed reconnaissance, helicopter escort/attack, and support of ground troops. With specifications calling for weapon delivery, reconnaissance, and light transport, the counterinsurgency aircraft can operate from rough clearings, primitive roads and waterways, as well as from prepared airfields and aircraft carriers. Powered by turboprop engines, the OV-10A can take off over a 50-foot obstacle in less than 800 feet with a 1,200 pound ordnance load and 3 hours of fuel; an ordnance load capacity of 3,600 pounds can be employed where longer take-offs are possible. Six passengers or 3,000 pounds of cargo can be carried internally and airdropped. A maximum level flight speed of 275 knots is required for helicopter escort duty, and minimum speed of less than 100 knots is specified for jungle search missions.

A major advance in the field of airborne early warning aircraft, the Grumman E-2A reached test flight stage in 1965. The E-2A has greater altitude, speed and endurance capabilities than any plane of its type in service with the fleet. The E-2A's Roto-dome contains fixed-stack antenna elements of an entirely new type airborne early warning radar which, with the plane's altitude advantage, provides a far greater detection radius than any of its predecessors. The aerodynamic design of the Roto-dome furnishes enough lift to offset its own weight in flight. A Nose-tow with which the aircraft is equipped for catapulting, simplifies its alignment on the carrier's CAT centerline, reducing the manpower necessary on the flight deck. The E-2A is equipped with an advanced detection and communications system, the Airborne Tactical Data System (ATDS) which includes a greatly improved auto-detection radar, airborne computers, a memory and high speed data links. With its automatic intercept data link system, the E-2A can direct a dozen fighter aircraft to as many targets without voice transmission or external assistance. This capability gives E-2A the role of Combat Information Center for interceptor aircraft, and allows the carrier task force to operate with minimum radio transmission.

Adaptation of the F-8 Crusader as a bomber was completed during the year and in May the aircraft performed for the first time as a bomber in combat. Developed as an all-weather fighter by Chance Vought Division of Ling-Temco-Vought, the aircraft is powered by the Pratt & Whitney J57-20 engine, has a large high-performance radar and an autopilot. It was modified to carry 500-pound bombs for 1965 combat missions.

Production and testing of the advanced antisubmarine torpedo Mark 46 were accomplished in 1965, incorporating several new design concepts for improved speed, depth performance and maneuverability. First Navy torpedo powered by a solid rocket-fueled hot gas propulsion system, the Mark 46 can be launched by several means. It is the first antisubmarine warfare torpedo to be ejected from a fixed wing aircraft at speeds up to 400 knots; it can also be delivered to an attack area by helicopter or surface ship. Surface ship delivery may be accomplished by torpedo tubes, drone helicopter (DASH), or antisubmarine rocket (ASROC). The Mark 46 torpedo has 4 major components—guidance and control system, explosive system, propulsion system, accessory system—and incorporates a modular design allowing replacement of one or more complete sections. Within a half-second of water entry, the propulsion system is activated by a sea water battery and the torpedo commences a dive to the preset search depth. When search depth is reached, the torpedo follows a programmed pattern, searching for the target by active echo ranging, or passive listening method. On locating the target, it begins the pursuit and attack program until it destroys the target. Should the target become lost, the torpedo returns to a search program to relocate it. The engine

Jointly developed by NOTS and Aerojet-General the Mark 46 solid rocket torpedo, shown here aboard an unmanned DASH helicopter, was tested during the year.

produces approximately 4 horsepower per pound of engine weight, making the torpedo capable of overtaking the most elusive submarine target known.

Development of a new gravity bomb, the Walleye, continued in 1965 at the Naval Ordnance Test Station, China Lake, California. The Walleye is guided by a TV system and manipulated onto target by remote control. NOTS was the only major contractor during 1965, although minor components for the weapon were contributed by civilian subcontractors.

Development also continued on the Poseidon, fourth of the family of submarine-launched Fleet Ballistic Missiles. Formerly known as the Polaris B3, the Poseidon will have approximately the range of the Polaris A3—2,500 nautical miles—but it will contain advances in accuracy and penetrability.

The X-22A V/STOL aircraft, developed by Bell Aerosystems as a combined Army, Navy and Air Force research effort, was unveiled in May and it made its first flight in the fall. Designed and built under a Navy-administered contract, the aircraft will be subject of an extensive research program to explore the mechanical and aerodynamic characteristics of the dual-tandem ducted-propeller V/STOL concept, and to evaluate its military potential. The compact X-22A, with high thrust-to-weight ratio, is the first of a pair developed by Bell. It combines vertical takeoff and landing capability with forward flight at 300 miles per hour cruise speed; 325, top speed. With a crew of 2, the aircraft carries a payload of 1,500 pounds of research instrumentation (or 6 passengers). Its design includes 4 7-foot propellers, surrounded by circular ducts mounted in a dual-tandem arrangement on the fuselage. The ducts serve as lifting surfaces during level flight and increase the static thrust of the propellers. They permit the use of elevons in the propeller slipstream; more powerful control during hovering and transition; a smaller overall configuration; and increased safety. Four T58-8D General Electric turboshaft engines, each developing 1,250 shaft horsepower, are mounted in pairs on both sides of the fuselage, between the 2 aft ducts. A system of shafts and gearboxes that transmits engine power to the propellers, is interconnected so that even a single engine can turn all 4 propellers. The X-22A's capabilities are based on a vertical takeoff requirement using only 3 of its 4 engines. In conventional flight the aircraft can cruise on 2 engines, conserving fuel. A system of overrunning clutches allows the pilot to shut down any 2 selected engines during flight. Using all 4 engines, the plane can operate at full maximum gross weight of 17,680 pounds in either VTOL or STOL modes, with a 200 percent increase in payload. For short takeoffs, it can clear a 50-foot obstacle in a distance of 700 feet. For vertical takeoff the ducted propellers are rotated to a vertical thrust position of 90 degrees and as altitude is gained, the aircraft makes transition to forward flight by gradually rotating the ducts to the horizontal thrust position. For vertical landing, the ducts are rotated to vertical thrust position, the plane hovers and descends. The X-22A is the first VTOL to incorporate a complete variable stability and control system—the VSS developed by Cornell Aeronautical Laboratory—with computer-coupled controls. The versatile VSS, combined with high control power levels, enables research of the handling qualities of this type V/STOL, and by simulating a variety of other designs in this category, permits a thorough investigation of flying characteristics and flight control problems applicable to other V/STOL aircraft. In addition to X-22A research missions, the Navy will study the suitability of this type aircraft for shipboard operations, over-water missions, takeoffs and landings in confined areas with unprepared surfaces. When the flight test program is completed in the summer of 1966, the X-22A will be delivered to a tri-service group at the Naval Air Test Center for flight and mission evaluation by the Army, Navy and Air Force.

FEDERAL AVIATION AGENCY

The program of the Federal Aviation Agency for constructing and equipping new air route traffic control centers within the contiguous 48 states was completed late in June, 1965, with the opening of the last center at Houston, Texas. The consolidation program reduced to 21 the total number of air route traffic control centers in the continental United States, with overall savings estimated at better than $100 million over a period of 16 years. The centers, controlling all aircraft operating instrument flight rules (IFR) between airports, and providing separation service so that each aircraft can fly in its own reserved block of airspace, promote the safe and efficient flow of air traffic. Since there are fewer centers for pilots to deal with, there is a consequent reduction in pilot-controller communications and fewer "handoffs" between centers. Significantly expanded use of long-range radar helped make the consolidation possible—from 4 long-range radars available for such purposes in 1958, there were at year-end 80 civil and jointly used civil-military radars controlling en route traffic.

Alpha-numeric generators were contracted for in July, to be used in the nation's first complete semiautomatic air traffic control system, scheduled for operation at the Jacksonville Center in late 1967. The generator is a major link in FAA's ultra-new computer-driven air traffic control system there. Coded information on aircraft identity, altitude in 100 foot increments, flight attitude, descending, climbing or level, and other vital data for air traffic controllers may appear, at the option of the controller, in the alpha-numeric tags.

Computer programming was ordered in July for the nation's first 2 semiautomatic air traffic control systems, scheduled for operation in 1967, one at FAA's National Aviation Facilities Experimental Center in Atlantic City, the other at the first field site in Jacksonville. IBM programmers will prepare the computers for taking over many routine, noncontrol functions of the air traffic control system, heretofore performed manually. The computers will also improve and expand radar displays of air traffic for the controllers and increase their ability to provide for greater safety and efficiency in the use of the nation's airspace.

To minimize possible adverse effects of turbulent air on jet aircraft, the FAA revised jet flight procedures for rough air operations and established special jet pilot training programs on turbulence penetrations. In cooperation with industry, the agency explored and tested new methods and equipment for identifying, tracking and displaying turbulent air masses. Pilot performance and engineering data under conditions of severe turbulence were obtained both in flight and in laboratory simulation programs.

Two research contracts were awarded in December for obtaining in-flight data to aid pilots of swept-wing jets in dealing more effectively with atmospheric turbulence. One was for development of a test program to gather highly precise data on responses of pilot and aircraft to turbulence encountered in regular jet airline service; the other, for conducting a meteorological study of clear air turbulence (CAT). Results of the second study will supplement findings gathered by airlines, in cooperation with FAA, to determine possible relationships between in-flight temperature changes and CAT. Data uncovered by the projects will determine requirements for improving techniques and instrumentation to cope effectively with rough air conditions.

Conclusions reached by the Coordinating Research Council of New York confirmed to FAA the opinion of combustion experts that adoption of a single type of jet fuel by the entire airline industry would not significantly improve the overall safety record of commercial aviation.

General William F. McKee (USAF, Ret.), left, is greeted by Pan Am chairman Juan T. Trippe on arrival at the heliport atop the Pan Am Building. General McKee became FAA Administrator during 1965.

In July, after a period of study, FAA announced that a 15 percent increase in the effective landing runway length was to be required beginning January 15, 1966, for airline turbojets when landing on a runway forecast to be wet at the aircraft's estimated time of arrival. An alternative, lesser increase requiring FAA approval was to be granted a particular type and model aircraft, upon its demonstrated capacity to land and stop on a wet runway in a shorter distance, using operational landing technique, with worn tires and partial reverse thrust.

A test was conducted in the Boston area, beginning late October, to determine the effectiveness of radar pictures transmitted from the ground to a TV receiver in an airplane cockpit, as a means of sighting and avoiding other aircraft, bad weather, and as a navigational aid.

Fuel tanks of large transport aircraft can be designed to reduce fire hazards associated with crash landings, according to a study made under FAA contract. Recommendations revealed early in the year were that fuel containment principles be considered during preliminary design of aircraft; that crash load criteria be established; and that areas of low damage probability be selected whenever possible for placement of fuel tanks. Parts of an aircraft which may be broken during a crash should be designed so that they will not rupture fuel tanks, and wing tips should be constructed to crush progressively under ground impact, rather than breaking off in large sections.

An 8-hour ban was proposed in November by FAA against pilots operating aircraft after drinking. The safety measure applied to other crewmembers as well. Studies by the FAA Civil Aeromedical Research Institute leading to this proposal had focused on human capabilities and limitations, changes in decision-making ability, mental and muscular coordination caused by various amounts of drugs and alcohol. Results of other tests by the Institute measuring psychological and physiological changes induced by fatigue will be used to develop scheduling recommendations which minimize fatigue and contribute to air safety.

A test model of an all-weather, fully automatic landing system, permitting an aircraft to touch down on an airport under zero-zero weather conditions was ordered by FAA in November. Besides increasing the safety of landings, the device will improve schedule reliability.

Plans were developed for a general aviation maintenance difficulty reporting sytem, similar to the present airline reporting system. Following completion of a field prototype system for general aviation, discrepancy reports on specific aircraft or component systems will be funneled daily into Washington by FAA field personnel and tabulated by automatic data processing equipment, alerting the FAA and users to materiel defects and maintenance system flaws.

The first Federal regulations specifically governing agricultural aircraft operations were devised to improve safety and to protect persons and property on the ground. Effective January 1, 1966, national standards and requirements were established for private and commercial agricultural operator certificates, operating rules, aircraft airworthiness, pilot qualifications and record-keeping for the 2,500 operators engaged in agricultural flying.

Advance notice was given by the FAA in May, proposing airborne equipment requirements in the next 10 years for planes flying under instrument flight rules or controlled visual rules in the national airspace system. The equipment required for general aviation operators would include 2-way radio, very high frequency omnirange receivers together with localizers, distance measuring equipment and radar beacon transponders. The notice was designed to give interested parties adequate time to plan individual needs and to cooperate with the agency in developing effective regulations to promote safety in air operations.

1965 developments in the supersonic transport program began with an international meeting in February of the French-Anglo-United States Supersonic Transport group, to consider airworthiness objectives in certifying future commercial transports of this category. Discussions at the meeting held by FAA in Washington, cited atmospheric problems, structures and sonic booms as they concern the SST.

Work under design contracts was accelerated during July, in accordance with President Johnson's decision to move ahead with development of the United States supersonic transport. The contracts had been funded by congressional appropriation of $60 million in the fiscal year 1965.

To implement the design and test phase of the program recommended by the President, 18-month cost-sharing contracts were signed in August with 2 airframe and 2 engine manufacturers, participating since July, 1964, in development of the SST. Boeing and Lockheed are the airframe contractors; General Electric and Pratt & Whitney, the engine contractors. Objectives for the 18-month period included completion and optimization of airframe detailed designs, engine prototype construction and operation, component development, and extensive testing of both airframe and engine to enable the construction of sound pre-production prototypes. A $140,000,000 appropriation requested by the President, was subsequently granted, to carry forward the 18-month plan requiring $37,000,000 for each airframe manufacturer, and $36,000,000 for each engine contractor.

A 5-week assessment by an 82-member joint government team began in mid-November, the first formal, comprehensive analysis in a year, of proposed airframe designs. Team members were drawn from NASA, FAA, the Air Force and Navy. Evaluation emphasis centered on operational performance consonant with a safe, economical aircraft, compatible to present airports, airline operating requirements, engine noise and sonic boom criteria.

Among subjects of special research at FAA, an extensive study of civil/military long-range radar systems resulted in an agreement with the Department of Defense on selection of hard-core systems to meet present and future needs. Plans were devised to reduce the overall number of long-range radars from 166 to a total of 145, through an expanded joint-use program eliminating an average recurring maintenance expense of at least $1,000,000 per system.

A government task force was formed to guide the development of V/STOL (Vertical/Short Takeoff and Landing) aircraft for commercial inter-urban and commuter transportation. FAA demonstrations and studies of V/STOL aircraft and system requirements showed the feasibility of integrating V/STOL aircraft into overall air traffic control flight patterns and procedures, including instrument operations. The task force will define the national program in terms of development needs, priorities and timing; identify military V/STOL vehicles appropriate for civil development and use; and recommend means of coordination and interchange of civil and military research and development for achieving program goals.

Sonic boom studies released by the FAA during the year shed much new light on one of the most difficult problems related to the supersonic transport program. The findings and conclusions in both the Oklahoma City and New Mexico studies indicated probable feasibility of operating a civil supersonic transport aircraft at restricted boom levels over populated areas, once public understanding of the phenomenon has been reached. No conclusive evidence was found that prohibits structurally tolerable operation of an SST over populated areas, although further intensive research was recommended on the response of other types of structures and conditions. In the intensive 6-month community reaction studies at Oklahoma City, substantial numbers of residents reported interference with ordinary living activities and annoyance, but the great majority felt they could learn to live with the numbers (1,253) and kinds of booms experienced during the course of the study. Acceptance fell, however, from 90 percent, interviewed during the first weeks, to about 75 percent of a comparable sample during the final weeks. Among the integral elements in this 5-volume study, boom overpressures in various geographical locations were recorded and analyzed and meteorological effects on boom levels were evaluated. In structural response studies, many buildings, including dwellings, were taken over in different parts of boom areas and outside for engineering instrumentation and observation.

A national symposium on measures to alleviate aircraft noise and related problems, was held in June by the FAA. The agency sought to focus industry attention on the social, political and economic problems of aircraft nuisance and public understanding on the advances being made.

FAA analysis of peak day instrument air traffic revealed that the busiest slice of sky was between 4,000 and 4,999 feet. The facts, gathered in a detailed count of peak day traffic, keep the agency and its customers advised of the loads along various airways to and from airports, and guide implementation of airway planning standards to assure priority of need.

A joint NASA and FAA coordinating board was created in May for exchange of research and development information and planning related activities. FAA was chartered with responsibilities in research and development for air traffic and safety aids, aircraft development and service testing. NASA was charged with conduct of scientific research programs, improvement of air vehicles and systems, and development of new concepts in aeronautics.

The Agency for International Development sponsored a 13-week International Air Systems Seminar which began May 10 in Washington, with FAA and industry cooperation. Attended by participants from some 19 countries, the meeting dealt with airspace and national development of the market for air transportation. Overall topic was air systems planning and management, covering military, commercial and private air transportation.

Automatic Terminal Information Service was operating at 13 of the nation's busiest airports by October. Due to be extended to another 59 airports, the continuous ATIS broadcasts ease controller workload, reduce radio frequency congestion and permit pilots to obtain routine noncontrol information when cockpit duties are least pressing.

Contracts for construction of the first FAA standard design airport control towers were awarded during the year, the contracts calling for 13 utility steel towers at visual-flight-rules airports. Site studies were conducted at 7 other airports which provide radar as well as VFR air traffic service, for later construction of concrete shaft type standard design towers.

The Federal Airport Program allocation for fiscal 1966 was $84,500,000 in matching funds, primarily for improvement of 371 existing airports ($74,700,000). Development was emphasized at airports used by the airlines, general aviation, and commercial air taxis, in order to relieve congestion at busy metropolitan facilities. The program provided $9,800,000 for construction of new airports.

A new 5-year National Airport Plan was issued in December by FAA, to blueprint the future needs of the nation for an adequate system of airports. New landing facilities proposed in the plan included airports, heliports and one seaplane base. Recommendations were based on a predicted rise in domestic air carrier service as well as in general aviation.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Manned Gemini missions, live Ranger pictures of the moon, Mariner's journey and close-ups of Mars combined to make 1965 the outstanding scientific year of the U. S. space age. During the year the National Aeronautics and Space Administration went to the launch pad 30 times and made an 82 per cent success record. Ninety per cent of the Agency's $5.175 billion budget paid some 20,000 prime contractors and subcontractors for the factory and laboratory work of 400,000 people.

Five history-making manned Gemini missions followed Gemini 2's unmanned suborbital flight. All of the Gemini spacecraft were launched by a modified version of the Air Force Titan II intercontinental ballistic missile. Astronauts Virgil Grissom and John Young proved the spacecraft's maneuverability by changing Gemini 3's orbital altitude and plane during 3 revolutions of the earth in March. Extravehicular activity was successfully achieved in June by Astronaut Edward White, using a hand-controlled propulsion gun for his 21-minute, 17,500 mile-per-hour stroll during Gemini 4's 62 orbits. Astronaut James McDivitt was the other member of the Gemini 4 crew. In August, NASA launched the Gemini 5 mission of Gordon Cooper and Charles Conrad, an 8-day operation designed to demonstrate man's ability to function in space for long periods. A "first" of the flight was the use of fuel cells to produce on-board electric power, a requirement for future long-duration and moon missions. The 2-week Gemini 7 flight of Frank Borman and James Lovell in December, marked the United States' thousandth manned space hour as well as the longest single flight. Gemini 6, with Walter Schirra and Thomas Stafford on board, blasted off 11 days after the launch of its companion craft and achieved with Gemini 7, the first rendezvous in space. Photographed by each other at rendezvous, Gemini 6 and 7 orbited the earth side by side. Final goal of the Gemini program was docking in space, a technique essential for future Apollo moon missions. Linking of a Gemini spacecraft with an orbiting Agena rocket was scheduled for early 1966. McDonnell Aircraft Corporation is prime contractor for Gemini spacecraft, and Martin Company supplies Titan II boosters.

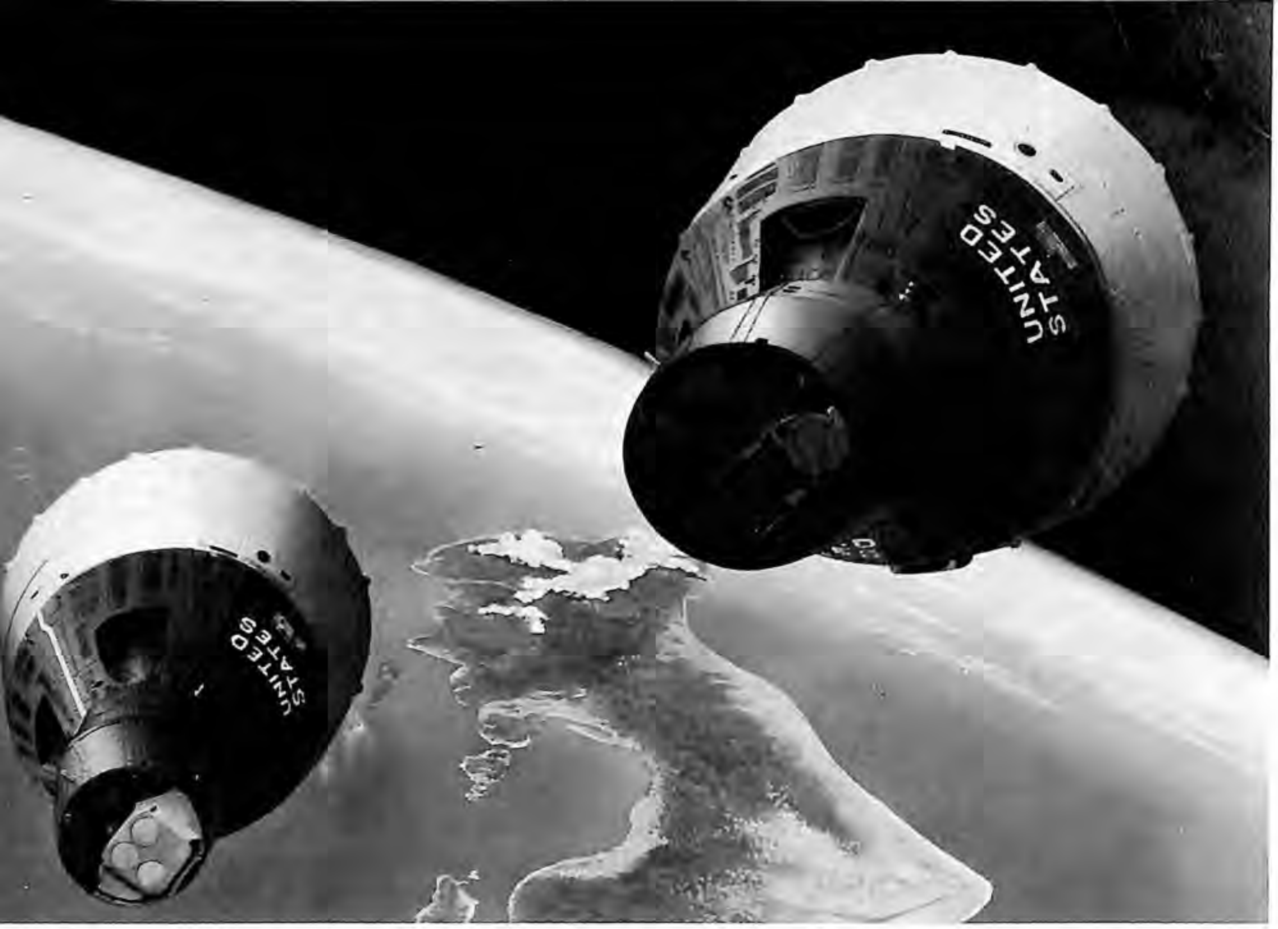
Preparations advanced during the year on Project Apollo, third step of NASA's program, with the goal of placing astronauts on the moon by the end of 1964.

Completion of the Saturn I program marked the first launch vehicle program in the space age that was 100 percent successful: 10 launches, 10 successes. First launch vehicle of the Saturn IB series and the first flight production Apollo spacecraft were delivered to Cape Kennedy and assembled on the launch pad for a test scheduled for early 1966. At White Sands, New Mexico, the Apollo Launch Escape System underwent further testing during 1965; booster for these tests was the Little Joe II launch vehicle. An early 1966 test was to complete the series.

All 3 stages of the Saturn V launch vehicle, largest in the world, were successfully ground-tested during the year. The 7.5-million-pound-thrust Saturn V, 365 feet long and weighing over 6,000,000 pounds at liftoff, is the rocket that will launch the moon shot. The Apollo spacecraft consists of 3 units—Command Module, Service Module and Lunar Excursion Module—plus adapter and the Launch Escape System, to be used only in a launch emergency situation. Apollo was to enter the unmanned phase of its flight program in 1966, with manned missions scheduled for the first half of 1967. NASA's Office of Manned Space Flight is program director for Apollo, with the Manned Spacecraft Center at Houston having responsibility for development of the spacecraft modules, and Marshall Space Flight Center at Huntsville, Alabama, in charge of the launch vehicles. The Boeing Company is developing the basic stage of Saturn V, North American Aviation and Douglas Aircraft being responsible for the upper stages. Prime spacecraft contractor is North American; Grumman Aircraft Engineering Corporation is building the LEM.

In unmanned space exploration, 2 Ranger missions made the greatest single advance in lunar knowledge since Galileo. Ranger VIII (February 17–20) and Ranger IX (March 21–24) telecast more than 14,000 close-ups, revealing lunar surface features as small as 10 inches across. A 2-stage Atlas-Agena rocket launched both Rangers, first into a 115-mile altitude earth orbit, then at a speed of 24,500 miles an hour, into a lunar trajectory. Ranger VIII swept over the mountainous area near the center of the Moon's visible face, then closed in on the Sea of Tranquillity, revealing thousands of craters believed caused by impact of large meteoroids and their debris. The lunar plains of the Sea of Tranquillity were judged to be sufficiently level for landing of the Lunar Excursion Module. Despite absence of wind and water there appeared to be significant erosion on the lunar surface.

Ranger IX made a more vertical descent on the



Artist's conception of the historic Gemini 7/6 rendezvous.

Crater Alphonsus with photographs showing strong evidence of volcanic activity on the moon, long believed to be a cold, dead body. In the center of Alphonsus is a mountain peak which, according to astronomers, appeared to give off gaseous emissions. Certain smaller craters within Alphonsus, surrounded by dark "halos" (deposits of dark material on the lunar surface), which some scientists believe erupted from the moon's interior through the craters, imply that the moon may not be dead. Crater Alphonsus and the Sea of Tranquillity are pitted by hundreds of craters. The "dimple" type craters indicate drainage of material from the moon's surface to the caverns below; lines of such craters suggest deep, long subsurface canyons, hidden below a thin surface layer. The gently rounded crater rims and mountains may prove more suitable than the plains or seas for spacecraft landing. Uneroded by wind or rain, this matter below the surface layer, little changed in the moon's lifetime, offers an opportunity to study the matter of the solar system as it appeared billions of years ago for clues to the moon's origin and evolution. The Rangers' complex high-quality system of television cameras and transmitters, in conjunction with the Goldstone (California) ground receiving station, made the moon close-ups possible. In addition to associated transmitters and power supplies, each Ranger carried 6 television cameras—2 full-scan, shooting a large area, and 4 partial-scan systems for sharper, detailed pictures. The cameras turned on approximately 20 minutes before each Ranger crashed on the moon, and took an average of 300 pictures per minute before impact. The faceplate of a vidicon tube behind the shutter of each camera was coated with a photo-conductive material on which light and dark areas seen through the shutter formed an image. A beam of electrons scanned the image, differentiating between light and dark areas by their differences in resistance, and as the beam swept across the image, it was converted into an electrical signal that was amplified and radioed to earth. Then, high-intensity light and high-frequency electron beams erased the image on the faceplate, completing the whole process in a fraction of a second. Huge 85-foot antennas at Goldstone picked up and amplified the Ranger video signals, which were also channeled to magnetic tape recorders for later telecasts. On March 24, the nation's television networks presented "live" pictures from Ranger IX as it hurtled toward the Crater Alphonsus. A system of sun and earth sensors, gyroscopes, and nitrogen gas jets kept the Rangers oriented in space, locking their solar panels on the sun for power, and their high-gain antennas on the earth for communication.

Mariner IV's 228-day journey and closeup pictures of Mars on July 14 culminated an unprecedented exploratory mission of 325 million miles.

Mariner IV, reporting back to earth on conditions encountered throughout its flight path, observed and measured aspects of the red planet from 5,700 miles distance. At encounter, the straight-line distance of Mariner from the earth was 134,000,000 miles. Weighing 575 pounds, and comprising some 138,000 individual parts, Mariner IV proved the accuracy and reliability of many vital components—the Atlas-Agena launch vehicle, the midcourse motor, attitude controls, etc. In a flight path of 325,000,000 miles, the miss from the aiming point was only about 1,000 miles. With one portion of the spacecraft locked on the sun and another portion locked on Canopus (selected for its brilliance and location), Mariner IV was fixed in position for cruise. On the first day of flight Mariner IV detected the shock wave produced by solar wind on the earth's magnetic field, at a greater altitude than ever before observed. A trapped radiation detector on the spacecraft recorded the best measurement yet made on the outer regions of the Van Allen belts. Setting communications records every day, the spacecraft finished transmitting data at a distance of 150,000,000 miles. First flight outside the earth's orbit away from the sun, it marked the first use of the star Canopus as a spacecraft attitude reference. Mariner performed scientific measurements in interplanetary space between the orbits of earth and Mars, and in the vicinity of Mars; it also provided engineering experience in operating spacecraft during long-duration missions aimed away from the sun. It detected 10 solar flares, 8 of which were confirmed by ground observation posts. Total hits of micrometeoroids topped 190.

After passing Mars, the spacecraft flew behind the planet for the occultation experiment, transmitting radio signals to earth through the planet's atmosphere. Changes in frequency and strength of the signals helped determine the density and depth of the Martian atmosphere, knowledge essential for designing capsules to land on the planet. The picture-taking experiment began at an altitude of 7,000 miles and lasted 25 minutes, each picture covering an area 120 miles square and revealing prominent surface features as small as 2 miles across. Between each picture transmission, the spacecraft returned 90 minutes of detail on scientific experiments and engineering data. Mariner, sampling only 1 percent of the planet's surface, demonstrated that at least a part of Mars is covered with large craters, a fact which leads to far-reaching fundamental inferences concerning the evolutionary history of the planet. The 70 craters shown on Mariner photos 5 through 15 range in diameter from 3 to 75 miles. Although more moon-like than earth-like, Mars has an atmosphere, and may therefore shed much light on early periods of the earth's history. Its ancient surface (2 to 5 billion years old) leads scientists to believe that no atmosphere significantly denser than the present very thin one has ever existed, since severe erosion would have resulted. The lack of internal activity (which creates mounttains and continents) confirmed Mariner's magnetometer experiment, indicating absence of a significant magnetic field. No proof or denial of the existence of life on Mars resulted from the experiments. Mars may prove, however, to be the place in the solar system best preserving clues to original organic development, and the Mariner photos have profoundly affected scientific views on the origin and evolution of planetary bodies in the solar system.

Final unmanned space project of the year, Pioneer VI embarked on its mission December 16, to return interplanetary data from space. Following a 40-million-mile-wide path in the plane of the earth's orbit, the spacecraft went into orbit around the sun. First vehicle to attempt a radio propagation experiment in interplanetary space, Pioneer VI was also the most magnetically "clean" spacecraft in order to allow its magnetometer experiments to function without interference from the craft itself. Weighing 140 pounds and carrying 35 pounds of instruments, it has the highest data-return capability of any interplanetary spacecraft and can respond to 57 distinct ground commands. Launched by the Thrust Augmented Delta, Pioneer VI is a cylinder 35 inches long and 37 inches in diameter. It was spin-stabilized at about 60 revolutions per minute in the plane of earth's orbit to give the experiments a 360-degree scan. The mission required the most ambitious flight trajectory in the 5-year history of Delta launchings. After 6 months of flight, the elliptical orbit was expected to carry the spacecraft to within 77,000,000 miles of the Sun. The scientific experiments aboard Pioneer VI were designed to improve knowledge of the magnetic fields of the sun; the turbulent solar atmosphere, or solar "wind" stream of charged particles; the physics of the sun itself; the boundary region between the solar atmosphere and interstellar space; and the basic interactions of high-energy charged particles and magnetic fields. Some 14 months of interplanetary measurements had been recorded by previous NASA missions, but since the characteristics of the sun change considerably over its 11-year cycle, much additional information is needed.

The following major satellites were hurled into orbit during the year by NASA:

TIROS IX, the new "cartwheel" version of NASA's weather satellites, was launched January 22, with all weather data received by the Weather Bureau and distributed to the worldwide meteorological network. Its rolling attitude (10 revolutions per minute) and sun-synchronous polar orbit enable the satellite's 2 vidicon cameras, placed on opposite sides, to cover the entire earth daily. The 305-pound Television Infrared Observation Satellite was launched by a Delta rocket into a 100-minute orbit, 460 miles high.

TIROS X, funded by the Weather Bureau, was launched July 2, to scan and photograph tropical storm breeding areas. Similar to TIROS IX, it takes over 400 pictures daily. The tenth consecutive successful weather satellite, its sun-synchronous, near-polar orbit was the best achieved in the series and almost perfect for space photography.

OSO II, providing detailed information on solar X rays, gamma rays and ultraviolet radiation, was launched February 3, by a 3-stage Delta rocket. The 545-pound satellite, heaviest ever orbited by Delta, sent an average of 7 miles of tape-recorded data daily to ground stations during its first month of operation. Second in a series of 8 satellites for extensive study of the sun, the Orbiting Solar Observatory II conducted the most intensive investigations of that body ever undertaken.

Pegasus I, launched February 16, was the first of a series of 3 satellites designed to gather data on meteoroid frequency to determine the extent of that hazard. Pegasus spacecraft, among the nation's largest and heaviest, have sensor panels of 3 different thicknesses, permitting analysis of the various sizes of meteoroids impacted. Wings, 96 by 14 feet, present a 2,300-square-foot surface, instrumented to detect collisions with meteoritic particles and provide necessary basic information for future spacecraft design. As the particles collide with the winged surface, penetrations are registered in a magnetic core memory and relayed to earth. Pegasus I sweeps around the earth in elliptical orbit, 390 to 463 miles high, 31 degrees north and south of the equator. In addition to impact information, data on temperature, power levels and intensity of radiation encountered, are transmitted to ground stations.

Pegasus II continued gathering data on meteoroid flux in the near-earth environment after its launch on May 25. The 1 1/2-ton improved version featured a new capacitor fusing arrangement, allowing ground engineers to disconnect a single malfunctioning capacitor, leaving others working. This corrected hampering effects of short circuits and consequent drain of power supply suffered by Pegasus I. Early figures on Pegasus II meteoroid punctures closely followed advance computations, marking progress in capability of predicting the number and size of meteoroid particles.

Pegasus III, last of the series returning impact data to evaluate the meteoroid hazard, was ejected into circular orbit on July 30. Pegasus III incorporated 48 detachable subpanels on the wings, which could easily be unhooked at some future data by an astronaut and carried back to earth. All of the Pegasus satellites, built by Fairchild Hiller, were boosted into orbit by Saturn I.

Early Bird I was launched April 6 for the Communications Satellite Corporation. Pioneer in a new era of global communications, the commercial satellite receives and transmits telephone calls, high quality color and 2-way black and white television, photos, teletype, facsimile and data. The 85-pound cylinder was launched by a Thrust Augmented Delta into elliptical earth orbit at 22,300 miles altitude. With a design life of 2–3 years, it is equipped with 2 VHF telemetry transmitters, 2 encoders, 2 communications transponders, an orientation system and 2 microwave beacons. Power is supplied by 6,000 solar cells and 21 nickel cadmium batteries. First step toward a worldwide network of satellites to provide new channels of communications to many nations, Early Bird I will be followed by 4 larger satellites, 3 times more powerful, produced by Hughes Aircraft Company.

Scheduled for early 1966, the Tiros Operational Satellite (TOS) System will provide continuous global weather data on a daily basis. The cartwheel satellite will transmit cloud picture coverage (by Automatic Picture Transmission camera) directly to the Weather Bureau which will operate the system after NASA launches the satellite into polar orbit at 750 nautical miles altitude.

As part of a broader program of international cooperation, NASA orbited the Canadian Alouette II and the French FR-1 satellites during the year, from the Western Test Range. Alouette was one vehicle in a double launch that also orbited an Explorer spacecraft.

Significant in the large research sounding rocket program (48 successfully fired during the year) was the expansion of geographical coverage. In addition to Wallops Island, Fort Churchill on Hudson Bay, and Ascension Island, rockets were fired from Point Barrow, Alaska, for the first time, and an agreement with Brazil made a station near Natal available for 1966 Nike Apache grenade experiments. A pitot-static tube experiment was conducted during NASA's mobile launch expedition off the west coast of South America.

Direction of smaller rocket technology (30 to 60 kilometer range) was toward improvement in design and development of rocket motors, sensors, data acquisition and data reduction systems. Of the smaller Arcus, Loki type, 100 to 150 are fired annually for development work itself. They are employed in support of other space tests and of the cooperative meteorological sounding rocket network, with schedules arranged to include as many of these functions as possible.

Sounding rockets in physics and astronomy applications numbered 138 during 1965. Studies of the upper atmosphere included research in structure and composition of planetary atmospheres; measurement of particles and the magnetic field structure; study of D, E and F regions of the ionosphere; spectroheliograph and coronagraph observations of the sun; optical gamma ray and X-ray studies of stellar objects.

Advanced research and technology saw developments in these NASA programs during 1965:

FIRE II, the in-flight re-entry experiment, gathered further data during extended measuring of the period of highest heating. Launched May 22 by a thick-skinned version of the Atlas-D booster, FIRE II included a velocity package powered by the solid-propellant Antares II rocket motor, designed to drive the re-entry payload back into the atmosphere at 37,232 feet per second, highest speed achieved by a man-made object in the atmosphere. The second FIRE flight, complementing the earlier experiment, defined more completely the heating curve with data to improve engineering applications for several national programs; it also confirmed findings and analyses of ground experiments. Onboard experiments included measurements of radiation from a hot gas cup with specially developed radiometers. One of the 3 radiometers was designed to provide information on the chemical composition of the gases in the radiant region. Radio "blackout" caused by plasma sheath formation was studied with careful measurement of variations in telemetry transmissions during the re-entry phase. The 32-minute flight followed a 5,000-mile ballistic trajectory from Cape Kennedy along the Eastern Test Range, to re-entry at 27,000 miles per hour near Ascension Island. Langley Research Center managed Project Fire, including General Dynamics' Atlas launch vehicle, Ling-Temco-Vought's velocity package, Hercules Powder Company's Antares II motor and the re-entry package of Republic Aviation Division.

In December, NASA took delivery from Northrop Corporation of the HL-10 lifting body research craft.

A Scout Evaluation Vehicle was launched in August to demonstrate in-flight operation of a number of its improved features, developed over the previous 18 months. Seventy-two feet long and weighing 20 tons at lift-off, Scout is the nation's only all-solid-propellant launch vehicle with orbital capability. By means of a new guidance technique known as yaw torquing, the launch vehicle proved it can fly a "dog-leg" course, achieving a higher orbit inclination angle. New second and fourth-stage rocket motors were incorporated: Castor IIA, with 58,000 pounds thrust and the FW-4, producing 5,600 pounds. Improved spin motors stabilized Scout's fourth stage. The air transportability concept of a fully assembled vehicle was confirmed when Scout was airlifted from Wallops Island after assembly, then returned to the launch site, simulating a transcontinental trip. A Radio Attenuation Measurement experiment addressed to the problem of radio communications blackout was flown on a Scout rocket in the spring, as part of Wallops Island electronic research on the problem.

Study of radio communications blackout at Langley Research Center, under way early in the year, led to the findings that this considerable problem is influenced by the shape of the space vehicle, choice of signal frequency, static magnetic fields and the atmospheric flow field. It was suggested that blackout can be overcome by proper design selection and the addition of certain liquids to the flow field.

The Atlas Centaur (AC-6) August launch simulated a full-scale mission to determine Centaur's capability to place a Surveyor model on course to the moon. NASA plans to soft-land the Surveyor to conduct lunar surface studies preliminary to manned Apollo missions. The Deep Space Net shows that less than one-tenth of Surveyor's midcourse correction capability would-have been needed to put the spacecraft on a final trajectory to the moon, a vast improvement over any previous lunar or planetary launch. With this fourth successful test flight in the series, Centaur was the nation's first launch vehicle to qualify operationally an all-inertial guidance system for deep space application. The Honeywell system includes an airborne digital computer which solves, on course, guidance equations for the system to correct and control the vehicle in flight. Following separation from Centaur, while traveling 34,000 feet per second, the 2,100-pound Surveyor model continued in a highly elliptical earth orbit. The high-energy, liquid-propellant Centaur second stage vehicle and its Atlas booster were built by General Dynamics' Convair Division.

NASA's Convair 990 chased the May 30 solar eclipse across the South Pacific, giving scientists an opportunity to observe the turbulent processes of the solar atmosphere and the effect of an abrupt interruption of sunlight on earth's upper atmosphere and the ionosphere. Flying at 38,000 feet, 600 miles an hour along the path of totality, the observers were afforded 9 1/2 minutes of total eclipse, 4 minutes more than ground observers. The research plane took off from Hilo, Hawaii, and intercepted the path of the eclipse at 131 degrees, 55 minutes west longitude and 1 degree, 37 minutes south latitude. Data gathered by the scientists and equipment aboard contributed to studies of ionization and excitation processes of the inner corona and furthered cataloguing of coronal lines; study of coronal structures; and the process of resolving apparent discrepancies between the relative abundances of elements in the corona and the photosphere.

The research jet also tracked the Ikeya-Seki comet over the Pacific for 13 days, beginning late October. To help remove some of the mystery about comets—their mass structure, composition and the effects of interaction with the solar environment—the aircraft carried instrumentation and a team of scientists aloft each morning, to a point 400 miles north of Hawaii. Spectral observations of the Ikeya-Seki's coma and tail were made in ultraviolet and infrared at 40,000 feet, to provide information on the comet's composition and structure. Photographs were taken of the comet's tail in the vicinity of the sun, to permit study of the solar corona and solar wind at high inclination angles and research on comet disintegration. Sounding rockets contributed to data gathered in both experiments.

The X-15 research plane, which has more than doubled the limits of manned flight in winged vehicles, completed its 150th mission in September. It measured boundary layer noise and aerodynamic and structural loads on the horizontal tail surfaces. The rocket-powered aircraft has flown to the record altitude of 67 miles at the record speed of 4,104 miles per hour. Destined for use in the Apollo spacecraft, the X-15's horizon scanner implements research coupled with space launches. An ultraviolet stellar photography experiment uses a prototype of equipment in the Orbiting Astronomical Observatory satellite. External propellant tanks were added on one ot the 3 aircraft in October, to carry anhydrous ammonia and liquid oxygen. The added propellant will increase engine burning time from 85 to 145 seconds, raising the speed to 5,000 miles per hour. X-15 number 3 underwent modifications in November for installation of the "energy management" system which automatically gives the pilot an up-to-the-minute picture of his position in flight, glide capability, plus the distance and procedures to follow for safe landing. Other advanced research projects under way in this program are atmospheric density measurements, meteorite collection, exhaust plume characteristics, vapor-cycle cooling, and a supersonic deceleration device.

A Lockheed JetStar was modified by NASA in 1965 for use as a flight research vehicle with particular reference to the supersonic transport program. Called the general-purpose airborne simulator, one of its many applications is to simulate the flight responses and flight characteristics of supersonic airfoils. NASA incorporated the Variable Stability System (VSS) developed by Cornell Aeronautical Laboratory, which has the capability of feeding in the flight responses of the supersonic transport and of other high performance aircraft. The JetStar was selected for this research project because of its high performance platform, with sufficient payload to incorporate the VSS and other test equipment and techniques.

Flight models of the M2-F2 and HL-10 lifting body wingless aircraft were delivered during the year, and flight tests were scheduled for 1966. Flight testing will investigate man's ability to control the vehicle during low-speed operations and landing. The lifting body program seeks to attain maximum ratios of useful volume to surface area, to reduce structural weight and problems of aerodynamic heating on re-entry of the earth's atmosphere.

The largest solid fuel rocket motor, in a September test firing, advanced technology and demonstrated feasibility of its use in future space launch applications. A "half-length" model was tested; full length, the Aerojet General motor would develop 7,000,000 pounds of thrust. Eighty feet long, with 260-inch diameter, it was made of special maraging steel casing and contained 1,680,000 pounds of solid propellant, cast in one piece. Thrust output was 3,500,000 pounds.

NERVA, first nuclear rocket engine system, underwent a December "breadboard" test, marking the first workout for such an integrated system from starting process into power phase. During the year, specific impulse of more than 750 seconds was achieved in the NRX-A3 reactor, with operating times topping one hour, and more than 16 minutes at full power condition achieved. Rapid startups became a common feature of the nuclear rocket program. Remaining tests in the scheduled NERVA engine series and in the first phase of the advanced Phoebus reactor program were to attain longer operating times in reactor systems, with higher temperatures and power. The first SNAP 8 reactor, developed by the Atomic Energy Commission to provide 600 kilowatts for space power, was operated over a continuous period of 209 days.

Phase II of the hypersonic ramjet research program began in April with General Electric, Marquardt, and Garrett Corporation's assignment to develop 3 engine concepts and prepare preliminary designs. The program seeks eventual construction of a ramjet research engine to advance the technology of air-breathing propulsion into the hypersonic regime of flight. The contracts, amounting to $1.5 million, covered independent detailed studies of advanced ramjet engine technology by the 3 companies, to define and develop a preliminary design for the best possible ramjet engine to implement a research flight program. Plans were to be submitted as technical proposals for further work on the project. Relative fuel economy at hypersonic speed will make the ramjet engine useful for hypersonic transports, boosters, and spacecraft flying within the atmosphere. Liquid hydrogen fuel was specified for operation at speeds between 2,000 to 5,000 miles per hour. Specifications detailed a weight limitation of 800 pounds and dimensions compatible with mounting the engine underneath the aft fuselage of the X-15, which will ultimately conduct flight research.

The Mission Control Center at Houston assumed primary control of manned space flights, previously directed from Cape Kennedy, beginning with the Gemini 4 mission in June.

Construction of NASA's moon-launch spaceport continued on schedule at the Merritt Island Launch Area, adjacent to Cape Kennedy. MILA's Vehicle Assembly Building, the largest in the world, was to be completed in 1966.

The Space Radiation Effects Laboratory connected with Langley Research Center, Virginia, was dedicated in December. High energy corpuscular radiation will be simulated and its effects studied there, in order to devise means of shielding spacecraft and components against that hazard.

At the Life Sciences Research Laboratory, completed at Ames Research Center, California, late in 1965, a broad research program covering all facets of space medicine and biotechnology was initiated.

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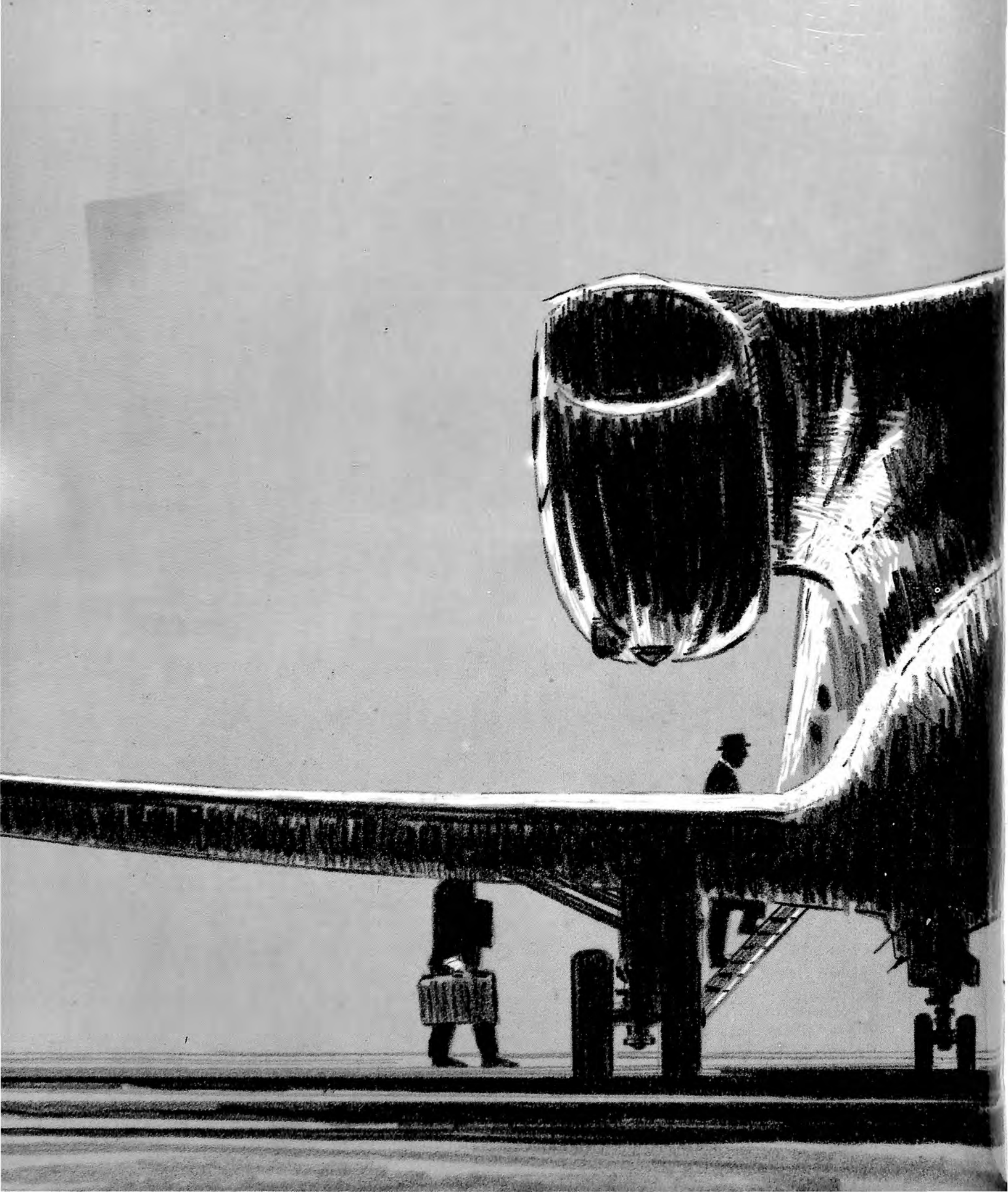

THE AIRLINES

The investment the U.S. scheduled airlines are making in new aircraft as part of the new transportation system they are building stood at more than $3.7 billion at the beginning of the fourth quarter of 1965.

This figure covered the cost of 704 jet and turboprop planes on order for delivery during the period 1965-69. The airlines had taken delivery of 107 of this number at the end of September.

Cost of all flight equipment in service at the end of 1964 was $4.5 billion. At year-end, commitments already amounted to 82 per cent of that amount.

A survey made by the Air Transport Association covering the first three quarters of 1965 showed the following breakdown of deliveries scheduled for the 1965-69 period:

	Jet and Turboprops	Valued at
Delivered January 1-September 30, 1965	107	$655,700,000
On Order as of October 1, 1965	597	3,093,500,000
TOTAL	704	$3,749,200,000
Delivery in 1965	161	880,600,000
Delivery in 1966	239	1,201,600,000
Delivery in 1967	187	1,033,900,000
Delivery in 1968	97	531,900,000
Delivery in 1969	20	101,200,000
TOTAL	704	$3,749,200,000

This delivery schedule includes only orders placed by the airlines at the time of the survey. More orders may be expected—particularly for delivery in the latter part of period.

TOWARDS AN ALL-TURBINE FLEET

Of the 704 airplanes to be delivered in the last half of the decade, 663 will be pure jet, 40 turboprops and one is a turbine-powered helicopter. Of the 663 pure jets, 472 are designed to operate in intermediate and short range services and will represent a major upgrading of the quality of service to the smaller and intermediate sized cities of the country.

In addition to the 704 new airplanes, the local service airlines were planning to convert 60 piston planes to turboprops at an estimated cost of $35 million. The industry also acquired delivery positions for 21 Concorde supersonic transports and 42 U.S. SST's for delivery in the 1970's.

INCREASED CAPACITY

Assuming average utilization, the new fleet of 704 airplanes, when delivered, will be capable of providing 73 billion seat miles a year. By way of comparison, the U.S. airlines' fleet of 1,855 aircraft offered 110 billion seat miles in 1964, 85 per cent of which represented jet and turboprop service.

As of September 30, 1965, the airlines were operating 670 pure jets, 272 turboprops, and 8 turbine helicopters for a total of 950 turbine-powered aircraft. The airlines were also operating 934 piston aircraft, bringing the industry's total fleet to 1,884 aircraft of all types.

PUBLIC DEMAND

Response of the shipping and traveling public to improved and expanded airline service was registered during the first half of 1965, when the airlines, both domestic and international, flew 4,448, 324, 000 revenue ton miles of passenger and cargo traffic, as compared with 3,705,655,000 revenue ton miles during the same period of 1964. This represented a gain of more than 20 per cent.

Reflecting the airline traffic increase was an improved earnings picture. Net profit for the consolidated industry for the first half of the year amounted to nearly $139 million, compared with $79.4 million in the same period of 1964.

JET SERVICE TO SMALLER COMMUNITIES

The part being played by the local service carriers in the industry's new equipment program marks a turning point in the history of this class of carrier. The local service airlines have long been plagued with obsolete and uneconomical equipment. The new jet and turboprop planes they have on order promise the same high quality service to hundreds of off-jet route communities as currently provided larger cities by the trunk carriers.

As of September 30, 1965, the 13 local service airlines had on order 42 pure jet and 36 new turboprop aircraft. In addition, 44 piston aircraft were being converted to turboprop engines. These aircraft are valued at more than $245,000,000 or more than three times the present net value of all the aircraft being used by the local service airlines in 1965.

The significance of jet service via local service carriers is underscored by the fact that of the more than 600 cities served by airlines in every state and territory, 402 are served exclusively by the local service airlines.

The growth of the local service airlines has been spectacular. In 1954, they carried 2,500,000 passengers. In 1964, they carried more than 10,000,000. In the first eight months of 1965, they carried approximately 8,000,000 passengers, for a gain of 16.5 per cent over the same 1964 period. It was expected that the new flight equipment would attract passengers at an even faster rate in the next few years.

GROWING DEMAND FOR AIR FREIGHT

Air freight is the fastest growing service in the airline industry. The scheduled airlines had an average annual growth rate of more than 15 per cent over years 1961-1965, as measured in ton miles of service. In 1964, air freight registered a gain of 26.9 per cent over 1963 and for the first eight months of 1965 was up 33-1/2 per cent over the same period in 1964.

To meet the growing demand of modern management for air freight, the scheduled airlines at year-end operated 53 jet airliners, each capable of hauling up to 92,000 pounds, more than a threefold increase in capacity and a near doubling of speed over the DC-6A, for example. Of this number, 29 were used specifically for cargo operations. The remaining 24 were convertible, that is, they were built with reinforced flooring, removable seats and movable bulkheads and could be transformed from a combination passenger-cargo jet airliner to an all-cargo jet freighter in from two to three hours.

In addition, from 6,000 to 19,000 pounds of freight can move in the cargo holds of each of the 10,800 airline passenger flights scheduled daily.

At the end of September, 1965, the airlines had made commitments to buy an additional 44 jet aircraft capable of all-cargo services—12 to be used strictly in all-cargo service and the remaining 32 to serve as "quick change" aircraft capable of being converted from passenger to all-cargo configuration. This represented an investment of $367,000,000 and an expansion of the 1965 long-range jet freighter fleet by 83 per cent.

The all-cargo and convertible jets are long-range aircraft designed for transcontinental and international use. The new quick change (QC) plane will be a short-to-intermediate-range aircraft extending the advantages of jet freighter service to medium-sized cities throughout the country. And instead of requiring from two to three hours for the change-over from passenger to all-cargo configuration (as in the case of the present convertible jets), the QC operation will require only 30 minutes.

This means that, when in cargo service, these aircraft will give the airlines an additional 3-1/2 hours of flying time per day, a gain of nearly 40 percent over the utilization of the standard, nonconvertible all-cargo jets.

AIRLINES SUPPORT NEW POST OFFICE PROGRAM TO EXPEDITE LETTER MAIL

The airlines strongly supported the Postmaster General's plan, announced in 1965, to deliver 95 per cent of the nation's letter mail anywhere in the country overnight by 1967. The plan calls for eliminating air mail as a separate classification and moving mail by the fastest mode of transportation available—air, rail, motor or water.

If such a program had been in effect in 1965, the airlines would have provided overnight delivery to about 7-1/2 billion letters a year, or two-and-a-half times the 1965 volume of mail carried by air.

The airlines were well prepared to play their role in the priority mail program because the more than 10,800 airline flights scheduled daily during 1965 represented an increase of 31 per cent over the number of daily flights ten years ago, because co-operation with the Post Office in expanding the practice of delivering truckloads of mail directly to planeside was reducing ground handling time for air mail by as much as 40 per cent at major cities; and because accelerated interchange of air mail between flights at major cities was permitting the interchange of as much as 32,000 pounds of air mail between aircraft in as little as 45 minutes.

These and other improved air mail operations resulted in the delivery of 71 billion pieces of mail in 1964. Seventy-two billion pieces were projected for 1965 and 74 billion for 1966.

EMPLOYMENT

Since the initiation of jet operations in 1958, the airlines have created some 39,000 new jobs. During the past decade, airline employment has increased from 109,500 to 190,000 employees, with an annual payroll of over one and one-half billion dollars. While the jobs involved cover a wide range of skills, of the total increase, aircraft and traffic service personnel numbered 51,800 at the end of 1964—an increase of 14,600, or 39 per cent since 1958. This category of employees includes those in jobs of a semiskilled nature not requiring technical training prior to employment. The indicated rate of increase in new positions was expected to continue.

In addition to providing new job opportunities, the industry has given top priority to training and upgrading employees. The industry is spending well over 100 million dollars a year on in-service training programs designed to upgrade the skills and capacities of airline employees. This includes mechanic apprenticeship programs, management development for foremen, stewardess instruction, customer service training, and flight personnel improvement.

MORE OPPORTUNITIES IN VIEW

The massive airline re-equipment and expansion program will provide tens of thousands of jobs in the aircraft manufacturing industry and its suppliers in every state of the union. Airlines alone are planning a net addition of 50,000 jobs during the delivery period of these airplanes.

Looking further into the future, as subsonic flight merges into supersonic flight, new challenges in navigation, meteorology, metallurgy and the application of the multiple uses of computers will require the ablest minds of our generation.

It is estimated that the SST would create some 40,000 new jobs in the aircraft industry alone. It would provide opportunities for hundreds of thousands of people in the supplier industries. Progress in the design of the SST today shows that it would be more than three times as productive for the airlines as today's subsonic jets.

On the following pages are resumes of the 1965 activities of the member companies of Air Transport Association of America.

AIR CANADA

Orders for 16 new jetliners, to be delivered in 1967, were placed by Air Canada in 1965. These aircraft, valued at about $83,000,000, together with eight others ordered by the airline in 1963 and 1964 and scheduled for delivery in 1966, will increase Air Canada's fleet of pure jet aircraft to 40.

The $40,000,000 worth of aircraft scheduled for delivery in 1966 will add 710 passenger seats to the airline's North American and overseas services to accommodate additional traffic expected in the coming years.

Included among the aircraft to be delivered in 1966 are two 139-passenger Douglas DC-8's and six 72-passenger Douglas DC-9 twin jets. Four extended versions of the DC-8 with a capacity for 196 passengers and 10 extended 94-passenger DC-9's will be delivered to the airline in 1967.

Air Canada carried 4,682,384 passengers on scheduled flights during 1965, an increase of 14 per cent over 1964.

The most impressive increase was on southern

Air Canada ordered 16 new jetliners in 1965 to increase its fleet to 40 jets by 1967.

routes where the number of scheduled passenger miles rose by 36 per cent, followed by a 32 per cent growth on Atlantic routes for a total of 1,000,000,000 international passenger miles. Traffic on North American routes recorded a 17 per cent increase to 2,588,430,000 passenger miles.

Available seat miles on scheduled flights increased by 15 per cent during 1965 to 5,372,994,000 while ton miles available showed an 18 per cent rise to 843,507,000.

Air freight ton miles showed a spectacular 32 per cent increase to 54,519,000 over the year with air express rising by 22 per cent to 5,368,000 and air mail seven per cent to 16,950,000 ton miles.

Passenger load factor in 1965 was 66 per cent, up three per cent from 1964.

The airline's change of name to Air Canada from Trans-Canada Air Lines became official on January 1, 1965, and by the end of the year all of the airline's DC-8 jetliners and most of its Vanguards and Viscounts, as well as most printed items and equipment carrying the company markings appeared in the new colors with identifying symbol.

New grey-colored uniforms for the company's male and female passenger agents were designed and adopted by Air Canada during 1965 and were worn for the first time by employees early in 1966.

With the introduction of the 1965 summer schedule in April, Air Canada inaugurated a new daily nonstop service between Montreal and Paris, the world's two largest French-speaking cities. The new flights, designated "Europe 870—Canada 871" continued on from Paris to provide daily service between Canada and Dusseldorf, Germany. The service proved so successful during the summer that it was decided to continue the flights throughout the winter months.

Air Canada acquired a new southern route towards the end of the year when service was inaugurated between Toronto and Freeport, Grand Bahama Island, on a once-a-week basis, beginning on Dec. 13. The following day, on Dec. 14, the airline began a once-a-week nonstop flight between Halifax and Bermuda, providing the Maritimes with direct service to the Atlantic Island and convenient connections from there to the Caribbean.

In October, Air Canada announced it would transfer its operations in Germany from Dusseldorf to Frankfurt next April. The change from Dusseldorf, which the airline has served since 1952, is being made primarily to facilitate proposed nonstop service between Germany and Canada. In line with the growth in traffic between Europe and Canada, Air Canada also announced it will open additional sales offices in Germany and that it has appointed sales representatives in Warsaw, Poland and Zagreb, Yugoslavia.

In April, it was announced that Air Canada would move into a new $20,000,000 passenger terminal at New York's John F. Kennedy International Airport in 1968. The carrier will share the majority of available space in the terminal with British Overseas Airways Corporation, builders of the project.

Air Canada became the first Canadian company to present the design and concept of its Expo '67 pavilion when it unveiled plans for a $1,500,000 structure on June 10. The pavilion will portray the story of aviation, while its unique helical design will seek to capture the spirit of flight.

Queen Mother Elizabeth was carried aboard an Air Canada aircraft for the second time when she flew from London to Toronto on June 23. The Queen Mother was in Toronto to present new colors to the Toronto Scottish Regiment, of which she is the Colonel-in-Chief.

The airline introduced more liberal free baggage weight allowances on North American routes in September. The new allowances permit both first and economy class passengers to carry, free of charge, the equivalent of one man's three-suiter, one two-suiter and an overnight bag, provided the latter can be carried into the cabin and stowed under the passenger's seat.

With the winter schedule, the airline announced it was doubling its winter service to the United Kingdom and Europe with 16 weekly return flights from Canada, in addition to three-times-a-week cargo/passenger service.

The airline also announced the introduction of all-cargo DC-8 service between Montreal and Vancouver, providing for the carriage of twelve 7,000-pound pallets in the cabin of the aircraft and an additional 10,000 pounds in the cargo holds.

Effective November 1, the airline introduced throughout its Canadian system an integrated air/off-line service for cargo shipments originating in Canada and consigned to any point in the world. The service includes surface transportation of goods between airports and points away from main airline terminals.

Following an International Air Transport Association traffic conference held in Bermuda in October, Air Canada announced plans for the introduction of new low trans-Atlantic fares in April, 1966. The new fares provide for the reductions of up to 15 per cent in round-trip economy excursion fares.

ALASKA AIRLINES

In 1965 Alaska Airlines recorded another peak year, both in revenues and passenger volume, primarily due to the Civil Aeronautics Board's realignment of jet routes to the nation's largest state. This realignment brought Alaska's Golden Nugget jet into direct competition in the fast growing Seattle-Anchorage market. The route realignment further strengthened Alaska Airlines' position as the only carrier serving the state's two largest cities.

The new route was flown for the first time on June 2, 1965, and the airline featured mid-afternoon departures directly to Anchorage five days a week thereafter. Due to the time differential, arrival in Anchorage was at the same midafternoon time, providing ample opportunity for a little early sightseeing and an early acquaintance with Alaskan hospitality. The remaining two days a week evening schedules were featured. This combination of schedules provided convenient connections from all points in the nation to Alaska, and was partially responsible for the tremendous surge in passenger volumes experienced during the summer months. Passenger revenues during August, for example, only fell $150,000 short of equalling the August passenger revenues of the preceding two years.

There were several reasons for this unparalleled increase. First was the convenience in scheduling, both with respect to departure and arrival times and with interline connections. Especially packaged vacations designed to acquaint the visitor with the beauty and grandeur of the northern frontier attracted many new guests to Alaska. Finally, the Visit USA Program, a tariff designed and initiated by Alaska Airlines to give greater opportunity and incentive to the foreign visitor to "See America," drew many foreign visitors. In 1963 Alaska Airlines carried only 300 tourists to Nome. An energetic sales promotion and advertising program, which included the Visit USA concept, increased this figure to over 1,400 in 1964. In 1965 the company carried over 2,500 tourists to Nome during the summer season. In addition, over 450 passengers were unable to include the Nome tour in their plans because of the shortage of accommodations. This latter group was primarily people who had sought to extend their Alaska vacation with a visit to the gold fields of Nome and had not made prior hotel reservations.

There were other changes in 1965. On May 12, Alaska Airlines completed a six month evaluation of the new high performance jet aircraft by signing an order for two Boeing 727C convertible jets for use throughout the interior of the state. This first step in Alaska's re-equipment program will bring jet convenience and reliability to the historic Seward Peninsula, and will mark the first commercial jet service north of the Arctic Circle in the nation's history. These new jets, with their Gold Rush motif, will retire Super Constellations presently serving the routes north of Anchorage.

To complement the change in equipment and to support the rapidly increasing tourist traffic to the Nome-Kotzebue area, Alaska Airlines will add another hotel in Nome. Completion was scheduled in time for the peak of the 1966 summer tourist season. The combination of the outstanding success enjoyed by the original Nugget Inn constructed in 1964, the need for additional facilities, and the promise of even greater future requirements, resulted in the program for a new, enlarged Nugget Inn in Nome.

ALASKA COASTAL-ELLIS AIRLINES

To meet growing demands and advance the Alaska Coastal-Ellis Airlines' overall objective to improve reliability of service, a fourth PBY Super Catalina was purchased in 1965. The capability of the Super Catalinas to be flown on instruments is a contributing factor to the increased completion of flights during the winter weather conditions. At year-end, the airline's fleet consisted of the 4 PBY Super Catalinas, 15 G21A Grummans and 4 Cessna 185 float planes.

Among the capital improvement programs of the company was the construction of additional hangar and maintenance facilities at the Juneau Municipal Airport. When completed, this will more than double the area of the existing facilities. A new sales office will open, serving the communities of Haines and Port Chilkoot.

The first of a series of modifications to the Grumman fleet was the modifying of the window areas, including enlarging passenger window, improved cabin heat distribution, more effective sound-proofing. Provisions were being made for the addition of these comfort features to the remainder of the fleet. One Grumman aircraft was converted and equipped with retractable wing tip floats.

A 1965 improvement was the start of conversion of one Grumman aircraft to turboprop engines. The installation will include two Pratt & Whitney PT6-A6 turboprop engines with the design being done by Strato Engineering Company, Inc. of Burbank, California. Fairey Canada Limited, Western Division, of Victoria, British Columbia, was fabricating many of the components. The actual conversion will be done by Alaska Coastal-Ellis Airlines at its maintenance facilities in Juneau, Alaska. Prop jet engines will make the popular Grumman quieter, smoother and about 30 miles per hour faster. One plane will be converted and evaluated before converting all 15 Grummans.

The directors of Alaska Coastal-Ellis Airlines also authorized negotiations for the purchase of suitable modern pressurized aircraft for the Juneau/Sitka/Annette route to be purchased upon completion of the Sitka airport. The airport was scheduled for completion in the latter part of 1966. This was of particular significance since Alaska Coastal-Ellis Airlines is an all amphibious carrier, serving 65 points of which only five have airports.

Among route changes the airline announced an improved schedule in its operation between Prince Rupert and Ketchikan. Arrangements were made with United States and Canadian Customs so the airline may operate nonstop between Annette Island and Prince Rupert in both directions, thereby providing convenient through-jet connections between the "South 48" and Prince Rupert.

For the first nine months of 1965, Alaska Coastal-Ellis Airlines transported 116,196 passengers, 2,921,003 pounds of freight, 1,461,777 pounds of mail, and operated 9,506,000 passenger miles. This represented a substantial increase over 1964. Reasons for the rise were increased commercial accounts coupled with growth of interest in Alaska as a vacation area.

ALLEGHENY AIRLINES

For Allegheny Airlines the year 1965 was a year of change. Early in the year President Leslie O. Barnes announced the company's plans for an all jet-powered fleet.

Transition to jet-power, which was expected to be complete by 1967 or sooner, called for DC-9-30 "Vistajets" for the dense, highly competitive routes; Convair 580 jet-prop "Vistacruisers" for both dense competitive and noncompetitive markets; and F-27J jet-prop "Vistaliners" for use in the small and intermediate markets.

This $50,000,000 shift to jet-power, which actually began in June when the first Vistacruiser jet-props were introduced, marked 1965 as Allegheny's year of greatest challenge. To meet the challenge of changing to three new types of aircraft, the company invested more than 100,000 hours and $1,000,000 in training during the year.

Allegheny also embarked on a multimillion dollar program to create an entirely "new look," on the ground as well as in the air. Beginning with a completely new color scheme for the exterior of its aircraft and custom interiors for the new planes joining its fleet, the program included redecorating and expansion of passenger lounges and other public areas.

A "Best Foot Forward" campaign which got under way at the start of the year concentrated on improved customer service. Exapnded in-flight services, new ramp service vehicles and air conditioners, new personnel uniforms and additional computerized reservations and flight information facilities were all aimed at providing passengers with fast, comfortable air transportation—in an attractive package.

Faced with the challenge of marketing its "new look" and jet powered service, Allegheny earmarked a $1,000,000 expenditure for advertising, sales promotion, publicity, and an employee incentive program.

The year of change and challenge also produced new records for Allegheny. More than 1,455,000 passengers were boarded for a 15 per cent increase over 1964. Revenue passenger miles exceeded 287,000,000 and cargo ton miles increased 28 per cent to nearly 5,000,000.

Looking to the future, anticipating even greater challenges, Allegheny was installing IBM's most advanced computer—the System/360. The new computer will provide an improved flow of information to management and will be used to forecast requirements and program work.

Allegheny will be the first regional airline to acquire the IBM System/360 Model 40 computer. The company expected considerable savings from expanded computer use, but even more promising was the application of the System/360 to market research and flight schedule planning.

Allegheny serves 38 airports in 12 Middle Atlantic and Eastern states. By the end of the year 31 of these airports were receiving jet-prop service, many for the first time.

During the year Allegheny replaced TWA service at Wilkes/Barre-Scranton and Williamsport on a new route between Pittsburgh and Boston, bypassing New York City. The company also introduced the first daytime Cargoliner service to New York and Pittsburgh at these points.

Still pending at year-end was Allegheny's application to serve Norfolk and Newport News, Virginia, on a new segment from Philadelphia, and its application to replace United's north-south service at Harrisburg, Williamsport and Elmira/Corning.

The Board set for hearing Allegheny's application to renew its Boston-Washington Segment 8 route. Applications for removal of restrictions on several key short haul markets were to be considered in a company proceeding.

Company officials saw sustained growth in all areas for Allegheny and other regional airlines, predicting that expansion would most likely occur in the form of relaxation by the Civil Aeronautics Board of route restrictions together with through mergers and interchange operations between the regionals.

ALOHA AIRLINES

Aloha Airlines planned to observe its 20th anniversary in 1966 by placing two BAC One-Elevens into service between the islands of Hawaii. The planes, ordered in 1965, will be called Alohajets.

The airline began in 1946 with 14 employees. At the end of 1965, it employed more than 500. The line continued through 1965 a perfect safety record of never a passenger or crew fatality.

Aloha grew out of a need for competitive air service in Hawaii and started up with a DC-3 equipped with bucket seats. After weathering severe legal storms and turbulence by those opposing its organization it received a temporary certificate as a scheduled carrier in 1949. President Eisenhower signed its permanent certificate July 20, 1956.

The airline marked an end of an era in January 1961 when it retired its five DC-3s and inaugurated jetprop service between the islands with Fairchild F-27s. So popular did the new planes become that

Article on Aloha Airlines continued on page 221

AMERICAN AIRLINES

American Airlines during 1965 continued to make jet travel more accessible and convenient for all the cities it serves, introduced new programs to stimulate pleasure and personal travel and extended its domestic lead in the freight field with new services and facilities.

As additional Boeing 727 Astrojets were delivered during the year, they were placed into service to provide new and more frequent jet schedules over many of American's routes. The first of the airline's sleek new 400 Astrojets were received before the end of the year to be introduced into service early in 1966 and to prepare for American's total conversion to an all jet-powered fleet by the end of 1966.

To expand jet service even further to meet the needs of travelers and shippers through the end of the decade, American announced in September of 1965 that it had signed a letter of intent with the Boeing Company to purchase 54 new jet aircraft—27 passenger 707s, five jet freighters and 22 extended versions of the 727.

As more jet aircraft went into service and as air travel and air shipping grew during the year, C. R. Smith, American's chairman of the board, noted that the jet revolution is not yet ten years old, yet "you have witnessed one of the great transportation advances of all time."

The jet revolution in domestic air transportation started early in 1959, when American introduced its first transcontinental jet service, Mr. Smith pointed out.

"From the end of 1958 to the end of 1965, American Airlines spent more than $750,000,000 for new airplanes and equipment, an average of more than $100,000,000 a year for seven consecutive years. During the same seven years the total of American's net earnings was $142,000,000," he said.

Jet service, he added, "is incomparably better than the service preceding it. Speed has been doubled and travel times cut sharply." Such a substantial improvement in the quality of a product is usually accompanied by an increase in its price, but that has not been true of air transportation, he said.

"In January, 1959, when American's first jet went into service, the average rate for American's system was 5.92 cents for each passenger-mile. Seven years later . . . the average rate was 5.89 cents. Whether measured in terms of constant 1959 dollars or current dollar values, the average rate is no higher," Mr. Smith said. He predicted that for 1966, with new discount plans, the average rate likely would be lower.

With an average 31,601 passengers each day during the year (as compared with an average of 27,678 in 1964), American carried 11,534,000 passengers, a total of 9,243,115,000 revenue passenger miles in 1965.

On the cargo side, American flew 254,251,551 ton miles of freight, 38,026,366 ton miles of mail and 15,887,511 ton miles of express. Of the total freight volume, 47.5 percent was carried in the airline's jet freighters, 12.9 per cent in DC-7F all-cargo planes and the remainder on other aircraft.

Revenues amounted to $612,435,000 and net earnings were $39,658,000. American's rate of return on investment in 1965 was 9.4 percent—a figure still short of the average return of 10.25 which the regulatory agency has said is a fair return for the larger airlines.

In a major effort to induce more people to enjoy the advantages of modern jet travel and to help promote the "Discover America" program, American during the year compiled an impressive list of innovations that make travel easier and more attractive.

As the originator of the family fare plan (in 1948) and the military half-fare plan (in 1963), American filed a new family fare discount proposal with the Civil Aeronautics Board. It was approved in June and it reduced fares materially for family groups and extended the days on which the low rates are available. (American carried its one-millionth military half-fare passenger in June, 1965).

SABRE equipment enables agents in the New York City reservations office of American Airlines to "talk" directly to the electronics reservations center at Briarcliff Manor, N. Y. In seconds the agent can reserve flight space or complete any particular action requested by the customer.

In an even more dramatic move, American in December announced an American Youth Plan through which young people the world over can travel at one-half the regular jet coach fare when seats are available at flight departure time. This plan has been eminently successful for American and has been adopted by most of the other major airlines.

Recognizing that many travelers want to spend time at their weekend or vacation destinations leisurely exploring scenic and historic areas, American conceived an "Autojet" plan that provides for a combination of a speedy jet flight to destination and a waiting rental car for the ground portion of the holiday. In the spring of 1965, American signed agreements with three national car rental firms that enable travelers to rent the autos for only $99 a week.

During the year also, the airline expanded its "Astrocruiser" program which permits a group to rent a mobile "home on wheels" for sightseeing trips in the western part of the United States.

American was responsible for another convenience for air travelers that became effective in 1965—a liberalized baggage allowance system based on number and size of bags rather than on weight. The plan, also adopted by other airlines, has eliminated what had been for many travelers one of the most tedious and bothersome of rituals—the airport baggage weigh-in. American also further refined during the year its "express service" which permits passengers at many airports to check their bags at the airport terminal entrance and to proceed directly to a departure gate, by-passing the old time-consuming ticket counter procedures.

American Airlines ticket agent issues cards to young people which permit sale of jet coach tickets at half fare, to be used on a standby basis, for flights on major airline domestic routes.

Credit card sales of transportation on American continued to grow. Sales through arrangements with American Express, Diners Club, Bank of America and Carte Blanche totalled more than $25,000,000 at year's end.

And in October, American launched a million-dollar promotion of Arizona as a vacation destination. The program not only stimulated increased air travel to that state, but its success set the stage for other area promotions the airline is conducting in 1966.

American also continued to chalk up domestic industry freight records during the year. On September 9, for instance, the airline hauled 1,087,000 ton miles of freight—the first million ton-mile day in the history of the domestic airline industry. Jet freighter service was expanded to five more cities—Newark, Philadelphia, Baltimore, Cincinnati and Dallas. A new freight terminal was opened in Boston, and construction was started on a new freight terminal at Los Angeles. The latter, a modern and advanced design, is expected to be the prototype for other new freight terminals around the country.

American continued to recruit and train hundreds of new pilots—men who had successfully met the airline's high professional standards. A second pilot training school was opened in Chicago to augment training facilities at Fort Worth, Tex. Hundreds of new stewardesses completed intensive seven-week training courses at American's unique Stewardess College at Fort Worth. And in December, the airline staged the air industry's first "recruitment fair" for college students. The "Jet Age Career Exposition" was held during the holiday vacation period in New York City.

Two new and important air route agreements were negotiated by the United States during the year, one with Japan and one with Canada. At year's end, these agreements were paving the way for American to seek new routes across the Pacific that would connect that fast-growing area with the heartland U. S. cities it serves, and routes from Toronto to Chicago and California that would be logical extensions of its present New York-Toronto Service.

four-engine Vickers Viscounts were added to the fleet in 1963. In 1965, Aloha operated four Viscounts in addition to its F-27s.

Aloha enjoyed the best year in its history in 1964 and indications were that it will break more records in 1965, although figures were not available. In 1964 it returned a profit of 19 per cent on its financial net worth. Its total of 528,000 passengers carried represented a 22 per cent increase over the previous year's volume. Although Aloha was only able to provide 39 per cent of the seats in the competitive market, it enjoyed a 48 per cent participation.

In 1964 for the fourth consecutive year Aloha achieved the highest average passenger load factor of any scheduled airline in the United States—63.8 per cent.

An Aloha milestone was the construction of a modern air-conditioned administration building adjacent to its hangar and maintenance shops at Honolulu International Airport. The new building houses administrative personnel, and the reservations and accounting departments. It is the only airline-owned administrative building in Hawaii.

Among Aloha's innovations are self-service baggage trucks which enable passengers to reclaim baggage without time-consuming unloading; self-service luggage carts, which can be wheeled onto baggage scales, furnished arriving and departing passengers, and attractive ground hostesses in island-style dress assigned to the terminal to assist passengers with baggage and babies and to answer questions. A recently installed closed-television circuit keeps passengers informed of the airline's arrivals and departures through sets installed in the terminal lobby.

The airline's 1965 terminals outside of Honolulu were located at Hilo, second largest city in the islands, located on the largest island, Hawaii; at Kailua in the Kona district on the western side of the same island; at Kahului, Maui, where the line in 1965 completed plans for its new office in a new terminal building; the Hoolehua terminal on the island of Molokai; and, on the island of Kauai, the terminal at Lihue.

BONANZA AIR LINES

Bonanza Air Lines anticipated 170,000,000 revenue passenger miles in the record book by the end of 1965, a six percent increase over 1964.

At the same time, Bonanza officials predicted a greater hike in 1966, a total of 200,000,000 passenger miles, or an increase of nearly 18 percent.

Introduction of DC-9 fanjets to augment a fleet of F-27 propjets was expected to stimulate traffic not only on the jet runs, but on routes served exclusively by F-27's.

Early in 1965, Bonanza filed exhibits with the Civil Aeronautics Board showing how subsidy payments could, in the opinion of officials of the airline, be eliminated over a period of approximately four years. Use of the DC-9's and strengthening of the Bonanza system were key points in the program submitted to the CAB.

To stimulate greater traffic between Las Vegas, Nevada, and Los Angeles, Bonanza was leaning heavily on a "Megalopolis" approach. Passengers may fly to any of three airports in the Greater Los Angeles area from Las Vegas, reducing cross-town travel time for those who live nearer one airport than the others. Nonstop service to Santa Ana, one of the Megalopolis airports, was instituted in 1965.

Bonanza also filed with the CAB a "Visit USA" tariff for 1966, to continue a program pioneered by the regional carrier to make it possible for foreign visitors to travel the country by air at a minimal cost. Initiation of the program earlier won the "President's E Award" for the airline.

Such promotional fares as those for youths, clergymen, and the popular "excursion fare" were continued by Bonanza, which standardized the round-trip return to seven days throughout the airline system except in Nevada, where state authorities ordered a 10-day return period.

Headquartered in Las Vegas, Nevada, throughout its 20-year-history—Bonanza observed its 20th anniversary in December—the airline was in the midst of moving as the year ended. The transfer was expected to be completed in about June.

For a number of reasons, the board of directors voted in mid-1965 to remove Bonanza's offices and personnel to Phoenix, Arizona. One of the primary reasons was to accommodate further growth of the

Artist's conception of Bonanza's new headquarters and maintenance facility at Sky Harbor Airport, Phoenix, Arizona, to be fully occupied by mid-1966.

airline not believed feasible at McCarran Field in Las Vegas.

Work on a new $3,000,000 dollar office and maintenance complex was underway in Phoenix when the first DC-9 was delivered to Bonanza by Douglas.

The fanjets were expected to go into service March 1, 1966, on major routes linking the cities of Las Vegas, Los Angeles, Phoenix, Reno and Salt Lake City.

Passenger boarding records were broken twice in 1965, the last time in August with 60,979 boardings reported. That was an increase of 100 percent over the record month in 1961, just four years earlier. Other records set during 1965 included express, freight, air mail and total cargo.

Bonanza officials said at the end of the third quarter that the airline "may achieve the earnings level of 1964" when earnings were 65 cents per share, despite an equipment disadvantage on the Las Vegas-Los Angeles route which began when a competitor introduced pure jet equipment. Fanjet service was expected to increase the share of the market served by Bonanza. In addition, the new aircraft should lower certain costs significantly, Bonanza officers believed.

Bonanza stock was listed on the American and the Pacific Coast stock exchanges in August.

Pending before the Civil Aeronautics Board near the end of the year was Bonanza's application to link Las Vegas to the Grand Canyon with direct service. An examiner's decision to grant Bonanza the route was reconsidered by the board, with oral arguments in Washington late in the year.

Bonanza also was actively participating in the "Service to Douglas" case dealing with service to the southern Arizona city by way of Tucson from Phoenix.

Serving the four states of Arizona, California, Nevada and Utah, Bonanza in November became the first airline in the nation to apply to the CAB for permission to carry free Christmas gifts destined for distribution to U.S. servicemen in Viet Nam.

Another regional airline and a trunk carrier followed suit. After the Bonanza application—which was granted in one day—the federal government announced "Operation Christmas Star," a program for overseas transportation of gifts for GI's in the Asian country.

Bonanza and Pacific Airlines cooperatively carried several tons of packages from Las Vegas and Phoenix.

The Las Vegas campaign was originated by a radio station there, while Bonanza representatives helped organize a campaign in Phoenix, and accepted such packages at 18 other points throughout the four-state 'BonanzaLand' area.

Braniff's new look includes a completely redesigned hostess wardrobe created by Italian master stylist Emilio Pucci.

BRANIFF INTERNATIONAL

In 1965, Braniff International introduced a colorful new concept in air travel, "the end of the plain plane."

"We are introducing color, flair and surprise to air travel," Braniff President Harding L. Lawrence said, "to reflect the improvements being made in our basic service, but at the same time to take the monotonous sameness out of jet flight for the traveler."

At a November 6, 1965, press conference held at Braniff's Dallas headquarters, Lawrence revealed an airline splashed in a rainbow of colors and detailed other accomplishments in the program he announced only five months previously to position Braniff as a leader in world air transport.

Jet planes with white wings and tails and each in one of seven different solid fuselage colors—yellow, orange, turquoise, dark blue, light blue, ochre and beige; seven different and colorful interiors; brightly and individually colored ground equipment; multicolored fashion collections for hostesses and new attire for all other flight and ground personnel; freshly designed ticket counters, offices and passenger lounges; and new in-flight services were some of the major changes rapidly becoming evident.

Lawrence became president of the international airline on April 5, 1965. In June he announced a program to strengthen the company's route structure over the long term, to provide more service with the present jet fleet, to achieve immediate operational improvement in on-time performance and to make Braniff really distinctive and different in its appearance as well as its service to customers.

He made these progress announcements:

—Braniff will be all jet-powered by February, 1967. Fourteen One-11's, first of the short-range jets, were placed in service during 1965 to join Braniff's fleet of 12 large Boeing jets. Deliveries begin in May 1966 on an order for 12 Boeing 727 Quick Change jets and five Boeing 707-320C intercontinental jets.

—Financing for the $160,000,000 investment in the 14 One-11's and 17 new Boeings was completed and loan agreements signed in October, with a group of banks and insurance companies.

—Aircraft planning for the future now includes a careful study of supersonic needs. Braniff has two delivery positions for American-built 2,000 mile-per-hour SST's.

—On January 1, 1966, available seat miles or passenger capacity on the Braniff system were 57 per cent greater than on January 1, 1965. By July 1, 1966, available seat miles will be up another 20 per cent.

—Braniff extended its service to Acapulco via the San Antonio gateway on December 1, and increased the Mexico service on January 2 to 12 weekly nonstop flights to Mexico City and 12 weekly flights to Acapulco including seven nonstop flights.

—Braniff submitted a joint application with Eastern Air Lines for authority to fly nonstop from New York to major South American points in addition to the present service via Miami.

—The airline applied for authority to fly from Miami nonstop to such points as Lima, Sao Paulo and Buenos Aires in addition to its present service through Panama.

—On-time performance, the percentage of flights arriving within 15 minutes of schedule, improved from 80.5 per cent in May to 84.2 per cent in October. Braniff's goal was 85 per cent or better.

—Braniff was in the forefront of development to reduce weather landing minimums, which also will help improve on-time performance and schedule reliability. Braniff probably will enter the Category II phase (ceilings of 100 feet and quartermile visibility) in 1966 with the use of radio altimeters, and "it is anticipated that Braniff will be among the first world carriers to be certified for landings with zero-zero visibility because all our new aircraft will be delivered with full provision for these landings."

—Daily utilization of jets was raised from 8 hours per day in May to 10 1/2 hours per day in October which meant more schedules for the communities Braniff serves as well as lower costs per mile. The goal was to achieve 11 hours daily utilization by year end.

—New innovations for customer convenience such as prewritten "Fastpack" tickets and a permanent "Fastcheck" baggage tag were introduced so that the passenger may now bypass the ticket counter entirely.

—Delivery time of baggage to the pickup area was down to a system average of 6.2 minutes for the "last bag" by October, with even faster times being sought.

CANADIAN PACIFIC AIR LINES, LIMITED

Inauguration of a Toronto-Montreal-Amsterdam-Rome flight on November 2, 1965, increased the unduplicated route mileage of Canadian Pacific Airlines to 50,072 of which 43,186 were overseas routes.

By December, 1965, all overseas route patterns were being serviced by DC-8 jetliners. These patterns included the polar route from Vancouver, Edmonton, and Calgary to Amsterdam; the mid-Atlantic route from Montreal to Santa Maria, Lisbon, Madrid and Rome; Vancouver–Hawaii; Vancouver–Tokyo–Hong Kong; the Latin American route from Vancouver, Calgary, Windsor, Toronto to Mexico City, Lima, Santiago and Buenos Aires; and the Fiji, New Zealand and Australia route earlier served by Britannia. In addition a daily trans-Canada route of 2,450 miles from Vancouver to Winnipeg, Toronto and Montreal and return was being served by jet aircraft. A Northern British Columbia and Alberta domestic route of 4,436 miles was served by DC-6B and DC-3 aircraft.

The fleet of six DC-8 jets was to be supplemented with another on order for the spring of 1966, and later by an additional three aircraft authorized in 1965 by the board of directors of the parent company, Canadian Pacific. These will likely be one of the "stretched out" versions of the DC-8.

A $1,500,000 DC-8 simulator was due for year-end installation at the Vancouver headquarters where DC-6 and Britannia simulators were already being operated. During 1965, senior administrative and sales and traffic staff moved from the Vancouver airport to new office accommodations in downtown Vancouver.

Most routes on Canadian Pacific Airlines' world route pattern showed substantial traffic increases during 1965. In addition to the general economic prosperity, lower North Atlantic fares introduced in the spring and the lowering of Canada/Hawaii fares in October contributed to the traffic increase.

CONTINENTAL AIRLINES

Continental Airlines, which was founded in El Paso, Texas, with a three-plane fleet of single-engine Lockheed Vegas, was dispatching huge, $8,000,000 Intercontinental Golden Jets more than half-way around the world during 1965, a symbol of its tremendous growth since 1934.

Continental's widespread international operations revolved around the company's Military Air Transport Services contract to operate between the West Coast and various Far East points, as well as a busy commercial charter business between the U. S. and Europe.

The company's operations in 1965 were a far cry from the original 520 mile route stretching from El Paso to Pueblo, Colorado. By October 31, 1965, Continental had flown about 655,000,000 revenue passenger miles and 47,000,000 cargo ton miles overseas and these figures promised to grow even more rapidly in the months ahead.

The airline's basic business was still scheduled air transportation within the United States with key routes running between Los Angeles, Denver, Kansas City and Chicago, between Los Angeles, Phoenix, El Paso and Houston, and throughout the Rocky Mountains, Midwest and Texas. Continental was flying some 2,500,000 miles a month over these domestic routes, primarily with pure jet aircraft. But the company's international business was also mushrooming rapidly.

At year-end, Continental was operating four of the Boeing 320C Intercontinental Golden Jets in overseas service and two more were on order for delivery in 1966.

In 1965, Continental invested approximately $40,000,000 in its overseas operations, or as much as the company's total investment in the first 25 years of its operation. The money was spent for the Boeing 320C's already in service and for ground support equipment, expanded maintenance facilities and crew training.

As one of the Military Air Transport Service's prime contract carriers, Continental operated out of Travis Air Force Base near San Francisco to Honolulu, Clark Air Base in the Philippines, Guam, Okinawa, Saigon, Bangkok, Taipei and Tokyo.

Commercially, Continental, in the summer and fall of 1965, operated about 50 civilian charter flights which took the firm's gold, black and white colors to such countries as England, Ireland, France, Germany, Holland, Denmark and Italy.

The Intercontinental Golden Jets which provided these overseas services can carry 165 passengers or 90,000 pounds of cargo, or a mixture of both, on non-stop flights of 6,000 miles at cruising speeds of 600 miles an hour. While the aircraft are used primarily overseas, the company also operates them from time to time on scheduled domestic flights, including some through El Paso.

Over 300 of Continental's 3,600 employees were engaged full time in planning, supporting or operating overseas flights, while many other employees were devoting part of their time to the program.

Even though Continental was flying the jet charters to Europe, Continental President Robert F. Six said the company's primary orientation was towards the Pacific.

"Today, the Pacific represents both a military and commercial market," Six said. "But tomorrow it will be a major business and vacation market for Americans heading west and for people from the western reaches of the Pacific heading east." At year-end, Continental had an application before the Civil Aeronautics Board for rights to fly between major cities in the U. S. and Pacific-Orient destinations.

Meanwhile, Continental has expanded its overseas interests on several other fronts through newly formed subsidiary operations. On September 1, 1965, Continental Air Services, a wholly owned subsidiary, formed a Southeast Asia Division to perform general aviation services throughout the Far East. By acquiring the assets of the air division of Bird & Sons, a San Francisco-based heavy construction company operating in the Orient, and adding to these assets with new equipment, the division began operations with a total of 35 planes and about 500 full-time employees. The Southeast Asia division was operating principally in Laos and Thailand, but it was anticipated that the subsidiary later would extend its operations elsewhere in Asia. Continental Air Services was providing aviation ground and flying services overseas for oil, construction and survey companies, and for the U. S. Agency for International Development (AID).

In another development, Continental Air Services and the National General Corporation, operators of a nationwide chain of movie theaters, formed a joint undertaking to engage in the construction and operation of theaters around the world.

Former White House press secretary Pierre Salinger was named president of the new firm, Fox Overseas Theaters, which will investigate motion picture operations and possibilities in all areas of the world. In addition, Salinger was appointed vice president-international affairs of both Continental Airlines and Continental Air Services, with assignments to help further expand the company's international activities.

DELTA AIR LINES

The year 1965 was one of continuing progress and prosperity for Delta Air Lines. A capsule resume showed: Delta's first quarter billion dollar year in sales; a growth rate that for the most part exceeded the industry average; a 2–1 stock split, distributed on December 13, the fourth split by Delta in as many years; acceptance of the world's first Douglas DC-9 fanjet and placing of the twinjet in scheduled service late in the year; the addition of four Douglas DC-8 fanjets to the fleet and the ordering of five more DC-8's for 1966 delivery, including three of the Super Sixty-One series with a passenger capacity in excess of 200; completion of the transition to Deltamatic, the IBM-built electronic reservations system; upgrading of Caribbean service to 133-passenger DC-8 fanjets to meet continuing traffic growth; opening of sales offices in Japan and Australia, in addition to expanding coverage of Central and South America and Europe; expansion of the daily interchange service with Pan American to Europe, offering daily service to London and Frankfurt; and setting the trunkline pace by being the first to offer a special "See The U. S." fare to encourage foreign visitors.

For the fiscal year 1965, which ended on June 30, gross revenues rose to $257,000,000, a 15 per cent increase over the previous year. Freight revenues showed a substantial gain of 31 per cent, reaching $11,616,000 with the rise due largely to increased jet utilization and expansion of services to California.

Net earnings were $23,000,000 or $7.22 per share, up 47 per cent over the previous fiscal year. The stock split was voted by the Board of Directors shortly after the new fiscal year's first quarter ended (September 30).

Delta inaugurated DC-9 service during the year.

The DC-9 twinjet was received in early October, some three months ahead of schedule and with the first four aircraft service was begun to 20 cities in December. Delta's firm order for the DC-9 was for 30 aircraft, valued in excess of $100,000,000 with an option for 12 more.

The DC-9 is the first American-built short-to-medium range jet to meet the requirements of the small and intermediate sized cities where it had not been economically feasible to schedule the larger four-engine jets. Delta service was to be expanded with the delivery of aircraft, the first 14 scheduled to be operating by October, 1966. Average trip length for the initial service pattern was 251 miles, well under half the average recorded by the Douglas DC-8's and Convair 880's.

At the year's end, Delta was operating 19 DC-8 fanjets with deliveries of two more Series 50 aircraft scheduled for 1966 delivery. Deliveries of three Super Sixty-One aircraft were slated for the late months of 1966. By that time, Delta's jet fleet was to consist of 54 aircraft—24 DC-8's, 16 Convair 880's, and 14 DC-9's. The last 16 DC-9's, set for 1967 deliveries, will be the stretched version with a capacity up to 108 passengers. Configuration of the original 14 DC-9's was 65 or 20 first class and 45 tourist.

Activation of Deltamatic highlighted a year of diligent effort to improve customer service. In just over one year, Delta's new reservation system linked over 400 agents' sets in 24 cities to the computer center in Atlanta. While it was necessary to remote a number of the smaller cities to the larger reservations centers, Deltamatic produced a quality of customer service earlier impossible under a less centralized manual system. For the fiscal year, which ended on June 30, Delta's number of revenue passengers reached a record 5,964,269, a 14 per cent increase over the previous year.

In the spring of 1965, Delta substituted the DC-8 for the Convair 880 on its Caribbean runs and expanded the overall service pattern in the area. The expansion resulted in a 58 per cent increase in the available seats to and from the Caribbean.

The opening of sales offices in Japan and Australia followed by a few months the fulltime coverage that had begun in Europe during the last half of 1964. The opening of these offices, together with the expanded coverage of Central and South America, was linked with the inauguration of a special fare to encourage foreign travel to the United States. The original fare was $300 first class and $250 tourist for virtually unrestricted travel anywhere on the domestic system over a 30-day period. For 1966, it was planned to lower the fare to $250 first class and $220 tourist.

Another popular fare that was continued during 1965 was the $325 Circle Fare, offering a Los Angeles-New York round trip via Jamaica and/or Puerto Rico for only $35 more than a roundtrip tourist ticket to New York. The price to or from San Francisco was $350.

The interchange service with Pan American, begun in mid-1964, was adjusted late in 1965 to operate daily to London and continue to Frankfurt. Previously, the flight from New Orleans and Atlanta, via Washington, operated to London five times weekly and to Paris the other two days. Paris was deleted with the commencement of daily service to London and Frankfurt.

Eastern's latest transport, the Boeing 727 "Whisperjet."

EASTERN AIRLINES

Eastern Airlines in 1965 made significant progress in profits and passenger volume. Profits were $26,200,000 for the ten months ending October 31, compared with a loss of $6,600,000 for the same period in 1965. Revenues were up 24 per cent to $421,800,000. Revenue passenger miles rose 25 per cent to 6.6 billion and passengers carried increased 15 per cent to a record 12,200,000 for the 10-month period. Available seat miles rose 21 per cent in the same period to 11,600,000,000.

Freight ton miles flown increased 12 per cent to 6,100,000 in the first ten months, and express ton miles flown rose 6 per cent to 802,000. Mail ton miles flown rose nearly 20 per cent to 2,100,000.

Fourteen pure jet aircraft were delivered to Eastern in the first 10 months of 1965. Seventy per cent of available seat miles were provided by jets in 1965, up from 60 per cent in 1964. Five Boeing 727 QC (Quick Change) jets, 7 Douglas DC-8 Series 61, 27 advanced model Douglas DC-9's and 15 regular model DC-9's were ordered for purchase or lease. The 29 aircraft to be purchased will cost an estimated $144,000,000. These orders in 1965 brought Eastern's total jet aircraft orders to 67, in addition to the 69 pure jet aircraft which it already operates.

In order to improve its financial position and provide capital for equipment needs, Eastern, with its creditor banks, replaced a $45,000,000 series of outstanding notes with a $50,000,000 revolving credit loan available through 1968. It also filed for the registration of 375,000 new common shares.

Eastern applied to the Civil Aeronautics Board for several new long-haul routes. One application called for nonstop service to Hawaii from New York, Chicago, St. Louis, Houston, and Dallas-Fort Worth, plus other co-terminals on the Eastern system. In addition, this application requested permission to provide nonstop service between Hawaii and Mexico City, service from Mexico City to New Zealand and Australia via Tahiti, and Australia to Hong Kong via Djakarta, Singapore, Bangkok, Saigon and Manila.

Another application requested authority for Eastern to extend its flights south of Florida to Nassau and Jamaica. Eastern pressed for a decision on its 1964 application for new routes between New Orleans and Houston to Seattle, and St. Louis and Seattle via major intermediate cities.

Eastern's New York–Mexico City route certificate was renewed on a permanent basis and the company was granted exception authority to increase frequency on this route and to extend the route to include service to Acapulco. The CAB, in another decision, reaffirmed Eastern's right to operate between Florida, New Orleans, and Dallas-Fort Worth.

Stockholders of Eastern and Mackey Airlines, Inc., approved a merger of the two carriers. If approved by the CAB, the merger will extend many of Eastern's present routes to points in the Bahamas now served by Mackey.

The Eastern Air Shuttle, an hourly, no-reservations, no frills service linking Boston–New York–Washington, celebrated its fourth anniversary in April, 1965. By the end of 1965, the shuttle had carried 10,000,000 passengers between these three cities.

By October, Eastern had phased in its fleet of turboprop Electras, and all first sections of the shuttle were served by this aircraft. They had previously been served by Super Constellations and Douglas DC-7B's. Flying time between the cities was cut one-half hour on the faster, more comfortable Electra. Eastern announced that by May 1, 1966, all first sections would be served by Boeing 727 Whisperjets.

Eastern stepped up its New York-Miami service by offering hourly on-the-hour flights southbound and hourly on-the-half-hour flights northbound between the two cities. This increased Eastern's seating capacity on this route by one-third, to 32,358 seats per week.

An equipment pool was formed by Eastern and Braniff World Airways to service an international interchange route between New York and South America. Through service on this route is provided from New York via Miami to Panama City-Balboa, Panama, Bogota, Colombia, Guayaquil, Ecuador, and Lima, Peru.

Eastern announced that it will build, in conjunction with the Massachusetts Port Authority, a new $11,000,000 terminal at Boston's Logan International Airport. The new terminal will initially increase Eastern's capacity at Logan by 50 percent, later by 75 per cent. The terminal will be over 100,000 square feet in size, with 12 gate positions expandable to 18. The new Eastern terminal will have parking facilities within the building. Eastern further increased its facilities by opening off-line offices in Paris, Frankfurt, Honolulu and Seattle during 1965.

FRONTIER AIRLINES

Frontier Airlines continued in 1965 to break all company records for passengers, revenue passenger miles, cargo and net profits.

During the first ten months ending October 31, total revenues were $20,555,000 compared with $18,509,000 reported for the same period of 1964. Net profit, before special items for the first ten months of 1965, amounted to $979,704, an increase of 25 per cent over the $782,075 reported for the same period in 1964.

Introduction of the turbine-powered, 52 passenger Convair 580 aircraft on Frontier's system in June, 1963, contributed much to increased passenger boardings throughout the Frontier-served "Frontierland" in the Rocky Mountain West, Southwest and Midwest. The 355 mile per hour Convair 580 proved particularly attractive to both online and interline passengers. Frontier had 13 of the 580's operating over the high country of the West at the end of 1965. The carrier's three remaining Convair 340's were to be converted to 580's in the early months of 1966.

While Frontier was increasing its turbine fleet, it was retiring the time-tested workhorse, the DC-3. At one time 27 of the DC-3's carried Frontier's colors. By the beginning of 1966, this fleet had been reduced to 7 of the aircraft, which operated into the smaller communities of Frontier's system where airport improvement had not provided runways long enough to handle the larger Convair 580's.

For the year ending December, 1965, compared with the same period in 1961, Frontier had a 38 per cent increase in revenue aircraft miles flown. At the same time there was a 105 per cent increase in ton miles flown; a 116 per cent increase in revenue passenger miles and a 101 per cent increase in revenue passengers carried. In the comparison of cargo carried, ton miles of U. S. mail was up 50 per cent, ton miles of express up 64 per cent and ton air freight up 109 per cent. In October, 1965, Frontier reported 1,909,000 pounds of air freight, a new record for the carrier and a first time that over 1,000,000 pounds was boarded into the cargo pits in a single month.

While Frontier Airlines served approximately 30 per cent of the continental United States in its operations north and south between Canada and Mexico and east and west between Kansas City-Omaha and Phoenix-Salt Lake City, it had only 2 per cent of the nation's population in the 60 cities strung out along Frontier's 6,500 mile route system. To broaden the base for greater air travel, the carrier initiated a number of fare saving, passenger appealing tariffs which attracted thousands of new users both in and outside of Frontierland.

The success of the company's Family Plan was attested by its growth from 5,300 passengers who used the Family Plan in the year 1961 compared with the 105,322 who traveled on the plan in 1965. This 1965 Family Plan travel was also a 33 per cent increase over 1964 showings and added nearly $2,000,000 to Frontier's passenger revenues for the year.

Making the most of the government-sponsored "Visit USA" and "Discover America" programs fostered by the United States Travel Service, Frontier combined the attractions of the Vacationland Fare with nine attractive 3 to 5 day vacation packages to such standout scenic attractions as the outstanding national parks of Yellowstone, Grand Tetons, Grand Canyon, Carlsbad Caverns, Mesa Verde, Canyonlands and such vacation attractions as the Black Hills, the Santa Fe/Taos country of New Mexico and the Mexican border cities of El Paso/Juarez. During the winter months 30 of the major ski areas of the West which are directly served by Frontier were also promoted along with their accessibility using the low cost $100 Vacationland Fare. For its vacation program the carrier won the coveted trophy and plaque of the National Association of Travel Organization.

In keeping with its overall program for progress, Frontier announced its plans for purchase of 600 mile per hour 103-passenger Boeing 727 jets. First delivery of these tri-jets will be in August, 1966. The first two jets will become operational the following October at which time a third 727 will be added. These aircraft will be used over Frontier's high density passenger routes in Colorado, New Mexico, Arizona, Nebraska, Wyoming, Montana and Utah. In the winter of 1966-67 two more tri-jets will join Frontier's fleet. The airline also had an option of five additional 727's should the carrier be successful in its extensive proposals in the pending Pacific Northwest/Southwest Area case.

HAWAIIAN AIRLINES

Hawaiian Airlines closed out 1965 having carried its 10,000,000th passenger and having traveled over 1-1/2 billion passenger miles in its 36 years of unparalleled service in the Hawaiian Islands. Inaugurated in November, 1929, as Inter-Island Airways, Hawaiian Airlines (its new name adopted in 1941) never had a passenger or crew fatality.

Passenger statistics for 1965 showed a 20 per cent increase or approximately 875,000 total passengers carried in 1965.

In late 1965 the first of eight Super 600 Convairs was placed in service. The 56-passenger aircraft, powered by the Rolls-Royce Dart-10 turboprop engine, will provide greater dependability and faster flight times between the growing neighbor island tourist destinations. The Dart-10 engine is 50 percent more powerful than any other turboprop engine being flown in the Islands.

The Super 600 Convairs were scheduled to be joined by two Douglas DC-9 fanjets early in 1966, giving Hawaiian the largest turbine-powered fleet in scheduled inter-island service.

Hawaiian in 1965 carried the majority lift to the opening of the $20,000,000 Laurence Rockefeller resort, the Mauna Kea Beach Hotel on the island of Hawaii. The hotel opened officially in late July, 1965, and the last few months of the year demonstrated the popularity of this neighbor island resort. One extra flight daily was added for the convenience of tourists, both local and mainland, and there were plans for an additional service in 1966, putting the Kamuela Airport, gateway to the hotel, only 25 jet minutes away from Honolulu.

During the September annual convention of the American Society of Travel Agents held in Hong Kong, a beautiful color poster jointly sponsored by Hawaiian Airlines and the Mauna Kea Beach Hotel, took "Best of Show" honors in the poster contest.

Early in January, 1965, HAL president Jack Magoon was present at the roll-out of the first Douglas DC-9. Hawaiian was the fifth carrier to order the beautiful twin jet aircraft and certification of the short-range Douglas DC-9 late in '65 marked a giant step forward in the progress of inter-island aviation.

Cargo operations in 1965 showed a marked increase, with over 31,000,000 pounds carried during the year. Greater cargo lift was also predicted for 1966 because part of the Super 600 fleet was scheduled for utilization in cargo carriage. Revenue volume in 1965 was expected to exceed $12,000,000, a record for the company.

LOS ANGELES AIRWAYS

The year 1965 marked a turning point in LAA's history of service to Southern California, for this was its year of permanent certification. After 18 years of operation under a temporary federal certificate, the CAB on October 22, 1965, ordered LAA's Certificate of Public Convenience and Necessity made permanent.

During 1965, LAA continued its remarkable record of growth and achievement of industry "firsts." Passenger traffic for the 10 months through October totalled 209,481 persons carried, representing a 20 per cent increase over the like period in 1964. LAA

LAA took delivery of the first of three Sikorsky S-61L "Copterliners."

expected to exceed the quarter million mark in passengers carried by the year's end. Express poundage through October showed a 16.4 per cent increase over the 1964 period.

In March of 1965, LAA became the first helicopter carrier to receive authority to fly helicopters in scheduled service under instrument flight rules. This was a first step toward all-weather performance.

Service to Whittier was reinstated early in 1965, after the completion in December, 1964, of a heliport suitable for the current generation of turbine-powered helicopters. In addition, LAA's Van Nuys heliport was moved to a more central San Fernando Valley location at the Van Nuys Airport, where improved station facilities supplanted the more limited services offered at the former location.

LAA's fifth S-61L helicopter was delivered in December of 1965. It was the first of three additional aircraft planned for the 1966 through 1970 period. This aircraft, equipped with updated engines of increased power, will boost LAA's available seat miles by over 25 per cent, because of substantial elimination of temperature accountability payload loss with present powerplants. The balance of the fleet will be retrofitted with the higher rated engines, virtually solving ambient temperature problems, in the years ahead.

In its order of October 22, the CAB approved LAA's proposed service between Los Angeles International Airport and the additional points of West San Fernando Valley, Thousand Oaks, and Oxnard/Ventura. These points were slated for inauguration of service in the 1966–1969 period. Additional points to which service was proposed under LAA's 50-mile radius exemption authority, are Downey, Pasadena, Arcadia, Wilmington and Long Beach.

Preliminary plans were drafted during the year for LAA's participation in the "Skybus" program, which contemplates the use by LAA of a commercial version of Sikorsky's Flying Crane to shuttle passengers between LAX and downtown Los Angeles in detachable pods. The pods convert to ground vehicles after landing. This program, jointly funded by the HHFA and the City of Los Angeles, seeks to determine the feasibility of direct lift aircraft in helping to solve urban transportation problems.

At the LAA annual stockholders meeting, held October 22, company President C. M. Belinn announced the election of Corwin Denney, president of Automation Industries, to the Board of Directors, filling the vacancy left by Kenneth Dyal, who left the board following his election to Congress.

MOHAWK AIRLINES

Mohawk Airlines, the nation's largest regional airline, in 1965 became the first regional airline to introduce pure-jet service. On July 15, the first scheduled commercial jet flights on the Mohawk system took place as two of the carrier's new 69-passenger BAC One-Eleven fanjets transported passengers from Utica and Syracuse to Kennedy International.

Mohawk originally ordered four of the 550-mile-per-hour English-built jets in July, 1962. Later orders were placed for three additional One-Elevens with options to purchase three more. By the end of 1965 five of the pure jets were operating on the Mohawk system. The One-Eleven is powered by two aft-mounted Rolls-Royce Spey fanjet engines.

The BAC One-Elevens represented the first phase of a complete re-equipment program being carried out by Mohawk. In January, 1965, the airline's president, Robert E. Peach, announced the purchase of 18 Fairchild Hiller FH-227 turboprop aircraft to replace its Convair 240's. The $24,000,000 order was the largest single new equipment purchase ever made by a regional airline. The combined purchase of the One-Elevens and FH-227's represented an investment of $50,000,000.

The 18 FH-227 s were to be delivered during 1966 and early 1967. The twin-engine, 300-mile-per-hour high-wing aircraft will seat 44 in the Mohawk configuration. The plane represents a major advancement of the Fairchild/Fokker F-27, flying with 40 airlines throughout the world. As a second generation aircraft, the FH-227 is backed by excellent records of passenger acceptance and equipment reliability, accumulated in 500,000,000 miles of F-27 operations. With additional purchases of these two types of aircraft Mohawk expected to be operating an all-turbine fleet by 1967.

The year 1965 marked the 20th anniversary of Mohawk. Its first flight was made from Ithaca to Teterboro, New Jersey, on April 6, 1945, as the Airline Division of Robinson Aviation, Inc. During that first year of operation the airline carried 900 passengers in two single-engine Fairchild F-24's and two twin-engine Cessna T-50's. One of the part-time pilots was an ex-Navy flier and Cornell law student named Robert E. Peach, who went on to become the company's president. Under his leadership the airline began its rapid growth.

The name was changed to Mohawk in 1952. By then the dependable DC-3's were flying the routes which had grown in include cities in eight Northeastern states. Mohawk was one of the early innovators of a system-wide communications and reservations network. It was the first regional airline to fly Convairs in 1955 and the first to order pure-jet equipment, the One-Eleven.

During the first six months of 1965 Mohawk earned a record profit of $1,436,688. This record topped the $1,217,025 earned during the entire year of 1964, and was more than two and one-half times the $539,367 earned during the first six months of 1964. For the year 1965 Mohawk expected to earn a net profit of about $2,000,000 and carry about 1,700,000 passengers.

Aside from the strong financial picture, Mohawk continued in 1965 to bring forth new ideas. The airline was joined by ten others in developing an improved method for handling the exchange of information about the availability of seat space aboard flights of other airlines. Following several years of successful experimentation and study by a committee of representatives of the eleven carriers an agreement was signed which will have each airline use its data processing equipment to store each other's interline flight availability information.

New high-speed electronic equipment, which confirms reservations in one second or less, was installed at the two central reservation offices in Syracuse and New York City. The old method, by telephone, averaged 34 seconds per confirmation.

Late in the year, the airline increased its free baggage allowance from 40 to 50 pounds. At the same time it was predicted that when the all-turbine fleet goes into operation even more liberal baggage allowances will be offered.

Plans for a jet training center at Mohawk's headquarters at the Oneida County Airport, Utica, New York, also were announced in 1965. For initial pilot training and for refresher courses Mohawk purchased nearly $2,500,000 worth of flight simulators. One simulator will duplicate all flying characteristics and conditions of the BAC One-Eleven and the other will do the same for FH-227 pilot training. These new simulators will not only improve the level of training for Mohawk pilots but will also cut in half the training time required in actual aircraft, thus freeing more aircraft for additional passenger service. Another first for Mohawk will be having two cockpit simulators operated by one computer system. The cockpits will be able to function singly or simultaneously.

The simulators will be housed in the new $1,200,000 jet training center to be built adjacent to the airline's corporate headquarters. Construction on the new facility was scheduled to begin early in 1966. When it is completed, Mohawk will offer jet training programs to the airlines of the world. In addition to the training center, a motel and restaurant complex are planned to house the trainees. With airlines in the Philippines, Hawaii and the Near East showing interest in the program, and with more and more of the world's carriers equipping with turbine aircraft, it was expected that the jet simulators may bring as many as 50 trainees per day to the upstate New York center.

There were these additional developments during 1965:

Robert E. Peach was named 1965 winner of the Harry E Salzberg Memorial Medal which is awarded annually by Syracuse University for outstanding achievement in the field of transportation.

Mohawk again called on the Civil Aeronautics Board to put a priority for consideration on its request for service to Washington, D. C. from Albany via White Plains. Mohawk filed its original application for this route in June, 1960, and refiled in December, 1963. In addition, Westchester County in 1965 filed a similar request. Mohawk proposed a full pattern of Albany-White Plains-Washington service using pure jet equipment with the schedule timed so as to provide needed commuter service in both directions.

By the end of the year Mohawk was serving 14 cities with its pure jet BAC One-Eleven. Boston, Hartford, New York, Newark, White Plains, Burlington, Utica, Syracuse, Rochester, Buffalo, Binghamton, Elmira, PIttsburgh and Cleveland were all on the jet schedule with more to come. Throughout 1966, as deliveries of the turboprop FH-227 begin, the intermediate points along the system will get turbine-aircraft service.

NATIONAL AIRLINES

National Airlines completed conversion to an all-jet fleet, effected additional fleet, service and schedule improvements and reported traffic gains well above the industry average during 1965.

Between July 1 and November 30, the first five months of the company's fiscal year, National had a capacity increase of 32 percent and an identical increase in passenger miles flown. Looking forward to the end of the fiscal year in mid-1966, National president L. B. Maytag, Jr., announced a total gain in capacity of 25 percent because of the staged introduction of new aircraft early in 1965. From December 1, 1964, through March, 1965, National added 10 103-passenger jetliners to its fleet.

In each month of its fiscal year, National set a new company record and looked for a continuation of the trend in the remainder of the year, especially with advance bookings for winter tourist traffic pointing toward the most successful season in Florida's history.

Preparing for additional traffic throughout the calendar year 1966, National ordered 3 additional Boeing 727's for summer delivery. The company also took options on eight other 727's and on a DC-8-61 with a seating capacity of more than 200. In addition to DC-8's and 727's, National was operating Lockheed Electras, a fleet offering flexibility in long and intermediate haul scheduling for service to the 40 cities in its route structure.

National continued to conduct its extensive and specialized advertising and sales promotion programs and in 1965 inaugurated a new $6,000,000 advertising program centered around Florida, the company's home base and hub of its route structure.

National was offering excursion round-trip fares between California and Florida, comparable to the air fare from California to Hawaii, historically the first choice of vacation spots among Californians. This promotion was coupled with trips to the Caribbean, an area not served by National but for which the company had applications pending.

As a transcontinental carrier serving main Atlantic Seaboard ports of entry for travelers from Europe and South America, and Pacific ports of entry for travelers from the Orient, National maintained sales offices in these areas. National was attracting a larger share of the continental travel of visitors from these foreign areas. At the same time, the company was delivering more and more American travelers to these cities for foreign travel via the international carriers.

NORTHERN CONSOLIDATED AIRLINES, INC.

The year 1965 was a good one for Northern Consolidated Airlines. Traffic in all categories showed substantial increases with mail volume being the most significant. All quarterly profit figures indicated a strong financial position.

There was an important change in the operational pattern with the opening of a new airport at St. Mary's on the lower Yukon. This enabled NCA to serve the lower Yukon and Bering Sea Coastal area with the F-27, using the new airport plus Hooper Bay and Meykoruk to reduce the length of bush flights into the smaller communities to not over 60 miles. Until 1965, everything had to be transferred at Bethel from F-27 to bush and some bush flights were as much as 160 miles. The change resulted in reduced fares and freight rates with much improved mail service.

The F-27 continued its excellent performance record and the NCA reached 5,200 hours between overhauls on the Rolls Royce turbine engines, the highest for any twin engine transport. The nonfatality record continued unmarred although operations cover some tough country and a good deal of NCA's flying is in single engine equipment. The company was using two Grumman Mallards and five Pilatus Porters on its bush runs.

NCA's fishing camps in and around the Katmai National Monument were well filled during the season. The bus trip from NCA's Brooks Lodge to the "Valley of 10,000 Smokes" was also very popular in 1965. Many Europeans discovered in 1965 the hunting and fishing offered in Alaska. The Bristol Bay salmon run was excellent in the 1965 season and produced heavy passenger traffic into this area during the season.

With the increased interest being shown in Alaska as a tourist mecca, and as a vast and increasing market offering great opportunities for resources development, Northern Consolidated looked with confidence toward 1966.

NORTHWEST ORIENT AIRLINES

The chain reaction of profitable operations, expanded and improved jet schedules and increased public use of air transportation made 1965 another banner year for Northwest Orient Airlines.

Donald W. Nyrop, NWA president, reported that both revenues and earnings set records in 1965. Total operating revenues for the year were estimated at about $262,000,000, based upon January-November actual results and projected revenues for December. During 1964, previous record year for Northwest, the airline reported net earnings of $26,785,523 on total operating revenues of $211,610,431.

Northwest in the first 11 months of 1965 surpassed the entire year of 1964 in both categories, with $41,274,924 in net profit after taxes and all other expenses, and $238,163,298 in total operating revenues. In January-November, 1964, NWA had net earnings of $23,716,796 on $192,985,723 in operating revenues.

During 1965, Northwest invested heavily in new aircraft and ground equipment. It took delivery of five 707-320C, intercontinental-range Boeing fanjets and 11 727 short-to-medium-range fanjets, worth a total (with related spare parts) of $93,500,000.

The additional fanjet aircraft enabled Northwest to inaugurate service on new routings, increase jet flight frequency, upgrade flight equipment on existing routes and completely phase out of passenger service its last remaining piston-engined transports.

One of Northwest's 1965 re-equipment moves was acquisition of 5 707-320C convertible passenger/cargo airliners.

Northwest was planning further improvements in service to the cities on its route structure with the 1966 addition of more jet airplanes.

During 1965, Northwest inaugurated service from Philadelphia, on route segments to Detroit and Cleveland, with flights continuing west on NWA's routes across the Northern states. Utilizing domestic route authority achieved in 1964 between Cleveland and Chicago, Northwest was able in 1965 to inaugurate the first through-plane service from Washington, D. C., and Cleveland to the Orient.

Frequency on the airline's important trans-Pacific route to the Orient was increased from 12 round trips a week at the end of 1964 to 16 round trip, U. S.-Orient flights at the end of 1965. New York is the Eastern terminus of 13 of these round trips—all 13 of which operate nonstop in both directions between Seattle-Tacoma and Tokyo—with Washington the Eastern terminal on the three other flights.

Frequencies also were increased on Northwest's route to Hawaii, and on Midwest-Florida and other domestic flight segments.

Through upgrading of flight equipment on a number of routings, Northwest in 1965 extended fanjet service to Winnipeg, Manitoba; Grand Forks, Fargo and Bismarck, North Dakota; Billings and Great Falls, Montana; Rochester, Minnesota; and Madison, Wisconsin.

Obsolete, piston-engined DC-6B transports were phased completely out of service in June, 1965, and sold. In October, Northwest's last piston-engined aircraft, DC-7Cs, were removed from commercial passenger service and used only in cargo and charter operations. Northwest in 1965 moved into an all-turbine-powered operation in passenger service—fanjet 707-320s, 720Bs and 727s, with jet-prop Electras being used on flights over shorter route segments.

Additional fanjet aircraft ordered for delivery in 1966, seven 320Cs and twelve 727s, at a total cost of $110,500,000 (including spares) will enable Northwest to begin to sell units of its jet-prop Electra fleet in 1966.

Northwest estimated that continuing growth in the air travel and air cargo markets, together with increased service to be provided by NWA's new fanjet aircraft to be delivered, would result in revenue increases of 18 to 20 percent for the airline in 1966.

All categories of Northwest's traffic grew during 1965. Northwest carried a total of 4,550,000 passengers in scheduled service in 1965 (December estimated), compared with 3,663,000 in 1964, an increase of 24 percent. Scheduled revenue passenger-miles flown totaled about 3,300,000,000, an increase of 24 percent from 1964's 2,669,000,000. Scheduled freight and express ton-miles increased 48 percent, to 81,700,000 in 1965 from 55,100,000 in 1964. Mail ton-miles totaled 49,800,000 in 1965, an increase of 30 percent over the 1964 total of 38,256,000.

OZARK AIR LINES

For Ozark Air Lines, 1965 was a year of decision. Plans were announced which will modernize every phase of the regional service carrier's operations, from new aircraft to more deluxe customer service, from modern maintenance to computerized reservations.

Modernization started in January when Ozark dedicated its new $3,200,000 office building and jet maintenance base at the southwest corner of Lambert Field, St. Louis. Later there came the announcement that Ozark had ordered three, 78-passenger Douglas DC-9 twin fanjet transports. In July, the Board of Directors revealed plans to double the first DC-9 order by the spring of 1967.

With all-time company boarding records falling in May, June, August and October, and load factors on given days reaching 70 per cent, a further equipment solution had to be found. The DC-3, Queen of Ozark's fleet for a dozen years, was being taxed too heavily and even with Martin 404's and Fairchild F27's to assist, profit margins were dropping too low.

Complete re-equipment plans had to be made and on November 3, President Thomas L. Grace announced that Ozark would purchase 21 new high wing Fairchild Hiller FH-227's, a 48-passenger, 300-mile-per-hour jet prop. With this order supplementing the DC-9 purchase, the airline's aircraft commitment climbed to more than $50,000,000. Under the terms of the contract every Ozark DC-3, Martin 404 and Fairchild F-27 would be replaced by modern turbine-powered equipment by May, 1967. The new aircraft would increase Ozark's available seat miles by more than 90 per cent.

Inauguration of one-stop service to and from Milwaukee brought a large gain in traffic. The traveling public quickly responded to this service by-passing Chicago's busy O'Hare Field. Within two months average load factors on the north and southbound flights had climbed to more than 70 per cent.

On the northbound evening flight from St. Louis Ozark began serving light meals and offered complimentary beer in keeping with the "Beer Capital" motif.

Ozark's advertising budget climbed to more than $500,000 as display bulletins on either side of Lambert Field gave travelers on Interstate 70 time of day and a new "go-getter" message.

Central Reservations Office (CRO) personnel trained ground hostesses at Peoria, Illinois. Ozark began providing passengers at Lambert Field and O'Hare Airport assistance even before they reached Ozark ticket counters. CRO expanded to include Ozark's 10 major cities. Direct telephone lines brought 67 per cent of the advance reservation sales into Peoria where more than 110 reservationists provided round the clock service and answered as many as 4,500 telephone calls daily.

In November it was announced that by early 1966 Ozark would team with Eastern Airlines in using a UNIVAC Real-Time computer to determine space not only on Ozark flights, but on other airlines' flights serving more than 90 per cent of the nation.

The company also initiated all-cargo operations to nine of the major industrial cities served by Ozark.

The investing public took note of Ozark's "new look." Common stock, which had been selling at about $5 a share at the start of the year, climbed to more than $9 late in November. The number of stockholders increased more than 25 per cent over the same period. The Board declared a four per cent stock dividend for the fifth straight year. After taxes, preliminary figures showed a net income of more than $600,000.

Daily boarding records three times surpassed 5,000 passengers in the banner month of October when Ozark flew 119,327 travelers. November marked seven straight months with 100,000 or more passengers aboard the youngest of the regional service carriers. And on November 20, Ozark flew its 7,000,000th passenger after carrying 1,000,000 for the first time during a calendar year. On September 24, the company celebrated its 15th anniversary.

PACIFIC AIR LINES

For Pacific, 1965 was a watershed year. Even as the airline marked with satisfaction its first quarter century of service, it took some giant steps forward in both internal operations and service capability.

Land was leased and architectural plans approved for Pacific's new headquarters installation at San Francisco International Airport. Occupancy of the new general offices, hangars and maintenance base was scheduled for late 1966.

The Marketing Department was completely reorganized during 1965, gaining greatly expanded responsibility and adding key personnel. Extensive programs, for implementation in 1966, were developed in the areas of tour promotion, passenger service and agency and interline relations.

While no new routes were acquired in 1965, service was both increased and improved throughout Pacific's system, highlighted by additional nonstops, greater frequency, and continued conversion from Martin 404 equipment to Fairchild F-27 prop-jets. At year-end, Pacific offered over 180 flights daily to thirty-seven cities in California, Oregon and Nevada.

The highlight event of 1965 was Pacific's $48,000,000 contract with Boeing for the purchase and lease of twelve 727 and 737 pure jets. First deliveries were due in early summer, 1966. The planes were slated for service on Pacific's most important routes.

PANAGRA (PAN AMERICAN-GRACE AIRWAYS)

Panagra (Pan American-Grace Airways) continued to set high standards of successful operation in 1965. Again it offered more flights and carried more people than any of its numerous competitors on its routes along the west coast of South America and across to Buenos Aires. Its load factor was one of the highest in the airline industry. It showed an increase of 10.2 per cent in passenger miles flown and a gain of 26.1 per cent in freight tonnage during the first three quarters of the year.

However, the year was most significant for moves which Panagra made to play an even larger role in U. S.-South America aviation. In petitions before the Civil Aeronautics Board the airline pointed out that, while it pioneered commercial flying in South America 37 years earlier and hung up an incomparable record of service to this area, Panagra was still forced to operate with an antiquated route structure that dates back to the early Thirties.

To correct this restriction the airline petitioned the CAB for the right to bring its own planes, with its own crews, to the U. S. gateway cities of Miami and New York which in 1965 it served only through interchange agreements with Pan Am and National. It asked also for permission to carry domestic traffic between New York and Miami, to extend its routes in the West to Los Angeles and San Francisco, and to serve new points in the Caribbean and South America, including Nassau, Kingston, Montego Bay, Rio de Janeiro, Sao Paulo, Asuncion, Guatemala and Bogota.

Panagra's year showed evidence of the company's health and growth.

Outstanding among the year's events was the purchase of $42,000,000 worth of ultra long-range intercontinental planes of the model 62 series DC-8's from Douglas Aircraft Company. These aircraft, capable of nonstop flights from New York to Sao Paulo or Buenos Aires, will be delivered in early 1967. One of the six jets will be convertible to either all cargo or combined cargo-passenger service.

During the year, Panagra made a series of mercy flights to areas it serves. First such flight brought 13,000 pounds of supplies to Chile.

During the twelve-month period ending October 31, 1965, Panagra invested over $689,000 in new facilities and equipment. These capital expenditures included well over $250,000 for a new building, offices and furnishings in Lima, Peru, and a similar amount for new offices, maintenance buildings and equipment in Panagra's New York headquarters and stations down the line from Panama to Buenos Aires. Added automotive and ramp equipment in five countries called for outlays of $174,000. Additional advanced communications facilities, such as single side-band radio equipment in Lima and Buenos Aires, accounted for expenditures of $49,000.

Equally significant as these gains in physical equipment were organizational changes which gave Panagra increased independence from its parent companies. Originally organized and still owned jointly by Pan American Airways and W. R. Grace and Co., Panagra used the Grace offices in South America as its sales agencies there and headquartered its accounting department in the Grace offices in New York. Early in 1965 the airline took over its own South American sales and centered them in a chain of new offices in principal cities which the line serves. In September the Panagra accounting department was moved to the airline's own new headquarters offices in the Chrysler Building in New York. Pan American still handled ticketing for Panagra in 1965 in the United States, but Panagra had its own independent sales organization.

In 1965 Panagra continued its long-time role of principal promoter of travel to South America, an activity in which it spent over $1,500,000 annually for ten years.

In addition to a heavy schedule of advertising to the general public and the travel trades, Panagra played a major part within the framework of the South American Travel Organization in the compilation, publication and distribution of the second edition of the South America Travel Digest. This authoritative book, edited after exhaustive travel and personal investigation by Charles and Babette Jacobs, was hailed by the travel press and travel agents as the most complete and most up-to-date guide for tourists to countries in the southern part of the hemisphere.

The airline again played a dramatic part in disaster relief to the countries it serves. In the spring, following severe earthquakes in Chile, a Panagra jet made a special nonstop flight from Miami to Santiago to speed 13,000 pounds of urgently needed medical supplies to the victims. The DC-8 flew 4,161 miles in 8 hours and 15 minutes on the first nonstop commercial flight ever made between the two cities. More than 12,000 pounds of additional emergency supplies were airlifted on later flights.

In August Chile was rocked again, this time by the worst snow and rain storms within living memory. Again Panagra donated its cargo space for the massive transport of relief materials. When the call went out for help in protecting the homeless against the cold of the South American winter, President Andrew B. Shea of Panagra stripped the airline's depots of blankets and shipped the entire supply to Santiago. The shipment was the first relief to arrive. Later flights brought in tons of used fur coats, winter clothing and medicines contributed by the American Red Cross and other charitable organizations.

In the field of voluntary public service the airline again granted travel fellowships to a selected group of South American graduate students to allow them to continue their education in U. S. colleges and universities. Since the beginning of this program in cooperation with the Institute of International Education in 1937, Panagra has flown 476 of these young people north in the summer and fall and provided them with transportation home at the end of their studies.

Early in the year Panagra introduced a new low excursion fare to Buenos Aires and lowered its first-class fares between U. S. gateway cities and South American points by as much as 30 per cent. The first class fare from New York to Buenos Aires, for example, came down from $1143 to $840.

In the summer the airline introduced sharply lowered tour basing fares from U. S. cities to Lima. For passengers on an advertised all-expense tour completed within 30 days, the saving on an economy round trip from Miami came to $102, and from New York or Washington, to $92.

Lower year-round fares for students at or recent graduates from colleges or universities were also put into effect, representing savings of from 20 to 50 per cent over regular excursion fares to key South American cities. For example, the student vacation rate from New York to Lima came down from $520 to $343.80.

PAN AMERICAN WORLD AIRWAYS

Pan American Airways' 38th year of international operations brought both continued growth and innovation. By any yardstick, the year 1965 was not only the best in Pan Am history, but also reflected the company's forward planning.

Worldwide passenger and cargo operations showed vigorous growth, with revenue passenger miles up 9.3 percent over the previous year and cargo ton miles ahead by 55.5 percent. The latter figure represented the highest rate of gain in the company's history, larger than that of the last five years combined.

During the year, the airline's jet fleet was increased to 86 aircraft. With expansions in Pan Am's route structure and a high rate of growth in air cargo especially, further additions were planned. Orders placed during the year brought the total number of turbojets scheduled for future delivery to 46, of which 12 were to enter service early in 1966.

New services introduced during the year added several thousand miles to the company's worldwide route structure. In July, Pan Am inaugurated U.S.-flag jet service to Prague, providing the first such direct flights between the United States and Czechoslovakia. Three months later, an extension of existing routes pioneered by Pan Am between the United States and capitals of West Africa was introduced across that continent. Pan Am at year-end was providing scheduled passenger and cargo service between the United States and East Africa, serving the cities of Nairobi, Kenya, and Entebbe, Uganda.

New all-jet routes across the South Pacific were inaugurated by Pan Am in November, almost 30 years to the day after the first transpacific flight by the airline's China Clipper on November 22, 1935.

Jet service to New Zealand was inaugurated that month from the U.S. West Coast, both via Hawaii and Tahiti, with one flight a week continuing to Sydney, Australia—the first U.S.-flag service across the 1,300-mile-wide Tasman Sea.

Existing services were also increased during 1965, providing greater capacity than in any previous year on all major routes. During the peak summer season, Pan Am scheduled 222 transatlantic flights each week; by December, capacity between the U.S. mainland and the Caribbean had been upped to 370 flights a week in both direction, and services between the West Coast and Hawaii were expanded to a total of 130 flights weekly.

In addition to these increases, Pan Am continued to seek to broaden markets for international passenger and cargo services. During the first weeks of the year, the airline's traffic between the United States and points in the Caribbean and Latin America showed a substantial upswing; gains of as much as 40 per cent were attributed to the introduction on January 1 of lower excursion fares to these destinations.

During the summer, Pan Am also introduced special charter tariffs to enable greater numbers of European vacationers to visit the United States. These "Thriftway to the U.S.A." fares, coupled with the New York World's Fair and Pan Am's worldwide promotional efforts, helped build westbound transatlantic traffic and contribute to alleviating the U.S. balance of payments deficit in the tourism account.

Late in the year, Pan Am also launched a three-year "See America-Sell American" program, designed to continue these efforts and bring about a longer range solution to this problem.

Cargo traffic gained at an unprecedented rate during the year, with Pan Am passing both the 300,000,000 ton-mile and 400,000,000 ton-mile marks in a single year and doubling its annual ton-mile total in two years.

Jet freighter services were also increased during 1965, both to Europe and the Middle East and to the Orient. All-cargo jet freighters were placed in service for the first time in Latin America and Round The World all-cargo service, introduced in mid-year, was by year-end operating on schedule following conclusion of new agreements between the United States and Japanese governments.

As in passenger operations, Pan Am undertook parallel efforts to revise cargo tariffs downward during the year. Lower rates were introduced between the Americas and the Far East and a number of transatlantic rate reductions helped bring new business to the industry.

Pan Am's response to requirements of the United States Defense Department also increased substantially during the year. Additional flights were scheduled between the West Coast and Viet Nam and in December alone a special airlift carried an additional 200 tons of Christmas parcels to U.S. forces in Southeast Asia. At the same time, on the other side of the world, Pan Am Clippers airlifted 2,571 refugees from Cuba to Miami in less than three weeks.

Other Pan Am activities in 1965 covered a wide range of endeavors. Scheduled helicopter service between the Pan Am Building in Manhattan and Kennedy International Airport was inaugurated during Christmas week, meeting with immediate acceptance by the traveling public. The flights, which cut travel time between the city and airport to seven minutes, drew from business and government leaders citations for progressive development for both Pan Am and New York Airways.

In August, Pan Am announced the creation of a new division and the signing of a 30-year agreement with the Port of New York Authority for the operation and administration of Teterboro Airport. When it comes under Pan Am management in 1966, Teterboro will serve as a base for the company's Business Jets Division, a New Jersey helicopter terminal and an expanded general aviation facility, particularly for executive aircraft being more and more widely used by business and industry.

Advances were made in development of the company's facilities to meet future needs. Typical of these was the dedication in November of the world's largest international stewardess college in Miami, geared to train from 850 to 1,000 students a year for service on Pan Am's worldwide Jet Clipper routes.

Also, construction work was started on a new air cargo terminal at New York's Kennedy International Airport which was scheduled to open in 1966. Capable of handling 10 times Pan Am's present cargo volume through the aerial port, the $8,000,000 structure, situated on a 20-acre site, will be the largest, most modern such facility in the world.

Progress in other areas was equally striking. Advancement of satellite communications techniques through tests with Syncom III and Early Bird kept the airline leading in such research, while installation of inertial navigation systems in the Pan Am jet fleet commenced. Other new equipment was acquired which will substantially improve operating efficiency under adverse weather conditions, enabling landings and take-offs to be made at lower minimums than ever before possible.

The company continued to lend its technical "know-how" to the national carriers of developing nations under the auspices of the Agency for International Development. To technical assistance programs underway in Iran and Afghanistan, Pan Am added a similar project in Guinea.

Despite a 10-day pilot strike in April, high rates of gain in all operations offset that interruption of services. By year's end, Pan Am's growth during 1965 had established new records and commitments for the future anticipated no let-up in every facet of Pan Am's activities.

PIEDMONT AVIATION, INC.

For its twenty-fifth year of service Piedmont Aviation celebrated 1965 as the most successful year in its history.

The second cash dividend of 10 cents per share was announced in March. The first one had been declared in October of 1964, making Piedmont the first publically owned local airline ever to disburse a cash dividend. The Board of Directors announced intentions of considering this practice on a semi-annual basis, and in October, 1965, a third dividend of 10 cents per share was declared.

During the year, Piedmont Airlines purchased four Martin 404 aircraft, bringing its total fleet to 35, 27 Martin 404 Pacemakers and 8 F-27 prop-jet Pacemakers. Piedmont's all air-conditioned, all pressurized, radar equipped fleet serves a nine state area and the District of Columbia. In 1965, new transponder units and DME equipment, as required by the FAA, were installed on all the planes.

In July Piedmont Airlines again received from the National Safety Council an Award of Merit for its flight safety record of the previous year. Piedmont's safety record was among the best in the industry.

An application by Piedmont for authorization to provide service between Roanoke, Virginia and New York City was filed with the Civil Aeronautics Board in August. Piedmont was investigating the possibility of offering jet service to many cities on its system. A number of different short haul jets were being studied with an eye to Piedmont's particular needs. The company was anticipating a definite selection by early 1966.

As the months of 1965 flew by Piedmont made passenger, pound and revenue records that were frequently supplanted 30 days later. For the first nine months of 1965, the number of passengers boarded was up 19 percent over the same period in 1964, to 936,684. As of November 4, 1965, the total boarding figures for the entire previous year had been exceeded by 2,387. Freight poundage figures compiled in September had increased 37 percent over that same nine month period of 1964. Freight revenue increased 32.4 percent while passenger 111revenue increased 20.3 percent in that length of time. With 40,924 scheduled miles per day shown for October, 1965, Piedmont saw an increase of 5,296 over the figures for the preceding year.

TRANS–TEXAS AIRWAYS

The eighteenth anniversary year of Trans-Texas Airways, 1965, was the greatest in the history of the regional airline which serves New Mexico, Texas, Arkansas, Louisiana, Mississippi and Tennessee.

During 1965, TTA was in the midst of a great re-equipment program. Aiming at being completely jet powered by the end of 1967, TTA commenced installation of the Rolls-Royce Dart Rd10A prop-jet engines on its Convair 240s. The new airplane, to begin service in 1966, is called the Convair Silver Cloud 600. It features an increased speed of over 50 miles per hour, a greater schedule reliability, a smoother, quieter ride and complete air conditioning inflight and on the ground.

On November 3, TTA announced plans to purchase a special convertible passenger-cargo version of the short-to-medium range pure-jet Douglas DC-9. On that date TTA signed a letter of intent to buy 7 DC-9s, with an option for another 8. Five of the first 7 airplanes will be capable of operating in all passenger, all-cargo, or mixed passenger/cargo configuration. The total order including exercise of the option represents an investment of about $51,000,000. Deliveries of the first DC-9s are set for September and October of 1966, with the balance of the initial order to be delivered in mid-1967. The TTA purchase marked the biggest order for the twin jet airplane received by Douglas from a regional airline.

Revolutionary was the word for another announcement made by TTA in November. Receiving approval by the Civil Aeronautics Board was TTA's First Rider Tariff providing for round trip travel between any two points on the airline's route system for only $25. Travelers will have to sign an affidavit stating they have never flown before to take advantage of the new fare.

Also in November TTA introduced a new concept in hostess uniforms. They no longer look like uniforms and come in one of four shades, Chinese blue, avocado green, tangerine, or hot pink. TTA hostesses choose the two colors most flattering to them.

In traffic figures for the first nine months of 1965, TTA carried 674,005 passengers, compared to 517,362 during the similar period last year.

Revenue passenger miles totaled 153,269,264 for the first nine months compared with 115,497,612 for the same period in 1964. Load factor on TTA flights was 40.51 per cent compared with 37.24 percent in 1964.

TTA set its sights on an even brighter future. TTA expected to become an international airline in early 1966 when service was scheduled to begin from the Texas Valley to Monterrey, Tampico, and Vera Cruz, Mexico. The routes were included in the bilateral agreement between the governments of the U. S. and Mexico and at year-end the case was pending before the CAB.

In other route cases before the CAB, TTA applied for extensive routes to the Pacific Northwest in the Pacific Northwest/Southwest case. TTA proposed giving local service to intermediate sized cities in the case.

TRANS WORLD AIRLINES

During 1965 Trans World Airlines rounded out its fifth year under the new management team headed by President Charles C. Tillinghast, Jr., a period in which TWA achieved what its officials termed "the most dramatic comeback in air transport history."

The airline's turnaround represented a swing from a net loss of $14,700,000 in 1961 to a substantial net profit, undetermined at year-end, in 1965.

In 1962, TWA suffered a net loss of $5,700,000 after taxes on gross revenues of $403,000,000. Traffic totaled 5.68 billion revenue passenger miles. But early in 1963 the new management's rebuilding efforts began to pay off. Boeing StarStream fanjets were joining TWA's fleet in growing numbers, permitting the airline to add new services on many routes. Traffic responded dramatically. Month after month, TWA showed traffic growth rates substantially ahead of its major competitors, reaching 7.02 billion revenue passenger miles for the year. Final 1963 figures showed revenues of $476,000,000 and profits of $19,800,000 after taxes. This upward swing continued throughout 1964 and 1965.

TWA's 1965 traffic volume amounted to 9,544,700 passengers boarded, an increase of 18 per cent over 1964, and 10.18 billion passenger miles, an 18.6 per cent increase. TWA's cargo traffic climbed sharply, too. In 1962 the airline carried 159,200,000 ton-miles of cargo. This figure increased to 187,800,000 ton-miles in 1963, and in 1964, with the new Boeing 707 CargoJets in full transcontinental and transatlantic operation, TWA carried 234,100,000 ton-miles. During 1965, this mark was again outstripped, with a total of 309,479,000 ton-miles carried.

The first of TWA's Boeing 727s entered service in June, 1964, and the airline's jet fleet (Boeing 707s, Boeing 727s and Convair 880s) passed the 100 mark in November, 1964. In January, 1965, TWA ordered 12 four-engine Boeing fanjets, 8 of them the Intercontinental model. In September the company placed still another order, this time for 23 jets. Of these, four will be 707-331B Intercontinentals, three will be 707-331C CargoJets, nine will be 707-131B domestic units, and six will be 727 QC "Quick-Change" aircraft. The Quick-Change 727s can be converted rapidly from passenger to cargo configuration, or any combination of the two. They will replace TWA's last piston-powered freighter aircraft. According to year-end orders, the TWA jet fleet will reach the 171 mark in 1967.

In addition, TWA placed orders for 16 supersonic transports (SSTs). TWA, in October, 1963, was the first to place a deposit for U.S.-built SSTs and subsequently increased its order to 10. The airline also ordered six of the British-French Concordes.

Early in 1966, TWA was to begin receiving its Douglas DC-9 twin-jets. Scheduled service with this short-haul aircraft was to start February 15. TWA purchased 20 DC-9s, which will enable the airline to retire its piston-engine Constellations and become the first major all-jet airline, probably by the end of 1966.

TWA's expansion and improvement of ground facilities kept pace with the growth of its fleet. During 1965, the airline added new facilities or major renovations at six passenger terminals, 10 cargo terminals, and 33 city ticket offices.

TWA took significant steps during 1965 to enlarge the mass appeal of air travel from a financial standpoint. Some fare reductions were offered, and the availability of travel to holders of general credit cards was also widened. The company offers credit-purchase privileges to the holders of American Express, Diners Club, Carte Blanche, and BankAmericard credit cards. Initial response to the credit-card tie-ins was most encouraging, and TWA marketing officials were convinced these plans offered a strong sales tool in the development of new business.

In April, TWA announced a new and greatly improved fly-drive plan in cooperation with the Avis, Hertz, and National rent-a-car companies. This arrangement permits travelers to pick up a rental car at any city on TWA's domestic system, drive it for seven days, and leave it at the same or any other TWA city for only $99.

On June 3 TWA put into effect its Family-Style Fare plan, offering much larger reductions than previous family fares. Under this plan the head of the family pays full coach fare, the spouse or first accompanying child under 22 years of age pays two-thirds fare, and all other children between two and 21 pay one-third. Thus a family of three travels for the equivalent of two full fares, and a family of six for the equivalent of three fares.

In August TWA instituted a liberalized free baggage allowance on domestic flights. This allowance permits each passenger to carry aboard his underseat baggage and check two additional bags, regardless of weight. By eliminating excess-baggage payments, except for suitcases larger than the specified size, the new plan effectively reduces the cost of flying for many travelers.

As attention continued to focus more closely on the U. S. balance of payments problem and the expenditures by U. S. tourists overseas, TWA stepped up its efforts to attract visitors from other countries to the United States.

In July TWA established a lower charter rate of only $3.40 per aircraft mile for its jet equipment on charters originating in and returning to countries overseas. This meant that a London-New York round trip would cost each member of a chartering group only $162.

For individual travelers from abroad who want to see all of the United States, TWA announced in October a special Visit USA fare. Effective January 1, 1966, the new fare permits foreign nationals living 100 miles or more outside the 48 continental states to make a complete circuit of TWA's domestic system within a 90-day period for only $220 in coach class.

TWA implemented extensive route and service expansion during 1965, increasing its service in terms of available seat-miles. In January, a New York-Phoenix nonstop jet roundtrip was inaugurated, featuring full-screen feature movies as on transcontinental nonstop flights. In April, TWA began through-plane international flights at Oklahoma City and also returned to Algiers after an absence of three and one-half years.

Later in the spring TWA began its first through-jet international service at Philadelphia. Late in June, the airline entered the New York-Cincinnati nonstop market, and in September nonstop jets were offered for the first time between Kansas City and San Francisco. In December, TWA began the first nonstop jet service by any airline between St. Louis and Phoenix.

During 1965, TWA agreed to supply financial assistance to New York Airways and to San Francisco and Oakland Helicopter Airlines. The two helicopter lines operate from TWA's gates at John F. Kennedy International Airport in New York and at San Francisco International Airport, offering added convenience for passengers headed toward other airports or surburban areas.

TWA's major domestic route aspirations during 1965 were contained in the Pacific Northwest/Southwest Service investigation. The airline was seeking a route from St. Louis and Kansas City through Denver to Salt Lake City, Portland, and Seattle. This route case involved the last major areas of the nation that do not already have single-carrier service.

Overseas, TWA in 1965 announced major plans for route expansion during the coming year. The airline intended to resume service beyond Bombay to Bangkok and Manila in 1966.

In June, TWA applied to the Civil Aeronautics Board for routes to Nairobi, Entebbe, and Dar-Es-Salaam in East Africa. The CAB granted its approval in late August, and negotiations with the governments of Kenya, Uganda, and Tanzania were started in order to obtain operating rights.

At the peak of the 1965 summer transatlantic travel season, TWA offered a record 196 flights per week. A total of 27,832 seats were available weekly.

TWA applied the electronic miracle of modern computer technology to flight planning on transatlantic routes. Weather information along the way is fed into a computer, which makes its calculations and then produces a set of alternative flight paths to be followed. The computer may "fly" across the Atlantic as many as 10,000 times in the course of deciding which route to follow.

On February 5, 1966, TWA planned to observe the 20th anniversary of its first transatlantic service. On that date in 1946, the carrier inaugurated the first scheduled service by any airline between New York and Paris, using the then-new L-49 Constellations.

In June, 1965, the company gave added tangible expression to its traditional support of world trade expansion by launching MarketAir, a new marketing program designed to help smaller firms develop their export/import potential. MarketAir supplies these companies with a monthly newsletter on international economic conditions and business opportunities abroad. Through MarketAir, companies can obtain market research in depth, temporary overseas staff assistance, and financing assistance.

UNITED AIR LINES

United Air Lines in 1965 set new records in almost every category of its operations, carrying 17,300,000 passengers and averaging in excess of 1 billion passenger miles per month for the year.

Highlight of the year was the airline's announcement of the purchase/lease/option of 144 new jet aircraft at a cost of $750,000,000 and the move toward an all jet status by the end of 1969. It was the largest aircraft acquisition in commercial aviation history.

Included in the giant order were seven Douglas DC-8-61 jets, largest in the world and measuring 36 feet longer than United's standard DC-8s. These planes will be used by United in its Hawaiian service and will carry at least 200 passengers.

The order also covered the purchase/lease of 30 Boeing 727QC jets, convertible tri-engine aircraft that will be capable of carrying passengers during daylight hours and cargo in night operations. Use of palletized seating permits the plane to be stripped for cargo use in less than 30 minutes. These planes, 15 of which were to be delivered in 1966, will bring cargo service to many cities not previously getting jet freighter service and will give United the largest domestic jet freighter fleet.

Reduced family fares introduced by United in June, 1965, helped stimulate a 150 percent increase in family travel during the peak summer vacation period and increased the size of the family flying from 2.3 to 3, indicating that considerable new business was achieved with this new family fare structure.

Initiated during 1965 was a liberalized baggage plan waiving the need for passengers to weigh baggage at check-in if it met size allowances. Lifting of the former 40-pound restriction helped speed check-in services and permitted the traveler to carry more luggage on business or vacation trips. A survey indicated the average air traveler was still carrying the same amount of luggage, but that he was adding only about 1 pound above that carried prior to the new allowances. The nation's carriers in introducing the new luggage plan lost about $17,000,000 in excess baggage revenue.

Credit card sales continued to climb in 1965 and United was honoring more credit cards than any other airline. Sales in 1965 exceeded $25,000,000 with travel agents handling about 10 percent of the total sales. In addition to American Express, Carte Blanche, Diner's Club, Bank of America, Bank of Hawaii, Citizens & Southern Bank (Atlanta), United also honored cards from the Mellon National Bank & Trust Company (Pittsburgh), which was added late in 1965.

United continued fog seeding operations on an expanded scale in 1965 with successful dispersal at such airports as Salt Lake City, Seattle, Portland, Boise, Pendleton, Medford, Spokane and Reno. In this operation a small plane takes off into the fog and begins to drop dry ice pellets into the super-cooled fog. A chemical reaction causes the moisture to change to fine snow crystals thereby releasing the fog and bringing visibility up to airline operating standards.

United, under the direction of W. B. Beckwith, chief meteorologist for the airline, spearheaded fog seeding developments during 1963–65 and won the cooperation of airport managers in the above named cities in the continuing war against weather.

Air travel as a personal gift was given new emphasis by United in 1965 when it launched a gift card program with travel agents in cooperation with one of the nation's largest greeting card companies. Special cards, designed for every occasion and containing a pocket for an airline ticket, are made available by the travel agents and United in the program. The gift of travel found wide acceptance with travel agents and was particularly popular during the Christmas season, United sales experts reported.

A new plan was launched late in the year with Holiday Inns, a "Meet-O-Matic" program whereby sales meetings and conventions will be arranged by United or through any Holiday Inn, including air transportation, reservations, meeting rooms, and audio-visual aids with a single telephone call. The program employs use of both United's Instamatic reservations system and the Holiday Inn "Holidex" computerized reservations systems which link the 640 Holiday Inns in 500 cities.

Compared with world traffic records United established a year ago, the new highs represented an increase of 18 percent in passengers and 22.5 percent in revenue passenger miles.

"Not only our company but the airlines in general will place 1965 on the books as their most successful year," it was announced by William A. Patterson, United's chairman of the board. "Revenue passenger miles flown by the domestic trunklines should show an increase of approximately 16 percent over 1964."

United also set world records in express and domestic trunkline mail carriage with gains of 13 per cent and 13.5 per cent respectively. An expanded fleet of five DC-8F Jet Freighters contributed to a 27 per cent increase in cargo ton miles (mail, express and freight).

Jet aircraft accounted for three-fourths of the 241,000,000 plane miles flown by the airline in the year. Two DC-8Fs, six DC-8s and 22 Boeing 727s were added to the company's fleet, which at year end consisted of 147 jets and 135 propeller airplanes. The company expected to become "all jet" by the end of 1969 as delivery is completed on additional 727s and the new twin engine Boeing 737 jets.

In 1966 alone, United was scheduled to take delivery on an additional 45 jet aircraft, including two DC-8-61s, three DC-8Fs, four regular DC-8s, 15 Boeing 727QC (quick change) passenger/cargo jets, and 21 standard Boeing 727s.

Patterson forecast 1966 gains of 21 percent in United's revenue passenger miles and 44 percent in cargo ton miles. The last includes an increase of 57 percent in freight ton miles, reflecting the additional 727QCs and DC-8Fs.

WESTERN AIR LINES

Western Air Lines in 1965 experienced a year of exceptional progress. The Los Angeles-based trunkline increased its Boeing 720B fanjet fleet to 18 aircraft, with four more on order. Profits were characterized by a leveling off during the first half of the year following 1964's record highs, but turned upwards towards the end of 1965.

Serving 12 Western states, Canada and Mexico, Western added Acapulco—another long-haul route—to its system. The company continued its long battle for a route to Hawaii from California. The Civil Aeronautics Board terminated the Transpacific Route Case without permitting Western to implement Hawaii awards originally granted the company in 1960. Western then took the case to the U. S. Court of Appeals.

The Civil Aeronautics Board began another important route case during the year—the Pacific Northwest-Southwest Service investigation—in which Western was an applicant. The case was instigated

A Western innovation was free use of dictating machines to businessmen flying Fanjet Commuter Service.

to determine the air service needs between the Northwest and major cities in the Southwest and Midwest. The case was expected to take as much as three years before final resolution.

Other route applications by the company were also pending, including service to Vancouver, B. C., Toronto and Montreal.

In August, Western placed a $70,000,000 order—biggest in the company's 40-year history—for 16 Boeing 737 twinjet aircraft, with options on nine more, and two 720Bs. Scheduled for delivery in 1968 and 1969, the twinjets will replace the company's fleet of 12 Lockheed Electras.

Earnings for the first 10 months of the year reached $10,537,000 or $2.45 a share, down from the previous year's $11,520,000, or $2.68 a share. Profits were up in October, however, reaching a record $841,000, or 19 cents a share, for the month, a 4.5 percent increase over the previous October high of $805,000, or 18 cents a share, earned in 1964.

Air cargo increased to record highs, and was carried on all flights throughout the system.

For the 15th consecutive year, Western's shareholders received cash dividends in 1965. Dividend payments were 20 cents a share on the 4,292,190 shares outstanding.

Among the new services introduced during the year, Western began the Fanjet Commuter flights between Los Angeles and San Francisco/Oakland on April 1 at the low fare of $13.50. The new commuter service replaced the company's DC-6B economy Thriftair service; it was aimed at recapturing much of the traffic lost on this highly competitive route with the introduction to competitive commuter service of jet aircraft in October, 1964.

On July 1, 1965, the Fanjet Commuter was extended to Las Vegas from both Los Angeles and San Francisco with outstanding success. Western expected continued growth in 1966.

GENERAL AVIATION

In the first nine months of 1965, the dollar value of new airplanes produced for the general aviation fleet passed the twelve month total of 1964, which had been a record year for the industry. By the end of October the number of airplanes sold had also surpassed the total for 1964.

Total production for the year was more than 11,000 airplanes. Retail value of the new airplanes exceeded $350,000,000. While production of new aircraft surged, utilization of the entire fleet of more than 90,000 planes grew in corresponding leaps as every segment of this part of the nation's air transportation system flew more hours and miles and attracted new users.

In the first six months more than 39,000 new student pilot permits were issued. Historically, the last six months of the year shows a marked increase in license issuances, indicating that more than 100,000 new pilots began their training during 1965.

Nearly 7 out of 10 takeoffs and landings at the 284 airports where the Federal Aviation Agency maintains control towers were made by general aviation airplanes. These flights averaged one movement every one and a half seconds, day and night, every day of the year. The figures reflect operations at only about 3 percent of the nation's airports.

The year marked a recognition for the capabilities of the general aviation airplane. Greater emphasis was placed on producing a wide variety of aircraft to meet the increasing number of missions for private air travel.

Manufacturers introduced dozens of new models in all classes of airplanes from trainers to pure jet business transports. Supercharged engines were used in the light twins in increasing numbers and offered in single-engine models. Greater carrying capacity also was evident in new models introduced. Single-engine airplanes grew to five and six seats in a wider variety of models; two-place trainers and personal airplanes were featured with optional seats to convert the capacity to four.

Business twins expanded in configurations and powerplants. The turbine powered airplane—both turboprop and pure jet—gained momentum with more than 175 delivered and a substantial backlog of orders to cause increased production schedules by all major manufacturers.

Industry observers credited many factors for the accelerated growth pattern. Increased emphasis on pilot training, improved marketing techniques and equipment with the capability to meet the travel need were but a few of the industry's efforts contributing to the upswing. Coupled with them were economic and social factors. Decentralization of business and industry plus more demands on individuals' time make the luxury of long, leisurely business trips impractical for businessmen. As the nation and the world turned more and more to air travel, general aviation moved to fill the gap that exists in the finest scheduled service.

Scheduled air service, constantly improving and increasing, by necessity is concentrated in the larger metropolitan centers. Some 45 percent of all scheduled service in the United States during 1965 was concentrated at only ten major cities. Ninety per cent of the airline passengers are enplaned at only 90 cities. For the vast areas not served and to those served with lower frequency of schedules, general aviation provided both direct and connecting service.

Much of the 1965 general aviation activity at major terminals was for the purpose of connecting passengers with scheduled carriers. Morristown, New Jersey, for instance, demonstrated how the general aviation airplane was providing a smaller community with an air link to the jet capitals of the world. One air taxi operator at this airport flew more than 38 flights a day to three major airline terminals serving New York City.

Transportation of personnel and cargo represented only a part of the service of the general aviation airplane. More than 5 out of 6 tillable acres were treated with millions of pounds of chemicals for improved agriculture. Law enforcement agencies, power and pipeline inspectors, forest fire fighters, fish spotters, and sport parachute jumpers, all took to the skies to follow their pursuits in general aviation aircraft.

As dynamic as general aviation was in the year 1965, it penetrated only a portion of the activities that are anticipated. Although there were at year-end more than 35,000 airplanes operated for business transportation, this was only about one-tenth of the immediate potential measured by market studies. At least 390,000 businesses have the need for and the ability to buy and operate their own aircraft, according to studies which reflect the types of businesses now operating them. This segment of the market is growing at the rate of two and a half per cent a year. Air taxi flying increased more than 32 per cent a year for the past five years concluding with 1965.

Increasing in this rapid fashion, general aviation was facing serious problems which the industry was acting upon. One of most concern remained the airport problem. The lack of proper landing facilities was posing immediate and long-range difficulties for communities to receive the benefits of air travel. While more airports in more places were sorely needed, ample parking places for based and transient aircraft at existing airports was becoming an acute problem in major congested areas.

Many communities were including the "industrial airpark" in their local planning. By locating airstrips adjacent to industrial development land the need for nearby aviation facilities is met for business while providing increased landing facilities for personnel and cargo flights. An airport in the industrial complex usually is easier to maintain and improve because of zoning regulations already in effect.

To meet the future needs of flight by general aviation aircraft, manufacturers invested millions of dollars in new plants, new tooling, new marketing methods and new designs.

Educational institutions also moved more heavily into the aviation field. Curricula based on the aeronautical sciences appeared in many areas and flight training as a credited course was placed in a number of high schools.

HELICOPTERS

In combat and on the home front, 1965 marked a year of achievement for rotary-wing aircraft. The versatile helicopter proved again and again its unique capabilities.

For example, in Viet Nam, as a troop transport, an armed escort and for rescues, the helicopter daily performed its missions under fire and penetrated areas inaccessible to any other type vehicle.

Recognition of the helicopter's multimission capabilities was made with the formation of the Army's First Cavalry (Airmobile) Division. The division is trained and equipped to be completely air transportable. The Army reported that the armed helicopter was well established in the Army's arsenal of weapons. The helicopter's outstanding record in Viet Nam demonstrated the survivability of the helicopter in a combat environment.

Statistics based on 800,000 Viet Nam combat missions record that a helicopter was hit by ground fire

Coast Guard helicopters were active in flood rescue operations during Hurricane Betsy.

once in 400 combat sorties, downed only once in about 8,000 sorties and lost to ground fire beyond repair only once in about 16,000 sorties.

By mid-1965, the Army had approximately 500 helicopters in Viet Nam. By year's end that total was more than doubled. The Army trained helicopter pilots at the rate of 96 a month in 1965, and the monthly output was slated to be increased to 290.

In addition to its accepted proven role of rescuing casualities on the battle field, the new Flying Crane heavy lift helicopter was adding still another capability to the rescue role. In a period of less than three months, more than 50 downed aircraft were picked up and airlifted by the flying crane to maintenance bases. It is safe to estimate that the rescue of these aircraft has saved millions of taxpayers' dollars. Without this modern method, the time required to resupply and maintain the combat aircraft inventory would escalate costs and delay for replacement would lessen combat strength.

One of the four flying Cranes in service in Viet Nam was equipped as a command headquarters, another as a battle field first aid station. The combat use of these heavy lift helicopters serves as a proving ground for similar use in civil life, in disasters and in the removal of crashed automobiles from the highways and freeways to avoid traffic pileups.

The Marine Corps in Viet Nam was using helicopters as close support vehicles, performing the Marines' concept of vertical envelopment, a concept that encompasses battlefield surveillance, troop carrying and armed helicopters in close battlefield support.

In 1962, the Howze Board was formed by the Secretary of Defense to plan for the Army's aviation requirements through 1970. In accordance with one of the Board's recommendations, during the summer of 1965, announcement was made of the Army's award for the Light Observation Helicopter (LOH). This turbine powered helicopter will replace the Army's training helicopters and airplanes and will ultimately be available for the civilian market.

The Army also announced the decision to proceed to production on the Advanced Aerial Fire Support System (AAFSS).

The 1965 Hurricane Betsy gave the helicopter another apportunity to prove itself. In the New Orleans area alone, the Coast Guard, Navy, Marine and Army helicopters rescued 2,229 flood victims. Again, no other vehicle could have so performed.

On the battlefield, medical aid is swiftly airborne to the combat casualty; at home, the highway accident victim may wait hours for the ambulance and needed first aid.

In recognition of this need, to provide the fast first aid to the highway accidents that kill more than 38,000 citizens annually—the Vertical Lift Aircraft Council of Aerospace Industries Association initiated a program to assist in the establishment of hospital heliports. Based on a 1965 Council survey, there were then 34 hospital heliports in the country. By year's end, the total was over 50.

To support this hospital heliport program and to assist in the establishment of needed city-center and suburban heliports, the Council prepared a five minute color, public service film, "When Minutes Really Count." Film prints, together with reprints of *The Modern Hospital* magazine article "Helicopters Expand Hospital Service Area" are available for showing before civic groups.

In further recognition of the need to improve highway safety, the Department of Commerce planned an operational test to develop a helicopter ambulance concept for both rural and urban areas. The Council was asked to cooperate on this Government project.

In 1963, at the invitation of the Administrator of the Federal Aviation Agency, the Council made a Presentation "Government-Industry Relations in The Field of Vertical Lift Aircraft." Tangible results can be acknowledged for the major recommendations proposed by the Council at that time, notably reinstatement of the annual review of FAA regulations covering rotorcraft and establishment of the government's Inter-Agency V/STOL Task Force.

At its September 1965 meeting, the Council determined to prepare a follow-on presentation to define the economies of VTOL systems and to recommend that a national policy for VTOL research and development be established. This presentation, scheduled for completion in the spring of 1966, is designed to show further the role of vertical riser aircraft as part of the transportation requirement in the Northeast Corridor.

The 1965 Directory of Helicopter Operators (commercial, executive, government and helicopter flight schools in the U.S. and Canada) listed 860 operators operating 2,053 helicopters. These totals represented an increase of 21 percent in the number of operators and 16 percent in the number of helicopters as compared with the 1964 totals. The number of helicopter flight schools increased from 121 in 1964 to 156 in 1965.

In response to numerous requests, the Council compiled and published the 1965 Directory of Foreign Helicopter Operators (military, civil government, commercial). This unique publication lists 544 operators in 81 countries operating 4,116 helicopters.

The Council's annual Directory of Heliports/Helistops in the U.S., Canada and Puerto Rico pointed to the need for more municipally owned heliports located in city centers to permit the use of the helicopter as a short-haul VTOL type transport. For example, of the 1,000 helicopter landing facilities listed in the 1964 Directory 579, or more than half, were privately owned and operated.

Notable during 1965 was the active interest and support of the larger trunk airlines in the operation of the scheduled helicopter airlines. The three scheduled helicopter carriers—Los Angeles Airways, Inc., San Francisco-Oakland Helicopter Airlines, Inc. and New York Airways, Inc.—were reporting increased passenger leads as a result. With the closing of Chicago's Midway Airport, Chicago Helicopter Airways cancelled scheduled service. However, with the announced service of the small jets to be permitted at Washington's National Airport, some aviation experts predicted that Midway would reopen and scheduled helicopter service would again be required to serve the Chicago area.

A milestone in helicopter transport history was established on December 22, 1965 when New York Airways, Inc., inaugurated scheduled service between the Pan Am Building rooftop heliport in mid-Manhattan and the three area airports—Newark, LaGuardia and Kennedy International Passenger acceptance of the new service was excellent; year-end figures from New York Airways revealed that approximately 2,000 people a day were "going all the way by air."

New York Airways inaugurated service from the roof of the mid-town New York Pan Am building.

QUALITY PRODUCTS FOR DEFENSE AND INDUSTRY

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WOOD-RIDGE, NEW JERSEY

REFERENCE SECTION

Introduction

The following pages, designed for reference use, contain specifications, performance, and other data on well over 500 products of the aerospace industry. In addition to the primary products—aircraft, engines, missiles, spacecraft and launch vehicles—the Aerospace Yearbook includes for the first time a special section on systems. The term system here denotes the major ground-based and airborne equipments other than the primary products; manufacture of units like these constitutes an important part of the workload of the aerospace industry. For easier reference, missiles and spacecraft are organized by functional groups. All other products are arranged in alphabetical order by name of the manufacturing company. For specific listings consult the index. The term *prime contractor* as used throughout this section refers to the builder of the product listed, regardless of whether it is a primary product or a subsystem.

AERO COMMANDER-100

Prime Contractor: Aero Commander Division, Rockwell Standard Corporation

Remarks

The Aero Commander-100 is a four-place, all metal, high wing tricycle geared monoplane equipped with a Lycoming 0-320-A 150 horsepower engine and a Sensenich M74DM-60V metal propeller. The aircraft has a 44 gallon fuel capacity. The -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, Rockwell Standard Corporation

Remarks

The Aero Commander-200 is a four-passenger monoplane all metal, low wing cantilever design with a retractable tricycle landing gear. The aircraft is equipped with a Continental 6-cylinder opposed 10-520-A, 285 horsepower Continental engine and a McCauley constant speed metal propeller. The Commander 200 has an 82-gallon fuel capacity including auxiliary fuel of 40 gallons in outer wing panel tanks.

Specifications

Span 30 feet 6 inches; length 24 feet 4 inches; height 7 feet 4 inches; empty weight 1,940 pounds; useful weight 1,060 pounds; gross weight 3,000 pounds; baggage capacity 200 pounds; wing loading 18.75 pounds per square foot; power loading 10.5 pounds horsepower.

Performance

Take-off distance over 50-foot obstacle 1,500 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 55 miles per hour (full flaps); service ceiling 18,500 feet.

JET COMMANDER

Prime Contractor: Aero Commander Division, Rockwell Standard Corporation

Remarks

The Jet Commander is an executive jet capable of carrying 7 passengers and 735 pounds of baggage on a trip of 1,150 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 7,240 pounds; gross weight 16,000 pounds; wing loading 53 pounds square feet; power loading 2.8 pounds per pound of thrust; engines two GE CJ-610- 1 rated at 2,850 pounds thrust at sea level; fuel capacity (JP-4) 990 gallons; cabin capacity 6–8; cabin pressure at sea level up to 20,000 feet, 7,000 feet at 30,000 feet; useful load 8,760 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 6,000 feet per minute; service ceiling 40,000 feet; range with 45 minute reserve 1,325 statute miles.

GRAND COMMANDER

Prime Contractor: Aero Commander Division, Rockwell Standard Corporation

Specifications

Span 49 feet 6 inches; length 41 feet 3.25 inches; height 14 feet 6 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.

Performance

Cruise speed, 70 percent power, 10,000 feet, 240 miles per hour; take-off distance over 50-foot obstacle, 1,560 feet; landing distance over 50-foot obstacle, 1,450 feet; cruising range with 30-minute fuel reserve, 1,310 statute miles; service ceiling 28,500 feet.

Note: The airplane is also available as the Pressurized Grand Commander which has identical specifications and performance with these exceptions: Empty weight 5,600 pounds; useful load 2,900 pounds.

TURBO COMMANDER

Prime Contractor: Aero Commander Division, Rockwell Standard Corporation

Specifications

Span 49 feet 6 inches; length 41 feet 3.25 inches; height 14 feet 6 inches; tread 12 feet 11 inches; maximum take-off weight 8,500 pounds; empty weight 5,100 pounds; useful load 3,400 pounds; maximum fuel capacity 282 gallons.

Performance

Cruise speed at 16,500 feet, 285 miles per hour; take-off distance over 50-foot obstacle, 2,000 feet; landing distance over 50-foot obstacle, 1,900 feet (with propeller reversal 1,200 feet); cruising range with 45-minute reserve, 1,100 statute miles; service ceiling 30,000 feet.

BEECHCRAFT MUSKETEER SPORT III, CUSTOM III AND SUPER III

Beech Aircraft Corporation

Remarks

The Musketeer, Beechcraft's popular line of sport and training airplanes, has been expanded to three models—the Sport III, Custom II, and the Super III. The new, two-place Musketeer Sport III is powered by a 150 horsepower Lycoming engine and comes equipped with the same standard items as the other Musketeers, including dual controls. The Musketeer Custom III performs with a 165 horsepower Continental fuel injection engine and can accomodate four people with an increased, 50-pound, useful load.

Specifications

Span 32 feet 9 inches; length 25 feet; height 8 feet 3 inches; gross weight (Sport) 2,030 pounds, (Custom) 2,400 pounds, (Super) 2,550 pounds; power plant (Sport) 150 horsepower Lycoming 0-320, (Custom) 165 horsepower Continental IO-346 A, (Super) 200 horsepower Lycoming IO-360.

Performance

Cruising speed (Sport) 131, (Custom) 137, (Super) 146 miles per hour at 75% power at 7,000 feet; cruise range, same conditions, (Sport) 800 miles, (Custom) 778 miles (Super) 678 miles; rate of climb, (Sport) 840, (Custom) 725, (Super) 805 feet per minute; service ceiling (Sport) 14,200, (Custom) 11,870, (Super) 14,500 feet.

BEECHCRAFT C33 AND C33A DEBONAIR

Beech Aircraft Corporation

Remarks

The Beechcraft C33 Debonair is a tough and rugged airplane with speed and range, capable of flying at a top speed of 195 mph. It has a non-stop range of over a thousand miles. The Beechcraft C33A Debonair has all the regular Debonair features plus new performance from a 285 horsepower Continental engine. Estimated top speed of the C33A is 209 miles per hour, with 202 miles per hour cruise speed at 75 percent power at 6,500 feet.

Specifications (C33)

Span 32 feet 10 inches; length 25 feet 6 inches; height 8 feet 3 inches; gross weight 3,050 pounds; useful load 1,270 pounds; engine 225 horsepower Continental IO-470K.

Performance

Cruising speed 185 miles per hour; cruise range 595 miles standard, 1,075 miles with optional 80 gallon tanks; rate of climb 930 feet per minute; service ceiling 17,800 feet.

BEECHCRAFT V35 AND V35TC BONANZA

Beech Aircraft Corporation

Remarks

Since the first Beechcraft Bonanza was delivered in 1947, it has proved an outstanding business airplane. The newest model of the Bonanza incorporates many refinements for pleasure and business flying. The new V35 Bonanza will be recognized by its fresh air scoop just forward of the familiar V tail. A one-piece, tinted windshield now gives an unobstructed view of the sky ahead. Pushing the Bonanza to even faster speeds and greater heights will be the compact light-weight AiResearch TEO 659 turbine in the turbocharged V35TC Bonanza, a new model in the Bonanza line. The V35TC has an estimated top speed of 245 miles per hour.

Specifications (V35)

Span 33 feet 5 1/2 inches; length 26 feet 4 1/2 inches; height 6 feet 6 1/2 inches; gross weight 3,400 pounds; useful load 1,485 pounds; engine 285 horsepower Continental IO-520B.

Performance

Cruising speed 203 miles per hour; cruise range 539 miles standard, 989 miles with optional 80 gallon tanks; rate of climb 1,136 feet per minute; service ceiling 17,500 feet.

BEECHCRAFT D95A TRAVEL AIR

Beech Aircraft Corporation

Remarks

Beechcraft's line of rugged, high-performance, light twins includes the highly efficient D95A Travel Air, which retains its classic airframe configuration. The quiet, dependable D95A Travel Air seats five persons in comfort and has room for 670 pounds of luggage in two compartments. Powered by two 180 horsepower Lycoming fuel injection engines, the Travel Air cruises at 200 miles per hour and is capable of 210 miles per hour at full speed. An expanded list of standard equipment items includes a one-piece windshield which offers greater visibility forward and a new fresh air system.

Specifications

Span 37 feet 10 inches; length 25 feet 11 inches; height 9 feet 6 inches; gross weight 4,200 pounds; useful load 1,645 pounds; engines 2 Lycoming IO-360-B1B, 180 horsepower each.

Performance

Cruising speed 65% power 195 miles per hour, 75% power 200 miles per hour; cruising range at 112 gallons and 65% power 1,035 miles; 2 engine rate of climb 1,250 feet per minute; absolute ceiling 19,700 feet.

BEECHCRAFT B55 AND C55 BARON

Beech Aircraft Corporation

Remarks

Inproved performance and an upgrading of standard equipment distinguish Beechcraft's B55 Baron, an airplane that retains its overall configuration but offers a 100-pound total increase in useful load. The B55 Baron is an easy-to-fly, four- to six-place ship. Short field performance has been appreciably upgraded in the latest model, which requires a total distance of only 1,370 feet over a 50-foot obstacle. Powerful new engines, increased speed, boosted useful load capacity, and improved performance mark Beechcraft's new C55 Baron (in photo). The C55 Baron is driven by new 285-hp Continental IO-520-C engines, providing a top speed of 242 miles per hour.

Specifications (B55)

Span 37 feet 10 inches; length 27 feet 3 inches; height 9 feet 7 inches; gross weight 5,100 pounds; useful load 2,075 pounds; engines 2 260 horsepower Lycoming IO-470-L.

Performance

Cruising speed 225 miles per hour; cruising range, 45% power, 142 gallons, 1,225 miles; rate of climb 2 engines 1,670 feet per minute; absolute ceiling 21,000 feet.

BEECHCRAFT QUEEN AIR 65

Beech Aircraft Corporation

Remarks

An established high-performance, medium twin-engine business airplane, the Beechcraft Queen Air 65 brings to light twin buyers such comfort features as built-in steps; center aisle that permits passengers to move about in flight; three individual compartments that insure privacy for crew and passengers and provide a restroom; an optional four-place couch; and many other features. Retaining its original configuration, the latest Queen Air 65 is powered by two supercharged, fuel injection engines.

Specifications

Span 45 feet 10 1/2 inches; length 33 feet 4 inches; height 14 feet 2 inches; gross weight 7,700 pounds; useful load 3,005 pounds; engines 2 340 horsepower Lycoming IGSO-480-AIE6.

Performance

Cruising speed 214 miles per hour; cruise range 760 miles standard, 1,035 miles with optional 230 gallon tanks; rate of climb at gross weight 1,300 feet per minute; service ceiling 31,300 feet.

BEECHCRAFT QUEEN AIR 88

Beech Aircraft Corporation

Remarks

Offering a combination of pressurization, supercharged engines and all-weather instrumentation in a new market price category, the Beechcraft Queen Air 88 has cabin pressurization identical to that in the turbine-powered Beechcraft King Air. It creates in the Model 88, 8,000-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 2 1/2 inches; gross weight 8,800 pounds; useful load 2,780 pounds; engines 2 380 horsepower Lycoming IGSO-540-AID.

Performance

Cruising speed 70% power at 15,000 feet 221 miles per hour; cruising range at 65% power at 17,000 feet 1,270 miles; rate of climb 2 engines 8,800 pounds 1,275 feet per minute; service ceiling 26,800 feet.

BEECHCRAFT SUPER H18

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 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; light-weight propellers; new feathering accumulaters; new bladder-type fuel tank arrangements; new main landing gear; 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 2 1/2 inches; height 9 feet 4 inches; gross weight 9,900 pounds; useful weight 4,220 pounds; engines 2 450 horsepower Pratt & Whitney Wasp.

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 KING AIR

Beech Aircraft Corporation

Remarks

The Beechcraft King Air is a turbine-powered, pressurized business transport designed to provide the most realistic and practical combination of size, performance, comfort, reliability and economy for modern executive mobility. It is fully equipped for all-weather operation, and its rugged design makes it possible to utilize virtually any airfield. With twin Pratt & Whitney turbine powerplants developing 550 shaft horsepower each, the King Air cruises at 270 miles per hour, can fly to a service ceiling of 31,300 feet, and is capable of flying almost 1,500 non-stop miles at maximum cruise power. Unprecedented customer acceptance of the King Air has dictated an increased production schedule of over 100 a year, and indications are that another substantial production increase is being considered.

Specifications

Span 45 feet 10 1/2 inches; length 35 feet 6 inches; height 14 feet 8 inches; gross weight 9,300 pounds; engines 2 500 shaft horsepower Pratt 2 Whitney PT6A-6 free turbines.

Performance

Cruising speed maximum cruise power 269 miles per hour; cruising range at 20,000 feet 1,495 miles; rate of climb 2 engines 9,300 pounds 1,900 feet per minute; service ceiling 2 engines 9,300 pounds 27,400 feet.

BEECHCRAFT MODEL 45 MENTOR

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, two-place airplane. As the Model 45 Mentor, designated T-34A by the Air Force and T-34B (photo) 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, Columbia, El Salvador, Japan, Mexico, the Philippines, Spain and Turkey. The Mentor also has been manufactured in Japan and Argentina under license from Beechcraft.

Specifications

Span 32 feet 10 inches; length 25 feet 11 inches; height 9 feet 7 inches; empty weight (T-34A) 2,174 pounds; empty weight (T-34B) 2,228 pounds; engine one 225 horsepower Continental 0-470-13; retractable tricycle landing gear (same as for Bonanza); tandem cockpits under continuous canopy.

Performance (T34A)

Maximum speed 189 miles per hour; maximum cruise speed 173 miles per hour; service ceiling, 20,000 feet; maximum cruising range 737 miles.

T-42A INSTRUMENT TRAINER

Prime Contractor: Beech Aircraft Corporation

Remarks

The T-42A is the military counterpart of the Beechcraft Model B55 Baron and will be 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 will be the twin-engine transition of single-engine rated aviators.

Specifications

Wing span, 37.9 feet; length, 27.3 feet; height, 9.6 feet; gross weight, 5,100 pounds; empty weight, 2,995 pounds; engines, two Continental 6-cylinder, IO-470-L, fuel injection engines rated at 260 horsepower; constant speed full feathering propellers; dual instrumented for student training and equipped for all-weather flying. Cabin is arranged for 3 students and an instructor and has a range of 5 hours.

Performance

High speed at sea level, 205 knots; cruise speed, at 65 percent, 195 knots; rate of climb, 1,730 feet per minute; service ceiling, 20,200 feet; absolute ceiling, 21,400 feet; range, 50 percent power, 10,500 feet, 1,065 nautical miles.

SK-1 HYDROSKIMMER

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The Hydroskimmer, designed and built by Bell during 1962 and 1963, is the largest and most powerful air cushion vehicle ever constructed in the United States. Built for the U.S. Navy as a research craft, the Hydroskimmer has provided technical data on the design and performance of air cushion vehicles during various test and evaluation programs over the last three years. Research programs have been conducted on Lake Erie at Buffalo, N.Y. and in the Norfolk, Virginia, area. Military missions considered for Hydroskimmer-type craft include anti-submarine warfare, landing and patrol operations, mine countermeasures, high-speed transport of personnel and cargo and rescue operations.

Specifications

Length 65 feet; width 27 feet; height 23.5 feet, plus four foot flexible trunks; engines 4 Solar Saturn marine gas turbines rated at 1080 horsepower each; gross weight 30 tons.

Performance

Maximum speed 70 knots.

SK-3 CARABAO

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The SK-3 Carabao, designed and built by Bell Aerosystems with company funds, is a rugged and versatile air cushion vehicle capable of performing a variety of missions over land, water, ice, snow, mud and marsh. The prototype vehicle began operational testing in March, 1963. During late 1963 and 1964, the Carabao completed a highly-successful series of operational demonstrations in the marshes and shallow waters of Lake Okeechobee, Florida and on the James and Potomac Rivers. In July 1964, the Carabao demonstrated the capability of the ACV concept as a means of transport in polar regions during a month-long evaluation program in Greeland. It is presently being utilized as a training vehicle for ACV operators.

Specifications

Length 18.7 feet; width 16 feet; height 10 feet; normal gross weight 3,200 pounds; lift engine 125-horsepower Franklin; propulsion, 150-horsepower Lycoming; Carabao has three circular plenum cells, or air chambers, equally spaced around its center lift fan.

Performance

Speed 60 miles per hour; endurance 4 hours; obstacle clearances 16 inch wall, 3 foot ditch, 10 foot hedge.

SK-5

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The Bell SK-5 air cushion vehicle is an American version of the SR. N5 Hovercraft produced in England by Westland Aircraft Ltd. Bell Aerosystems has a U.S. Navy contract to deliver three SK-5s, marking the first U.S. military application of this new means of transportation. In addition, two SK-5s, called Jet-Skimmers, are in scheduled passenger service in the San Francisco-Oakland Bay area under the Mass Transportation Demonstration Grant program.

Specifications

Length 39.2 feet; width 22.9 feet; height 16.6 feet; gross weight 15,000 pounds; engine one General Electric LM100 marine gas turbine rated at 1000 shaft horsepower.

Performance

Maximum speed 60 knots; range 210 nautical miles; obstacle clearances, solid wall 3.5 feet, earth mound 5 feet, vegetation 6 feet.

X-22A V/STOL RESEARCH AIRCRAFT

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The X-22A research aircraft was developed by Bell Aerosystems as part of the Tri-Service V/STOL program to explore the mechanical and aerodynamic characteristics and evaluate the military potential of this revolutionary concept of flight. Under a Navy-administered contract, Bell built two of these airplanes which make use of a dual-tandem, ducted-propeller configuration. An unique variable stability and control system is combined with high control power levels and a three-engine hovering capability to provide an extremely versatile V/STOL research aircraft. First X-22A was rolled out May 25, 1965. First flight was scheduled for fall, 1965.

Specifications

Span 39.2 feet; length 39.6 feet; height 20.69 feet; VTOL gross weight 15,980 pounds (standard day, one engine out); engines 4 General Electric YT-58-8D turboshaft (1,250 horsepower each).

Performance

Speed 325 miles per hour; endurance three hours; range 480 nautical miles.

X-14A VTOL RESEARCH AIRCRAFT

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The X-14, designed and built by Bell under an Air Force contract awarded in 1955, was the first VTOL airplane to employ the jet vectored thrust principle. The airplane was delivered to the National Aeronautics and Space Administration's Ames Research Center at Moffett Field, Calif., in October 1959. NASA replaced the original Armstrong-Siddeley Viper engines with General Electric J85 turbojets for increased thrust and redesignated the airplane the X-14A. Primary purpose of NASA's X-14A program is to research and define the stability and control system requirements for V/STOL aircraft. In addition, it has been used for test pilot familiarization and to investigate and simulate the approach phase of lunar landings for Project Apollo.

Specifications

Span 34 feet; length 25 feet; tail height 8 feet; gross weight 4,000 pounds.

Performance

Operational speed 160 knots; maximum speed 180 knots.

47G-4 TROOPER HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The 47G-4, first delivered in January 1964, is a three-place utility helicopter. Currently in production in service use, it is the latest of the Bell commercial line.

Specifications

Fuselage length 31.6 feet; overall length 43.2 feet; main rotor diameter 37.1 feet; normal gross weight 2,950 pounds; empty weight 1,777 pounds; useful load 1,173 pounds; engine Lycoming VO-540 220 horsepower.

Performance

Maximum speed 105 miles per hour; cruise speed 84–91 miles per hour; maximum range at 5,000 feet, 324 miles; rate of climb 600 feet per minute; hovering ceiling, IGE, 7,700 feet; service ceiling 17,500 feet.

47G-3B-1 HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

Newest of Bell's turbosupercharged models, the 47G-3B-1 three-place utility helicopter was first delivered in January, 1963 and is still in production.

Specifications

Fuselage length 31.6 feet; overall length 43.2 feet; main rotor diameter 37.1 feet; normal gross weight 2,950 pounds; empty weight 1,794 pounds; useful load 1,156 pounds; engine Lycoming TVO-435 turbosupercharged, 220 horsepower.

Performance

Maximum speed 105 miles per hour; cruise speed 83–93 miles per hour; maximum range at 5,000 feet, 315 miles; rate of climb 880 feet per minute; hovering ceiling, IGE, 16,100; feet; service ceiling 20,000 feet.

47J-2A RANGER HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The versatile 47J-2A Ranger is quickly convertible from a four-place executive transport to a rugged cargo hauler. First delivered in January, 1964, it is in service and in production.

Specifications

Fuselage length 32.4 feet; overall length 43.4 feet; main rotor diameter 37.1 feet; normal gross weight 2,950 pounds; empty weight 1,833 pounds; useful load 1,117 pounds; engine Lycoming VO-540 220 horsepower.

Performance

Maximum speed 105 miles per hour; cruise speed 91–103 miles per hour; maximum range at 5,000 feet, 268 miles; rate of climb 870 feet per minute; hovering ceiling, IGE, 15,100 feet; service ceiling 17,600 feet.

204B HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

Largest of Bell's commercial line, the 10-place 204B was first delivered in April, 1963. In service and in production, 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 T5309 gas turbine 900 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.

OH-13S SIOUX HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

In service since September, 1963, the OH-13S is a three-place Army observation helicopter.

Specifications

Fuselage length 32.6 feet; overall length 43.2 feet; main rotor diameter 37 feet; normal gross weight 2,850 pounds; empty weight 1,936 pounds; engine Lycoming TVO-435-25 supercharged 260 horsepower.

Performance

Maximum speed 105 miles per hour; cruise speed 83–93 miles per hour; normal range 324 miles; rate of climb 1,190 feet per minute; hovering ceiling, IGE, 18,000 feet, OGE, 18,000 feet; service ceiling 18,000 feet.

TH-13T HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The TH-13T is a basic instrument trainer first delivered to the Army in December, 1964. Still in production, it is a two-place derivative of the Model 47.

Specifications

Fuselage length 32.6 feet; overall length 43.2 feet; main rotor diameter 37 feet; normal gross weight 2,950 pounds; empty weight 2,057 pounds; engine Lycoming TVO-435-25 supercharged 220 horsepower.

Performance

Maximum speed 105 miles per hour; cruise speed 83–93 miles per hour; normal range 324 miles; rate of climb 880 feet per minute; hovering ceiling, IGE, 20,000 feet, OGE, 18,600 feet; service ceiling 20,000 feet.

UH-1B IROQUOIS HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1B is an Army utility helicopter which seats up to nine. In service since, March, 1961, it is still in production. Advanced model, called Huey Cobra, is under test.

Specifications

Fuselage length 42.6 feet; overall length 53 feet; main rotor diameter 44 feet; normal gross weight 8,500 pounds; empty weight 4,519 pounds; engine Lycoming T53-L-11 900 shaft horsepower.

Performance

Maximum speed 138 miles per hour; cruise speed 135 miles per hour; normal range 212 miles; rate of climb 2,350 feet per minute; hovering ceiling, IGE, 16,800 feet, OGE, 12,700 feet; service ceiling 16,700 feet.

UH-1D IROQUOIS HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1D is a tactical transport helicopter with a capacity of 12–15 seats in service with the Army since June, 1963.

Specifications

Fuselage length 44.6 feet; overall length 53.9 feet; main rotor diameter 48 feet; normal gross weight 9,500 pounds; empty weight 4,717 pounds; engine Lycoming T53-L-11 900 shaft horsepower.

Performance

Maximum speed 138 miles per hour; cruise speed 135 miles per hour; normal range 315 miles; rate of climb 2,350 feet per minute; hovering ceiling, IGE, 18,200 feet, OGE, 14,000 feet; service ceiling 22,000 feet.

UH-1E IROQUOIS HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1E, which can carry eight to 10 personnel, is a Marine Corps utility/observation helicopter in service since March, 1964.

Specifications

Fuselage length 42.6 feet; overall length 53 feet; main rotor diameter 44 feet; normal gross weight 8,500 pounds; empty weight 4,750 pounds; engine Lycoming T53-L-11 900 shaft horsepower.

Performance

Maximum speed 138 miles per hour; cruise speed 135 miles per hour; normal range 212 miles; rate of climb 2,350 feet per minute; hovering ceiling, IGE, 16,800 feet, OGE, 12,700 feet; service ceiling 16,700 feet.

UH-1F IROQUOIS HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1F is the Air Force version of the Model 204 series. In service since March, 1964, it seats 11 and is used as a missile site support vehicle.

Specifications

Fuselage length 44.6 feet; overall length 57.1 feet; main rotor diameter 48 feet; normal gross weight 9,000 pounds; empty weight 4,403 pounds; engine General Electric T58-3 1,039 shaft horsepower.

Performance

Maximum speed 138 miles per hour; cruise speed 135 miles per hour; rate of climb 2,350 feet per minute; normal range 392 miles; hovering ceiling, IGE, 18,700 feet, OGE, 15,200 feet; service ceiling 22,000 feet.

YUH-1B COMPOUND HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The YUH-1B is an advanced research compound helicopter equipped with Bell's new four-bladed rigid rotor which makes possible speeds as high as 250 miles per hour in level flight. The YUH-1B is being developed by Bell under contract with the Army Transportation Research Command; the four-bladed rotor system was developed independently with company funds. The helicopter's normal power plant is a 1,100 horsepower Lycoming T53 engine; in addition, the craft has stub wings protruding outward from the cabin section and from the aft fuselage, and two auxiliary Continental J69-T29 jet engines. The YUH-1B has been flown a number of times at speeds above 200 miles per hour.

B-47E MEDIUM BOMBER

Prime Contractor: The Boeing Company

Remarks

The B-47, first multi-jet airplane produced following World War II, was designed as a strategic weapon system capable, with aerial refueling, of operating over extended ranges and is in service with the USAF's Stategic Air Command. The first B-47 was delivered to SAC in October, 1951, and the last one in February, 1957. During the production period, 2,041 B-47s were produced, 1,390 of them at Boeing-Wichita and the remainder under license agreements with two other aircraft firms. The bulk of the B-47s produced were bomber versions, of which the B-47E was the last. Other configurations in which the Stratojet was delivered included a variety of reconaissance versions designated RB-47E, RB-47H, and RB-47K.

Specifications

Span 116 ft; sweepback 35 degrees; length 107 feet; height 28 ft; 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 wheels 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 GAM-77 Hound Dog missiles in underwing installations; the air-to-surface weapons can be released hundreds of miles from their targets. Principal feature of the B-52H fuel system is the wing in which integral tank construction of the entire wing forms virtually one huge fuel tank. The "H" was the final model of the B-52 Stratofortress series, 744 of which were delivered to the Air Force. The last "H" was delivered on October 26, 1962.

Specifications

Span 185 feet; length 157 feet 6.9 inches; height 40 feet 8 inches; wing sweepback 35 degrees; weight 488,000 pounds; engines 8 Pratt & Whitney TF-33 turbofan, 17,000 pounds thrust each; gear 8 main wheels in tandem, single outrigger near wing tip.

Performance

Speed 650-plus miles per hour; unrefueled range 12,500-plus miles; service ceiling over 60,000 feet.

BOEING 707-120 SERIES JETLINERS

Prime Contractor: The Boeing Company

Remarks

The Boeing 707-120 (maiden flight—Dec. 20, 1957) was America's first jet airliner to go into service. First commercial flight of this four-engined jetliner was made by Pan American World Airways on Oct. 26, 1958, from New York to Paris with 111 passengers. The turbojet airplane was developed from the Boeing 707 sweptwing jet prototype, as was the KC-135 tanker series for the USAF. The -120 gave way later to the advanced 707-120B (first flight June 22, 1960; in service March 2, 1961), which incorporated turbofan engines of greater power, a redesigned wing, plus new control surfaces. The -120 was designed for transcontinental use but was capable of over-ocean ranges from the beginning. Sales of this veteran model have been virtually eclipsed by second and third generation jetliners.

Specifications

Span 130 feet 10 inches; length 144 feet 6 inches; height 42 feet; wing sweepback 35 degrees; weight 258,000 pounds; engines 4 Pratt & Whitney JT3C-6 turbojets of 13,000 pounds thrust (-120 model), and JT3D-1 turbofans of 17,000 pounds thrust for -120B model; tricycle gear with four-wheel bogie-type truck main units and dual nose wheels; payload is up to 179 passengers.

Performance

Speed up to 600 miles per hour; range more than 3,000 miles; ceiling over 30,000 feet.

BOEING 707-320 SERIES JETLINERS

Prime Contractor: The Boeing Company

Remarks

Designed to serve very long-range routes of more than 4,000 miles, the 707-320 Intercontinental jetliner first went into service Oct. 26, 1959. First flight was January 11, 1959. It was supplanted later by the 707-320B with a range of more than 6,000 miles nonstop with a normal passenger load. The -320B (first flight January 31, 1962, in service April 4, 1962) incorporated turbofan engines, new leading and trailing edge wing flaps, and other aerodynamic improvements. Then, in 1962, a 7 x 11-foot forward cargo door plus use of integral floor tracks and a cargo handling system, and some structural strengthening, further developed the -320B into a multipurpose jet called the 707-320C. This airplane is capable of carrying all cargo on pallets, or can be converted to carry all passengers, or a combination of both.

Specifications

Span 145 feet 9 inches; length 152 feet 11 inches; height 42 feet 5 inches; wing sweepback 35 degrees; weight 328,000 pounds for -320B, 332,000 pounds for cargo version of -320C, and 336,000 pounds for passenger version of -320C; engines 4 Pratt & Whitney JT3D-3 turbofans of 18,000 pounds thrust; tricycle gear, main undercarriage units four-wheel bogie-type trucks, dual nose wheels; payload 199 passengers for -320B and -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 over 30,000 feet.

BOEING 720/720B JETLINER

Prime Contractor: The Boeing Company

Remarks

A lighter, faster and slightly smaller version of the original Boeing 707 jetliner, the medium-range 720 first flew November 23, 1959, and went into service in July, 1960. Less than one year later, on October 6, 1960, a version with more powerful turbofan engines, the 720B, was introduced. The 720 differed from the -120 in that it had 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. Nearly 150 of the series have been ordered by 16 airlines.

Specifications

Span 130 feet 10 inches; length 136 feet 2 inches; height 41 feet 6 inches; sweepback 35 degrees; weight 230,000 pounds (720), 235,000 pounds (720B); engines 4 Pratt & Whitney JT3C-7 turbojets of 12,000 pounds thrust for the 720, JT3D-1 turbofans fo 17,000 pounds thrust or JT3D-3 turbofans of 18,000 pounds thrust for the 720B; gear tricycle with four-wheel bogie-type truck main units, dual nose wheels; payload up to 165 passengers.

Performance

Speed up to 615 miles per hour; range 3,300 miles; ceiling over 30,000 feet.

BOEING 727 SHORT-TO-MEDIUM-RANGE JETLINER

Prime Contractor: The Boeing Company

Remarks

The 727, first American jet transport to depart from wing-mounted engine installation, has three engines grouped at the tail. It three-engine configuration was designed to give the best compromise between four-engine power and reliability and twin-engine economy. In service since early 1964 it is designed specifically for short-to-medium-range routes, and has takeoff performance superior to all jets in its class. Boeing offers five versions of this highly successful, widely-sold airliner: the standard 727-100, the 20-foot longer 727-200, plus the 727C (cargo/convertible), 727QC (quick-change cargo/convertible) and the proposed 727M (military).

Specifications

Span 108 feet; length 133 feet 2 inches (-200 is 153 feet 2 inches); height 34 feet; wing sweepback 32 degrees; weight 161,000 pounds (for other versions it is 170,000 pounds); engines 3 Pratt & Whitney JT8D-1 turbofan, 14,000 pounds thrust each; gear tricycle, dual-wheel units; payload up to 131 passengers economy class, -200 payload up to 170 passengers economy class, QC payload up to 44,440 pounds.

Performance

Speed 600 miles per hour; normal operating range 1,700 miles (-200 is 1,400 miles); operational ceiling 42,000 feet.

BOEING 737 SHORT RANGE JETLINER

Prime Contractor: The Boeing Company

Remarks

The 737 twin-jet is the smallest member of the Boeing jetliner family, with maximum gross taxi weight of 97,800 pounds, compared to 161,000 pounds for the three-engined 727. Contrary to the current trend in twin-jet airliners toward aft-mounted engines, Boeing placed the engines under the wings on the 737 for the following advantages: easier maintainability, reduction in structure weight, additional passenger space in the cabin, better balance characteristics, simplified systems, more loading flexibility and better aerodynamic efficiency. Two versions of the 737 went into production during the latter part of 1965, the 737-100 and the six-foot-longer 737-200. Designed for short ranges of from 50 to 1500 miles, the 737 features the same wide body that distinguishes Boeing's other jet transports, making it the only short-range jet in production offering six-abreast tourist class seating.

Specifications

Span 93 feet; length 94 feet (-200 is 100 feet); height 37 feet; wing sweepback 25 degrees; weight 97,800 pounds maximum gross taxi (both versions); engines 2 Pratt & Whitney JT8D-7 turbofans of 14,000 pounds thrust each; gear tricycle, dual-wheel units; payload 29,256 pounds (structural limit) or up to 100 passengers for -100, 27,806 pounds or up to 113 passengers for -200.

Performance

Speed 550 to 600 miles per hour; normal operating range up to 1,500 miles; ceiling 35,000 feet.

THE BOEING SUPERSONIC TRANSPORT

Prime Contractor: The Boeing Company

Remarks

The Boeing proposal for a variable-sweep wing supersonic transport is designed to cut current long-range commercial jet travel times by more than half in carrying more than 200 passengers intercontinental distances at speeds of 1,800 miles an hour. It differs from its competitors mainly in its wing design. The Boeing SST's wings will make it capable of matching the low-speed performance of present-day jetliners as well as cruise at nearly three times the speed of sound. To do this, the wings are designed to be swept back from a 20 degree position for takeoff and landing to 72 degrees for efficient supersonic flight. Boeing SST studies, begun as a company-funded project in 1958, are continuing in a cost-sharing competition sponsored by the U.S. Federal Aviation Agency.

Specifications

Wing span (20 degree sweep) 169 feet 3 inches, (72 degree sweep) 98 feet 5 inches; length, 271 feet; height, 45 feet 3 inches; weight (intercontinental version) 500,000 pounds, (transcontinental version) 425,000 pounds.

Performance

Speed, 1,800 miles per hour (Mach 2.7); range (with 215 passengers), 4,000 miles; cruising altitude, 60,000 to 70,000 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 a number of transports, flying command posts or reconnaissance aircraft. A total of 820 KC/C-135s were built. The tankers and some transports all used water injection turbojet engines, while a "B" model using turbofans was developed and put into transport service by the USAF in 1961.

Specifications

Span 130 feet 10 inches; length 136 feet 6 inches; height 38 feet 5 inches (KC-135), 41 feet 8 inches (C-135B); wing sweepback 35 degrees; weight 297,000 pounds (KC-135), 275,000 pounds (C-135B); engines 4 Pratt & Whitney J-57 turbojet of 13,750 pounds thrust (KC-135), four P&W TF33-P-5 turbofans of 18,000 pounds thrust (C-135B); gear tricycle four-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) up to 7,000 miles (transport); ceiling 41,000 feet.

CH-46A SEA KNIGHT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The CH-46A, a medium assault transport helicopter, is in production for the Marine Corps and Sea Knight units are in operational service with Marine Squadrons of both the Atlantic and Pacific Fleets. The tandem-rotor helicopter, with all-weather and shipboard capabilities, features a power blade folding system which enable the blades to be folded automatically in winds up to 45 knots in less than one minute.

Specifications

Fuselage length 44 feet 10 inches; maximum height 16 feet 11.6 inches; gross weight 19,000 pounds (alternate gross 21,400 pounds); rotor diameter 50 feet; capacity 17 troops or 4,000 pounds cargo; engines 2 General Electric T58-8 1,250 shaft horsepower each.

Performance

Maximum speed 168 miles per hour; cruise speed 150 miles per hour; radius 115-plus miles; rate of climb 1,550 feet per minute.

107 TWIN-TURBINE TRANSPORT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The Boeing Vertol 107 is a multipurpose transport helicopter designed for military and commercial users requiring high performance, high load capacity and operational economy. It has been ordered by the U.S. Marine Corps, the Royal Canadian Air Force and Army, and the Royal Swedish Air Force and Navy. Commercial versions have been ordered by New York Airways, Kawasaki Aircraft Company of Japan, and Pan American World Airways.

Specifications

Fuselage length 44 feet 7 inches; gross weight 19,000 pounds; rotor diameter 50 feet; capacity (commercial) 25 passengers; engines 2 General Electric T58 turbines or 2 Bristol Siddeley Gnomes.

Performance

Maximum speed 168 miles per hour; cruise speed 150 miles per hour; range more than 200 miles with reserve; rate of climb 1,550 feet per minute.

CH-47A CHINOOK HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

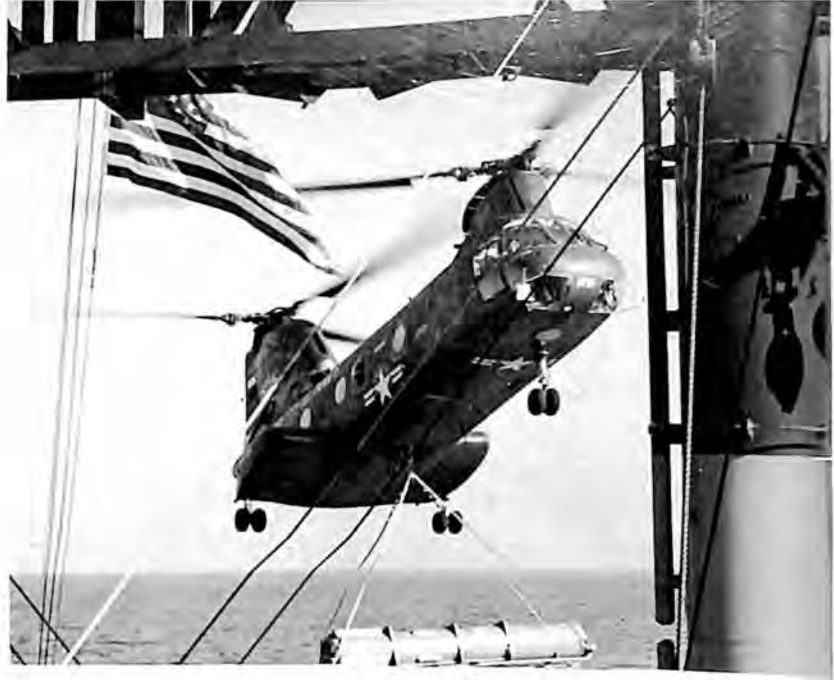
The CH-47A in service and in quantity production, is the Army's standard "A" medium transport helicopter. The Chinook can transport several types of missile systems complete with launch crews, tube type artillery weapons with crews, fuel, ground vehicles, high density cargo and command and control centers. An important mission is air movement of combat elements; the Chinook can transport a full rifle platoon of 44 combat-equipped troops.

Specifications

Fuselage length 51 feet; rotor diameter (both) 59 feet 1.25 inches; usable cabin volume 1,440 cubic feet; gross weight 33,000 pounds (alternate 38,550 pounds); empty weight 17,878 pounds; payload 10,366 pounds; engines 2 Lycoming T55-L-7 2,200 shaft horsepower.

Performance

Miximum speed 145 knots; cruise speed 130 knots; radius 100 nautical miles; hovering ceiling, OGE, 7,750 feet; service ceiling 14,200 feet; rate of climb 1,750 feet per minute.



CH-113 RCAF HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The CH-113 is a twin-turbine, tandem rotor helicopter used as a medium transport and a search and rescue craft by the Royal Canadian Air Force. It has a crew of three plus space for as many as 25 combat-equipped troops or 15 litter patients and two medical attendants.

Specifications

Fuselage length 44 feet 6.8 inches; rotor diameter (both) 50 feet; design gross weight 18,700 pounds (alternate gross 21,400 pounds); empty weight 11,251 pounds; useful load 667 pounds; engines 2 General Electric T58-8 1,050 shaft horsepower.

Performance

Cruise speed 130 knots; maximum rate of climb, 1,570 feet per minute; service ceiling 15,600 feet (at alternate gross 11,200 feet); hovering ceiling, IGE, 10,050 feet (at alternate gross 5,400 feet).

Note: With slight variations in specifications and performance, this vehicle is used by the Canadian Army as the CH-113A medium transport, by the Royal Swedish Air Force as the HKP-4 search/rescue and logistics helicopter, and by the Royal Swedish Navy as the HKP-4 antisubmarine warfare and mine countermeasures helicopter.

UH-46A MEDIUM TRANSPORT HELICOPTER

Prime Contractor: The Boeing Company, Vertol Division

Remarks

The UH-46A is a twin-turbine, tandem-rotor helicopter, 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-46A has a 24 foot 2 inch cabin which features straight-in loading through a hydraulically-operated rear ramp.

Specifications

Fuselage length 44 feet 10 inches; rotor diameter 50 feet; takeoff gross weight normal mission 19,431 pounds, overload gross weight 21,400 pounds; empty weight 12,571 pounds; payload 4,000 pounds (overload 5,934 pounds); engines 2 General Electric T58-8 1,050 shaft horsepower.

Performance

Maximum speed, sea level, 134 knots; best range cruise speed 130 knots; radius 100 nautical miles; rate of climb 1,400 feet per minute, hovering ceiling, OGE, 6,525 feet; service ceiling 14,790 feet.

CESSNA MODEL 150

Prime Contractor: Cessna Aircraft Company

Specifications (Standard and trainer Versions)

Gross weight 1,600 pounds; empty weight 970–1,000 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 8 inches; length 23 feet; height 8 feet 9 inches; engine 4-cylinder 100 horsepower.

Performance

Maximum speed 123 miles per hour; cruise speed, 75 percent power at 7,500 feet, 120 miles per hour; range at cruise speed 480 miles, with long range tanks 745 miles; rate of climb at sea level 670 feet per minute; service ceiling 12,650 feet.

Note: Model 150 is also available in commuter version with slight variations in specifications and performance.

CESSNA 172

Prime Contractor: Cessna Aircraft Company

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) 1,255 pounds baggage weight 120 pounds; wing loading 13.2 pounds per square foot; power loading 15.9 pounds per horsepower; fuel capacity 42 gallons; engine Continental O-300-C; propeller all-metal, fixed pitch 76-inch diameter.

Performance

Top speed at sea level 138 miles per hour; cruise speed 75 percent power at 7,000 feet 130 miles per hour; cruise range 75 percent power at 7,000 feet 595 miles; optimum range at 10,000 feet 720 miles; rate of climb at sea level 645 feet per minute; service ceiling 13,100 feet; take-off run over 50-foot obstacle 1,525 feet; landing run over 50-foot obstacle 1,250 feet.

CESSNA SKYHAWK

Prime Contractor: Cessna Aircraft Company

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) 1,320 pounds; baggage weight 120 pounds; wing loading 13.2 pounds per square foot; power loading 15.9 pounds per horsepower; fuel capacity 42 gallons engine Continental 0-300-D; propeller all-metal fixed pitch diameter 76 inches.

Performance

Maximum speed at sea level 139 miles per hour; cruise speed 75 percent power at 7,000 feet 131 miles per hour; cruise range 75 percent power at 7,000 feet; 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.

CESSNA 180

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 36 feet 2 inches; wing area 174 square feet; length 25 feet 6 inches; height 7 feet 6 inches; gross weight 2,800 pounds; empty weight (approximate) 1,525 pounds; baggage capacity 350 pounds; wing loading 16.1 pounds per square foot; power loading 12.2 pounds per horsepower; fuel capacity 65 gallons; engine 230 rated horsepower; propeller constant speed 82 inches diameter.

Performance

Maximum speed at sea level 170 miles per hour; cruise speed 75 percent power at 6,500 feet 162 miles per hour; cruise range 75 percent power at 6,500 feet 695 miles per hour; optimum range at 10,000 feet 1,215 miles; rate of climb at sea level 1,090 feet per minute; service ceiling 19,600 feet; take-off run over 50-foot obstacle 1,205 feet; landing roll over 50 foot obstacle 1,365 feet.

Note: Model 180 also available as float plane and amphibian.

CESSNA 185

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 36 feet 2 inches; wing area 174 square feet; length 25 feet 6 inches; height 7 feet 7 inches; gross weight 3,200 pounds; empty weight (approximate) 1,560 pounds; baggage capacity 350 pounds; wing loading 18.4 pounds per square foot; power loading 12.3 pounds per horsepower; fuel capacity 65 gallons; engine 6-cylinder fuel-injection; propeller constant speed diameter 88 inches.

Performance

Maximum speed at sea level 176 miles per hour; cruise speed 75 per cent power at 7,000 feet 167 miles per hour; cruise range 75 percent power at 7,000 feet 730 miles; optimum range at 10,000 feet 945 miles; rate of climb at sea level 1,000 feet per minute; service ceiling 17,300 feet; take-off run over 50 foot obstacle 1,510 feet; landing roll over 50 foot obstacle 1,265 feet.

CESSNA 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, leather bucket seats, heavy foam-padded carpeting, walnut inlaid seat backs and trim and optional center-aisle consoles for storage.

Specifications

Span 36 feet 7 inches; length 28 feet 2 inches; height 9 feet 9 inches; gross weight 3,100 pounds; empty weight 1,860 pounds; useful load 1,240 pounds; wing loading 17.7 pounds per square foot; power loading 10.9 pounds per horsepower; fuel capacity 65 gallons standard, 84 gallons optional; engine 6-cylinder 285 horsepower; propeller constant speed diameter 82 inches.

Performance

Top speed 199 miles per hour; cruise speed 75 percent power at 6,500 feet 191 miles per hour; range at cruise speed 765 miles; maximum range with maximum fuel 1,305 miles; rate of climb at sea level 1,210 feet per minute; service ceiling 21,000 feet.

CESSNA 310J

Prime Contractor: Cessna Aircraft Company

Specifications

Gross weight 5,100 pounds; empty weight 3,094 pounds; baggage capacity 600 pounds; wing loading 29.1 pounds per square foot; power loading 9.8 pounds per horsepower; fuel capacity 102 gallons; engines 2 6-cylinder fuel-injection IO-470-U's; propeller constant-speed full-feathering diameter 81 inches.

Performance

Maximum speed at sea level 238 miles per hour; maximum recommended cruise speed 75 percent power at 6,500 feet 223 miles per hour; cruise range 780 miles; maximum range at 10,000 feet 980 miles; rate of climb at sea level 1,590 feet per minute (twin engine), 360 feet per minute (single engine); service ceiling 20,300 feet (twin), 7,500 feet (single); take-off run at sea level over 50-foot obstacle 1,640 feet; landing roll at sea level over 50-foot obstacle 1,540 feet.

CESSNA SKYNIGHT

Prime Contractor: Cessna Aircraft Company

Specifications (4,800 pound Skynight)

Wing span 36 feet 11 inches; wing area 175 square feet; length 29.5 feet; height 10.3 feet; weight 4,800 pounds; empty weight 3,260 pounds; baggage capacity 600 pounds; wing loading 27.4 pounds per square foot; power loading 9.2 pounds per horsepower; fuel capacity 102 gallons; engines 2 Continental 6-cylinder fuel injection TSIO-470-D; propeller constant-speed full-feathering.

Performance

Maximum speed at 16,000 feet 266 miles per hour; cruise speed 75 percent power at 10,000 feet 224 miles per hour; maximum recommended cruise range 75 percent power at 19,500 feet 866 miles, 75 percent power at 10,000 feet 788 miles; rate of climb at sea level 2,050 feet per minute (twin engine), 510 feet per minute (single engine); service ceiling 29,200 feet (twin), 18,450 feet (single); take-off run (maximum performance) over 50-foot obstacle 1,343 feet, landing roll over 50-foot obstacle 1,767 feet.

CESSNA EXECUTIVE 411

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 39.86 feet; length 33.46 feet; height 11.55 feet; gross weight 5,200 pounds; engines 2 GTSIO-520 6-cylinder fuel-injection with turbochargers, 340 rated horsepower; propellers 3-bladed 88-inch constant-speed full-feathering; stall speed 84 miles per hour; maximum landing weight 6,500 pounds; empty weight 3,820 pounds; fuel capacity 170 gallons; seating 6-8; baggage allowance 700 pounds; wing loading 32.5 pounds per square foot; power loading 9.6 pounds per horsepower.

Performance

Maximum speed (16,000 feet) 274 miles per hour; cruise speed 75 percent power (20,000 feet) 254 miles per hour, (10,000 feet) 231 miles per hour; normal cruise range 1,055 miles; maximum cruise range at 10,000 feet 1,400 miles; rate of climb at sea level (twin engine) 2,350 feet per minute, (single engine) 605 feet per minute; service ceiling (twin) 28,600 feet, (single) 19,550 feet; take-off run over 50-foot obstacle 1,090 feet; landing run over 50-foot obstacle 1,335 feet.

CESSNA 182 AND SKYLANE

Prime Contractor: Cessna Aircraft Company

Specifications (182)

Wing span 36 feet 2 inches; wing area 174 square feet; length 27 feet 3 inches; height 9 feet; gross weight 2,800 pounds; empty weight (approximate) 1,550 pounds; baggage capacity 120 pounds; wing loading 16.1 pounds per square foot; power loading 12.2 pounds per horsepower; fuel capacity 65 gallons; engine 6-cylinder 230 rated horsepower; propeller constant speed 82-inch diameter.

Performance (182)

Top speed at sea level 167 miles per hour; cruise speed 75 percent power at 6,500 feet 159 miles per hour; cruise range 75 percent power at 6,500 feet 685 miles; optimum cruise range at 10,000 feet 905 miles; rate of climb at sea level 980 feet per minute; service ceiling 18,900 feet; take-off distance over 50-foot obstacle 1,205 feet; landing distance over 50-foot obstacle 1,350 feet.

Note: Skylane version also has gross weight of 2,800 pounds, but empty weight is 1,610 pounds; other specifications identical. Performance slightly higher than above for Skylane.

CESSNA SUPER SKYLANE

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 36 feet 7 inches; wing area 175.5 square feet; length 28 feet 4 inches; height (nose strut depressed) 9 feet 9 inches; gross weight 3,300 pounds; empty weight (approximate) 1,790 pounds; fuel capacity standard 65 gallons optional 84 gallons; oil capacity 12 quarts; wing loading 18.8 pounds per square foot; power loading 11.6 pounds per horsepower; engine, 6-cylinder fuel injection 285 horsepower; propeller constant speed diameter 82 inches.

Performance

Top speed at sea level 177 miles per hour; cruise speed 75 percent power at 6,000 feet 166 miles per hour; cruise range 63.5 gallons no reserve 4 hours at 165 miles per hour; optimum range at 10,000 feet 825 miles; rate of climb at sea level 1,075 feet per minute; take-off run over a 50-foot obstacle 675 feet, total distance 1,265 feet; landing run over 50-foot obstacle 735 feet, total distance 1,340 feet.

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 4,200 pounds; empty weight (approximate) 2,615 pounds; baggage allowable 365 pounds; wing loading 20.9 pounds per square foot; power loading 10.0 pounds per horsepower; fuel capacity 93 gallons; engine 2 6-cylinder fuel-injection IO-360's; propellers constant speed full-feathering diameter 76 inches.

Performance

Top speed at sea level 200 miles per hour; cruise speed 75 percent power at 5,500 feet 192 miles per hour; normal range 75 percent power at 5,500 feet 765 miles optimum range at 10,000 feet 1,000 miles; rate of climb at sea level 1,300 feet per minute (twin engine); service ceiling 20,500 feet (twin engine); take-off run over 50-foot obstacle 1,435 feet; landing ground roll over 50-foot obstacle 1,465 feet.

CESSNA SUPER SKYWAGON

Prime contractor: Cessna Aircraft Company

Specifications (3,300-pound model).

Wing span 36 feet 7 inches; wing area 175.5 square feet; length 27 feet 9 inches; height (nose strut depressed) 9 feet 9 inches; gross weight 3,300 pounds; configuration 6-place; empty weight (approximate) 1,780 pounds; baggage capacity 88 pounds; wing loading 18.8 pounds per square foot; power loading 11.6 pounds per horsepower; fuel capacity 65 gallons; engine 6-cylinder fuel injection; propeller constant-speed 82-inch diameter.

Performance

Maximum speed at sea level 177 miles per hour; cruise speed 75 percent power at 6,000 feet 166 miles per hour; cruise range 75 percent power at 6,000 feet 665 miles (optimum at 10,000 feet 825 miles); rate of climb at sea level 1,075 feet per minute; service ceiling 16,700 feet; take-off run over 50-foot obstacle 1,265 feet; landing run over 50-foot obstacle 1,340 feet.

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 800 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 10 inches; length 29 feet 4 inches; height 9 feet 3 inches; empty weight 4,056 pounds; wing loading 35.7 pounds per square foot; power loading 3.2 pounds per pound thrust; engines 2 Continental J69-T25.

Performance

Maximum speed 408 miles per hour; cruise speed at normal rated power 368 miles per hour; gross weight landing speed 85 miles per hour; rate of climb at sea level 3,200 feet per minute; service ceiling 39,200 feet; range with maximum fuel 796 miles.

X-19 VTOL AIRCRAFT

Prime Contractor: Curtiss-Wright Corporation

Remarks

A twin-engine intershafted tandem high-wing aircraft, the X-19 is being developed under USAF contract for tri-service evaluation as a VTOL airplane. The flight system of the X-19 utilizes propeller radial force for vertical take off and landing, combining the versatility of the helicopter with the high speed of a propjet aircraft. The plane can land vertically and it has a speed range from zero at hover to over 400 miles per hour in level flight. During take-off and landing, the propellers are tilted vertically so that they operate in a horizontal plane. For forward operation, the propellers tilt to any selected position between vertical and horizontal.

Specifications

Length 44 feet; width 34.5 feet over the propellers; six places; weight 13,000 pounds; useful load 5,705 pounds; engines 2 Lycoming T55-5 turboshaft.

Performance

Speed zero to 400-plus miles per hour; rate of climb 3,250 feet per minute; range 800-plus nautical miles.

A-3 SKYWARRIOR

Prime Contractor: Douglas Aircraft Group, Long Beach

Remarks

The A-3 Skywarrior is a long-range bomber designed to perform various missions at high or low levels. Versions of the basic A-3 include the RA-3B photo-reconnaissance aircraft, the TA-3B bomber-trainer and the EA-3B reconnaissance model. An in-flight refueling system converts it to a high-speed jet tanker. First A-3 flight was on October 28, 1952. It is now the largest of the Navy's carrier-based aircraft. Wings and vertical tail surface fold for convenience in carrier handling. The A-3 was phased out of production in 1961.

Specifications

Wing span 72 feet 6 inches; length 74 feet 8 inches; height 22 feet 9 inches. Normal gross weight 70,000 pounds; engines 2 Pratt & Whitney J57; basic crew of 3.

Performance

Range more than 2,500 nautical miles. Other data classified.

A-4E AND TA-4E SKYHAWK TRAINER-ATTACK BOMBER

Prime Contractor: Douglas Aircraft Group, Long Beach

Remarks

The 2-place TA-4E Skyhawk jet trainer is a modification of the single-seat A-4E attack bomber with the addition of a 28-inch section for a second seat and dual controls. Now in production for the Navy, it retains the A-4E capabilities with bombs, rockets, missiles and guns. The TA-4E made its first flight on June 30, 1965. Maximum range is about 2,000 miles and its endurance of more than 4 hours is nearly double the flight time of previous jet trainers. New safety features include the Navy-Douglas ESCAPAC zero-level, zero-speed ejection seat system for both instructor and student. The trainer is powered by a Pratt & Whitney J-52P-8A engine which has 10 percent greater thrust than the A-4E engine. The A-4E is produced and subassembled at Long Beach and final assembly is at Palmdale, California. In photo TA-4E.

Specifications (TA-4E)

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 J52.

Performance

Range transcontinental; speed 600-700 mile per hour class.

B-66 DESTROYER BOMBER

Prime Contractor: Douglas Aircraft Group, Long Beach

Remarks

Several versions of the B-66 tactical bomber are in service with the Air Force. Produced in bombing and reconnaissance versions, the Destroyer performs at stratospheric or minimum altitudes. The B-66 and RB-66 were built at the Douglas Long Beach plant and the RB-66C and WB66D were produced at the Tulsa facility. The RB-66B is designed to be used with a wide selection of bomb combinations including the H-bomb. The RB-66C is a special purpose reconnaissance plane and the WB-66D, last in the series, is a weather reconnaissance aircraft. Special features include a pressurized air-conditioned compartment, in-flight refueling system and thermal-cyclic de-icing system.

Specifications

Wing span 72 feet 6 inches; length 75 feet 2 inches; height 23 feet 7 inches; gross weight 70,000-78,000 pounds. Engines 2 Allison J71 jets; crew of 3, RB-66C, 4; armament 2 20-millimeter tail turret guns electronically operated.

Performance

Speed 600-700 miles per hour. Other data classified.

C-124 GLOBEMASTER

Prime Contractor: Douglas Aircraft Group, Long Beach

Remarks

The C-124 Globemaster, first flown in November, 1949, has been daily flying supply lines reaching practically around the world since May, 1950, when it was first delivered to the Air Force. The C-124 can transport general cargo, 200 fully-equipped troops or many categories of military vehicles fully assembled. Special features include a clamshell nose door, self-contained ramp and an elevator located amidships permitting loading and unloading at both points. The last C-124 was delivered in May, 1955.

Specifications

Wing span 174 feet 2 inches; length 130 feet; height 48 feet 3 inches; empty weight 101,052 pounds; gross weight 185,000 pounds; alternate gross weight 194,500 pounds; wing loading 74 pounds per square foot; power loading 12.2 pounds per brake horsepower; engine 4 Pratt & Whitney R-4360-63A; fuel capacity 11,000 gallons; wing area 2,506 square feet.

Performance

Maximum payload 70,000 pounds; 50,000 pound payload can be delivered 1,000 miles and plane can return to base without refueling.

C-133 HEAVY CARGO TRANSPORT

Prime Contractor: Douglas Aircraft Group, Long Beach

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 Division.

Specifications

Wing span 179 feet 7.86 inches; length 157 feet 6.44 inches; height 48 feet 9 inches; empty weight 120,363 pounds; wing loading 107.0 pounds per square foot; power loading 9.75 pounds per shaft horsepower; engines T34-P-9W, 5650 shaft horsepower normal rated; fuel capacity 18,112 gallons.

Performance

Maximum speed 312 knots at Military Power at 286,000 pounds gross weight at 8,700 feet; cruise speed 284 knots at approximately 90 percent normal rated power at altitudes varying from 17,000 feet at 280,000 pounds to 35,000 feet at 130,000 pounds; landing speed 117 knots at 250,500 pounds; rate of climb 1,280 feet per minute; range with maximum payload 1,973 nautical miles,

DC-6 (C-118 LIFTMASTER)

Prime Contractor: Douglas Aircraft Group, Long Beach

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 four Pratt & Whitney Aircraft R-2800 engines, the DC-6 repeatedly set commercial records with its cruising speed of 315 miles an hour. It also introduced new levels of comfort to air travel with cabin pressurization and air conditioning. With an overall fuselage length of 100 ft. 7 in., the DC-6 carries up to 74 passengers. After 174 were produced, an enlarged version five feet longer to seat up to 102 was designed and designated the DC-6B. This design was the basis of the first commercial air freighter, the DC-6A, and the military C-118 Liftmaster ordered by the Air Force and Navy for cargo, troop transport and medical evacuation purposes. More than 700 DC-6 aircraft of all types were produced. First DC-6 flight was February 15, 1946; first delivery was March 28, 1947.

DC-7 COMMERCIAL TRANSPORT

Prime Contractor: Douglas Aircraft Group, Long Beach

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 non-stop in both directions between California and New York, it also pioneered polar routes between the U. S. West Coast and Europe and between Europe and Asia. Three models were built, in approximately equal numbers for a total of 336, culminating in the DC-7C. Dubbed the "Seven Seas" because of its extended range overwater capabilities, the DC-7C is powered by four Wright R-3350 compound engines giving it a maximum speed in excess of 400 mph. It carries up to 99 passengers and their baggage on nonstop flights of 4,000 miles with ample fuel reserves. First DC-7 flight, December 20, 1955; certification, May 15, 1956.

DC-8 JET TRANSPORT

Prime Contractor: Douglas Aircraft Group, Long Beach

Remarks

Four basic models of the DC-8, including three new extended fuselage Series 60 versions, are manufactured. Each is also made in a cargo or combination cargo-passenger variation. Pratt & Whitney Aircraft JT3D turbofan engines are used in all models. Series 50 DC-8 and DC-8F models are identical in dimensions to the original Model 10, but have increased capacity to 189 passengers. Model 61, first of the Series 60 versions, has a fuselage extension of 440 inches to a total of 187.4 feet and carries up to 251 passengers. Model 62, an ultra-long range transport, seats up to 189 passengers in a fuselage extended 80 inches to 157.4 feet and has a six-foot increase in wing span, increased fuel capacity and redesigned engine pylons and ducted fan nacelles. Model 63 is a combination of the full fuselage extension of Model 61 with the pylon and engine pod modifications of the Model 62. First DC-8 flight was May 30, 1958; first delivery in June, 1959; certification August, 1959.

Specifications

Span 142 feet 5 inches; length 150 feet 6 inches; height 42 feet 4 inches; wing area 2,773 square feet; crew 3-5 plus cabin attendants; engines 4 Pratt & Whitney JT3D-3 18,000 pounds thrust; design gross weight 318,000 pounds.

Performance

Level flight speed 579 miles per hour; rate of climb 2,380 feet per minute; maximum range 7,090 statute miles.

DC-9 JET TRANSPORT

Prime Contractor: Douglas Aircraft Group, Long Beach

Remarks

The short-to-medium range DC-9 twin-jet transport is produced in two versions—the Model 10 with a fuselage 104.4 feet in length to accommodate up to 90 passengers, and Model 30 with an extension of 15 feet, seating as many as 115. Convertible passenger-cargo and executive models also are in production. All have Pratt & Whitney Aircraft JT8D ducted fanjet power plants, mounted on the aft fuselage. All versions are designed to operate from relatively short airfields. Wings of the larger Model 30 have leading edge slats and triple-slotted flaps to increase lift on takeoff. Features such as a self-contained boarding ramp and chest-level baggage compartment are of special value for service at airports of limited facilities. First flight February 25, 1965; first delivery September, 1965; certification, November, 1965.

Specifications

Span 87.4 feet; length 104.4 feet; height 27.4 feet; wing area 925 square feet; crew 2 plus cabin attendants; engines 2 Pratt & Whitney JT8D-5 ducted fanjet 12,000 pounds thrust; maximum take-off weight 77,700 pounds.

Performance

Level flight speed 557 miles per hour; rate of climb 2,750 feet per minute; range at optimum cruise speed 1,470 statute miles.

F-27J PROPJET TRANSPORT

Prime Contractor: Fairchild Hiller Corporation

Remarks

Fairchild Hiller has built 120 F-27 airplanes that are flown by 11 airlines and many corporations. This aircraft, one of the most efficient and economical twin-propjets in service, is now available in a new more powerful version—the F-27J. It is pressurized and completely air-conditioned on the ground as well as in flight. Important features of the F-27 are a highly reliable completely pneumatic retractable landing gear and braking system and fuel-carrying wings that have never experienced algae corrosion. The F-27 meets medium and short range requirements of regional airlines; offers 36, 40 or 44 passenger seating; operates from short runways and unimproved fields.

Specifications

Wing span 95 feet 2 inches; length 77 feet 6 inches; empty weight 21,961 pounds; operational weights: 42,000 take-off, 40,000 landing; engine Rolls-Royce Dart RDa 7/Mark 532-7 2,050 maximum horsepower; fuel capacity 1,364 or 2,063 gallons; propeller Rotol 4-blade constant speed; wing area 754 square feet.

Performance

Cruise speed 300 miles per hour at 20,000 feet; rate of climb 2,200 feet per minute at sea level; service ceiling 32,700 feet.

FH-227 PROPJET TRANSPORT

Prime Contractor: Fairchild Hiller Corporation

Remarks

Fairchild Hiller has just introduced the FH-227, an enlarged and improved version of the F-27. With a 6-foot longer fuselage, the FH-227 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: 43,500 take-off, 43,000 landing; engine Rolls Royce Dart RDa 7/Mark 532-7 2,050 maximum horsepower, fuel capacity 1,364 or 2,063 gallons; propeller Rotol 4-blade constant speed; wing area 754 square feet; aileron area 37.6 square feet; total flap area 136.9 square feet; vertical tail including dorsal 190 square feet; rudder area (aft of hinge line) 33 square feet; horizontal tail surfaces 172 square feet; elevator area (aft of hinge line) 34 square feet.

Performance

Cruise speed 300 miles per hour at 20,000 feet; rate of climb 2,200 feet per minute at sea level; service ceiling 32,700 feet.

TURBO-PORTER

Prime Contractor: Fairchild Hiller Corporation

Remarks

Fairchild Hiller has started production of 100 units of the Turbo-Porter high performance single-engine turbine-powered STOL aircraft for both military and commercial markets. A spectacular performer, it is the first single-engine propjet airplane to be certified in the United States. The Turbo-Porter is an all-purpose aircraft capable of operating from extremely small unprepared fields. It features large double doors installed on either or both sides, depending on customer requirements. Interior configuration can be changed by one man in a matter of seconds without tools because of 4 "T" rails built into the floor to receive passenger seats, cargo tie-down rings, or stretchers. Arranged as a passenger aircraft, it can transport 8 people including the pilot.

Specifications

Wing span 50 feet; length 36 feet; empty weight 2,270 pounds; gross weight 4,850 pounds; useful load 2,500 pounds; wing area 310 square feet; 2 integral wing tanks have total capacity of 130 gallons.

Performance

Cruise speed 140 knots; range 550 nautical miles plus 30-minute fuel reserve; take-off run 360 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.

CONVAIR CHARGER

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

The Charger is a lightweight, two-place, twin-engine airplane with twin booms and a high all movable horizontal tail. The constant-section short-span wing has full-span flaps that are designed to be completely immersed in the propeller slipstream for maximum lift for short takeoffs and landings in less than 500 feet. It is especially suitable for surveillance and reconnaissance missions to support ground forces. Charger made its first flight in November, 1964. A 130 hour company-sponsored flight test program, during which the Charger's stability and control, STOL performance and high-speed capabilities were demonstrated, was completed in early August, 1965.

Specifications

Span 30 feet, 10 inches; height overall 13 feet, 8 inches; length 34 feet, 10 inches; powerplants two turboprop United Aircraft of Canada Ltd. YT74 engines with 650 shaft horsepower each, driving three-bladed, counter-rotating Hamilton Standard nine-foot propellers; empty weight 4,457 pounds.

Performance

Short takeoffs and landings in less than 300 feet and over 50 foot obstacle in less than 500 feet; maximum speed 405 miles per hour; cruise speed 265 miles per hour; normal range 655 nautical miles.

CONVAIR 600

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

Convair 600 is the general designation for a Convair-Liner 240, 340 or 440 airframe modernized with Rolls-Royce Dart turboprop engines. To differentiate among versions a 440 airframe with Dart engines is designated Convair 600/440D. Among improved performance features of the 600's are a payload increase of up to 2,850 pounds and a cruising speed increase of 50 miles an hour.

Specifications

600/240D: 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 47,000 pounds.

600/440D: 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

600/240 D: 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.

600/440D: 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.

F-102A ALL-WEATHER INTERCEPTOR

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

The single-seat F-102A, world's first supersonic all-weather interceptor, is a prime air defense weapon of the Air Force in America, Europe and the Far East. The F-102A carries Hughes Falcon missiles and 2.75 inch folding-fin rockets. The TF-102A combat proficiency trainer is similar to the F-102A except for a wider nose section to accommodate pilot and student in side-by-side seating. First flight of the YF-102 prototype was made October 23, 1953 at Edwards AFB, Calif. First flight of the YF-102A was on December 20, 1954. First deliveries to the Air Force were made in June, 1955.

Specifications

Span 38 feet 1.6 inches, length 68 feet 5 inches; height 21 feet 2.5 inches; engine one Pratt & Whitney J57-P-23 turbojet, with afterburner; 10,000 pounds thrust class.

Performance

Speed: supersonic; ceiling above 50,000 feet.

F-106A ADVANCED ALL-WEATHER INTERCEPTOR

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

The single-seat F-106A carries Hughes AIM-4F and AIM-4G missiles and Douglas AIR-2A special weapon equipped with a nuclear warhead. The F-106B is the two-seat version of the F-106A with all-weather capabilities and carrying the same armament. First flight of the F-106A was made December 26, 1956, at Edwards Air Force Base, California. First flight of the F-106B was on April 9, 1958, at the same base. First deliveries of the F-106A to operational Air Force North American Air Defense Command squadrons were made in 1959.

Specifications

Span 38 feet 1.6 inches; length 70 feet 9 inches; height 20 feet 3.33 inches; engine 1 Pratt & Whitney 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 880 AND 880-M

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

The basic Convair 880 was designed for operation from runways of 5,000 to 8,000 feet and for favorable operating costs on medium range up to transcontinental flights. Its sister airliner, the Convair 880-M, offers increased range, fuel capacity, operating weights and shorter runway requirements. It has wing leading edge slats, power boost rudder and engines with increased thrust. Both Convair 880's can cruise at 615 miles an hour. In a first-class 4-abreast seating arrangement as used by initial operators, the 880 carries 84 passengers. In a 5-across coach configuration, it will carry 110 persons.

Specifications

Wing span 120 feet; length 129 feet 4 inches; height 36 feet 4 inches; empty weight 84,300 pounds; wing loading 92.95 per square foot; at maximum 880 take-off weight of 184,500 pounds; engines 4 General Electric CJ-805-3 turbojets with 11,200 pounds thrust each, (880-M) 4 General Electric CJ-805-3B turbojets with 11,650 pounds static thrust each.

Performance

Maximum speed 615 miles per hour at maximum cruise thrust at 22,500 feet; cruise speed 556 miles per hour at Mach 0.84 at 35,000 feet; landing speed 145 miles per hour, 1.3 stall speed landing weight 121,000 pounds; rate of climb 3,565 feet per minute at sea level; service ceiling 41,000 feet; cabin altitude 8,000 feet at 41,000 feet airplane altitude; range with maximum payload 3,200 statute miles.

CONVAIR 990A

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

The Convair 990A is a medium-range jet airliner with cruising speed and fuel capacity to fly nonstop transcontinental routes at near sonic speeds. The speed of the Convair 990A is boosted by 4 "speed capsules" which resemble inverted canoes extending beyond the trailing edge of the swept wing. They increase the airliner's speed by delaying formation of shock waves of air which tend otherwise to cling to the trailing edge of the wing and create drag. Some of the Convair 990A's fuel capacity comes from the fact that these speed capsules also serve as fuel tanks.

Specifications

Wing span 120 feet; length 139 feet 5 inches; height 39 feet 6 inches; empty weight 110,750 pounds; wing loading 106 pounds per square foot at take-off weight of 239,200 pounds; engines 4 CJ-805-23B aft fan turbojets with 16,050 pounds static thrust each; fuel capacity 15,188 gallons; wing area 2,250 square feet.

Performance

Cruising speed 621 miles per hour; landing speed 145 miles per hour, 1.3 stall speed landing weight 151,000 pounds; rate of climb 3,250 feet per minute at sea level; service ceiling 41,000 feet; cabin altitude 8,000 feet at 41,000 feet airplane altitude; range with maximum payload 4,050 miles.

B-58 HUSTLER BOMBER

Prime Contractor: Fort Worth Division of General Dynamics

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-58's have been operational since 1960, and are now used by the 43rd Bomb Wing at Little Rock Air Force Base, Arkansas, and the 305th Bomb Wing, Bunker Hill Air Force Base, Indiana. They were designed and produced at the Fort Worth Division of General Dynamics. First flight was November 11, 1956. One hundred sixteen were produced. Air Force crews flying B-58's set 19 world speed and altitude records and won the Thompson Trophy, The Mackay Trophy twice, the Bleriot Trophy, and the Harmon Trophy twice. The design uses the delta wing pioneered by the Convair Division of General Dynamics.

Specifications

Span 56 feet 10 inches; length 96 feet 9 inches; height 29 feet 11 inches; gross weight 160,000 pounds; engines four General Electric J79 turbojets mounted in pods; engine thrust each 15,600-pound at takeoff with afterburners; landing gear tricycle (dual-wheel nose gear, 8-wheel truck main gear); wing area 1,542 square feet.

Performance

Maximum speed over 1,300 miles an hour (Mach 2); service ceiling above 60,000 feet; range intercontinental with refueling.

F-111 VARIABLE-WING FIGHTER

Prime Contractor: Fort Worth Division of General Dynamics
Principal Subcontractor: Grumman Aircraft Engineering Corporation

Remarks

The F-111 supersonic fighter is the world's first production aircraft to use variable-sweep wings. The first F-111 contract covered the research, development, test, and evaluation phase of the program. It included 18 aircraft designated F-111A's for the U. S. Air Force and five aircraft designated F-111B's for the U. S. Navy. The first production program, announced by the U. S. Department of Defense in April, 1965, covered 431 aircraft. These are for the U. S. Air Force, U. S. Navy, and the Royal Australian Air Force. The F-111A is a USAF Tactical Air Command tactical fighter. The F-111B, which operates from aircraft carrier decks, is a Navy air superiority fighter. The variable-sweep wing enables the pilot to extend the wing outward (with a wingsweep angle of only 16 degrees) to provide maximum lift for short and quick takeoff (well under 3,000 feet) and to sweep the wings back to 72.5 degrees, or to any angle between for higher speeds.

Specifications (F-111A)

Span, wings extended, 63 feet, wings fully swept, 32 feet; height 17 feet; length 73 feet; weight approximately 70,000 pounds; engines 2 Pratt & Whitney TF-30 turbofans; armament conventional and nuclear, including air-to-surface missiles and rockets.

Performance (F-111A)

Speed, supersonic at sea level, up to Mach 2.5 at 60,000 feet; range, transoceanic without refueling, in-flight refueling capability; take-off and landing capability under 3,000 feet.

Specifications (F-111B)

Span, wings extended, 70 feet, wings fully swept, 34 feet; height 16 feet 8 inches; length 66 feet 9 inches; engines 2 Pratt & Whitney TF-30 turbofans; armament conventional and nuclear, including air-to-surface and air-to-air missiles (designed to use Phoenix missile).

Performance (F-111B)

Speed, supersonic at sea level, up to Mach 2.5 at 60,000 feet; range, transoceanic without refueling, in-flight refueling capability.

S-2A TRACKER

Prime Contractor: Grumman Aircraft Engineering Corporation

The S-2A was the earliest version of the Tracker series. Prototype of the "A" first flew in December, 1952. The S-2A was replaced by the S-2E, currently in production at the Grumman Aircraft Engineering Corp. This new version of the Tracker is employed by the U. S. Navy in Vietnam. The Tracker carries out the anti-submarine warfare hunter-killer mission and carries a wide variety of armament and detection gear.

Specifications

Span 69 feet 8 inches; length 42 feet 3 inches; height 16 feet 3 inches; engines 2 Wright R-1820-82 of 1,525 horsepower each.

Performance

Classified

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 on air-sea rescue, cargo, transport or photographic duty. Most recent version is the HU-16B, which has greater wingspan, larger vertical and horizontal tail surfaces, and greater range and speed than its predecessor, the HU-16A. Both types are still in service but the plane is no longer in production.

Specifications

Span 96 feet 8 inches; length 61 feet 4 inches; height 25 feet 10 inches; engines 2 Wright R-1820-76 of 1,425 horsepower each.

Performance

Maximim speed military power at sea level 236 miles per hour; normal cruise speed 207 miles per hour.

OV-1 MOHAWK

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

Designed to operate from small, unimproved fields, the Mohawk is used by the Army for observation work. Its bugeye canopy offers exceptional visibility to its two-man crew. Featuring a 55-knot stall speed and short take-off and landing capabilities like the Army's light single-engine aircraft, the Mohawk is able to "live" with the field Army.

Specifications

Span 42 feet; length 41 feet; height 12 feet 8 inches; engines 2 Lycoming T53-L-3 each of 865 equivalent shaft horsepower.

Performance

Maximum speed 325 miles per hour; normal cruise speed 207 miles per hour; landing speed 76 miles per hour; service ceiling 33,000 feet; range with maximum payload 774 miles.

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 five 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.

Specifications

Span 80 feet 7 inches; length 56 feet 4 inches; height 16 feet; engines 2 Allison T56-A8 rated at 4,050 horsepower.

A-6A INTRUDER

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

The A-6A is a versatile, low-altitude jet attack aircraft. With all-weather capability, it can fly long distances to deliver its nuclear punch or fly close support for tactical ground troops with conventional weapons. The plane has an integrated display system, which enables the crew to "see" targets or the environment around the aircraft (by means of visual displays presented on viewing screens) in the dark or in obscuring weather.

Specifications

Span 53 feet; length 53 feet 3 inches; height 15 feet 1 inch; engines 2 Pratt & Whitney J52 8,500 pounds thrust each.

Performance

Classified.

12E HELICOPTER

Prime Contractor: Hiller Aircraft Company, Subsidiary of Fairchild-Hiller Corporation

Remarks

The 12E is a 3-place craft which has been in civilian service since 1959 and in Army use since 1962 as the OH-23G. It is also in service with the Canadian Army, the RCAF and the British Royal Navy.

Specifications

Main rotor diameter 35.4 feet; tail rotor diameter 5.5 feet; length 28.5 feet; height 9.3 feet; empty weight 1,759 pounds; engine 1 Lycoming VO-540 305 horsepower.

Performance

Maximum speed 96 miles per hour at sea level; maximum rate of climb 2,030 feet per minute; service ceiling 19,800 feet.

E4 HELICOPTER (OH-23F)

Prime Contractor: Hiller Aircraft Company, Subsidiary of Fairchild-Hiller Corporation

Remarks

Built to meet the Army's high-altitude, rugged terrain requirements, the OH-23F is a four-place utility helicopter. As a civilian craft, the E4, it is in wide service in forestry work, missile site construction support, executive transportation and off-shore oil rig supply.

Specifications

Main rotor diameter 35.4 feet; tail rotor diameter 5.5 feet; length 29.8 feet; height 9.8 feet; empty weight 1,813 pounds; engine 1 Lycoming VO-540 305 horsepower.

Performance

Maximum speed 96 miles per hour at sea level; cruise speed 92 miles per hour; maximum rate of climb 1,920 feet per minute; service ceiling 19,300 feet; range with maximum load 225 miles.

SL4 HELICOPTER

Prime Contractor: Hiller Aircraft Company, Subsidiary of Fairchild-Hiller Corporation

Remarks

Powered by a superchared engine that automatically maintains full power through 13,000 feet, the SL-4 has a service ceiling of almost 19,000 feet at full gross weight. It is a four-place craft, sister ship to the non-supercharged L-4.

Specifications

Main rotor diameter 35 feet; tail rotor diameter 5.5 feet; length 29.1 feet; height 9.5 feet; empty weight 1,960 pounds; engine 1 Lycoming TIVO-540-A2a 315 horsepower.

MODELS 200, 200 DELUXE, 300 AND 300 AG

Prime Contractor: Hughes Tool Company, Aircraft Division

Remarks

The Model 200, with a design gross weight of 1,670 pounds and a speed of 86 miles per hour, offers an economy of fuel consumption of as little as 8 gallons per hour. The model is useful in such areas as patrol of traffic and powerlines, aerial photography, sport and transportation. The 200 Deluxe has a luxury interior plus such features as a fuel injection engine, specially designed instrument clusters, a high capacity air cooler and an electric trim. The Model 300 is a three-place craft offered with optional equipment including floats, litters, cargo racks and an external load sling. The Model 300 AG, designed for agricultural use, has a 35-foot spray boom and sufficient power to carry 60 gallons of spray. In photo, top helicopter is the Model 200 Deluxe; Model 300 is in center and 300 AG at bottom.

TH-55A HELICOPTER TRAINER

Prime Contractor: Hughes Tool Company, Aircraft Division

Remarks

The TH-55A is a two-place primary helicopter trainer in production for the Army. In 1965 Hughes received a contract for 215 helicopters bringing the total purchase to 235. The helicopter features low maintenance, low operating cost and low initial purchase price.

Specifications

Crew 1; main rotor diameter 25.29 feet; length 28 feet 5 inches; height 8 feet 2 inches; design gross weight 1,600 pounds; useful load 590 pounds; engine Lycoming H10-360-B1A 180 horsepower.

Performance

Maximum speed 75 knots; endurance 2 1/2 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

In 1965, the Army awarded Hughes an initial contract for 714 OH-6A light observation helicopters, with deliveries to start in the summer of 1966. Able to lift a useful load greater than its empty weight, the OH-6A is basically a four-place machine, but it is capable of carrying a five-man firepower team plus pilot. Hughes is also building two commercial versions of the craft, the Model 500 executive transport and the 500U utility helicopter; the former carries five persons in addition to the pilot, the latter seven.

Specifications (OH-6A)

Length 30.3 feet; height 8.2 feet; main rotor diameter 26.33 feet; empty weight 1,163 pounds; design gross weight 2,163 pounds; useful load 1,537 pounds at overload gross weight of 2,700 pounds; engine Allison T63 250 shaft horsepower.

Performance

Maximum speed 128 knots; cruise speed 125 knots; range 300-plus nautical miles; rate of climb 2,120 feet per minute; endurance more than 3.7 hours.

HH-43B, HH-43F RESCUE/UTILITY HELICOPTER

Prime Contractor: Kaman Aircraft Corporation

Remarks

The Kaman Huskie has a unique intermeshing rotor system and servo-flap control system. In service with the Air Rescue Service of the Air Force and foreign governments around the world the Huskie has demonstrated an ability to perform in the jungles, mountains and remote corners of the world previously inaccessible to aircraft. The Huskie has established a record of safety and reliability far exceeding that of any military aircraft ever in service. In over six years of service with ARS there has not been a single fatality or major injury to pilot, copilot, crewman or passenger of a Huskie.

Specifications

HH-43B powered by Lycoming T53-L-1B and HH-43F by T53-L-11A. Two intermeshing, counter-rotating two-bladed rotors, diameter 47 feet; height 12.6 feet; empty weight 4469 (B model), 4620 (F model); gross weight: 5969 (B model), 6500 (F model); maximum gross weight: 9150 (both models).

Performance

Maximum speed: 120 miles per hour (both models); cruise speed 110 miles per hour (both models); range 277 statute miles (B model), 504 statute miles (F model); rate of climb: 2000 feet per minute (B model), 1800 feet per minute (F model); hover OGE: 18,000 feet (B model), 16,000 feet (F model); service ceiling: 25,000 feet (B model), 23,000 feet (F model).

UH-2A/B UTILITY/RESCUE HELICOPTER

Prime Contractor: Kaman Aircraft Corporation

Remarks

This compact high-speed turbine-powered helicopter is in production for the Navy. The Seasprite carries a complete complement of the latest navigational and electronic flight aids including APN-130 Doppler, ASA-13A Air Mass Computer and a Kaman-developed autostabilization system. With all-weather instrumentation, retractable landing gear and water alighting capabilities the Seasprite operates on a 24 hour basis and at long ranges compatible with today's around-the-clock dispersed-fleet operations. The UH-2 is used for search, rescue, gunfire observation, reconnaissance, plane guard, courier, personnel transfer, ship-to-ship resupply and tactical air controller operations. The UH-2 was first flown in June, 1959, and there are now over 150 in service with the fleet and at shore stations around the world.

Specifications

Length 52.5 feet; height 13.6 feet; empty weight 6,100 pounds; gross weight 8,637; overload gross weight 10,200 pounds; engine GE T58-8 with 1,250 shaft horsepower; single 4-blade main rotor 44 feet diameter; 3-blade tail rotor 9.3 feet diameter.

Performance

Maximum speed 162 miles per hour; cruise speed 152 miles per hour; normal range 671 miles; ferry range 950 miles; rate of climb at sea level 1,740 feet per minute; hover, OGE, 5,100 feet; service ceiling 17,400.

LA-4 AMPHIBIAN

Prime Contractor: Lake Aircraft Corporation

Remarks

The Lake LA-4 is an all-metal mid-wing 4-passenger amphibian aircraft. It has retractable tricycle gear and large flaps, both actuated by an engine-driven hydraulic system. This system is backed up for emergency use by a manually-operated hand pump. The aircraft is powered by the Lycoming 180 horsepower 0-360A1A used in pusher configuration and it utilizes a Hartzell forged dural controllable constant-speed metal propeller. The aircraft is unusually rugged and is capable of operating from short fields and in extremely rough water conditions. This high-performance amphibian is enjoying a wide acceptance on the world market, several having been flown to Europe and to Australia.

Specifications

Wing span 38 feet; wing area 170 square feet; wing load 14.1 pounds per square foot; length 24 feet 11 inches; height 9 feet 4 inches; gross weight 2,400 pounds; empty weight 1,555 pounds; useful load 845 pounds.

Performance

Speed 132 miles per hour; stall speed 50 miles per hour; take-off run 650 feet (land), 1,125 feet (water); landing roll 475 feet (land), 600 feet (water); rate of climb 800 feet per minute.

MODEL 23 BUSINESS JET AIRCRAFT

Prime Contractor: Lear Jet Corporation

Remarks

Designed in Switzerland and brought to Wichita, Kansas, for final engineering and manufacture in the fall of 1962, the Lear Jet Model 23 was first flown on October 7, 1963. On July 31, 1964, Lear Jet received its Federal Aviation Agency Type Certificate and October 13, 1964, the first Lear Jet was delivered to a corporate owner. By the end of 1965 more than 80 Lear Jets were in service in the United States and around the world. On May 21, 1965, a Lear Jet was flown from Los Angeles to New York and back in 10 hours 21 minutes flying time, establishing 3 world speed records for business jets. Production rate is 10 units per month.

Specifications

Wing span 35.60 feet; length 43.23 feet; height 12.58 feet; wing sweepback 13 degrees; gross weight at take-off 12,500 pounds; engines 2 General Electric CJ610-4 turbo-jet with 2,850 pounds of thrust each; pressurization differential 8.3 pounds per square inch.

Performance

Speed 570 miles per hour; stall speed (9,000 pounds) 96 miles per hour; maximum range 1,920 miles with 45 minutes fuel reserve; cruising altitude 41,000 feet; service ceiling 45,000 feet; rate of climb at sea level 6,900 feet per minute; take-off over 35-foot obstacle (2 engines) 2,800 feet; land over 50-foot obstacle (9,000 pounds) 2,850 feet.

A-7A CORSAIR II

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.

Remarks

Newest attack plane in the Navy's arsenal is the A-7A Corsair II, designed to carry twice the bomb load twice as far as any other light attack aircraft in that service. The Navy wanted a light attack aircraft with more capability and versatility, built around an existing Navy airframe. The A-7A outwardly resembles the F-8 Crusader fighter series, although it is a completely new aircraft, smaller and more sturdily built to carry the heavy bomb and rocket loads on attack and close air support missions. Factory-completed three weeks ahead of schedule, the A-7A made its first flight in October, 1965, with approximately 185 production aircraft to be delivered in 1966. The A-7A has a larger wing than the F-8, without the variable incidence feature, a stubbier and fatter fuselage and is equipped with the Pratt & Whitney TF30 engine. It can carry a wide variety of bombs, rockets and missiles on two fuselage pylons and six wing store pylons.

Specifications

Wingspan 38.7 feet; length 45.4 feet; height 16.2 feet; engine Pratt & Whitney TF30.

Performance

Subsonic.

F-8 CRUSADER

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.

Remarks

Eight versions of the famous F-8 Crusader Navy and Marine Corps aircraft are in active service with squadrons of those two services. A ninth, the latest in the line, the F-8E(FN) fighter, is in operational duty with two French Navy squadrons aboard the carriers Clemenceau and Foch. The F-8A, F-8B, F-8C, F-8D, and F-8E Crusaders are still on active duty, as well as RF-8A photo reconnaissance versions and the new RF-8G modifications equipped with wing pylons, ventral fins, a new navigational system and improved camera stations. A TF-8A two-seater trainer version is in service at NATC Patuxent River, Md. Besides its two 20 millimeter cannon, the latest F-8 fighters are equipped to carry Zuni, Bullpup, or Sidewinder missiles, and up to two 2000-pound bombs. Naval and Marine Reservists began flying F-8A aircraft in 1964, and half a dozen Reserve Air Stations have fighter squadrons equipped with the early version. LTV built 1259 of the Crusader series.

Specifications

F-8E, span 35 feet 2 inches; length 54 feet 6 inches; height 15 feet 9 inches; engine, Pratt & Whitney J57-P20. Other versions equipped with P-4, P-12, P-16 and P-20A.

Performance

Near Mach 2.

XC-142A V/STOL

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.
Associate Contractors: Hiller Aircraft and Ryan Aeronautical Company.

Remarks

The world's largest V/STOL aircraft, the tri-service XC-142A is now undergoing operational flight testing at Edwards Air Force Base, California. Two of the tilt-wing assault transports were delivered to Edwards in July and August, 1965, where a 12-man pilot team from the Air Force, Navy and Army began tests which will include high altitude, rough terrain and aircraft carrier operations over an 18-month period. Three other aircraft were built, two being delivered to the armed services in December and a fifth retained at the LTV plant for company tests. Designed to operate from landing areas as small as 350-feet square, the XC-142A will carry 32 fully-equipped combat troops or 8,000 pounds of cargo. With its wing tilted straight up, its four T64 truboprop engines permit it to make vertical take-offs, transition to level flight and fly up to 430 miles an hour. The XC-142A made its first flight September 29, 1964; its first hover flight December 29, 1964, and first full transition flight on January 11, 1965.

Specifications:

Wingspan 67 feet 7 inches; length 58 feet; height 26 feet; engines 4 General Electric T64-6; propellers, 15.5-foot Hamilton Standard fiberglass.

Performance:

Speed zero to 430 miles an hour.

F-104G SUPER STARFIGHTER

Prime Contractor: Lockheed-California Company

Remarks

Lockheed-California Company's F-104 prototype made its initial flight in February, 1954. In January of 1958, the multi-mission fighter-interceptor went into service with the USAF. Starfighters are serving with the USAF's Tactical Air Command and the Air Defense Command. The aviation industry's largest international production program has provided more than 2,000 Super Starfighters for the air arms of 14 free world nations—Germany, Canada, Belgium, The Netherlands, Italy, Japan, Norway, Turkey, Greece, Nationalist China, Pakistan, Denmark, Spain and the United States.

Specifications

Span 21 feet 11 inches; length 54 feet 9 inches; height 13 feet 6 inches; gross weight 28,800 pounds; engine General Electric J79 16,000 pounds thrust with afterburner.

Performance

Speed Mach 2 plus; altitude above 100,000 feet.

P2V-7 NEPTUNE

Prime Contractor: Lockheed-California Company

Remarks

The P2V 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 P2V modern and up-to-date through seven models. Although the P2V is gradually being replaced in the Navy by Lockheed's P-3A Orion, the P2V still bears the insignia of seven other nations, including The Netherlands, France, Canada, Australia, Brazil, Japan and Argentina.

Specifications

Span 103 feet; length 91 feet 5 inches; height 29 feet 4 inches; gross weight 72,000 pounds; engines 2 Wright R3350-32 turbo compounds.

Performance

Speed 300 miles per hour; altitude 22,000 feet.

P-3 ORION

Prime Contractor: Lockheed-California Company

Remarks

The P-3 Orion is an advanced, long-range, 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.

Specifications

Span 99 feet 8 inches; length 116 feet 10 inches; height 33 feet 9 inches; gross weight 127,200 pounds; engines 4 Allison T56-14 4,591 shaft horsepower each.

Performance

Speed 413 knots; altitude above 30,000 feet.

SR-71 LONG RANGE STRATEGIC RECONNAISSANCE AIRCRAFT

Prime Contractor: Lockheed-California Company

Remarks

Few details have been disclosed of the SR-71 Air Force strategic reconnaissance aircraft, which made its first flight on December 22, 1964. One of the highest-performance planes ever to enter service, the SR-71 is capable of flying at more than three times the speed of sound at altitudes above 80,000 feet; on its initial flight it reached 45,000 feet and topped 1,000 miles per hour. The plane is powered by two Pratt & Whitney J58 engines. In late 1965, the aircraft were assigned to the Strategic Air Command at Beale AFB, California.

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 two Pratt & Whitney J58 engines, it has a speed capability of more than 2,000 miles per hour and a ceiling in excess of 70,000 feet. It has an ASG-18 fire control system developed by Hughes Aircraft Corporation and it is equipped with the Hughes AIM-47A air-to-air guided missile. Other details classified.

T-33A JET TRAINER

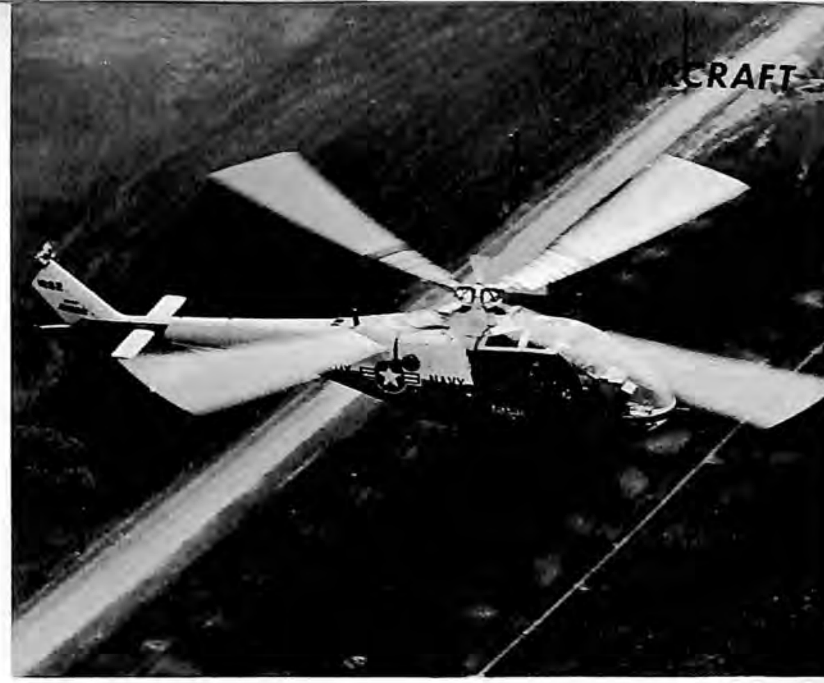
Prime Contractor: Lockheed-California Company

Specifications

Span 38 feet 10 1/2 inches; length 37 feet 8 1/2 inches; height 11 feet 8 1/3 inches; empty weight 8,084 pounds; gross weight 14,442 pounds; useful load 6,358 pounds; wing loading 60.8 pounds per square foot; power loading 3.3 pounds per square foot; fuel capacity 683 gallons; gear tricycle, fully retractable; engine Allison J33-23-400C5 turbojet 4,600 pounds thrust.

Performance

Maximum speed 580 miles per hour; stall speed 117 miles per hour; rate of climb 5,525 feet per minute; service ceiling 40,000 feet; range 1,345 miles.



WV-2 AND RC-121 EARLY WARNING AIRCRAFT

Prime Contractor: Lockheed-California Company

Remarks

Derivatives of the Lockheed Constellation series, the WV-2 (Navy) and RC-121 (Air Force) are radar-equipped flying sentinels for long distance early warning missions. Carrying six tons of electronic equipment to high altitudes, the planes were designed as aerial sentries, locating sneak raiders at interception points far away from the nation's borders. High fuel capacity and operational economy of the Wright turbo-compound engines give the airplane an extremely long on-station time. Wing tip fuel tanks extend distance of scouting missions. The WV-2 is an enlarged version of the WV-1 which was the initial picket plane in Navy service.

Specifications

Span 123 feet; length 116 feet; height 24 feet 10 inches. WV-1 same span, length 94 feet 4 inches, height 23 feet 9 inches.

Performance

Endurance of approximately 18 hours.

XH-51A HELICOPTER

Prime Contractor: Lockheed-California Company

Remarks

The XH-51A is a two-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. In October, 1964, the XH-51A reached a 200-mile per hour speed—highest known for any pure helicopter under 10,000 pounds. The four-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 9 feet; main rotor blade diameter 35 feet; normal gross weight 4,000 pounds; engine one Pratt & Whitney PT-6B-6 turboshaft produced by United Aircraft of Canada, Ltd.

Performance

Speed 175-plus miles per hour; cruise speed at sea level 160 miles per hour; still air range 240 miles.

XH-51A COMPOUND ROTORCRAFT

Prime Contractor: Lockheed-California Company

Remarks

The XH-51A compound is a four-blade aircraft converted from a "pure" XH-51A helicopter in 1964 with the addition of stub wings and an auxiliary jet engine (mounted on left wing) under an Army-sponsored program. In May 1965, the four-blade XH-51A compound reached 272 miles per hour. 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 9 feet; main rotor blade diameter 35 feet; normal gross weight 4500 pounds; engines 1 Pratt & Whitney PT-6B-6 turboshaft and 1 Pratt & Whitney J60-P-2; wing span 17 feet.

Performance

Maximum speed 272 miles per hour; maximum rate of climb 3000 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, 1965, to NASA's Langley Research Center, Hampton, Va., where it is being used for advanced flight research in the rotary wing aircraft field. It can carry five persons. The XH-51N has the Lockheed-developed rigid-rotor system and retractable landing gear.

Specifications

Fuselage length 33 feet; rotor blade diameter 35 feet; weight 4000 pounds; engine 1 Pratt & Whitney PT-6B-9 turboshaft produced by United Aircraft of Canada, Ltd.

Performance

Speed 174 miles per hour; range 225 miles.

MODEL 286 UTILITY HELICOPTER

Prime Contractor: Lockheed-California Company

Remarks

The five-place Model 286 helicopter made its first flight June 30, 1965, at the Lockheed plant in Burbank, Calif. It has a wide range potential for transport, rescue, and various military missions. As a light antisubmarine helicopter, it would be capable of rapid-action response from various Navy attack vessels. The similar Lockheed-built Army-Navy XH-51A has made landings on and take-offs from the deck of a moving destroyer at sea. The four-blade Model 286 has the Lockheed-developed rigid-rotor system and is equipped with retractable landing gear.

Specifications

Length 32 feet; rotor blade diameter 35 feet; weight 4,700 pounds; engine 1 Pratt & Whitney PT6B-9 turboshaft produced by United Aircraft of Canada. Ltd.

Performance

Design speed 176 miles per hour; estimated range 225-plus miles.

U-2

Prime Contractor: Lockheed-California Company

Remarks

The U-2, originally proposed as an independent Lockheed project in 1954, has been in service with the Air Force and other government agencies since Then. The planes furnish weather, fall-out, radiation and photographic data from lengthy flights at sustained high altitudes. A recent assignment has been investigation of HI-CAT (high altitude clear air turbulence) above 55,000 feet. Specifications and performance data are classified.

C-130A HERCULES TRANSPORT

Prime Contractor: Lockheed-Georgia Company

Remarks

The C-130A is the first of 30 versions of the Hercules series aircraft and was designed for the Air Force's Tactical Air Command. More than 200 of this model Hercules are in use throughout the world today by the USAF. Prototypes flew in 1954 and the first production models became operational with the Tactical Air Command in 1956. In addition to performing tactical and logistics missions, it was apparent that the C-130A was also suitable for other specialized missions. C-130A aircraft can be operated with or without 2 450-gallon pylon-mounted external fuel tanks.

Specifications

Wing span 132.6 feet; fuselage length 97.7 feet; height of tail 38.4 feet; propeller diameter 15 feet; cargo compartment length 41 feet 4 inches; cargo compartment height 108 inches; cargo compartment width 120 inches; cargo volume including ramp 4,300 cubic feet; maximum gross weight 124,200 pounds; personnel capacity 3-4 crew, 92 ground troops, 64 paratroops, 74 litters; engines 4 Allison T56-A-1A or T56-A-9 rated at 3,750 shaft horsepower.

Performance

Maximum cruise speed at 100,000 pounds gross weight 318 knots; maximum payload 36,000 pounds; range with maximum payload approximately 1,700 nautical miles; take-off run at maximum gross weight 2,530 feet; landing ground run at 100,000 pounds gross weight 1,550 feet.

C-130B HERCULES TRANSPORT

Prime Contractor: Lockheed-Georgia Company

Remarks

The C-130B model of the Hercules series is similar in external appearance to the C-130A but includes several major modifications which give it greater capabilities. The "B" model incorporates more fuel capacity, higher powered engines and greater structural strength than the C-130A. These improvements permit operation at higher gross weights and result in better payload-range performance than the C-130A. Almost 200 of the C-130B model aircraft are in operational use with the Air Force, Navy, and Coast Guard. Additional numbers are in service with several foreign countries. More than 100 C-130B's have augmented the combat transport arm of the Tactical Air Command.

Specifications

Wing span 132.6 feet; fuselage length 97.7 feet; height of tail 38.4 feet; propeller diameter 13.5 feet; cargo compartment dimensions: length 41 feet 4 inches height 108 inches width 120 inches; cargo volume including ramp 4,300 cubic feet; maximum gross weight 135,000 pounds; crew of 4; fuel capacity 6,960 gallons; engines 4 Allison T56-A-7 rated at 4050 shaft horsepower.

Performance

Maximum payload 35,600 pounds; take-off run at maximum gross weight 3,000 feet; landing ground run at 120,000 pounds gross weight 2,000 feet; 4-blade Hamilton Standard propellers.

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 more than 2,200 nautical miles. Using an overload take-off weight, the payload can be carried over 3,100 nautical miles. The C-130E is designed for the optional use of externally mounted wing fuel tanks. The use of these external tanks gives this model Hercules true transocean capability. Increased structural strength permits the "E" to operate from unprepared airfields—at equivalent gross weights and payloads—with a greater degree of safety than the C-130A and C-130B. More than 250 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 turboprop 4,050 shaft horsepower each.

Performance

Range with maximum payload approximately 2,200 nautical miles; high speed cruise 315 knots; take-off run at 155,000 gross weight 4,200 feet; landing ground run at design weight 2,200 feet; propellers Hamilton 4 blades 13.5 feet diameter, full reversing capability.

HC-130H HERCULES EXTENDED RANGE SEARCH, RESCUE AND RECOVERY AIRPLANE

Prime Contractor: Lockheed-Georgia Company

Remarks

The Lockheed HC-130H Hercules, the newest member of the Hercules family, is one of the few military systems designed specifically for extended range search and rescue operations. The primary mission of the HC-130H is to search for, locate and retrieve personnel and/or material from any surface, under any circumstances in support of Air Force operations. A unique nose mounted recovery system is employed in air-to-ground recoveries and provides the capability of making repeated ground pick-ups of up to 500 pounds. The HC-130H enters operational service with the Air Rescue Service early in 1966. It incorporates the Allison T56-A-15 engine which provides improved hot day, climb and altitude performance and improved fuel specifics. The engine is rated at 4,200 shaft horsepower. Normal crew for the HC-130H is ten.

Specifications

Wing span 132.6 feet; overall length 98.8 feet; height 38 feet (approximate); maximum fuel capacity including pylon tanks 13,280 gallons; maximum take-off weight 175,000 pounds; design take-off weight 155,000 pounds.

Performance

Range at maximum fuel capacity over 4,500 nautical miles; maximum cruise speed 320 knots; take-off run at 155,000 pounds gross take-off weight 3,600 feet; take-off run at 175,000 pounds gross take-off weight 4,900 feet.

LOCKHEED 382B HERCULES COMMERCIAL AIRFREIGHTER

Prime Contractor: Lockheed-Georgia Company

Remarks

The Lockheed 382B Hercules is the fully certificated commercial airfreighter version of the C-130 Hercules which is used by the air forces of twelve nations. Powered by four propjet engines, the L382B will carry a 50,000 pound payload nonstop over 2,000 statute miles. At maximum landing weight of 130,000 pounds, normal landing distance is 4,750 feet, further reduced with reversers. Fully pressurized and air conditioned, the L382 is an uncompromised airfreighter designed for either on-line scheduled cargo service, or for the delivery of large outsize cargo into remote construction, mining or oil drilling sites. The clear-cube cargo compartment is over 40 feet long, 10 feet wide and nine feet high; more than adequate to handle a standard vantainer. The 9 by 10 foot rear door opening makes loading of objects this size easily accomplished.

Specifications:

Wing span 132.6 feet; length 97.7 feet; height 38 feet; cargo floor above ground 3.4 feet; maximum payload 50,000 pounds; engines Allison 501-D22 turboprop 4,050 shaft horsepower each; maximum take-off weight 155,000 pounds; maximum landing weight 130,000 pounds; normal crew 3.

Performance

Range with maximum payload 2,000 statute miles; range with 30,000 pounds payload 3,100 statute miles; high speed cruise 305 knots; propellers Hamilton Standard 54H60-91; clear cube volume 4,200 cubic feet; bulk loaded volume 5,020 cubic feet.

C-141 STAR LIFTER 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 68,480 pound payload 4,226 miles nonstop, or 31,840 pounds 6,154 miles nonstop. Ferry range is 6813 miles. It will transport the Minuteman missile. It will transport 154 troops or 123 paratroopers or 80 litters with 8 attendants. The StarLifter began squadron duty in 1965, and is flying supplies to Viet Nam. It received its FAA certificate as a commercial freighter in January, 1965, and it is first fanjet from which troops have jumped. Truckbed level, straight in loading, which takes advantage of mechanized loading systems, in a feature.

Specifications

Wing span 160 feet; length 145 feet; height 39.3 feet; wing sweepback 25 degrees; take-off weight 316,100 pounds; engines 4 Pratt & Whitney TF-33-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 6,813 miles; maximum payload range 4,226 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-140 JETSTAR EXECUTIVE AND MILITARY JET TRANSPORT

Prime Contractor: Lockheed-Georgia Company

Remarks

The JetStar is a 575-mph, four engine, multi-mission transport, stressing reliability and safety with double and triple backup systems, the only four-engine executive jet, and the only one equipped with thrust reversers. JetStars are in use around the world, flying five chiefs of state and other high government officials, as well as the executives of more than 50 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. Famed flyer Jacqueline Cochran set 69 world aviation records during one transoceanic flight in a JetStar. The compact jetliner seats 10 passengers and a crew of two. It is also available in a 19-place military version, and this version can be quickly transformed to a cargo-personnel transport with a 3,500-pound combined payload, or to a hospital plane.

Specifications

Span 54 feet 5 inches; length 60 feet 5 inches; height 20 feet 5 inches; wing sweepback 30 degrees with 25 percent chord; weight 41,500 pounds; engines 4 Pratt & Whitney JT 12A-6A, 3,000 pounds thrust each; gear twin wheel, tricycle-type hydraulically retractable.

Performance

Speed 575 miles per hour; unrefueled range 2,250 statute miles; certificated altitude 43,000 feet.

XV-4A HUMMINGBIRD

Prime Contractor: Lockheed-Georgia Company

Remarks

The XV-4A Hummingbird is a vertical take-off and landing (VTOL), two-place, mid-wing monoplane. It resembles most closely a compact, twin-engine jet observation aircraft in configuration. The Hummingbird achieves vertical flight by diverting the high velocity jets from both engines through a series of nozzles and ducts into mixing chambers in the center of the fuselage and thence downwards toward the ground. Bombay-type doors in the top and bottom of the fuselage are opened to expose the mixing chambers and the nozzles. The high velocity and low pressure of exhaust gases from both engines induce free air from the outside, resulting in a thrust greater than that of the basic engines, with no increase in fuel consumption. In actual practice, vertical flight, hover, transition and horizontal flight take place in this manner: With the diverter valves positioned to cause the engines' exhaust to flow through the mixing chamber and with the doors open, the throttles are advanced and the plane rises vertically, small jets in the wing tips, nose and tail are used to correct roll, pitch and yaw; the nose and tail "reaction" controls are fed with engine exhaust. After attaining the desired height over adjacent obstacles, the transition to forward flight is accomplished by tilting the nose down to provide a horizontal thrust component from the ejectors, and the airplane begins to accelerate horizontally.

Specifications

Length 32 feet; wingspread 25 feet; 2 Pratt & Whitney JT-12 turbojet engines; 8,300 pounds thrust with a normal static thrust of 6,600 pounds.

MARTIN 2-0-2 AIRLINER

Prime Contractor: Martin Company, Baltimore

Remarks

Forty-one Martin 2-0-2's were produced between 1947 and 1950. The 2-0-2 featured a number of safety, ease of maintenance and design advances stemming from aircraft development during World War II.

Specifications

Length 71 feet 4 inches; span 93 feet 3.75 inches; height 28 feet 5-3/8 inches; gross weight 38,000 pounds; engines 2 Pratt & Whitney R-2800.

Performance

Maximum range with reserve and 6,013 pound payload, 1,435 miles; 40 passengers maximum; maximum payload 9,013 pounds; high speed in level flight 312 miles per hour at 11,400 feet altitude; cruising speed 282 miles per hour at 10,000 feet with weight of 36,000 pounds; service ceiling 28,700 feet.

MARTIN 4-0-4 AIRLINER

Prime Contractor: Martin Company, Baltimore

Remarks

The 4-0-4 is an improved version of the earlier Martin 2-0-2. It has a crew of three and carries 40 passengers. Tricycle landing gear and 32-foot-wide, retractable passenger steps facilitate ground operations. One hundred and three 4-0-4's were built between 1951 and 1952.

Specifications

Length 74 feet 7 inches; height 28 feet 5-3/8 inches; span 93 feet 3-3/8 inches; fuel capacity 1,350 gallons; weight at take-off 44,900 pounds (maximum), landing 43,000 pounds, operating empty 30,701 pounds, design useful load 15,774 pounds; engines 2 Pratt and Whitney R-2800 CB16.

Performance

Range 925-miles with 40 passengers and baggage plus 1,000 pounds cargo (total of 8,800 pounds); 2,525 miles maximum engineering range with full fuel, 10,000 feet altitude and 5,694 pound payload; 312 mile per hour level flight high speed at 14,500 feet; 280 mile per hour cruising speed at 18,000 feet; 1,250 feet per minute maximum rate of climb at sea level, maximum take-off gross weight; 29,000 feet service ceiling with engines at normal rated power and 40,000 pounds gross weight.

SP-5B MARLIN PATROL SEAPLANE

Prime Contractor: Martin Company, Baltimore

Remark

The SP-5B was designed for a crew of eight for anti-submarine warfare missions. The low bow chine (lower than on the P5M-1) permits higher gross take-off weights and lessens the possibility of spray damage to surfaces and propellers, while the long hull afterbody provides increased control during rough-water landings and take-offs. The high T-shaped tail reduces structural weight and aerodynamic drag and eliminates spray damage to horizontal tail surfaces. Hydroflaps on both sides of the hull afterbody act as a brake when opened together, or as a rudder when operated separately. First flight August 1953 and first delivery June 23, 1954. Martin delivered 117 aircraft to the Navy between 1953 and 1960.

Specifications

Length 101.8 feet; overall height 33 feet; hull width 10 feet; span 118 feet; gross weight 76,635; powered by two Wright R-3350-32WA engines.

Performance

Range 1,790 nautical miles; maximum speed 250 miles per hour.

B-57 BOMBER

Prime Contractor: Martin Company, Baltimore

Remarks

The B-57A, B and C are designed to destroy surface military targets during tactical operations. Speed brakes on either side of the fuselage permit steep dives and additional control during low altitude operations and landing approaches. Tactical versions carry a pilot and radar operator-navigator-bombardier and can operate from most fighter strips, including sod fields; turns can be made within the boundaries of average airports; and starting cartridges eliminate the need for ground equipment or outside power. The RB-57 and RB-57D are reconnaissance versions and the "E" model is a tow-target version. Martin built 403 planes between 1953 and 1959.

Specifications

Span 64 feet (RB-57D span 82 feet); length: 65.5 feet; height: 15 feet; gross takeoff weight 50,000 pounds; tricycle gear; powered by 2 Curtiss-Wright J-65 jet engines, each with 7,200 pounds thrust; tactical versions have rotary bomb doors, pylon weapons mounts under the wings and four 20 millimeter cannons or eight .50 calibre machine guns fire from the leading edges of the wings.

Performance

Speed over 600 miles per hour; range more than 2,000 miles; service ceiling over 45,000 feet.

F-4B PHANTOM AIR SUPERIORITY FIGHTER

Prime Contractor: McDonnell Aircraft Corporation

Remarks

The F-4B Phantom is the fastest, highest-flying and longest-ranged U.S. Navy fighter. The two-place, twin-jet all-weather F-4B is in volume production for the U.S. Navy and Marine Corps. The Phantom, with Navy and Marine pilots, established 15 world speed, altitude, and time-to-climb records. The Phantom has the greatest firepower of any Navy fighter. The crew consists of a pilot and a radar intercept officer. The plane is equipped with detection and tracking systems which make it capable of destroying supersonic as well as subsonic enemy aircraft by day or night in any weather. Although it is one of the free world's fastest operational fighters, the Phantom is also the "slowest" and can be flown with minimum level flight speeds in the vicinity of 125-130 miles per hour. The F-4B Phantom holds eight time-to-climb world records including climbing to 12,000 meters (39,370 feet) in 1 minute, 17 seconds.

Specifications

Length 58 feet; span 38 1/2 feet; wing sweepback 45 degrees; horizontal stabilizer slopes downward at 23 degrees; boundary layer control; engines 2 GE J-79-8, 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.

F-4C PHANTOM FIGHTER-BOMBER

Prime Contractor: McDonnell Aircraft Corporation

Remarks

The F-4C, the Air Force's newest, fastest and highest-flying fighter-bomber aircraft, is in service with the Tactical Air Command and with Air Force units in Europe and the Far East. First flight of the F-4C was made on May 27, 1963, less than 14 months after contractual go-ahead from the Air Force. The Air Force has ordered more than 1,000 Phantoms and this will be augmented. Basic armament of the F-4C is four all-weather, radar-guided Sparrow III air-to-air missiles carried semi-recessed under the fuselage; two additional Sparrows or four infrared-guided Sidewinder missiles may also be carried on wing stations. About eight tons of miscellaneous external payload (conventional or nuclear bombs, fuel tanks, rockets, mines, guns, etc.) can be carried on five stations beneath the wings and fuselage.

Specifications

Length 58 feet; span 38 1/2 feet; wing sweepback 45 degrees; engines 2 GE J-79-15 engines, 17,000 pounds thrust each.

Performance

Speed 1,600 plus miles per hour; ferry range 2,000 miles; airborne in less than 3,000 feet, lands in even less distance.

RF-4B PHANTOM RECONNAISSANCE FIGHTER

Prime Contractor: McDonnell Aircraft Corporation

Remarks

The RF-4B is a tactical all-weather multi-sensor reconnaissance aircraft that utilizes the same basic configuration and engines as the fighter and attack versions of the Phantom. McDonnell has designed and is building the RF-4B to increase the reconnaissance capability of the Marine Corps. The basic changes in the RF-4B from the RF-4C reconnaissance version are: (1) the RF-4B is carrier-suitable, including the smaller wheels used on the Navy version; (2) the RF-4B has flight controls in the cockpit only, unlike the RF-4C which has dual controls. The RF-4B has in-flight rotatable camera mounts in two camera stations. Cameras in the Air Force version can only be repositioned on the ground. The RF-4B has no armament capability.

Specifications

Length 63 feet; span 38 1/2 feet; wing sweepback 45 degrees; engines 2 J-79-GE 8, 17,000 pounds thrust each.

Performance

Speed 1,600 plus miles per hour; ferry range 2,000 miles; forward looking radar utilizing its terrain following or terrain avoidance mode, permits operation at very low altitude over varying terrains.

RF-4C PHANTOM RECONNAISSANCE AIRCRAFT

Prime Contractor: McDonnell Aircraft Corporation

Remarks

The RF-4C Phantom is a high-performance fighter-type aircraft with an effective, tactical all-weather multi-sensor reconnaissance capability. The Air Force RF-4C incorporates optical, infra-red and electronic sensors necessary to perform reconnaissance missions, day or night, in any kind of weather. Its optical system includes cameras of various focal lengths and operational modes, an integrated sensor control system, automatic in-flight film process and film ejection from the low altitude panoramic camera station. By adding an HF communications transceiver to the electronics system, voice communication is possible between the aircraft and its home base anywhere within the performance envelope of the Phantom. In addition the RF-4C has forward looking radar for ground mapping and low-level penetration; side-looking radar; an infra-red reconnaissance system (IRRS); and an inerted navigation set.

Specifications

Length 63 feet; span 38 1/2 feet; retains air-to-ground nuclear attack capability of other Phantom versions; no conventional weapons; engines 2 GE J-79-15 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 mph; ferry range 2,000 miles; service ceiling above 60,000 feet.

F-101B VOODOO INTERCEPTOR

Prime Contractor: McDonnell Aircraft Corporation

Remarks

The F-101B has the greatest combination of speed and long-range of any operational interceptor in the Air Defense Command. It is equipped with Genie rockets possessing a nuclear capability. In addition, it carries conventional rockets and Falcon missiles. The F-101B is a two-place interceptor; the second crewman is a radar operator. The F-101B operates under all-weather conditions to execute two primary missions: the identification of unknown aircraft and then destruction if they are hostile. There are 15 squadrons of the F-101B Voodoo currently in service with the Air Defense Command and three squadrons now in the inventory of the Royal Canadian Air Force.

Specifications

Length 67 1/2 feet; span 40 feet; height 18 feet; wing and stabilizer swept back at angle of 35 degrees; engines 2 Pratt and Whitney J-57.

Performance

Speed 1,200 plus miles per hour; range 2,000 plus miles; service ceiling 55,000 plus feet.

188E STOL TRANSPORT

Prime Contractor: McDonnell Aircraft Corporation

Remarks

The 188E is designed to carry an eight-ton payload 575 miles, land safely with less than 500-foot ground roll on a 1000-foot unprepared surface and return to its base with payload, without refueling. Flight safety for short field operations and maneuverability at low speed is provided through cross-shaft interconnection of the four engines. The 188E can make steep turns and gear-down landing approaches at airspeeds as low as 50 knots. The Breguet-designed aircraft will be built to U.S. military standards by McDonnell with U.S. tooling; material and equipment with the technical assistance of Breguet.

Specifications

Length 77 feet; span 77 feet; height 31 feet; gross weight 58,400 pounds; payload for 575-mile radius missions 8 tons; troop capacity 55.

Performance

Cruise speed 250 knots; ferry range 3,500 plus miles.

MOONEY MARK 21

Prime Contractor: Mooney Aircraft, Inc.

Remarks

The 4-place retractable gear Mark 21 features positive control for "wings level" flight attitude. Its 4-cylinder, 180 horsepower engine uses 91/98 octane fuel. The fuel is contained in two integral sealed tanks. A full trim tail gives maximum stability at low speeds and minimum drag at high speeds. Cabin construction features a welded chrome-moly steel tube frame structure. Electric or manual gear retraction system is available.

Specifications

Span 35 feet; length 23 feet 2 inches; height 8 feet 4 1/2 inches; gross weight 2,575 pounds; empty weight 1,525 pounds; useful load 1,050 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 3/4 inches; engine 1 Lycoming 0-360-180 horsepower; propeller 74 inches constant speed; fuel capacity 52 gallons.

Performance

Maximum level speed 185 miles per hour; maximum cruising speed at 79 percent power 182 at 7,500 feet; stall speed 57 miles per hour; rate of climb 1,010 feet per minute; maximum range 1,031 miles; service ceiling 17,200 feet.

MOONEY SUPER 21

Prime Contractor: Mooney Aircraft, Inc.

Remarks

The Mooney Super 21 has all the features of the Mark 21 plus a 200 horsepower engine. This 4-cylinder engine has fuel injection and ram air power boost. The power boost adds 10 to 12 additional horsepower at altitude. The Super 21 averaged 20.9 miles per gallon in the Mooney/Mobil coast-to-coast mileage flight.

Specifications

Span 35 feet; length 23 feet 2 inches; height 8 feet 4 1/2 inches; gross weight 2,575 pounds; empty weight 1,560 pounds; useful load 1,015 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 3/4 inches; engine 1 Lycoming I0-360-200 horsepower; propeller 74 inches constant speed; fuel capacity 52 gallons.

Performance

Maximum level speed 197 miles per hour; maximum cruising speed at 75 percent power 187 miles per hour at 7,500 feet; stall speed 57 miles per hour; rate of climb 1,120 feet per minute; maximum range 1,024 miles; service ceiling 18,800 feet.

MOONEY MARK 22 MUSTANG

Prime Contractor: Mooney Aircraft, Inc.

Remarks

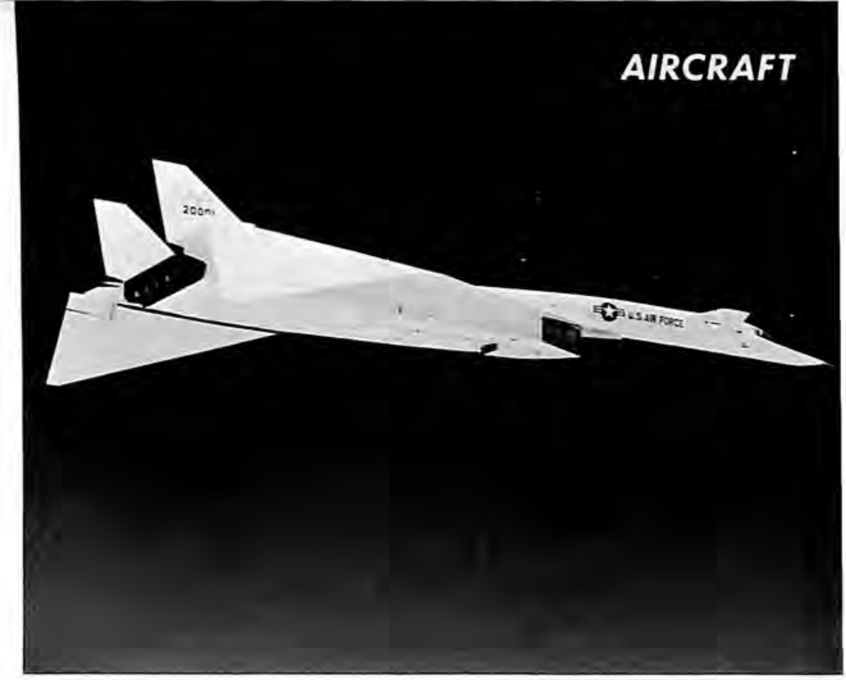
The Mark 22 Mustang is an advanced single engine business aircraft with pressurized cabin seating 4–5. It was designed as a high performance airplane capable of going anywhere, anytime, at a practical price. With an operational ceiling of 24,000 feet, the Mustang will fly above virtually any en route weather. The 310 horsepower engine is turbocharged. The Mark 22 will fly at speeds up to 250 miles per hour.

Specifications

Span 35 feet; length 26 feet 11 inches; height 9 feet 4 1/2 inches; gross weight 3,680 pounds; useful load 1,370 pounds; engine 1 Lycoming TI0-541-AIA; fuel 100 gallons.

Performance

Maximum level speed 250 miles per hour; maximum recommended cruise 230 miles per hour; stall speed under 70 miles per hour; gross weight rate of climb at sea level 1,100 feet per minute; take-off over 50-foot obstacle 1,800 feet; maximum certificated operational ceiling 24,000 feet; maximum range over 1,100 statute miles.



MOONEY MASTER

Prime Contractor: Mooney Aircraft, Inc.

Remarks

The Mooney Master is a 4-place fixed gear aircraft engineered for conversion to retractable gear. It was designed as a practical solution to the need for an airplane which can bridge the gap between the training period requirements of the beginning pilot and those of the pilot who needs the high performance of retractable gear. It is powered with a 4-cylinder, 180 horsepower engine and is available with either a fixed pitch or constant speed propeller.

Specifications

Span 35 feet; length 23 feet 2 inches; height 8 feet 4 1/2 inches, gross weight 2,575 pounds, empty weight 1,475 pounds; useful load 1,100 pounds; baggage 120 pounds; wing loading 15.4 pounds per square foot; power loading 14.3 pounds per horsepower; wing area 167 square feet; engine 1 Lycoming 0-360-180 horsepower; fuel capacity 52 gallons.

Performance

Maximum level speed 147 miles per hour at sea level; cruise speed at 75 percent power 139 miles per hour at 9,600 feet; stall speed 57 miles per hour; rate of climb 740 feet per minute; maximum range, 776 miles; service ceiling 13,600 feet.

XB-70A RESEARCH AIRCRAFT

Prime Contractor: North American Aviation, Inc.
Associate Contractor: General Electric Corporation

Remarks

The XB-70A is a high-speed, high altitude six-jet aircraft currently being flown in research programs at Edwards AFB, California. Originally conceived as an intercontinental bomber, its development began in 1956 following a two-company study competition. In 1963, the decision was made to produce only two aircraft, both to be used only for research programs. The first XB-70A was rolled out on May 11, 1964 and made its first flight on September 21 of that year. The second aircraft was completed on May 29, 1965 and made its maiden flight on July 17. On October 14, the No. 1 airplane first reached its design goals of Mach 3 (2000 mph) at 70,000 feet. Approximately 70 percent of the aircraft structure is stainless steel honeycomb, and the entire forward section is made of titanium. The aircraft also makes extensive use of H-11 tool steel. Its design features include a canard on the forward fuselage, wing tips that fold downward during high speed flight to increase directional stability, and use of the "compression lift" principle which enables the aircraft to "ride" its own shock waves at high Mach numbers.

Specifications

Span 105 feet; length 185 feet; height 30 feet; weight over 450,000 pounds; engines six General Electric YJ-93 in 30,000-pound thrust class; crew pilot and co-pilot; fuel JP-6.

Performance

Speed 2,000 miles per hour; altitude, 70,000 feet.

T-39 SABRELINER

Prime Contractor: North American Aviation, Inc.

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 four passengers and crew of two, and for use as a trainer or utility aircraft; the T-39B, a radar navigation trainer for the Air Force and the T-39D, a radar navigation trainer for the Navy. Since it was originally designed to meet transport aircraft requirements, the Sabreliner was able to meet business aircraft requirements. It was placed on the civilian market in October, 1962 and since that time more than 50 executive aircraft have been delivered.

Specifications

Span 44.5 feet; length 44 feet; height 16 feet; maximum gross take-off weight 18,650 pounds; capacity seven passengers, two crew (business version); engines two Pratt & Whitney JT 12A-6A turbojets 3,000 pounds thrust each; (military version Pratt & Whitney J60-P-3A).

Performance

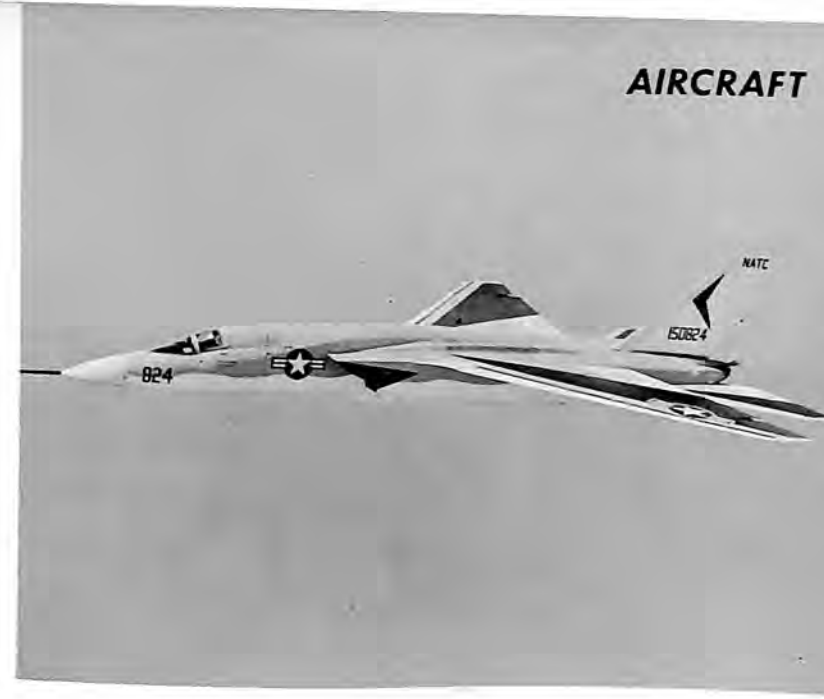
Speed 500 miles per hour plus; range 1,900 miles; altitude 40,000 feet, certified to 45,000 feet.

X-15 RESEARCH AIRCRAFT

Prime Contractor: North American Aviation, Inc.

Remarks

The X-15 is a special purpose research airplane whose initial development was funded jointly by the Air Force, Navy and the National Aeronautics and Space Administration. Three aircraft were built and the first to fly took to the air on June 8, 1959. In the course of its long career, the X-15 has made a great many contributions to research, particularly in the hypersonic area, and it has attained speeds of Mach 6 and altidues above 350,000 feet. Currently the No. 1 plane is exploring atmospheric density and collecting micrometeorites and is used for a study of the solar spectrum. It is scheduled to continue operations into early 1968. No. 2 aircraft is employed in a program of ultraviolet photography of stars at very high altitudes. Later, it will be modified as a ramjet test bed and will be used in a new program to explore the still untouched flight regime of Mach 6-8. Under current schedules it will continue operations into 1969. No. 3 will be used in experiments with supersonic deceleration devices, ultraviolet exhaust plume characteristics and horizon definition, with operations extending into mid-1968.



OV-10A LIGHT ARMED RECONNAISSANCE AIRCRAFT

Prime Contractor: North American Aviation (Columbus)

Remarks

The OV-10A is the first aircraft designed specifically for counter-insurgency and limited war operations. It is intended for use by the three military services, allied foreign countries and the Military Assistance Program. Its mission capabilities include: observation and reconnaissance, helicopter escort, limited ground attack, gunfire spotting, liaison, transport and training. The LARA can operate from rough clearings, waterways and primitive roads, as well as prepared airfields and small carriers. The OV-10A fuselage is mounted below the wing, providing unobstructed visibility well ahead of the propellers for pilot and observer. Cockpits are equipped with the North American LW3-B escape system, allowing for ejection at zero airspeed and ground level. The 111-cubic-foot fuselage cargo compartment can carry loads up to 3,200 pounds. Bombs, rockets and napalm can be mounted on a fuselage sponson which contains four fixed 7.62 millimeter machine guns.

Specifications

Span 30 feet 3 inches; length 40 feet; height 15 feet; gross weight 5,200 pounds; engines AiResearch T76-G6 (left) and T76-G8 (right) 660 shaft horsepower each; tricycle or detachable float landing gear.

Performance

Speed 265 knots; range 1200 nautical miles; service ceiling 25,000 -plus feet.

RA-5C ATTACK/TACTICAL RECONNAISSANCE VEHICLE

Prime Contractor: North American Aviation (Columbus)

Remarks

The RA-5C is an all-weather, carrier-based reconnaissance aircraft, capable of delivering both conventional and nuclear weapons at high or low altitudes. It is the third model in the Vigilante series, and has a top speed in the Mach 2 range. The RA-5C incorporates design features which give it a greater fuel capacity and improved slow-flight and lateral control characteristics. Stores are carried internally in a linear bomb bay and delivery is by rearward ejection out the tail section. The pilot and reconnaissance/attack navigator occupy tandem cockpits. The Vigilante carries the latest reconnaissance equipment, including frame and panoramic cameras, side-looking radar and passive electronic countermeasures devices, in a detachable fuselage pod. The aircraft and its equipment comprise one half of the Navy's Integrated Operational Intelligence System, which is on most attack carriers.

Specifications

Span 50 feet; length 70 feet; height 20 feet; wing, tail, nose hinged for folding aboard carrier; gross weight 42,132 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: North American Aviation (Columbus)

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: North American Aviation (Columbus)

Remarks

An improved version of the T-2A, the T-2B Buckeye entered production in 1965. It will be used as a land or carrier-based trainer to instruct Navy and Marine Corps student pilots from first jet flight to the advanced training phase. The two-engine configuration provides the Buckeye with performance and safety characteristics superior to the T-2A. Waist-level engine compartments and equipment bays afford ease of access for ground maintenance and servicing. In addition to internal fuel storage, each wing tip carries a hundred gallon fuel tank. Underwing 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; gross weight 8,474 pounds; engines 2 Pratt & Whitney J60 turbojets 3,000 pounds thrust each; tricycle landing gear.

Performance

Speed 460 knots; range 780 nautical miles; service ceiling 42,000 feet.

F-5 TACTICAL FIGHTER

Prime Contractor: Northrop Norair, Division of 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. In addition, Spain has ordered 70 F-5A's under a production sharing agreement. Single seat F-5A fighters and twin cockpit F-5B models are produced. Utilizing the same basic design, the F-5B combines the combat capability of the F-5A with training capability. The aircraft is intended for close support of troops, interception, attacks on communications and supply lines and armed reconnaissance missions over enemy territory. It can operate from short, semiprepared or unprepared fields in forward battle areas.

Specifications

Span 26 feet 7 inches with wing tip armament; length 45 feet; height 13 feet 2 inches; weight 12,920 pounds with full internal fuel; external lead 6,200 pounds of air-to-air and air-to-ground weapons, reconnaissance and surveillance equipment and extra fuel; engines two General Electric J85-13 turbojets 4,080 pounds thrust each.

Performance

Speed Mach 1.4-plus; altitude 52,000 feet; rate of climb more than 28,000 feet per minute; range more than 1,500 nautical miles with external tanks, tactical mission radius up to 760 nautical miles.

T-38 TALON TRAINER

Prime Contractor: Northrop Norair, Division of Northrop Corporation

Remarks

A supersonic jet trainer, the T-38 is a twin-jet, low wing monoplane with "coke bottle" fuselage. It is used as an advanced trainer by the Air Force and it has been selected by NASA for astronaut space flight readiness training.

Specifications

Span 25 feet 3 inches; length 42 feet 2 inches; height 12 feet 11 inches; weight 11,550 pounds; crew 2; engines two General Electric J85-5 turbojets; two independent fuel supply systems, one for each engine.

Performance

Speed Mach 1.2 (guaranteed), Mach 1.35 (highest attained); range 980 nautical miles; rate of climb over 30,000 feet per minute; ceiling 55,000 feet.

X-21A LAMINAR FLOW CONTROL AIRCRAFT

Prime Contractor: Northrop Norair, A Division of Northrop Corporation

Remarks

The two X-21A's were formerly WB-66D weather observation planes; they were modified for a USAF investigation of Laminar Flow Control by the addition of larger wings. Two Laminar Flow Control pumping pods are installed in the former engine positions on the wings of the aircraft. This system, developed by AiResearch Manufacturing Division of The Garrett Corporation, uses turbine-driven compressors to draw air from the upper and lower surfaces of each wing. In each pod, a low pressure compressor pulls upper wing air from the leading edge to about the rear spar. This air is fed to a high pressure compressor which also sucks the remainder of the upper wing air plus under wing air. All "inhaled" air is then discharged from the rear of the two pods. The displaced engines are mounted on the rear fuselage.

Specifications

Span 93.5 feet; wing area 1,250 square feet; aspect ratio 7.0; overall length 75.5 feet; gross weight 83,000 pounds; metering holes 815,338 per airplane; tributary ducts 67,944 per airplane; engines 2 General Electric J79-13 9,400 pounds thrust each.

PIPER PA-25 PAWNEE "B"

Prime Contractor: Piper Aircraft Corporation

Remarks

The Pawnee was specifically designed for the safe, efficient, economical dispersal of liquid and solid agricultural chemicals, insecticides and salt; and for ease of maintenance under field conditions. The Pawnee was first introduced in 1959; the present horsepower Pawnee "B" is equipped with a Lycoming 0-540-B2B5 235 horsepower engine. In worldwide use it has earned the universal respect of ag-operators and their customers—farmers, municipalities and highway departments—and of ag-pilots for its handling ease and its unique "safety capsule" cockpit.

Specifications

Wing span 36.2 feet; length 24.7 feet; height 7.2 feet; gross weight 2,900 pounds; empty weight sprayer 1,488 pounds, duster 1,479 pounds; wing area 183 square feet; fuel capacity 42 gallons; all-metal McCauley propeller with 84-inch diameter.

Performance

Top speed 110 miles per hour for duster, 117 for sprayer; cruise speed at 75 percent power 100 miles per hour for duster, 105 for sprayer; stall speed 61 miles per hour; take-off run 956 feet for duster, 800 for sprayer; landing roll 850 feet; rate of climb at sea level, duster 500 feet per minute, sprayer 630 feet per minute; cruising range at 75 percent power, duster 285 miles, sprayer 300 miles.

PIPER CHEROKEE 140

Prime Contractor: Piper Aircraft Corporation

Remarks

The Cherokee 140 is a 2–4 place fixed-gear sport/trainer powered by a Lycoming 0-320-E2A 150 horse power engine. Since its introduction in 1963 the Cherokee 140 has become one of the most popular aircraft for the fixed-base operator, flying clubs, flight schools, as well as for private individuals. Its low wing design with low center of gravity, coupled with the 10-foot wide landing gear, has made the Cherokee 140 an extremely forgiving airplane for student work and has permitted flight operations in wind conditions heretofore considered too risky for student solo operations.

Specifications

Wing span 30 feet; length 23.3 feet; height 7.3 feet; gross weight 2,150 pounds; empty weight 1,201 pounds; wing area 160 square feet; wing loading 13.4 pounds per square foot; power loading 14.3 pounds per horsepower; fuel capacity 50 gallons; propeller all-metal fixed pitch Sensenich with 74-inch diameter.

Performance

Top speed 142 miles per hour; cruise speed, 75 percent power, 133 miles per hour; stall speed 54 miles per hour; take-off run 800 feet; landing roll 535 feet; rate of climb 600 feet per minute; service ceiling 14,300 feet; cruising range 725 miles.

PIPER CHEROKEE "C"

Prime Contractor: Piper Aircraft Corporation

Remarks

The Cherokee "C" is the latest version of the Cherokee line of 4-place fixed-gear aircraft which was originally introduced in 1961. The Cherokee "C" is available in a choice of 3 engines: Lycoming O-320-E2A (150 horsepower), Lycoming O-320-D2A (160 horsepower) or the Lycoming O-360-A3A (180 horsepower).

Specifications

Wing span 30 feet; length 23.5 feet; height 7.3 feet; gross weight 2,150 pounds (150), 2,200 (160), 2,400 (180); empty weight 1,210 pounds (150), 1,215 (160), 1,230 (180); wing area 160 square feet; wing loading 13.4 pounds per square foot (150), 13.8 (160), 15.0 (180); power loading 14.3 pounds per horsepower (150), 13.8 (160), 13.3 (180); fuel capacity 50 gallons; propeller all-metal fixed-pitch Sensenich with 74-inch diameter for the 150 and 160, and 76-inch diameter for the 180.

Performance

Top speed 144 miles per hour (150), 146 (160), 152 (180); cruise speed at 75 percent power 135 miles per hour (150), 137 (160), 143 (180); stalling speed 54 miles per hour (150), 55 (160), 57 (180); take-off run 780 feet (150), 740 (160), 720 (180); landing roll 535 feet (150), 550 (160), 600 (180); rate of climb at sea level 690 feet per minute (150), 730 (160), 750 (180); service ceiling 14,900 feet (150), 15,800 (160), 16,400 (180); cruise range at 75 percent power 725 miles (150), 735 (160), 725 (180).

PIPER CHEROKEE 235

Prime Contractor : Piper Aircraft Corporation

Remarks

The Cherokee 235 can carry 4 passengers, 200 pounds of luggage, 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 235 can operate out of even the shortest fields, and then cruise at 155 miles per hour for a range of over 900 miles. The new "mid-model" Cherokee 235 incorporates many new improvements, such as "shock-mounted" cowling, Dynafocal engine mounting, increased soundproofing and a new even larger instrument panel that will accommodate even the most professional type of equipment.

Specifications

Wing span 32 feet; length 23.5 feet; height 7.1 feet; gross weight 2,900 pounds; empty weight 1,410 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; 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.

PIPER CHEROKEE 6

Prime Contractor: Piper Aircraft Corporation

Remarks

The all new Cherokee 6 is ideal for family flying, business travel, farm and ranch, charter, air taxi, or cargo. With its Lycoming O-540-E4B5 260 horsepower engine, the Cherokee 6 cruises at 158 miles per hour and can carry 6 passengers, 200 pounds of luggage and a full fuel load of 84 gallons. In just seconds without tools, the rear and middle seats slip out of sockets converting the Cherokee 6 into a half-ton cargo carrier or ambulance. In fact, as much as 1,338 pounds of cargo can be carried with pilot and full main tanks.

Specifications

Wing span 32.8 feet; length 27.7 feet; height 7.9 feet; gross weight 3,400 pounds; empty weight 1,640 pounds; wing area 174.5 square feet; wing loading 19.5 pounds per square foot; power loading 13.1 pounds per horsepower; fuel capacity 84 gallons; propeller either fixed-pitch metal McCauley or Hartzell constant speed with 82-inch diameter.

Performance

Top speed 166 miles per hour; cruise speed at 75 percent power 158 miles per hour; stall speed 63 miles per hour; take-off run 740 feet; landing roll 630 feet; rate of climb at sea level 850 feet per minute; service ceiling 14,500 feet; cruise range at 75 percent power 950 miles.

PIPER 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 horse power engine and holds the world's altitude record for piston powered light aircraft by attaining 30,203 feet. The Super Cub is certified on floats and skis and is used throughout the world for pleasure, training, patrol, survey, agricultural and general utility work.

Specifications

Wing span 35.3 feet; length 22.5 feet; height 6.7 feet; gross weight 1750 pounds; overload gross weight 2070 pounds; empty weight 930 pounds; wing area 178.5 square feet; wing loading 10.0 pounds per square foot; power loading 11.6 pounds per horsepower; fuel capacity 36 gallons, propeller all-metal Sensenich with 74-inch diameter.

Performance

Top speed 130 miles per hour; cruise speed at 75 percent power 115 miles per hour; stall speed 43 miles per hour; take-off run 200 feet; landing roll 350 feet; rate of climb at sea level 960 feet per minute; service ceiling 19,000 feet; cruising range at 75 percent power 460 miles.

PIPER COMANCHE B

Prime Contractor: Piper Aircraft Corporation

Remarks

The Comanche B is the latest version of the proven Comanche line of airplanes. The new Comanche B has a longer cabin that seats up to 6 people, more luxurious styling, and has a maximum gross weight of 3,100 pounds. Powered by either a Lycoming O-540-E carburetor induction engine or a Lycoming IO-540-D fuel injection engine, the Comanche B cruises at over 180 miles per hour and has a range of 1,100 miles at 75 percent power.

Specifications

Wing span 35.98 feet; length 25.29 feet; height 7.47 feet; gross weight for take-off 3,100 pounds; gross weight for landing 2,945 pounds; empty weight 1,728 pounds; wing area 178 square feet; wing loading 17.42 pounds per square foot; power loading 11.92 pounds per horsepower; fuel capacity 90 gallons; propeller Hartzell constant speed with 77-inch diameter.

Performance

Top speed 194 miles per hour; cruise speed at 75 percent power 182 miles per hour; stall speed 66 miles per hour; take-off run 760 feet; landing roll 655 feet; rate of climb at sea level 1,370 feet per minute; service ceiling 20,000 feet; cruising range at 75 percent power 1,108 miles.

PIPER TWIN COMANCHE B

Prime Contractor: Piper Aircraft Corporation

Remarks

A longer cabin that seats 6 passengers, new luxurious styling, and even quieter operation are added to the already proven design of the Twin Comanche to make the Twin Comanche B. Powered by 2 Lycoming IO-320-B fuel injection engines developing 160 horsepower each, the Twin Comanche B cruises at over 190 miles per hour at 75 percent power. If even better performance is desired for high altitude, the Turbo Twin Comanche B can cruise at 24,000 feet at 223 miles per hour at 75 percent power. It holds the light twin nonstop distance record.

Specifications

Wing span 35.98 feet; length 25.2 feet; height 8.2 feet; gross weight 3,600 pounds (3,725 pounds for the Turbo); empty weight 2,210 pounds (2,408 pounds for the Turbo); wing area 178 square feet; power loading 11.3 pounds per horsepower; fuel capacity 90 gallons; propeller Hartzell constant speed full-feathering with 72-inch diameter.

Performance

Top speed 205 miles per hour (240 for Turbo); cruise speed at 75 percent power 194 miles per hour (223 for Turbo); take-off run 950 feet; landing roll 700 feet; rate of climb at sea level 1,460 feet per minute (1,350 at 10,000 feet for Turbo); service ceiling 18,600 feet (Turbo ceiling is 30,000-plus feet); single engine ceiling 7,100 feet (19,000 feet for Turbo); cruising range at 75 percent power 1,270 miles (1,425 miles for Turbo).

PIPER APACHE 235

Prime Contractor: Piper Aircraft Corporation

Remarks

The Apache 235 is the latest version of the original Piper Apache first introduced in 1954. The Apache 235 is a 4–5 passenger twin-engine airplane powered by 2 Lycoming O-540-B1A5 engines. Advanced aerodynamic design incorporating a swept tail and all-moving stabilator is translated into exceptional efficiency, stability and flying ease. The distinctive Apache wing gives not only high speeds but at maximum gross weight stalls at only 62 miles per hour, allowing the use of even the shortest and roughest of fields. With its standard 144 gallons fuel capacity and its more than a ton of useful load, the Apache 235 can carry 5 passengers and full luggage 1,185 miles nonstop.

Specifications

Wing span 37 feet; length 27.6 feet; height 10.3 feet; gross weight 4,800 pounds; empty weight 2,735 pounds; wing area 207 square feet; fuel capacity 144 gallons; propeller Hartzell constant speed full-feathering with 74 inch diameter.

Performance

Top speed 202 miles per hour; cruise speed at 75 percent power 191 miles per hour; take-off run 830 feet; landing roll 880 feet; rate of climb at sea level 1,450 feet per minute; service ceiling 17,200 feet; absolute single engine ceiling 6,600 feet; cruising range at 75 percent power 980 miles.

PIPER AZTEC "C" AND TURBO AZTEC "C"

Prime Contractor: Piper Aircraft Corporation

Remarks

The Aztec "C" is powered by 2 Lycoming fuel-injection IO-540-C4B5 engines developing 250 horsepower each. It cruises at 206 miles per hour at its maximum gross weight of 5,200 pounds and will travel nonstop well over 1,000 miles. For even better high altitude performance the Turbo Aztec "C" is equipped with 2 Lycoming fully modified IO-540-J4A5 engines which increase cruise speed to 236 miles per hour at 24,000 and give the Turbo Aztec "C" a ceiling of over 30,000 feet.

Specifications

Wing span 37 feet; length 30.2 feet; height 10.3 feet; gross weight 5,200 pounds; empty weight 2,933 pounds (3,023 pounds for the Turbo Aztec); wing area 207.56 square feet; fuel capacity 144 gallons; propellers Hartzell constant speed full-feathering with 77 inch diameter.

Performance

Top speed 216 miles per hour (256 for Turbo); cruise speed at 75 percent power 206 miles per hour (Turbo 236 at 24,000 feet); stall speed 68 miles per hour; take-off run 820 feet; landing roll 860 feet; rate of climb at sea level 1,490 feet per minute (Turbo rate of climb at 10,000 feet 1,390 feet per minute); service ceiling 19,800 (absolute ceiling for Turbo plus 30,000 feet); cruise range at 75 percent power 1,055 miles (1,135 for Turbo); single engine ceiling 6,400 feet (18,500 for Turbo).

PIPER PA-31 NAVAJO

Prime Contractor: Piper Aircraft Corporation

Remarks

Piper Aircraft has announced a new medium twin-engine aircraft designated the PA-31 Navajo. The Navajo has been under development for the past three years and is scheduled for production during fiscal 1966. Currently flying in prototype, the Navajo is powered by two Lycoming TIO-540-A1A 310 horsepower engines and has a top speed of over 260 miles per hour. The Navajo, with walk-around cabin, is designed to give maximum room and comfort for passengers. Six and eight place seating as well as executive interiors will be available. Entry is by air-stair door at the left rear of the fuselage. Luggage arrangements are similar to those in the Aztec, with one compartment in the nose section and a second behind the passenger section.

F-84F THUNDERSTREAK FIGHTER BOMBER

Prime Contractor: RAC Corporation

Remarks

The F-84F single-engine, single seat Thunderstreak, afterunner of the famed F84 Thunderjet of the Korean War, is an atomic bomb carrier. It first flew in June 1950 with a J-35 engine which was changed in the spring of 1951 to a J-65 turbo-jet engine producing 7200 pounds of thrust, making it capable of Mach 1 speeds with a service ceiling of 45,000 feet. Volume production began in 1953 and the plane was put into service with USAF fighting units in 1954. With an overall length of 43-feet and span of 33-feet, its wings and tail are swept back at an angle of 40 degrees. In addition to its normal armament of six .50 calibre machine guns, the F-84F can carry more than 6000 pounds of rockets, bombs and other weapons. Its normal range of 2,500 miles is extended to limitless capability with in-flight refueling provisions. At present, about 400 are in service with the Air National Guard and there are about 1,100 in service with air forces of the NATO Alliance. While the F-84F Thunderstreak's primary mission is that of a fighter-bomber, its high performance and versatility make it a highly desirable plane for other missions.

Specifications

Span 33 feet; wing sweep 40 degrees; empty weight 14,000 pounds; power J65 turbo-jet 7220 pounds thrust; tricycle gear.

Performance

Speed Mach 1, unrefueled range 2,500 nautical miles, service ceiling 45,000 feet.

F-105 THUNDERCHIEF FIGHTER BOMBER

Prime Contractor: RAC Corporation

Remarks

The F-105 Thunderchief is a Mach 2, multi-purpose, all-weather fighter-bomber capable of delivering conventional, as well as nuclear and thermonuclear weapons. There are two models—the single-seat F-105D and the two-place F-105F. The F-105 is in service with eight Air Force wings in the U.S., Europe, and the Far East. Its speed, maneuverability, and aerial firepower qualify it for use in counter-air, close support or interdiction roles in either limited or general war situations. The F-105 enables its pilot to perform a round-trip, low-or-high level bombing mission in any weather, day-or-night, over any terrain, without ever seeing the ground. The F-105 has been the "work horse" in North Viet Nam for strikes on heavily defended ground targets and has demonstrated a ruggedness equal to the Republic P-47 "Jug" of World War II. Its Vulcan 20 millimeter cannon has been particularly effective on all targets.

Specifications

Span 34 feet 11 inches; length (F-105D) 64 feet 3 inches, (F-105) 69 feet 7 inches; height (F-105D) 19 feet 8 inches, (F-105F) 20 feet 2 inches; engine Pratt & Whitney 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.

XV-5A V/STOL VERTIFAN

Prime Contractors: Ryan Aeronautical Company and General Electric Company

Remarks

A cooperative project of Ryan and General Electric, the XV-5A is an Army research aircraft, a V/STOL craft of the fan-in-wing variety capable of a speed range from zero to more than 400 knots. The jet-powered plane gets its vertical lift from downward thrust produced by two five-foot diameter fans submerged in the wings. The fans are powered by the exhaust from two General Electric J85 engines. The XV-5A made its first flight on May 25, 1964 and the first complete transition from vertical to forward flight and vertical landing on November 17, 1964. The plane completed its Phase II evaluation late in 1965.

Specifications

Span 29.83 feet; length 44.52 feet; height 14.75 feet; tread 8.39 feet; design gross weight 9,200 pounds; engines 2 General Electric J85; maximum VTOL useful load 4,419 pounds.

Performance

Maximum horizontal speed at sea level 475 knots (Mach .72); transition speed up to 105 knots; stalling speed, flaps down 82 knots; maximum rate of climb 9,500 feet per minute; altitude 40,000 feet; ferry range 650 nautical miles.

XV-8A FLEEP

Prime Contractor: Ryan Aeronautical Company

Remarks

A manned flexible wing aerial utility vehicle, the XV-8A Fleep is being developed by Ryan under contract with the Army Aviation Materiel Laboratories. The XV-8A is the first manned flight vehicle using wings of flexible material attached to a keel and leading edge members which form a V-shaped, kite-like surface supporting the fuselage suspended below the wing. It is capable of transporting cargo and personnel in and out of rugged, unimproved areas where conventional airstrips are not available. The Fleep completed its initial flight test program at the Army's Yuma Test Station and advanced tests and evaluation were in progress late in 1965.

Specifications

Span 33.4 feet; length 26 feet; wing area 450 square feet; empty weight 1,029 pounds; gross weight 2,359 pounds; payload 1,000 pounds; engine 1 Continental pusher 210 horsepower.

Performance

Maximum speed 70 knots; cruise speed 48 knots; stall speed 35 knots; take-off distance at maximum gross weight 253 feet; take-off distance at 1,300 pounds gross weight 80 feet; range 115 miles.

S-58 TRANSPORT HELICOPTER

Prime Contractor: Sikorsky Aircraft

Remarks

The S-58 is an all-purpose transport flown by the U.S. Navy, Marine Corps, Army, many foreign countries, and domestic and foreign commercial operators. More than 1,750 S-58's have been manufactured. The S-58 has a seating capacity of crew (pilot and co-pilot), 12–18 passengers or eight 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 four bladed tail rotor are all metal. The first flight took place March 8, 1954.

Specifications

Empty weight 7,900 pounds; normal gross weight 13,000 pounds; useful load 5,100 pounds; engine Wright R-1820 1,525 horsepower.

Performance

Maximum speed 122 miles per hour; service ceiling 9,500 feet; range 247 miles.

SH-3A ANTISUBMARINE HELICOPTER

Prime Contractor: Sikorsky Aircraft

Remarks

The SH-3A has a flying boat hull and twin gas turbine engines and is being produced for the U.S. and Canadian navies as well as the Japanese Defense Forces as an antisubmarine warfare weapons system. The SH-3A established a world helicopter speed record of 210.6 miles an hour, becoming the first helicopter ever to exceed 200 mph in a sanctioned speed test. On March 6, 1965, an SH-3A established a distance record of 2,116 miles when it was flown from an aircraft carrier near San Diego, Calif. to a carrier at Jacksonville, Fla. The event was the first nonstop coast to coast helicopter flight. The SH-3A gives the Navy a helicopter that can both search out and destroy enemy submarines; it was flown publicly for the first time March 24, 1959. The SH-3A is in the weight class of a medium transport helicopter and can alight on and take off from water in an emergency. It also has the capability to take off, land or fly on a single engine at low gross weights, and it is the first helicopter produced under the Navy's weapons system concept.

Specifications

Empty weight 11,419 pounds; normal gross weight 18,044 pounds; useful load 6,625 pounds; engines 2 General Electric T58-8 1,250 shaft horsepower each.

Performance

Maximum speed 162 miles per hour; service ceiling 14,700 feet; range 540 miles.

S-61N HELICOPTER AIRLINER

Prime Contractor: Sikorsky Aircraft

Remarks

The S-61N is the amphibious version of the first helicopter ever designed specifically for airline use and to airline standards. It carries from 25 to 28 passengers depending on the seating arrangement. The aircraft is powered by twin gas turbine engines and can continue flight to normal landing areas with one engine inoperative. The S-61L land version has been flown in scheduled passenger service by Los Angeles Airways since early 1962. S-61Ns have been delivered to Ansett-ANA, British European Airways, Greenlandair, Nishi Nihon and Pakistan International Airlines for scheduled passenger service in their respective countries as well as San Francisco-Oakland Airlines in this country. First flight of an S-61 passenger liner took place December 6, 1960. Basically, the S-61L and N use the major mechanical components of the twin-turbine SH-3A helicopter, which is produced by Sikorsky as an antisubmarine warfare weapons system for the U.S. Navy.

Specifications

Empty weight 11,732 pounds; normal gross weight 19,000 pounds; useful load 7,268 pounds; engines 2 General Electric CT58-110-1 1,250 horsepower each.

Performance

Maximum speed 149 miles per hour; service ceiling 11,500 feet; range 276 miles.

S-61R TRANSPORT HELICOPTER

Prime Contractor: Sikorsky Aircraft

Remarks

The S-61R was chosen by the Air Force as its long range rotary wing support system for cargo and personnel transportation duties with various USAF commands. Sister ship of the speed record-breaking Navy SH-3A, the S-61R is designated CH-3C by the Air Force. The S-61R FAA type certificate was presented coincidentally with the delivery of the first CH-3C to an operational AF squadron in December, 1963. Twin gas turbine engines provide power. The cargo door and ramp to the rear of the cabin permit rapid loading and unloading. A watertight boat hull and large sponsons provide water alighting capability. The CH-3C performs a variety of missions with six major USAF commands. These missions include assault airlift support, overwater drone retrieval, support of remote missile and radar sites, logistics supply, personnel rescue, recovery of space personnel and hardware, advanced pilot training, and geodetic survey in mountains and deserts.

Specifications

Empty weight 11,500 pounds; normal gross weight 19,500 pounds; useful load 8,000 pounds; engines 2 General Electric T58-110-1 1,250 horsepower each.

Performance

Maximum speed 165 miles per hour; service ceiling 11,700 feet; range 500 miles.

S-62 SEARCH & RESCUE HELICOPTER

Prime Contractor: Sikorsky Aircraft

Remarks

The single-turbine S-62, the first amphibious helicopter built with a flying boat-type hull, is used by the Coast Guard as its search and rescue helicopter. The S-62 was the first American turbine-powered helicopter to be certified by the Federal Aviation Agency for commercial operations. The FAA certificate permits it to carry a pilot, a co-pilot, and 11 passengers. It can operate from land, water, ice, snow, swamp, mud or almost any other surface. The first flight took place May 22, 1958. Besides its Coast Guard application, the S-62 is used in airline and industrial operations. It is especially useful to the oil industry in supplying offshore drilling platforms.

Specifications

Empty weight 4,857 pounds; normal gross weight 8,100 pounds; useful load 3,243 pounds; engine General Electric T58-8 1,250 horsepower.

Performance

Maximum speed 110 miles per hour; service ceiling 10,200 feet; range 449 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. Delivery of six was made to the U.S. Army in 1964. The S-64 is designed to carry its cargoes externally. It has a rear-facing pilot's seat to provide a clear view of the cargo during pick-ups or deliveries. By means of a hoist it can pick up or deposit loads without landing. A lightweight van, capable of carrying artillery pieces, six jeeps or other vehicles, can be attached to the Skycrane fuselage.

Specifications

Empty weight 17,240 pounds; normal gross weight 38,000 pounds; useful load 20,760 pounds; engines 2 Pratt & Whitney JFTD-12A 4,050 horsepower each.

Performance

Maximum speed 124 miles per hour; service ceiling 10,500 feet; range 172 miles.

CH-53A HEAVY ASSAULT TRANSPORT

Prime Contractor: Sikorsky Aircraft

Remarks

The Sikorsky S-65A was designed for the Marine Corps as a heavy assault transport with a payload capacity of four tons. A normal gross weight of 33,484 pounds makes it the largest transport helicopter produced in the free world. Designated CH-53A by the Marine Corps, the helicopter has a three-man crew and seats for 38 troops or four medical attendants plus litters for 24 patients. First flight took place October 14, 1964.

Specifications

Empty weight 20,950 pounds; normal gross weight 33,484 pounds; useful load 12,534 pounds; engines 2 General Electric T64-6 turboshaft.

Performance

Cruising speed 172 miles per hour; service ceiling 16,700 feet; range 282 miles.

SA-26T CORPORATE AIRCRAFT

Prime Contractor: Swearingen Aircraft

Remarks

The SA-26T or Merlin II is a 7–9 place pressurized twin-engine airplane designed for corporate use. It has a cylindrical fuselage with a pressure differential of 5.5 pounds per square inch. The SA-26T is powered by 2 United Aircraft of Canada Ltd., Pratt & Whitney PT6A-20 free turbine engines equipped with propeller reversing features and rated at 550 maximum continuous shaft horsepower. The SA-26 made its initial flight on April 12, 1965.

Specifications

Span 45 feet 10 1/2 inches; length 37 feet 6 7/8 inches; height 14 feet 5 5/8 inches; cabin dimensions: length 128 inches, width 62 inches, height 59 inches; fuel capacity 400 gallons; designed gross weight 9,000 pounds; empty weight 5,495 pounds; designed landing weight 8,050 pounds.

Performance

Speed at 18,000 feet 280 miles per hour; range at 18,000 feet 1,340 miles; at 25,000 feet 1,700 miles; rate of climb at sea level 1,950 feet per minute; service ceiling 30,000 single engine ceiling 12,000 feet; stall speed 87 miles per hour.

WREN-460 STOL AIRPLANE

Prime Contractor: Wren Aircraft Corporation

Remarks

The Wren 360 is a 4-place high wing single engine airplane which derives its STOL and slow speed abilities through aerodynamic devices. New Cessna 182 airframes are utilized in the manufacture of the Wren for economy and to assure the user of parts and service availability in most of the free world. The Wren 460 is capable of sustained patrol for up to 11 3/4 hours at speeds of 45 to 60 miles per hour using less than 35 percent power while maintaining a level flight attitude and maneuverability through the use of slow speed control devices. The prototype Wren 460 first flew in January, 1963, and FAA certification was received June, 1964.

Specifications

All-metal high wing fixed gear; span 36 feet 6 inches; length 27 feet 4 inches; height 8 feet 9 inches; empty weight 1,698 pounds; useful load 1,202 pounds; gross weight 2,800 pounds; fuel capacity 65–84 gallons.

Performance

Maximum speed 160 miles per hour; cruise speed 75 percent power at 6,500 151 miles per hour; take-off and landing speed 35 miles per hour; rate of climb at sea level 1,080 feet per minute; service ceiling 19,200 feet; cruise range 872 miles; maximum range 1,150 miles; take-off to clear 50-foot obstacle 605 feet; landing to clear 50-foot obstacle 612 feet.

MINUTEMAN ICBM

Weapon System Integrator: The Boeing Company; technical direction by TRW Space Technology Laboratories.
Associate Contractors: Thiokol Chemical Corporation, first stage engine; Aerojet-General Corporation, second-stage engine; Hercules Powder Company, third-stage engine; Autonetics Division of North American Aviation, guidance and control system; AVCO or General Electric Company, re-entry vehicles; Sylvania Electronics, ground communications.

Remarks

Minuteman is an intercontinental ballistic missile operated by the USAF's Strategic Air Command. Eight hundred Minuteman missiles are on strategic alert at four 150-missile wings and a fifth wing with 200 missiles. An advanced version, the Minuteman II, is being deployed in 150 underground sites near Grand Forks Air Force Base, North Dakota, and will be deployed in 50 sites in Montana. Starting in 1966, the 800 operational missiles will be replaced by Minuteman II. Minuteman is a three-stage, solid-fuel missile which can be launched from blast-proof underground launch facilities within seconds after a command is received. Multiple-channel communications connect an underground launch control center, manned by two SAC officers, with 10 launch facilities. Minuteman II has a larger second stage engine, improved guidance system, greater range and payload capabilities, more flexible targeting and increased survivability. Minuteman carries a nuclear warhead. In photo, Minuteman II.

Specifications

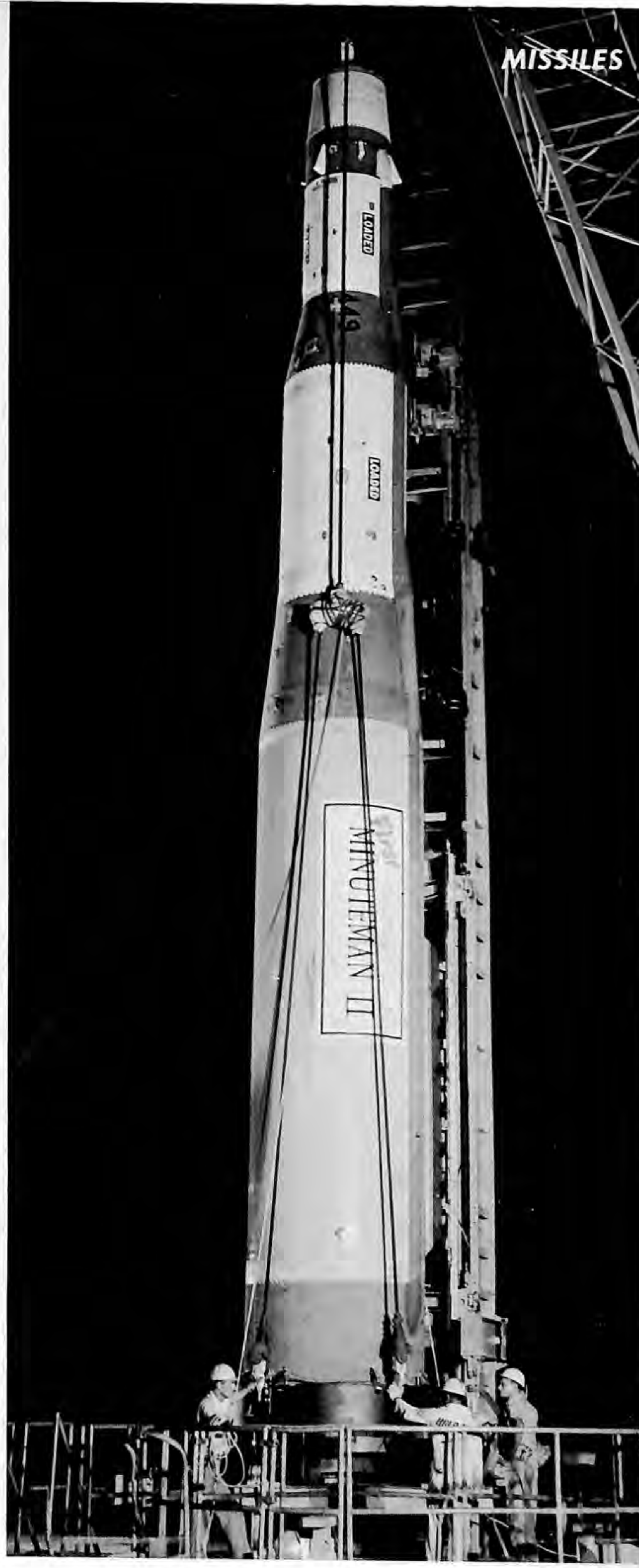
Minuteman I (WS-133A)
Model LGM-30A 54 feet, Model LGM-30B 55.9 feet; weight approximately 65,000 pounds; diameter, approximately 6 feet at first stage interstage.

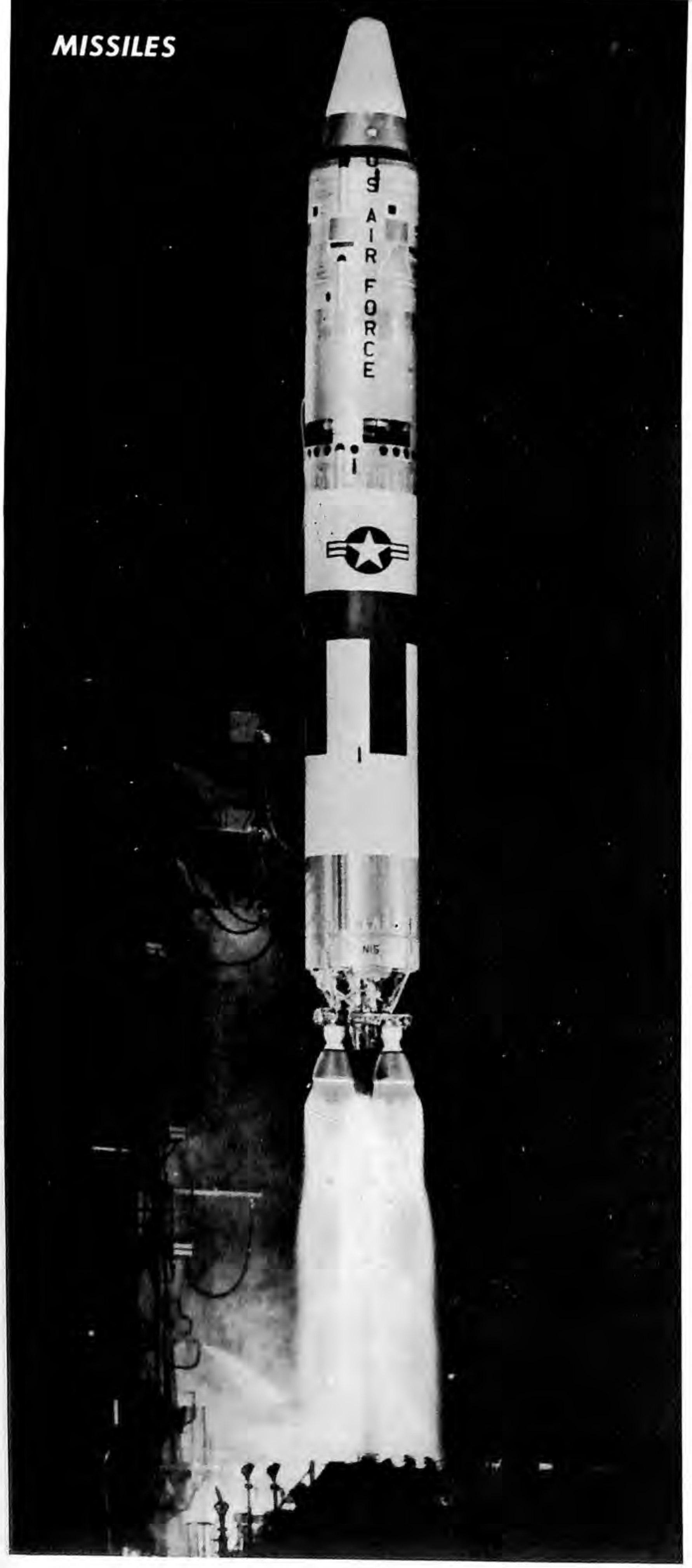
Minuteman II (WS-133B)
Length, 59.8 feet; weight approximately 70,000 pounds.

Performance

Minuteman I—range more than 6,300 nautical miles; speed more than 15,000 miles per hour.

Minuteman II—range more than 7,000 nautical miles; speed more than 15,000 miles per hour.





TITAN II ICBM

Program Management: Ballistic Systems Division, Air Force Systems Command.
Prime Contractor: Martin Company, systems integration, base integration, airframe.
Associate Contractors: Aerojet-General Corporation, (propulsion); AC Spark Plug Division, General Motors, (guidance); GE Missile and Space Vehicle Division, (re-entry division); TRW Space Technology Laboratories, (technical direction).

Remarks

Titan II is an intercontinental ballistic missile operated by the USAF's Stategic Air Command. In 1965 SAC had 54 operational missiles at 3 bases. Largest of the U.S. ICBM's, Titan II is equipped with sophisticated penetration aids. It is a 2-stage weapon with 430,000 pounds of rocket thrust in its basic stage and 100,000 pounds in the upper 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 during 1965.

Specifications

Length 103 feet; diameter 10 feet; weight 330,000 pounds.

Performance

Range 6,300 nautical miles with Mark VI re-entry vehicle.

ATLAS ICBM (SERIES D, E, AND F)

Prime Contractor: Convair Division of General Dynamics Corporation.
Associate Contractors: Rocketdyne Division of North American Aviation, Inc., engines; General Electric, Burroughs Corp., and American Bosch Arma, guidance; General Electric, and Avco Corp., re-entry 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 1950's and early 1960's. Installed at launch sites across the nation under the Air Force policy of concurrence, Atlas missiles and their launch sites were produced in three basic versions, the Series D, Series E, and Series F. Series D missiles were emplaced in "soft," above-ground launch sites. Series E missiles were installed in above-ground "coffin" launch facilities providing greater protection from enemy attack than the Series D emplacements; Series F missiles served as deterrents in underground "silo" launch sites, fully hardened against all but a direct hit. Series D missiles used engines producing 360,000 pounds thrust with radio-inertial guidance systems. Series E and Series F missiles employed uprated engines capable of 390,000 pounds thrust, and used all-inertial guidance systems. Atlas ICBM's in test flights placed re-entry 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 considered for flights in the Air Force ABRES (Advanced Ballistic Re-Entry Systems) program and the Nike-Target program.

POLARIS/POSEIDON FLEET BALLISTIC MISSILES

Prime Contractor: Lockheed Missiles & Space Company
Associate Contractors: Aerojet-General Corporation and Hercules Powder Company (power plants); General Electric Company and Hughes Aircraft Company (guidance and fire control); Nortronics Division of Northrop Corporation (nose cone).

Remarks

Now in full production at Lockheed, the third generation Polaris A3 became operational with the Navy in September, 1964. It was preceded into service by the A1 version, which had a range of 1,200 nautical miles, and the A2, with 1,500 nautical miles range. While A2 was an outgrowth of A1, the A3 is a 90 percent new missile. Among many innovations was a switch from the "champagne bottle" shape of the earlier missiles to a simple, bullet-shaped configuration. The A3, with a range of 2,500 nautical miles, will arm 28 of the planned 41 Polaris submarines; the remaining 13 will carry the A2 weapon. The A1, operational since November, 1960, is being retired from fleet duty but will find utility as a booster in developing and testing missile and space programs; its first such assignment was 1965 employment in a test program aimed at USAF development of a new stellar inertial guidance system. All three versions of the Polaris are two-stage, solid propellant, inertially guided ballistic missiles which can be fired from submerged or surfaced submarines, from surface ships or from land bases. In early development is a new, follow-on Fleet Ballistic Missile designated Poseidon C3 and designed to be "eight times as effective as the A3." Poseidon will have range comparable to that of the A3 but twice the payload.

PERSHING SURFACE-TO-SURFACE WEAPON SYSTEM

Prime Contractor: Martin Company, Orlando

Remarks

Pershing is a two-stage, surface-to-surface ballistic missile which is now operational with Army artillery battalions. It was deployed with the U.S. Seventh Army in Europe in early 1964. 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 by cargo aircraft and helicopter. 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 at the launch site.

Specifications

Length 34 1/2 feet; diameter 3.3 feet; weight approximately 10,000 pounds; speed supersonic; trajectory ballistic; propulsion two-stage, solid propellant; guidance inertial; warhead nuclear.

Performance

Range 100-400 nautical miles.

SERGEANT SURFACE-TO-SURFACE MISSILE

Prime Contractor: Sperry Rand Corporation, Sperry Utah Company Division

Remarks

The Sergeant is reliable, mobile, simple to operate and, with its ease of maintenance and degree of immunity to countermeasures, represents an Army weapon system comparable in general field worthiness to the shorter-range unguided rockets. Sergeant has been purchased and deployed in the Federal Republic of Germany with U. S. and German troops. Status: Operational

Specifications

Length 35 feet; diameter 31 inches; weight 10,000 pounds.

CORPORAL SURFACE-TO-SURFACE MISSILE

Prime Contractor: Jet Propulsion Laboratory (Development): Firestone Tire and Rubber Company; and Gilfillan, Incorporated (Manufacture)

Remarks

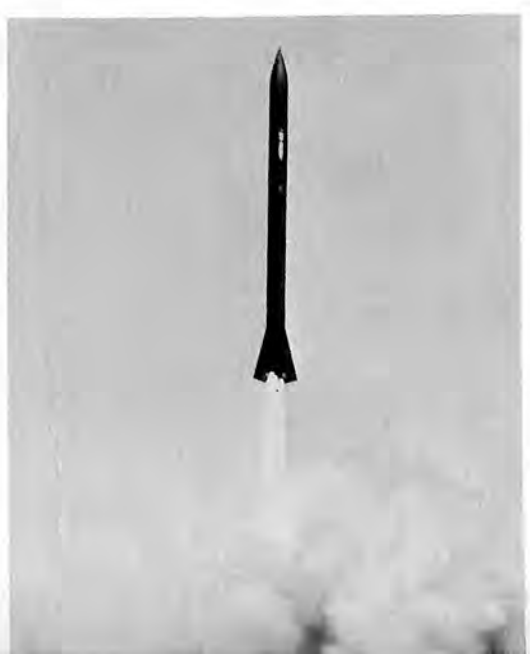
The first Army ballistic missile, the Corporal was in operational service in the United States and in Europe for more than a decade until 1965, when it was phased out.

Specifications

Length 45 feet; weight 11,000 pounds.

Performance

Range 75 nautical miles; conventional or nuclear warhead.



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 weapon system but it has research utility. The Army Missile Command, under sponsorship of the Defense Department's Advanced Research Projects Agency, has contracted the Chrysler Missile Division for the modification and launch of several Redstone missiles in connection with Project DEFENDER. The missiles will be launched from the Pacific Missile Range. Redstone was selected because of its proven reliability, availability, mobility and flexibility which permits adaptation to the mission with minimum cost and reaction time. Several other programs utilizing Redstones for new missions are being considered.

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 Company
Associate Contractors: Allison Division of General Motors Corporation, (engine); Thiokol Chemical Corporation, (booster); Goodyear Aircraft Corporation, (ATRAN guidance) (A version); AC Spark Plug Division, General Motors Corporation, (interial guidance) (B version).

Remarks

An improved version of Matador first launched in 1959, Mace is an all-weather guided missile incorporating enough innovations to justify its classification as an entirely new weapon system. Mace TM-76A is fired from a truck-drawn zero-length launcher; Mace TM-76B, from hardened underground bases.

Specifications

Swept-wing missile; length 44 feet; span 23 feet; diameter 54 inches; guidance Mace A self-contained ATRAN (Automatic Terrain Radar and Navigator) map-matching system; guidance Mace B all-inertial; warhead nuclear or conventional; power Allison J33 jet engine, booster Thiokol motor.

Performance

Speed over 650 miles per hour, supersonic in terminal dives; range over 650 miles (Mace A), over 1,200 nautical miles (Mace B); thrust 5,200 pounds (engine), 100,000 pounds (booster).

LANCE SURFACE-TO-SURFACE MISSILE

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.
Associate Contractors: American Bosch Arma Corporation, (gyroscope); Systron-Donner Corporation, (guidance components); North American Aviation, Rocketdyne Division, (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 is destined to replace LaCrosse, Honest John and possibly the Little John. It would complement division tube artillery and extend the division commander's capability for nuclear and non-nuclear supporting fire. Lance is built at the Army's Michigan Ordnance Missile Plant near Detroit by the LTV Michigan Division as prime contractor. 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. Prime mover is the M-113-A1 tracked vehicle with modified hull. Guidance is a simplified inertial unit developed in the Army Missile Command's Guidance and Control Laboratory.

REGULUS I SURFACE-TO-SURFACE MISSILE

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.

Remarks

One of the earliest operational missiles, Regulus I is still in Navy service aboard a number of Navy submarines. The Navy has made nearly 1,000 launches of Regulus I in the past decade.

Specifications

Length 34 feet; engine Allison J33 turbojet plus solid boost rocket.

Performance

Speed subsonic; range 500 nautical miles; conventional or atomic warhead.

SHILLELAGH SURFACE-TO-SURFACE MISSILE

Prime Contractor: Aeronutronic Division, Philco Corporation, A Subsidiary of Ford Motor Company

Remarks

The tank-fired Shillelagh surface-to-surface guided missile system is to be the main armament of the Army General Sheridan armored reconnaissance airborne assault vehicle. It is designed for use against hard-point targets, such as armored vehicles or pillboxes, where high accuracy and first-round "kill" probability are important. Shillelagh is also being adapted to the Army's new compact turret for retrofitting M-60 Main Battle Tanks. Launched from a combination gun/launcher (closed breech), Shillelagh has completed a highly successful development test program at White Sands Missile Range, N. M., in which Army gunners literally punched bulls'-eyes out of both moving and stationary targets at maximum range. A command guided missile, Shillelagh is handled in the field with the ease of a conventional round of ammunition. Aeronutronic is now beginning the Shillelagh industrial program at an Army missile plant in Lawndale, Calif., where the weapon system will be mass produced. Performance and specifications are not yet releasable.

LITTLE JOHN SURFACE-TO-SURFACE ROCKET

Prime Contractor: Electronics and Space Division, Emerson Electric

Remarks

Little John is a surface-to-surface rocket, designed for support of airborne operations. The Little John is propelled by a single-stage, solid propellant engine. It is unguided. Payload capabilities of the Little John include either nuclear or high-explosive warheads. The Little John attains a top speed in the supersonic range. Originally designed to supplement medium and heavy artillery in airborne divisions, the Little John is now scheduled to be replaced by the Lance.

Specifications

Length 14.5 feet; diameter 12.4 inches; weight 800 pounds.

Performance

Range more than 10 miles; speed supersonic.

HONEST JOHN SURFACE-TO-SURFACE ROCKET

Prime Contractor: Electronics and Space Division, Emerson Electric

Remarks

Honest John is a surface-to-surface rocket propelled by a single-stage, solid propellant engine, with spin stabilization provided by small spin rockets. Unguided, it attains a top speed of Mach 1.7. The Honest John is capable of carrying either a nuclear or high-explosive warhead. The current status of the Honest John is operational. Army inventory requirements will be filled shortly. It is scheduled to be replaced by the Lance.

Specifications

Length 24.8 feet, diameter 30 inches; weight 4,500 pounds.

Performance

Range 12 miles; maximum speed Mach 1.7.

TOW ANTITANK MISSILE

Prime Contractor: Hughes Aircraft Company
Associate Contractor: Army Munitions Command, Picatinny Arsenal (warhead development).

Remarks

TOW is the first supersonic missile guided in flight by means of a two-wire link between launcher and missile. It gets its name from the description: Tube-launched, Optically-tracked, Wire-Guided. A major improvement of this weapon over earlier antitank missiles is the simplified and highly accurate aiming device. To fire at a stationary object or a moving target, the gunner simply aligns the crosshairs of his telescopic sight on the target and then launches the missile, which automatically flies along his line of sight. With TOW, the gunner does not have to estimate range to the target, speed of the target of angle between target course and his weapon. If he keeps the crosshairs centered, signals transmitted through the two-wire link automatically correct the missile's course. TOW can be carried by troops and fired from a simple lightweight launcher mounted on a tripod. It can also be mounted on a variety of ground vehicles, including the M113 armored personnel carrier. TOW is in development status and developmental models have been successfully test fired.

MAW (MEDIUM ANTITANK WEAPON)

Prime Contractor: McDonnell Aircraft Corporation

Remarks

McDonnell and the Army Missile Command are taking separate approaches to development of a new Medium Antitank/assault Weapon light enough to be carried by a single soldier. The weapon will be used by infantry troops at the platoon level against tanks and armored vehicles.

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 two men or mounted on a vehicle.

LACROSSE CLOSE SUPPORT MISSILE

Prime Contractor: Martin Company, Orlando

Remarks

A close support weapon in service for several years, Lacrosse carries either conventional or nuclear warheads for a range of about 20 miles. It is 19.2 feet long and 20.5 inches in diameter; power is a single Thiokol rocket. Lacrosse is launched from a tube and track assembly mounted on a standard truck. It is guided by an external command system which employs a forward observation station.

SUBROC ANTISUBMARINE MISSILE

Prime Contractor: Goodyear Aerospace Corporation
Subcontractors: Librascope Division, General Precision, Inc., fire control system; Aerospace Systems Division, 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

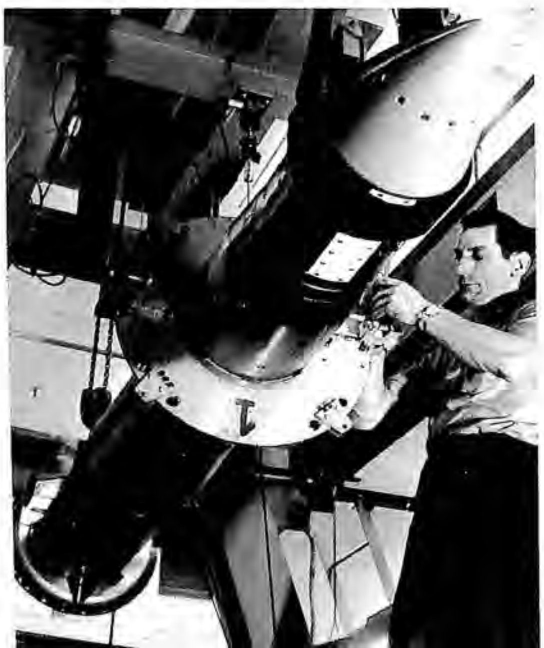
Subroc, an underwater-to-air-to-underwater antisubmarine missile, has been developed by Goodyear Aerospace Corporation for the Bureau of Naval Weapons under technical direction of the Naval Ordnance Laboratory, White Oaks, Md. It is being manufactured in production quantities as a submarine-launched, 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. In 1965, operational test firings of the Subroc were conducted successfully from the USS Plunger in the mid-Pacific.

Specifications

Weight approximately 4,000 pounds; length and diameter classified.

Performance

Classified.



MARK 46 ANTISUBMARINE TORPEDO

Prime Contractor: Aerojet-General Corporation
Associate Contractors: Bendix Corporation (guidance and control system); Clevite Corporation (engine).

Remarks

The Navy's Mark 46 is a solid rocket propellant driven, high speed, deep running, passive/active acoustic homing antisubmarine torpedo. It is designed to seek, acquire, pursue and destroy conventional and nuclear submarines. The Mark 46 can be launched from aircraft, the torpedo tubes of antisubmarine vessels, from conventional or drone helicopters or by ASROC (antisubmarine rocket). The Mark 46 is now in production at Aerojet's Von Karman Center, Azusa, Calif.

Specifications

Approximate dimensions: Length 101 inches; diameter 12 3/4 inches; weight 570 pounds.

ASTOR MARK 45 GUIDED TORPEDO

Prime Contractor: Westinghouse Electric Corporation

Remarks

The Astor Mark 45 is a wire-guided torpedo carried by Navy submarines for use against enemy submarines. It is in operational status.

Specifications

Length 20 feet; weight 2,000-plus pounds.

ALFA SURFACE-TO-UNDERWATER WEAPON

Prime Contractor: U.S. Navy
Associate Contractors: Avco Corporation (frame); Navy Propellant Plant (propulsion).

Remarks

The Alfa is a surface-to-underwater high explosive depth charge used in antisubmarine warfare. In operational status, it is deployed aboard destroyers and cruisers. Alfa is being replaced by the ASROC ASW system.

Specifications

Weight 500 pounds; propulsion solid rocket; guidance free flight.

Performance

Range 1,000 yards.

ASROC/TERRIER

Prime Contractors: Honeywell Inc. (ASROC) and General Dynamics (Terrier)

Remarks

The ASROC/Terrier system is a new concept in shipboard weaponry. It combines the ASROC (anti-submarine rocket) and Terrier supersonic guided missile weapons system in an advanced ASROC/Terrier combination aboard a new class of ship. The ASROC has been modified so that it can be fired from a Terrier launcher on the forward deck of the ship. Two Terrier or two ASROC missiles can be alternately mounted on the launcher and fired in rapid succession, although one cannot be on the launcher with the other at the same time. Combining the systems leads to several advantages, including reduced manpower requirements, greater missile storage capacity and less topside weight and deck area. The first of the new class of ships to be equipped with the system is the USS Belknap (DLG-26).

SPRINT ANTI-MISSILE MISSILE

Prime Contractor: Martin Company, Orlando (under contract to Bell Telephone Laboratories, Inc.)

Remarks

The Sprint missile is one of the major components being developed for the Army's Nike-X missile defense system. Its mission is to intercept ICBM warheads, or the warheads of medium range missiles which might be launched from submarines, after they have entered the earth's atmosphere. Reaction time is a major consideration, since these missiles approach the earth at velocities over 17,000 mph. Sprint's time of flight—from launch to intercept—will be only a matter of seconds. Sprint is designed to be "popped" from its launch cell rather than flown out under its own power. A gas generator placed under the missile will eject it like a dart from a blowgun. The Sprint booster will ignite after the missile is above ground. At the same time, the missile will pitch over on a trajectory that will take it to the vicinity of the computer-calculated intercept point. Fine adjustments will be made in flight via radar signals from the ground.

Specifications

Length 27 feet; diameter 4.5 feet at base; configuration cone shaped; propulsion two-stage, solid propellant; guidance command via ground radar; warhead nuclear; type surface-to-air interceptor.

Performance

Speed hypersonic; other details classified.

NIKE ZEUS ANTIMISSILE MISSILE

Prime Contractors: Western Electric Company (for complete Nike X ground and flight system); Douglas Aircraft Company (for Nike Zeus flight system).

Remarks

In advanced development, Nike Zeus is one of the two missile components of the Nike X antimissile missile system, which also includes a battery of tracking radars and computers on the ground. Zeus complements the Sprint missile to provide the system with a wide variety of intercept ranges and altitudes, Zeus being the long-range member of the missile team.

Specifications

Three stages, all solid propelled; overall length 48 feet; basic stage thrust 450,000 pounds.

Performance

Has successfully intercepted both ICBM nose cones and satellites.

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, a target tracking radar, a missile tracking radar, electronic and data processing equipment, and remote controlled launchers. The system is continually being modified to meet new threats and to incorporate advances in missile technology.

Specifications

Length 41 feet; diameter 31 1/2 inches; weight 10,000 pounds at launch; propulsion system two 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 ANTI-AIRCRAFT MISSILE

Prime Contractor: Raytheon Company
Associate Contractors: Aerojet-General Corporation (propulsion); Northrop Corporation (launcher/loader/carrier).

Remarks

Hawk is a surface-to-air anti-aircraft missile in operational service with the Army and the Marine Corps. In addition, Hawk is deployed overseas in Europe, Panama and the Far East, and is being produced by five nations for their own use. Hawk employs a radar homing system. It is effective from targets ranging from tree-top level to about 50,000 feet. Hawk is now employed in South Viet Nam. Although designed primarily as an anti-aircraft missile, Hawk has had successful intercepts of tactical missiles such as Honest John, Little John and Corporal. For additional performance against tactical ballistic missiles, Raytheon is developing an advanced ATBM/Hawk.

Specifications

Weight 1275 pounds; solid propellant; high explosive warheads.

Performance

Speed supersonic.

TARTAR SHIPBOARD ANTIAIRCRAFT MISSILE

Prime Contractor: Pomona Division of General Dynamics Corporation
Associate Contractor: Aerojet-General Corporation (propulsion).

Remarks

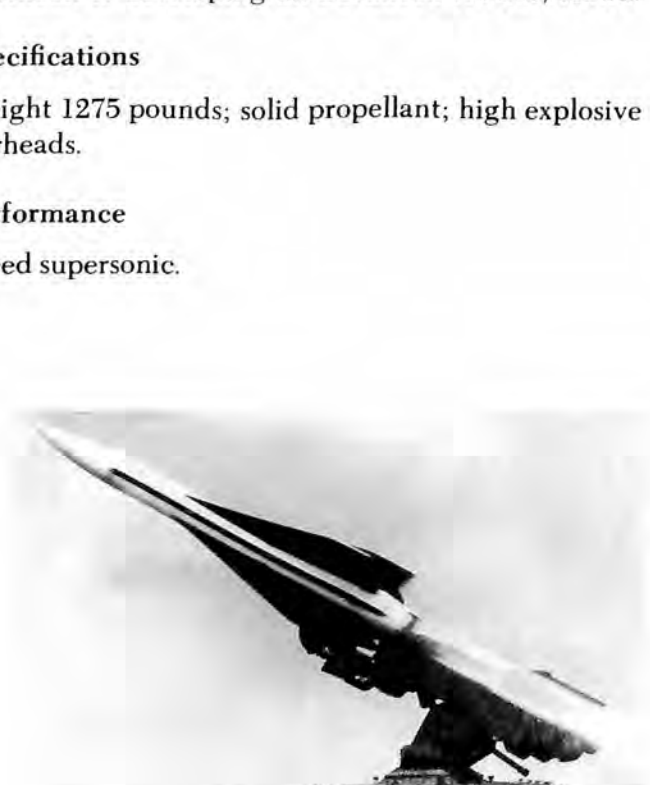
Tartar is a high-performance guided missile that arms 23 destroyers and three cruisers of the U.S. fleet. In addition, Tartar serves four other navies of the free world—France, Italy, Japan and Australia. In a minimum of space, the missile contains a complex homing system, a dual-thrust rocket motor and a new type auxiliary power supply. Tartar's semi-active homing guidance system is made up of several interrelated units so constructed to form the basic airframe of the missile. Each unit houses a major part of the homing and control system. The auxiliary power supply uses the hot gases from solid grain fuel to generate its own electrical and hydraulic power.

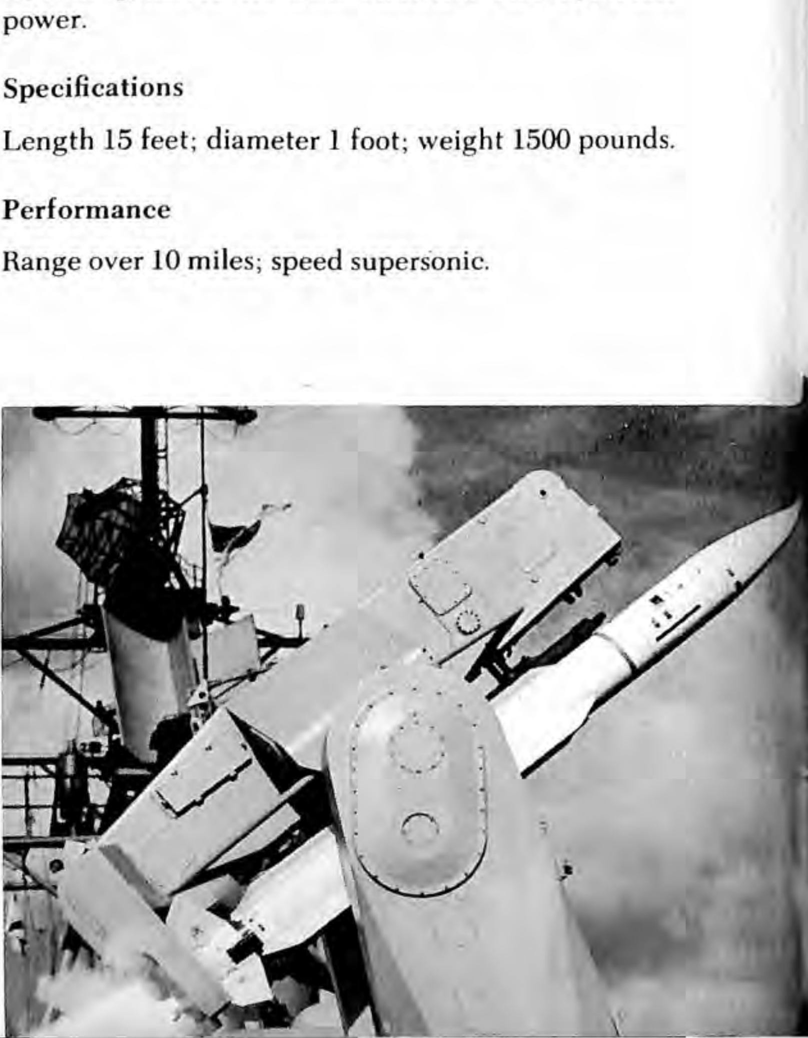
Specifications

Length 15 feet; diameter 1 foot; weight 1500 pounds.

Performance

Range over 10 miles; speed supersonic.





ADVANCED TERRIER SHIPBOARD ANTIAIRCRAFT MISSILE

Prime Contractor: Pomona Division of General Dynamics Corporation
Associate Contractor: Hercules Powder/Allegheny (propulsion).

Remarks

The Advanced Terrier guided missile is fulfilling its design role as a major element in the Navy's missile arsenal. This surface-to-air antiaircraft weapon already arms 28 of the 39 warships that eventually will carry Terrier. Terrier is powered by two 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 three conventional carriers, five cruisers, and three nuclear-powered warships.

Specifications

Length 27 feet (with booster); diameter 1 foot; weight 2600 pounds.

Performance

Range, over 10 miles; speed supersonic.

TALOS SHIPBOARD MISSILE

Prime Contractor: Bendix Mishawaka Division, The Bendix Corporation.
Associate Contractors: McDonnell Aircraft Corporation (airframe); Sperry Gyroscope Company (guidance).

Remarks

Talos is a supersonic surface-to-air missile designed to provide the Navy with a system of long-range, high-fire power defense against air attack. It also has a surface-to-surface capability. It is a two-stage weapon with a solid-fuel rocket booster and the missile is powered by a 40,000 horsepower ramjet engine. It is operational with the Navy's fleet of missile cruisers which includes the 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 3000 pounds; booster 10 feet long.

Performance

Range over 65 nautical miles; speed 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. In 1965 there were eight operational 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 two 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.

REDEYE SURFACE-TO-AIR MISSILE

Prime Contractor: Pomona Division of General Dynamics
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.

CHAPARRAL AIR DEFENSE GUIDED MISSILE SYSTEM

Prime Contractor: Aeronutronic Division, Philco Corporation, A Subsidiary of Ford Motor Company

Remarks

Now in development, Chaparral uses the Sidewinder 1C guided missile in a multiple mount on a vehicle chassis to provide maximum mobility for an air defense of Army divisions on the battlefield. The Navy-developed Sidewinder uses an infrared guidance system and is currently used by the Navy, Marines and Air Force as an air-to-air missile. Adaptation of the existing Sidewinder and standard Army vehicle to forward area air defense role is designed to avoid costly and time-consuming development work.

STANDARD SHIPBOARD MISSILE

Prime Contractors: Pomona Division of General Dynamics Corporation (guidance, control and airframe) and The Johns Hopkins University Applied Physics Laboratory.

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 two versions of Standard Missile: extended range (ER) and medium range (MR). The principal difference between the two 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 development status.

Specifications

Length 27 feet (ER) and 15 feet (MR); diameter 1 foot.

Performance

Speed, supersonic; range, classified.

ANTI-SATELLITE WEAPONS

Prime Contractors: The Boeing Company (Air Force Program); Douglas Aircraft Company (Army Program)

Remarks

The Department of Defense is developing two types of weapons designed to destroy hostile space satellites. Both are in operational status but advanced development continues. Test firings are conducted at Johnston Island in the Pacific and intercepts have been made at distances of "hundreds of miles." The Air Force and the Army are developing separate weapons based on existing missiles. The Air Force system consists of a Thor-Agena combination with a terminal stage; the Army employs a Nike-Zeus with a terminal stage. Other details are classified.

SHRIKE MISSILE

Prime Contractor: Texas Instruments Incorporated (Responsible for engineering and manufacturing support and production. Shrike was developed by the U.S. Naval Ordnance Test Station, China Lake, California.)
Associate Contractor: Rocketdyne, A Division of North American Aviation (propulsion).

Remarks

Shrike is an air-launch missile of the Bureau of Naval Weapons, used primarily as a penetration aid. It provides a new attack capability against heavily defended tactical targets through its anti-radiation homing capability.

ADM-20C QUAIL

Prime Contractor: McDonnell Aircraft Corporation
Associate Contractor: General Electric (Lynn) (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 pre-programmed 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 5 1/2 feet; weight 1200 pounds.

Performance

Same operating envelope as the B-52

HOUND DOG (AGM-28) MISSILE

Prime Contractor: North American Aviation, Inc., Space and Information Systems Division
Principal Subcontractors: Pratt & Whitney Aircraft (J-52 turbojet engines); Autonetics Division of North American Aviation (guidance and controls).

Remarks

The AGM-28 Hound Dog (formerly GAM-77) is a B-52-launched air-to-surface strategic missile operated by the USAF Strategic Air Command. Nearly 30 SAC bases throughout the United States are equipped with the double-sonic missile. The B-52 carries two inertially guided Hound Dogs—one under each wing. Capable of carrying a nuclear payload, the Hound Dog can be used as a penetration aid for the bombers, or can be directed to strike at primary targets. The Hound Dog engines, using the same fuel as the mother bomber, can be used to supplement the thrust of the B-52.

Specifications

Length 43 feet; fuselage diameter 30 inches; weight approximately 5 tons.

Performance

Range 700-plus miles; speed over Mach 2.

BULLPUP A (AGM 12-B), BULLPUP B (AGM 12-C) AND NUCLEAR BULLPUP (AGM 12-D) MISSILES

Prime Contractor: Martin Company, Orlando

Remarks

Extremely accurate and reliable, the Bullpup is launched more than two miles away from surface targets such as airfield installations, trains or truck convoys, tanks, bridges, etc. Tracking flares in the tail enable the pilot to "follow" the missile while sending commands for changes in direction. Bullpup reaches speeds near Mach 2. Martin-Orlando design and production reliability permit missile to be handled as a "round of ammunition" with no prefiring checkout required. Very little ground support required. Can be loaded on aircraft ready for firing in about five minutes using only normal bomb-handling equipment or special ground handling equipment now in production at Orlando. In photo, Bullpup B.

Specifications

Bullpup A: length 11 feet; diameter 1 foot; weight 571 pounds including warhead. Bullpup B: length 13.6 feet; weight 1785 pounds. Nuclear Bullpup: classified. Bullpup A: 250-pound conventional warhead. Bullpup B: larger conventional warhead. Nuclear Bullpup: Nuclear warhead. Bullpup A range 3–6 miles. Bullpup B range more than 6 miles. Nuclear Bullpup range classified. Propulsion pre-packaged liquid rocket; guidance radio command, controlled by pilot.

CONDOR AIR-TO-SURFACE MISSILE

Prime Contractor: Naval Ordnance Test Station

Remarks

Condor is the name assigned a new air-to-surface missile designed for use with the Navy F-111B and A-6 aircraft. It is in developmental status and all details are classified.

WALLEYE GUIDED BOMB

Prime Contractor: Naval Ordnance Test Station

Remarks

A guided bomb with a range of several miles, Walleye weighs approximately 1,000 pounds. It is equipped with movable fins for television guidance by the pilot.

ZUNI AIR-TO-SURFACE MISSILE

Prime Contractor: Naval Ordnance Test Station

Remarks

One of the earlier Navy mi siles, Zuni is used on fighter and attack aircraft as a ground strafing weapon. It is an unguided rocket, five inches in diameter, with a range of about five miles. It warhead is a conventional high explosive charge.

HORNET AIR-TO-SURFACE MISSILE

Prime Contractor: Columbus Division, North American Aviation

Remarks

Hornet is a proposed system developed by Columbus Division and funded through evaluation tests by the Air Force. It is an air-launched, electro-optically guided antitank missile.

WASP ROCKET

Prime Contractor: Electronics and Space Division, Emerson Electric

Remarks

The WASP is a 40 millimeter, unguided, spin-stabilized, zero-launch rocket. It carries an anti-personnel, high-explosive warhead. The WASP can be launched in a variety of ways; including light-weight, highly-mobile, jeep-mounted or even backpack-carried launchers. Another type of launcher is a component part of a helicopter armament system, aimed and fired by the pilot. The WASP is being developed under an Army contract. Additional details are classified.

SPARROW AIR-TO-AIR MISSILE

Prime Contractor: Raytheon Company
Associate Contractor: Rocketdyne, A Division of North American Aviation (propulsion).

Remarks

Sparrow is an air-to-air guided missile carried into use by F4B and F4C Phantom jet interceptors. It is currently in operation with Navy, Marine Corps and Air Force and is being deployed in Viet Nam. Guidance for the Sparrow is CWFM homing system.

Specifications

Weight 400 pounds; length 12 feet; diameter 8 inches.

Performance

Can destroy targets at any angle. Speed supersonic.

SIDEWINDER 1-C AIR-TO-AIR MISSILE

Prime Contractors: Philco Corporation, A Subsidiary of Ford Motor Company, and Raytheon Company
Associate Contractors: Rocketdyne, A Division of North American Aviation (propulsion) and General Electric Company (guidance)

Remarks

Sidewinder 1-C is a second generation version of the Navy's air-to-air missile. A simple aluminum tube powered by a Rocketdyne Mark 36 solid rocket motor, Sidewinder 1-C is a rugged, inexpensive missile used on fighter aircraft by both the Air Force and the Navy. The first guided missile to destroy enemy aircraft in combat, it has interchangeable infrared and radar heads.

Specifications

Length 9 feet; diameter 5 inches; warhead conventional.

Performance

Speed Mach 2.5.

FALCON AIR-TO-AIR MISSILES

Prime Contractor: Hughes Aircraft Company
Associate Contractors: Thiokol Chemical Corporation and Lockheed Propulsion Company (propulsion).

Remarks

Among the smallest missiles in service, the Air Force's Falcon family consists of several different types of air-to-air missiles which are guided either by radar or by a heat-seeking (infrared) homing device. Among the later versions are the AIM-26, which has a nuclear warhead, and the AIM-47, which arms the YF-12A interceptor. 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: Litton Systems (computer, controls and displays); Rocketdyne, A Division of North American Aviation (motor).

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: Douglas Missile & Space Systems Division
Major Subcontractor: Aerojet General Corporation

Remarks

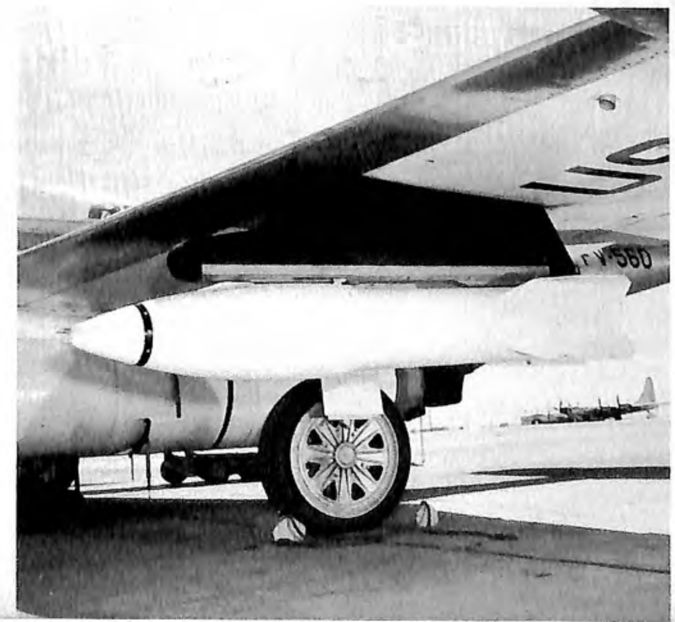
The AIR-2A Genie is an air-to-air rocket with a solid-propellant motor capable of carrying a nuclear warhead. Douglas builds the Genie weapon system for the USAF's Air Defense Command. It is carried on the F-101B Voodoo and the F-106 Delta Dart.

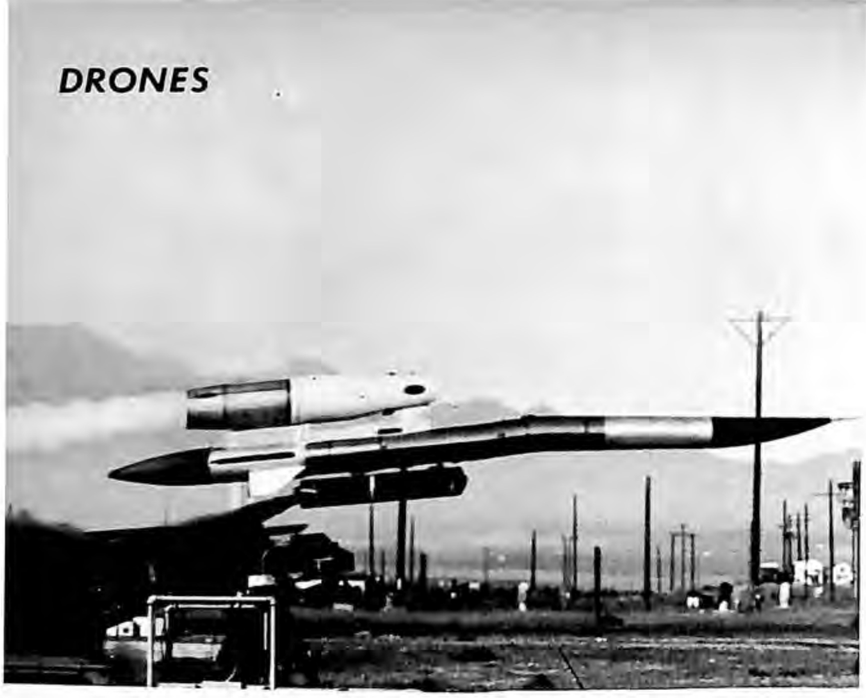
Specifications

Length 9 feet; width 1 foot 5 inches; weight 830 pounds.

Performance

Classified.





MQM-42A GUIDED TARGET MISSILE

Prime Contractors: North American Aviation, Columbus Division, airframe and guidance/control; Rocketdyne, A Division of North American Aviation, booster rocket

Associate Contractor: The Marquardt Corporation, ramjet engine

Remarks

The MQM-42A Redhead/Roadrunner was developed for the Army Missile Command as a low unit-cost, dual-purpose target missile capable of operation at up to twice the speed of sound and at very low and high altitudes. It is used primarily for realistic training of crews of the Hawk-type of anti-air warfare batteries of the Army Air Defense System. The Redhead/Roadrunner is capable of simulating the speeds and flight patterns of a wide variety of attack missiles and high-performance aircraft. Launch and flight are controlled electronically from a ground control station. Power is provided by a solid propellant booster which drops away after burnout, and in-flight propulsion is furnished by a top-mounted ramjet engine. The missile body contains two Luneberg passive augmentation lenses to enhance tracking by ground radars throughout the mission profile. Recovery is effected by activation of a parachute/retro-rocket system housed in the rear equipment section.

Specifications

Length 24.8 feet; diameter 12 inches; gross weight 861 pounds

Performance

Speed Mach 0.9–2.1; service ceiling 60,000 feet.

REGULUS I AND II DRONES

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.

Remarks

Both Regulus I and II drones are in active service with the Navy. Regulus I, known in drone version as the KDU-1 and BQM-6C, is a 34-foot air-breathing vehicle with J-33 jet engine. Regulus II, known as the KD2U-1 and MQM-15A as a drone, was designed to carry atomic warheads at Mach 2 speed from submarines and missile ships. Powered by a J79 General Electric jet engine, it has a 1,000-mile range. With the success of the Polaris submarine missile, Regulus II was relegated to drone operations, mostly in the Pacific at Pt. Mugu, California. It is 54 feet long. Both Reguluses are launched with jet-assist bottles to achieve flying speed. Both have versions equipped with landing gear so that they can be landed on air strips and reused as target drones.

DH-2C DRONE HELICOPTER

Prime Contractor: Del Mar Engineering Laboratories

Remarks

The Del Mar Whirlymite Drone Helicopter is a small, lightweight, pilotless aircraft specifically developed to meet military requirements. It is presently in service with the Army as a target drone, but it is readily adaptable for numerous other purposes—such as surveillance platforms, critical cargo carriers, decoys, and aerial weapons delivery vehicles. The target drone helicopter is silhouetted to an exact 7/16th scale of the Army's UH-1B helicopter. The purpose of the DH-2C is to assist the Army in learning more about the combat development of helicopters and anti-helicopter weaponry in combat situations.

Specifications

Length 16 feet 8 inches; height 7 feet; main rotor diameter 16 feet; weight 560 pounds; engine 1 AiResearch GTP 30–91 gas turbine 85 shaft horsepower.

Performance

Speed 85 miles per hour; range 90 miles; ceiling 13,000 feet.

MODEL 1025 TARGET DRONE (MQM-39A, MQM61-A)

Prime Contractor: Beech Aircraft Corporation

Remarks

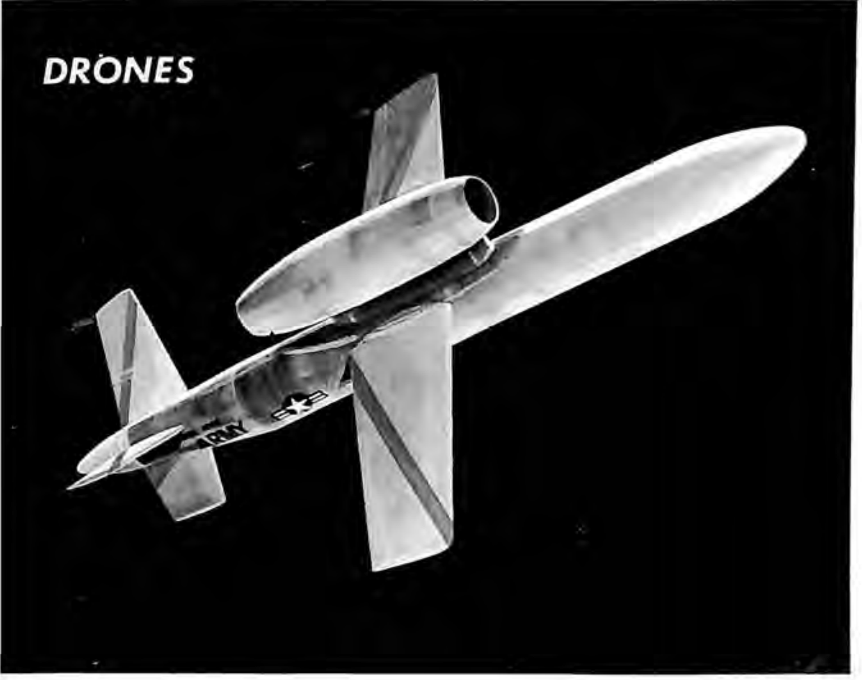
A target missile system designed principally for programs involving developmental and evaluation testing and personnel training of surface-to-air and/or air-to-air weapon systems. The system features make it ideal as a realistic threat simulation for radar guided weapons. Infrared augmentation can be provided to make it compatible with heat seeking type weapons. Some of the weapon systems the Beech Model 1025 target has been successfully used with are the Hawk, Sparrow, Terrier, Tartar, Sidewinder, Nike-Hercules, Nike-Ajax and Redeye. If desired, the Model 1025 may be used as a tug for towing banner type targets for gunnery practice.

Specifications

Span 155 inches; length 181 inches; diameter 17 3/4 inches; weight 664 pounds; engine McCullough turbosupercharged 125 horsepower with Beech constant speed propeller.

Performance

Maximum speed 305 knots; service ceiling 40,000 feet; endurance 82 minutes on station.



MODEL 1025-TJ TURBOJET TARGET MISSILE

Prime Contractor: Beech Aircraft Corporation

Remarks

A new target missile system, that provides "out of sight" target for surface-to-air and air-to-air weapons systems. It is a remote-controlled, recoverable target missile, capable of speeds in excess of 400 knots for a duration of over 90 minutes. It was designed for such weapons systems as the Hawk, Nike, Mauler and Redeye. This drone is the turbojet version of both the standard MQM-39A and MQM-61A target drones.

Specifications

Wing span, 142.8 inches; length, 204 inches; diameter, 17.75 inches; weight, 999 pounds without launch booster; engine one Continental 321-2 turbojet.

Performance

Maximum speed Mach .8; service ceiling, in excess of 40,000 feet; endurance, in excess of one hour.

AQM-37A TARGET DRONE

Prime Contractor: Beech Aircraft Corporation

Remarks

This supersonic missile target simulates enemy threat systems for air-to-air and surface-to-air missile evaluation and training. The target provides active or passive radar area augmentation for simulating threat systems by means of an optical Luneberg lens or traveling wave tube installation. A chemical flare is provided for missions which require infrared augmentation. Two miss-distance indication systems are also available. The target is normally air launched, but does have surface launch capability from shipboard or land-based launcher systems. The target's universal launch capability and high performance uniquely suit it to a number of tactical and support missions. The target utilizes a liquid bipropellant rocket engine. The engine is a prepackaged system consisting of a booster and sustainer thrust chamber; an orifice selector valve for propellant flow control; fuel, oxidizer, and nitrogen tankage; regulator and start valves; and the necessary interconnecting structure and plumbing.

Specifications

Span, 39 inches; length, 161 inches; diameter, 13 inches; weight, 560 pounds; frame, swept delta wings with canard controls, cylindrical centerbody and a tangent ogive nose; engine, one Rocketdyne liquid-propellant engine with 630 pounds thrust.

Performance

Maximum speed Mach 2; service ceiling, 70,000 feet.

NV-105 TARGET DRONE

Prime Contractor: Northrop Corporation

Remarks

A new low-cost target drone aircraft, the NV-105 was designed for Army and Navy use to fill the gap between low speed and supersonic targets now in service. The small jet-powered aircraft provides realistic training to increase proficiency of military gunnery and antiaircraft missile crews and is suitable for exercising a wide range of operational missiles. Featuring ease of handling and high reliability, the NV-105 was brought from design to construction in less than 4 months. The rapid evolution of the new recoverable drone has been facilitated by incorporation of many components already in operation. Using radio control and tracking systems, it will be 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.

Specifications

Wing span 52 inches; weight 218 pounds empty, 335 pounds fully fueled for flight; launch standard zero-length from ground or shipboard; guidance radio control; power plant 30-pound-weight 100-pound-thrust turbojet Williams engine.

Performance

Speed to 400 knots; service ceiling 25,000 feet; endurance 0.5–1.5 hours.

NV-101 AUTOGYRO DRONE AIRCRAFT

Prime Contractor: Northrop Corporation

Remarks

Designed to fulfill a variety of essential missions, particularly in limited war situations, the NV-101 is an autogyro drone aircraft. Low cost, with speed/range adapted to surveillance, it simulates a helicopter for target purposes, functions as a communications relay and can deliver supplies by remote control to front line troops fighting in jungle or rugged terrain. Radio control can be passed from one ground station to another.

Specifications

Length 12 feet 4 inches; height 3 feet 9 inches; rotor diameter 24 feet; guidance radio control, visual and radar; power plant McCullough 0-100-1 2-cycle 72 horsepower; preflight rotor spinup by compressed air or propellant charge.

Performance

Speed 20–160 miles per hour; rate of climb 1,700 feet per minute; service ceiling 14,000 feet; jump take-off zero velocity; landing speed virtually zero (flareout); endurance more than 60 minutes at full throttle, over 3 hours at reduced power setting.

MQM-57A SURVEILLANCE DRONE

Prime Contractor: Northrop Corporation

Remarks

Developed for the Army Signal Corps by the Northrop Ventura Division, the propeller-driven MQM-57A has been operational since 1959. The small mobile radio-controlled aircraft travels with Army field units by truck and trailer including ground launcher, tracking and other equipment. It can be set up and launched quickly in rough terrain from a camouflaged position and flown by remote control over enemy installations to provide field commanders with rapid photo reconnaissance. After the aircraft's camera has exposed its film by radio command over the target, it is flown back and recovered by parachute. The camera is removed, the film processed and prints delivered within minutes without risking a pilot and man-carrying aircraft. The MQM-57A provides greater surveillance flexibility than ever before to combat units. Sensory equipment other than aerial camera is optional.

Specifications

Span 11 feet 6 inches; length 13 feet 5 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.

RP 76-4 ROCKET TARGET AIRCRAFT

Prime Contractor: Northrop Corporation

Remarks

An advanced version of the AQM-38B under evaluation by the armed services and NATO, the RP-76-4 was developed by Northrop Ventura as a versatile air-launched target to operate at speeds to Mach 2 and above and at altitudes from sea level to 80,000 feet. The drone simulates a large enemy bomber when equipped with a special radar reflectivity device. As with the AQM-38B, this advanced drone is provided as a complete target service package in which the drones, their launch planes, tracking, control equipment and personnel are provided under a single contract with mobility for operation virtually anywhere in the world. If the target drone is not destroyed by missile fire, it may be recovered by parachute for reuse. Missile crews tracking from radar ground stations gain hours of economical tracking experience without target destruction.

Specifications

Span 4 feet 4 inches; length 11 feet; fuselage diameter 1 foot; guidance radio control from ground station; launch from any standard fighter type aircraft; power plant solid propellant rocket.

Performance

Speed Mach 2.25; rate of climb 10,000 feet per minute; ceiling 80,000 feet; duration 4 minutes powered, 30 minutes controlled glide.

AQM-38B TARGET AIRCRAFT

Prime Contractor: Northrop Corporation

Remarks

An advanced target for surface-to-air and air-to-air weapon training and evaluation, the AQM-38B is a complete flight service package. The drone aircraft are supplied, maintained and operated (flown and tracked) by Northrop personnel allowing military missile crews a maximum amount of operational training at minimum cost. The AQM-38B is a simple low-cost lightweight target launched from jet fighter aircraft and radio-controlled from the ground. Since 1960 it has been deployed against the Nike Ajax, Hercules and Hawk missiles with high performance at high and low altitudes. Its solid-propellant rocket engine is the key structural component. Aluminum honeycomb wings, plastic nose section and aft fuselage are attached to the steel engine case. Luneberg lens passive radar augmenter provides radar cross-section of large aircraft. Provision is made for proximity or miss distance scorer. Northrop Ventura RPTA-1 is the tracking aid system. The integral flight control package including control vanes, is located in the nose section. Recovery after flight is by 2-stage parachutes.

Specifications

Span 5 feet; length 9 feet 8 inches; height 1 foot 6 inches; fuselage 1 foot diameter; guidance Northrop Ventura autopilot with radio command override; powerplant solid propellant rocket.

Performance

Thrust 100 pounds.

OQ-19 AERIAL TARGET

Prime Contractor: Northrop Corporation

Remarks

The OQ-19 type radio-controlled aerial target is a propeller-driven, all metal, high wing monoplane used by the Army, Air Force and Navy as a training target for surface-to-air missiles. For many years it has been the worldwide standard target for antiaircraft weapon training. This drone's rugged construction and simplicity of maintenance permit multiple missions in rapid sequence. All versions are recoverable by parachute.

Specifications

Span 11 feet 6 inches; length 13 feet 7 inches; height 2 feet 7 inches; launch rotary, zero-length or catapult (also fitted optionally for air launch); powerplant 2-cycle 4-cylinder aircooled McCulloch engine.

Performance

Speed 175 knots; rate of climb 3,060 feet per minute; ceiling 23,000 feet; flight endurance 60 minutes.

NV-104 ADVANCED SURVEILLANCE DRONE

Prime Contractor: Northrop Corporation

Remarks

An improved version of the SD-1, the NV-104 is capable of doubling the present surveillance drone's performance while utilizing 98 percent of its existing ground support equipment. It is being developed under an independent company research program for Army use. Equipped with still or motion picture cameras, the NV-104 can be flown by remote control over enemy terrain and returned with vital intelligence information without risking a pilot's life or expensive man-carrying aircraft.

Specifications

Span 11 feet 2 inches; length 14 feet 9 inches; payload volume 5 cubic feet; payload weight 150 pounds; guidance radio control, visual and radar; powerplant 250 horsepower T-63 Allison turbojet engine.

Performance

Speed 280 miles per hour; altitude 27,600 feet; endurance 210 miles or 45 minutes; rate of climb 3,600 feet per minute.

RYAN FIREBEE JET TARGET DRONE (MQM-34D ARMY) — (BQM-34A NAVY, AIR FORCE).

Remarks

Ryan Firebee jet target drone has been modified for multi-purpose use, featuring beefed-up payload capability and Towbee targets that are streamed astern Firebee during weapons exercises. Ryan has delivered more than 2,500 Firebee targets to the military services since 1947. The Firebee/Towbee systems have been used extensively at White Sands in support of research and development studies and at McGregor for Hawk missile exercises.

Specifications

Speed, 200–600 knots TAS; altitude, 50 to 60,000 feet; endurance, up to 100 minutes; range, more than 1,200 kilometers; payload, up to 1,000 pounds; reliability, over 7,500 flights; maintainability, high-quality, interchangeable components; mobility, requires only standard military vehicles.

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, North American Aviation Space & Information Systems Division; S-IVB stage, Douglas Missile & Space Systems Division; propulsion, all stages, Rocketdyne Division of North American Aviation.

Remarks

The superbooster which will send American astronauts to the moon under NASA's Project Apollo/Saturn V is a three-stage vehicle 364 feet tall which is capable of placing a 240,000 pound payload in earth orbit or sending 90,000 pounds into a lunar trajectory. The first or basic stage, known as S-IC is 33 feet in diameter and 138 feet long. Its key component is the mighty F-1 rocket engine which develops 1,500,000 pounds of thrust in a single chamber. Five such engines, fueled with kerosene and liquid oxygen, give the first stage a launch output of 7,500,000 pounds to start the 6,400,000 pound vehicle on its journey. The lunar mission profile will begin with launching of the Saturn V space vehicle at Cape Kennedy, Florida, with the first stage reaching full thrust three seconds after ignition. S-IC engine cutoff occurs 150 seconds later, placing about 700 tons of equipment toward a low-earth orbit, 50 miles down range at an altitude of approximately 40 miles and at a velocity of about 6,000 miles an hour. After engine cutoff, the S-IC stage is jettisoned and the S-II stage takes over. NASA has contracted with The Boeing Company for the assembling of eight flight and two test first stage vehicles. NASA has built two test and two flight stages at the Marshall Space Flight Center from parts supplied by Boeing. First unmanned flights of the Saturn V are set for 1967.

S-IC STAGE

Prime Contractor: The Boeing Company

Remarks

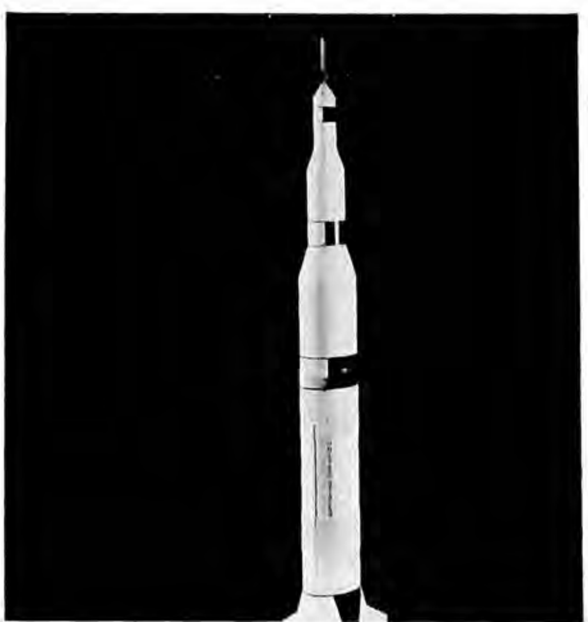
The S-IC is the first stage booster for the Saturn V launch vehicle. More than 7,500 Boeing employes are working on this largest and most powerful booster stage in the free world at six sites in the United States. Most of the major subassembly and vertical assembly tasks are accomplished at NASA's Michoud Operations plant in New Orleans. Burning liquid oxygen and kerosene, the S-IC will propel the three-stage Saturn V and the Apollo spacecraft during the first two and a half minutes of flight. Initial stages produced were the S-IC-D (for "dynamic test") and S-IC-F (for "facilities test"); both are ground test versions. Flight vehicles are now in production.

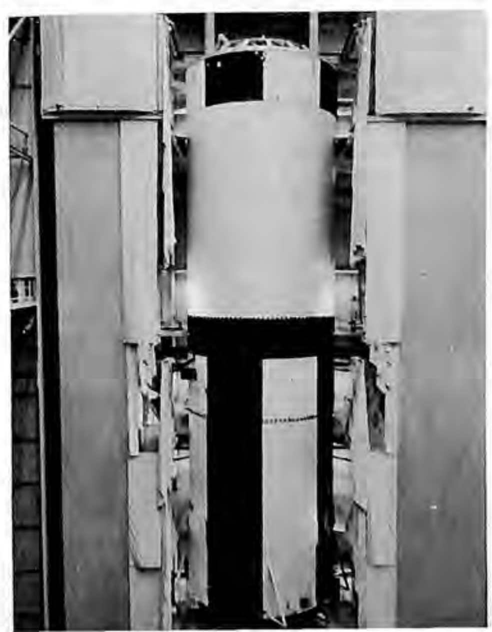
Specifications

Length 138.5 feet; diameter 33 feet.

Performance

Thrust 7,500,000 pounds produced by 5 Rocketdyne F-1 engines; lunar voyage firing endurance 150 seconds.





S-II STAGE

Prime Contractor: North American's Space and Information Systems Division

Major Subcontractors: Acoustica Associates, controllers; American Brake Shoe Company, hydraulic pumps; Consolidated Electrodynamics Corporation, tape recorder; Electrada Corporation, test conductor console; Electroplex, Subsidiary Borg-Warner Corporation, logic modules, power supplies; Fairchild Precision Metal Products, cryogenic lines; B. H. Hadley, disconnects; W. O. Leonard, Inc., vent valves; Parker Aircraft Company, hydraulic systems; Solar Division—International Harvester Corporation, cryogenic lines.

Remarks

The S-II is the second stage of NASA's Apollo launch vehicle—the giant Saturn V. Most powerful hydrogen-fueled booster under production, the S-II is destined for Apollo manned lunar missions and will help power three Americans to the moon. The S-II is being developed and manufactured at Seal Beach, California, by North American's Space and Information Systems Division, Downey, 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 five Rocketdyne J-2 engines of 200,000 pounds thrust each, the S-II develops a total thrust of one million pounds. The S-II is powered by a combination of liquid hydrogen and liquid oxygen propellants. The four outer engines gimbal. The fifth engine, which is centered, is fixed.

Specifications

Height 81 1/2 feet; diameter, 33 feet; weight, 80,000 pounds empty and 1,025,000 pounds loaded.

Performance

Thrust (combined engines) 1,000,000 pounds.

S-IVB STAGE

Prime Contractor: Douglas Missile & Space Systems Division

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 10 minutes. It sends the Apollo spacecraft into earth orbit, but, unlike the two 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 72-ton stage is fabricated of lightweight aluminum except for "battleship" or ground test versions which were made of heavy stainless steel. In addition to its use as topmost stage of the Saturn V "stack," the S-IVB is also used as the upper stage of the Saturn IB vehicle. In the latter version the stage has a 22-foot diameter, as compared with 33 feet in the Saturn V application. Propellant capacity, however, is the same for both versions. The earlier S-IV stage, powered by six Pratt & Whitney RL10 engines producing 90,000 pounds thrust, was used on Saturn I.

Specifications

Length 58 feet; diameter (Saturn V) 33 feet; engine Rocketdyne J-2; propellants liquid oxygen/liquid hydrogen; propellant capacity 230,000 pounds.

Performance

Thrust 200,000 pounds.

SATURN IB

Contractors: Marshall Space Flight Center, NASA, engineering and systems assembly; S-IB stage, Chrysler Corporation Space Division; S-IVB stage, Douglas Missile & Space Division; Apollo spacecraft, Space & Information Systems Division, North American Aviation, Inc.; propulsion, S-IB & S-IVB stages, Rocketdyne, A Division of North American Aviation, Inc.

Remarks

The primary mission of the Saturn IB is to launch the Apollo spacecraft into earth orbit for spacecraft testing and astronaut training. Saturn IB will launch increasingly complex versions of the Apollo spacecraft until the equipment and rendezvous and docking techniques required for manned lunar landings are perfected. The three stage Saturn IB is larger and more powerful than Saturn I. A major change is in the S-IB first stage which has been redesigned by Chrysler to eliminate 9 tons of weight. The first of 12 Saturn IB flight tests is scheduled for early 1966.

Specifications

Length 224 feet, with Apollo payload and escape tower; weight, approximately 1,300,000 pounds. S-IB stage is 80 feet long, 21.4 feet in diameter; S-IV stage is 60 feet long, 21.7 feet in diameter. Apollo spacecraft is 49 feet long, 12.8 feet in diameter. The escape tower is 33.3 feet long.

Performance

The S-IB stage is powered by eight Rocketdyne H-1 engines, each of which produces 200,000 pounds of thrust or a total of 1,600,000 pounds. The S-IVB is powered by a single Rocketdyne J-2 engine which generates 200,000 pounds of thrust at altitude. Auxiliary propulsion systems provide attitude during coast. Saturn IB is capable of placing approximately 18 tons in earth orbit and 2.5 tons in lunar orbit.

SATURN I

Contractors: Marshall Space Flight Center, NASA, systems, engineering and assembly; S-I stage, Chrysler Corporation Space Division; S-IV stage, Douglas Missile & Space Systems Division; Apollo spacecraft, Space and Information Systems Division, North American Aviation; propulsion, S-I stage, Rocketdyne, A Division of North American Aviation; S-IV stage, Pratt & Whitney Division, United Aircraft Corporation.

Remarks

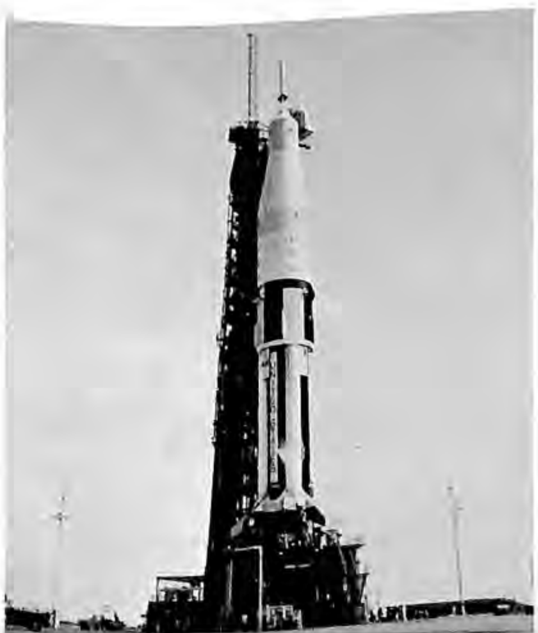
The successful launch of the Pegasus III Meteoroid Detection Satellite on July 30, 1965 marked the tenth and final flight of the Saturn I rocket. All ten flights in the Saturn I series, beginning with SA-1 on October 27, 1961, were completely successful. The S-I stages fired in the first eight flights were built by NASA's Marshall Space Flight Center. The last two S-I stages were provided by Chrysler Corporation's Space Division. In the first four flights, only the S-I stage was live. SA-5, 6 & 7 involved flight tests of both the S-I and S-IV stages. SA-9, 8 &10 launched Pegasus Meteoroid Detection Satellites into orbit.

Specifications

The Saturn I, without the boilerplate Apollo spacecraft, stands 162 feet high and weighs 1,016,000 pounds fully fueled. With Apollo spacecraft added, the configuration has a height of 188 feet and weighs about 1,300,000 pounds. The S-I stage is 80 feet long, 20 1/2 feet in diameter; S-IV is 40 feet long, 18 feet in diameter.

Performance

The S-I stage is powered by a cluster of eight Rocketdyne H-1 engines, each of which produces 188,000 pounds of thrust for a total of 1,500,000 pounds. The S-IV stage has six RL-10 engines, each generating 15,000 pounds of thrust for a total of 90,000 pounds. Saturn I is capable of placing 11 tons in earth orbit.



GEMINI–TITAN II LAUNCH VEHICLE

Prime Contractor: Martin Company, Baltimore
Associate Contractors: Aerojet-General Corporation (propulsion); General Electric Company and Burroughs Corporation (guidance)

Remarks

The Gemini-Titan II launch vehicle, a modified Titan II ICBM, is a two-stage, liquid fueled rocket powered by storable, hypergolic propellants. Fire-in-the-hole staging is employed, whereby the second stage engine ignites before separation from the first stage is complete. A number of modifications were made to man-rate the Titan II rocket, including: addition of a malfunction detection system; substitution of radio guidance for inertial guidance; addition of instrumentation; substitution of a new second stage forward oxidizer skirt assembly to mate the rocket with the Gemini spacecraft.

Specifications

Length, minus the space craft, 90 feet; diameter 10 feet; weight fueled prior to liftoff 331,500 pounds; total weight of Aerozine 50 (fuel) more than 105,000 pounds; total weight of nitrogen tetroxide (oxidizer) more than 198,000 pounds; Stage I engine Aerojet-General YLR87-AJ-7 comprised of two independently operating subassemblies mounted on a single engine frame; Stage II engine Aerojet-General YLR91-AJ-7 similar to a single subassembly.

Performance

Average weight of spacecraft orbited 7,500 pounds; Stage I thrust 430,000 pounds; Stage II thrust at altitude 100,000 pounds; Stage I burn about 2.5 minutes; Stage II burn about 3 minutes; altitude at staging about 40 miles; downrange distance at staging about 50 miles; altitude at spacecraft separation about 90 miles; and downrange distance at spacecraft separation about 450 miles.

TITAN III

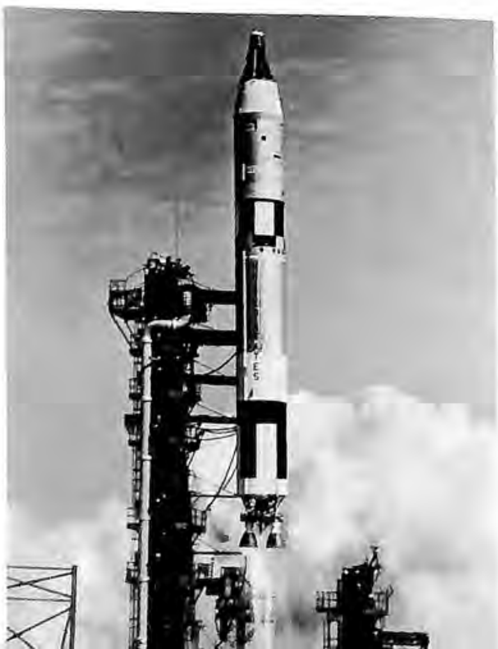
Program Management: Space Systems Division, Air Force Systems Command.
Major Contractors: Martin Company, Denver, (systems integration, airframe, flight test); Aerojet-General Corporation, (liquid propulsion); AC Spark Plug Division, General Motors, (guidance); United Technology Center, (solid propellant boosters); The Ralph M. Parsons Company, (launch facilities design and engineering); and Aerospace Corporation, (general systems engineering).

Remarks

Titan III is the nation's heavy-duty military space booster. All propellants are storable for long hold and quick reaction capabilities. Because it utilizes the building-block principle, its weight-lifting capabilities vary from 5,000 to 27,000 pounds into earth orbit, and up to 5,000 on a lunar trajectory. The largest version which has flown to date, Titan III-C, produced a liftoff thrust of 2.4 million pounds. Titan III-C has been designated the Manned Orbiting Laboratory booster.

Specifications

Titan III-C is 127 feet tall with a standard payload fairing; the MOL version will be about 145 feet tall. Diameter of all stages is 10 feet. Weight, 1,400,000 pounds.



TITAN III TRANSTAGE

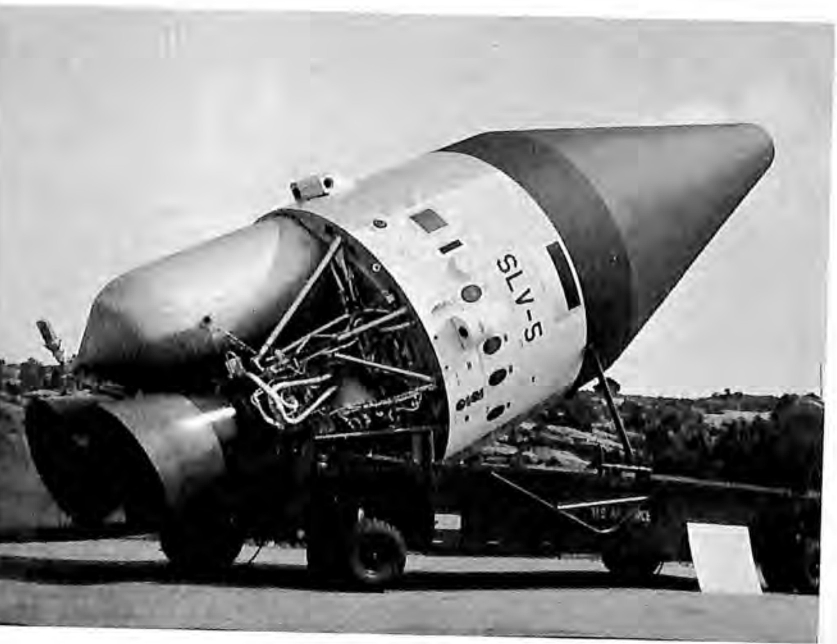
Program Management: Space Systems Division, Air Force Systems Command.
Major Contractors: Martin Company, Denver, (systems integration and airframe); Aerojet-General Corporation, (propulsion); AC Spark Plug Division, General Motors, (guidance).

Remarks

Transtage currently is being used as a space "taxi-cab," delivering multiple payloads to multiple destinations as needed. In addition, it will serve as an in-orbit propulsion package for the Air Force Manned Orbiting Laboratory.

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, A Division of North American Aviation, Inc.; General Electric Company; Acoustica Corporation.

Remarks

An uprated version of the reliable and versatile Atlas space launch vehicle, the Atlas SLV-3 is scheduled for use as the booster for Lunar Orbiter, OAO (Orbiting Astronomical Observatory), OGO (Orbiting Geophysical Observatory), PRIME, Gemini, and military spacecraft. The vehicle is standardized, providing standardized electronic system kits on a basic airframe. Kits for guidance, telemetry, tracking, autopilot, and electrical systems are installed to tailor each vehicle to its particular space mission and its launch site. Required kits may be installed closer to delivery dates than ever before for greater flexibility in scheduling launches. The Atlas SLV-3 is propelled by the most powerful engines developed for the Atlas program producing 390,000 pounds thrust. The vehicle stands 66 feet tall without adapter or payload, is 10 feet in diameter, and weighs more than 260,000 pounds fueled (without upper stage and/or payload). Guidance is radio-inertial. Launch sites are available at either the Eastern Test Range or the Western Test Range. The Atlas SLV-3 can boost 4,100-pound payloads from ETR without upper stages or payloads up to 6,850 pounds using an Agena upper stage (from ETR). It can boost 1,150 pound payloads to escape. Using a Centaur upper stage with the Atlas SLV-3, 9,900-pound payloads are possible from ETR, and 2,412 pound payloads to escape.

SLV-3X

Prime Contractor: Convair Division of General Dynamics Corporation.
Associate Contractors: Rocketdyne, A Division of North American Aviation, Inc.; General Electric Company; Acoustica Corporation.

Remarks

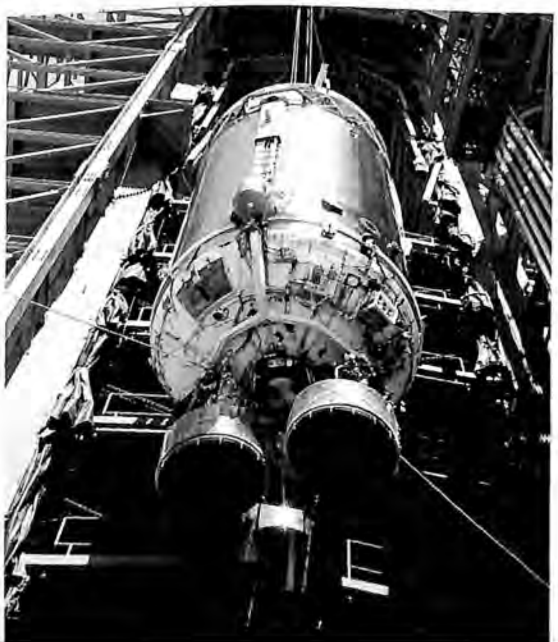
The SLV-3X is being developed to meet program requirements for launching increased payloads for the Surveyor program. Principal improvements over the SLV-3 include engine uprating, weight reductions, and systems modifications. Specific differences between the SLV-3X and the SLV-3 include: uprating of booster engines from 330,000 to 340,000 pounds thrust, sustainer engine uprated from 57,000 to 65,000 pounds thrust, H-1 injectors substituted in booster engines, new turbines in the sustainer engine, skin material strength increased to 220,000 pounds per square inch, and lengthening of the propellant tank allowing for 23,000 additional pounds of propellant. Utilizing the improvements of the SLV-3, the SLV-3X offers additional performance increases for heavier payloads. SLV-3X is capable of boosting 6,150 pounds from ETR without upper stages, 8,600 pounds with an upper stage Agena, and 11,253 pounds with the high-energy upper stage Centaur. With development of the SLV-3X now underway, launch agencies can reduce orbital delivery costs of payloads to less than $500 per pound. Several growth versions of SLV-3X are currently being defined. One is a direct-ascent vehicle called SLV-3MX, capable of inserting payloads of up to four tons into 100-nautical mile orbits without an upper stage.

CENTAUR

Prime Contractor: Convair Division of General Dyanmics Corporation.
Associate Contractors: Pratt and Whitney 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, (hydrogen peroxide, ullage, and attitude-control system).

Remarks

Now operational, Centaur is a high-energy upper stage currently using an Atlas first stage of similar diameter and construction. Centaur's primary mission is Surveyor, designed to soft-land instruments on the moon prior to manned landings. Centaur is a high-specific impulse vehicle powered by two 15,000-pound-thrust liquid hydrogen and liquid oxygen engines. Centaur is 46 feet long with its nose fairing, and weighs about 37,500 pounds at launch. Centaur weight in orbit is about 5,000 pounds. Atlas vehicles used as the first stage employ the 390,000 pound thrust Rocketdyne propulsion system. Centaur tank structure, like Atlas, is fabricated from thin-gauge stainless steel. Centaur features unique jettisonable insulation to protect its payload, flight control equipment, and fuel from aerodynamic forces during ascent through the atmosphere. Insulation is jettisoned, allowing Centaur to shed unnecessary weight early in flight—a concept that buys 14 pounds of payload capability for every 15 pounds of discarded insulation. Centaur is capable of boosting 2,500 pounds to escape with an Atlas first stage, 3,200 pounds using a Titan III-X first stage, and 10,400 pounds to escape atop a Titan III-C booster. Using a Saturn IB in combination with Centaur, 13,500-pound payloads can be boosted to escape velocity.



IMPROVED THOR

Prime Contractor: Douglas Missile & Space Systems Division
Associate Contractors: Rocketdyne, A Division of North American Aviation (liquid propulsion); Thiokol Chemical Corporation (solid propulsion); Western Electric (guidance).

Remarks

The Improved Thor is the most recent of the Thor family of launch vehicles. With the phase-out in 1965 of the standard Thor, the Improved Thor becomes the basic Thor vehicle that can be used in combination with a variety of upper stages. Douglas builds the Improved Thor for the Air Force for use in military space programs. With its strap-on solid rockets, the vehicle is the direct result of Douglas' "building block" philosophy, which seeks to steadily increase the effectiveness of proven, existing systems at substantial savings to the government. The Improved Thor is carrying on in the tradition of the standard Thor "Workhorse of the Space Age," which demonstrated impressive reliability and versatility in more than 200 firings.

Specifications

Length 59 1/2 feet; diameter 14 feet 2 inches; thrust, 330,000 pounds; lift-off weight, 135,954 pounds; propulsion, liquid fuel (liquid oxygen and kerosene) plus three solid motors.

Performance

Capability varies depending upon upper stage and payload used.

DELTA

Prime Contractor: Douglas Missile & Space Systems Division.
Associate Contractors: Aerojet General Corporation (propulsion system, second stage); Rocketdyne, A Division of North American Aviation (first-stage propulsion); Allegany Ballistics Laboratories (third-stage propellant motor); Western Electric (first and second stage guidance).

Remarks

The Delta launch vehicle is an economical and extremely accurate three-stage vehicle used in launching spacecraft packages into space-probe and earth-orbital missions. Its first stage is a modified Thor rocket. Its first two stages are liquid propellants; a solid propellant is used in the third. With a reliability record of more than 90 per cent, Delta has lifted the majority of the nation's scientific and communications satellites, including the Tiros, OSO, Explorer, Telstar, Relay and Syncom payloads. Improved Delta, with larger second stage, was scheduled to go into service late in 1965.

Specifications (DSV-3C model, the standard Delta)

Length 93 feet 2 inches; diameter 8 feet; lift-off weight 114,000 pounds; thrust 172,000 pounds (first stage), 7,575 pounds (second stage); 6,100 pounds (third stage). Improved Delta has 92-foot length, 149,606-pound weight.

Performance

875-pound payload in a 500-nautical-mile circular orbit; Improved Delta 1,100 pounds in 500-mile circular orbit, 220 pounds to escape.

THRUST AUGMENTED DELTA

Prime Contractor: Douglas Missile & Space Systems Division
Associate Contractors: Aerojet-General Corporation (second stage propulsion); Rocketdyne, A Division of North American Aviation (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 three "strap-on" propellant rocket motors that bring TAD's first-stage lift-off thrust to 330,000 pounds—almost double the 172,000-pound-thrust capability of the standard Delta. Addition of the solids enables TAD to boost heavier payloads higher and farther. TAD has launched the Syncom C satellite that relayed on-the-spot television pictures of the Olympic Games from Japan to the U.S. and the Communication Satellite Corporation's history-making Early Bird, first link in a proposed worldwide communications network.

Specifications

Length 93 feet 2 inches; 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

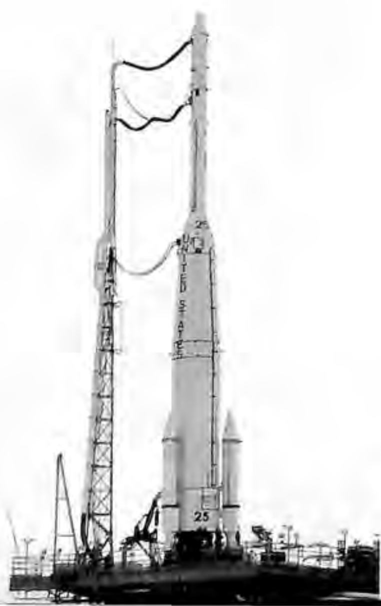
1,000-pound payload in a 500-nautical-mile circular orbit.

LITTLE JOE II

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

The Little Joe II booster was designed to launch unmanned Apollo service and command modules into suborbital trajectories up to 300,000 feet altitude at engine burnout. The most powerful U. S. solid propellant rocket, Little Joe II weighs about 85 tons at launch and stands 33 feet high without payload. Little Joe II can employ up to 7 Algol solid rocket motors in a variety of firing combinations, producing approximately 850,000 pounds of thrust. Various combinations of Algol and Recruit solid motors can be used with different firing sequences to provide optimum thrust for a variety of missions. Little Joe II is capable of carrying a 20,000-pound payload to 900,000 feet altitude, and can boost an 80,000-pound payload to lower test altitudes. The vehicle is extremely uncomplicated. Its air-frame consists of an aluminum cylindrical shell about 13 feet in diameter. Four swept back fins, each 50 square feet in area, extend from the base of the vehicle for in-flight stability. The fins have movable surfaces to control the vehicle's flight attitude, with additional hydrogen motors on each fin for supplemental control. Completely successful in three operational launches, Little Joe II flights for the Apollo program are conducted at the White Sands Missile Range, New Mexico.



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 and fourth stages); Honeywell, Inc. (guidance).

Remarks

The Scout research rocket is a four-stage, solid-fueled rocket developed by the National Aéronautics and Space Administration to provide the U. S. with a small, reliable, flexible and low-cost research vehicle for a variety of space exploration tasks. The first U. S. solid-propellant rocket capable of placing payloads in orbit, the multi-mission vehicle is currently being launched from NASA's Wallops Island facility in Virginia, and by Air Force crews from Point Arguello, California, on the Pacific Missile Range. Scout was designed to put a 150-pound satellite in a nominal 300-mile orbit or send a 50-pound scientific package nearly 8,500 miles in a probe shot. First launching of Scout was at Wallops on July 1, 1960. Numerous foreign nations, including Italy, France and Great Britain have scientific payload launches scheduled on Scout rockets.

Specifications

Scout length is 72 feet, weight is 37,000 pounds. First stage: Algol by Aerojet-General develops 100,000 pounds of thrust, fin stabilized and controlled in flight by jet vanes; 30 feet long. Second stage: Castor by Redstone Division of Thiokol Chemical, develops 60,000 pounds of thrust; 20 feet long. Third stage: Antares by Allegany Ballistics Laboratory of Hercules Powder Company develops 13,500 pounds of thrust; 10 feet long. Fourth stage: Altair developed by Allegany Ballistics Laboratory of Hercules Powder Company develops 3,000 pounds of thrust; 6 feet long.

AGENA

Prime Contractor: Lockheed Missiles and Space Company
Associate Contractors: Bell Aerosystems (primary and secondary power plants); Honeywell, Inc. (guidance).

Remarks

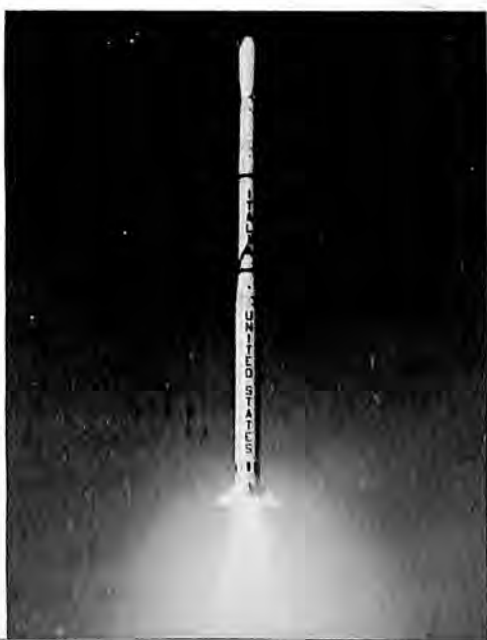
One of the real workhorses of U. S. space exploration, Agena is an upper stage which is also employed as a spacecraft, the whole vehicle going into orbit. Agena plays a key role in manned space flight; it is the target vehicle for rendezvous and docking maneuvers in NASA's Gemini project. Agena has a main rocket engine capable of multiple re-starts in space; in the modified target vehicle version it also has two secondary engines to provide small changes in velocity and position in orbit. In the Gemini Agena, a control system can handle 96 commands from the astronauts or from ground stations. Agena is used as an upper stage with the Thor, augmented Thor and Atlas boosters; it has played important roles in such military and NASA programs as Discoverer, Samos, Mariner, OGO and Ranger and will be used for launching the Orbiting Astronomical Observatory. In photo, Gemini Standard Agena with astronauts Schirra and Stafford.

Specifications

Length 19–40 feet depending on version, Gemini version 25 feet; diameter 5 feet; all-inertial guidance.

Performance

Thor/Agena, 1,500-plus pounds in earth orbit; Atlas/Agena, 5,000 pounds in 300-mile orbit.



APOLLO

Prime Contractor: North American's Space and Information Systems Division

Major Subcontractors: Aerojet General Corporation (service module propulsion motor); 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); General Precision, Inc., (mission simulator trainer); General Time Corporation (central timing system); Giannini Controls (reaction control gaging system); Honeywell, Inc. (stabilization and control); Lockheed Propulsion Company (launch escape and pitch control motors); Micro Systems, Inc., Electro-Optical Systems (pressure and temperature transducers); Motorola, Inc., (up-data link digital); The Marquardt Corporation, (reaction control motors service module); Northrop Corporation Electronics (Astro Division) (television cameras); Remanco, Inc., (rocket engine test set); Sciaky Bros., Inc., (tooling, welding and machinery); Simmonds Precision Products (propellant gaging mixture ratio control); Thiokol Chemical Corporation (escape system jettison motors); Transco Products, Inc., (telemetry antenna system); United Aircraft Corporation, Pratt & Whitney Aircraft Division, (fuel cell); Westinghouse Electric, Aerospace Electrical Division (static inverter conversion unit).

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 Project Apollo is under NASA's Manned Spacecraft Center, Houston, Texas. The Apollo spacecraft comprises three separable major parts called "modules" which are fastened together in tandem. North American's Space Division is producing the Apollo spacecraft Command and Service Modules. The Lunar Excursion 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 three-man crew. The command module consists of two 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.

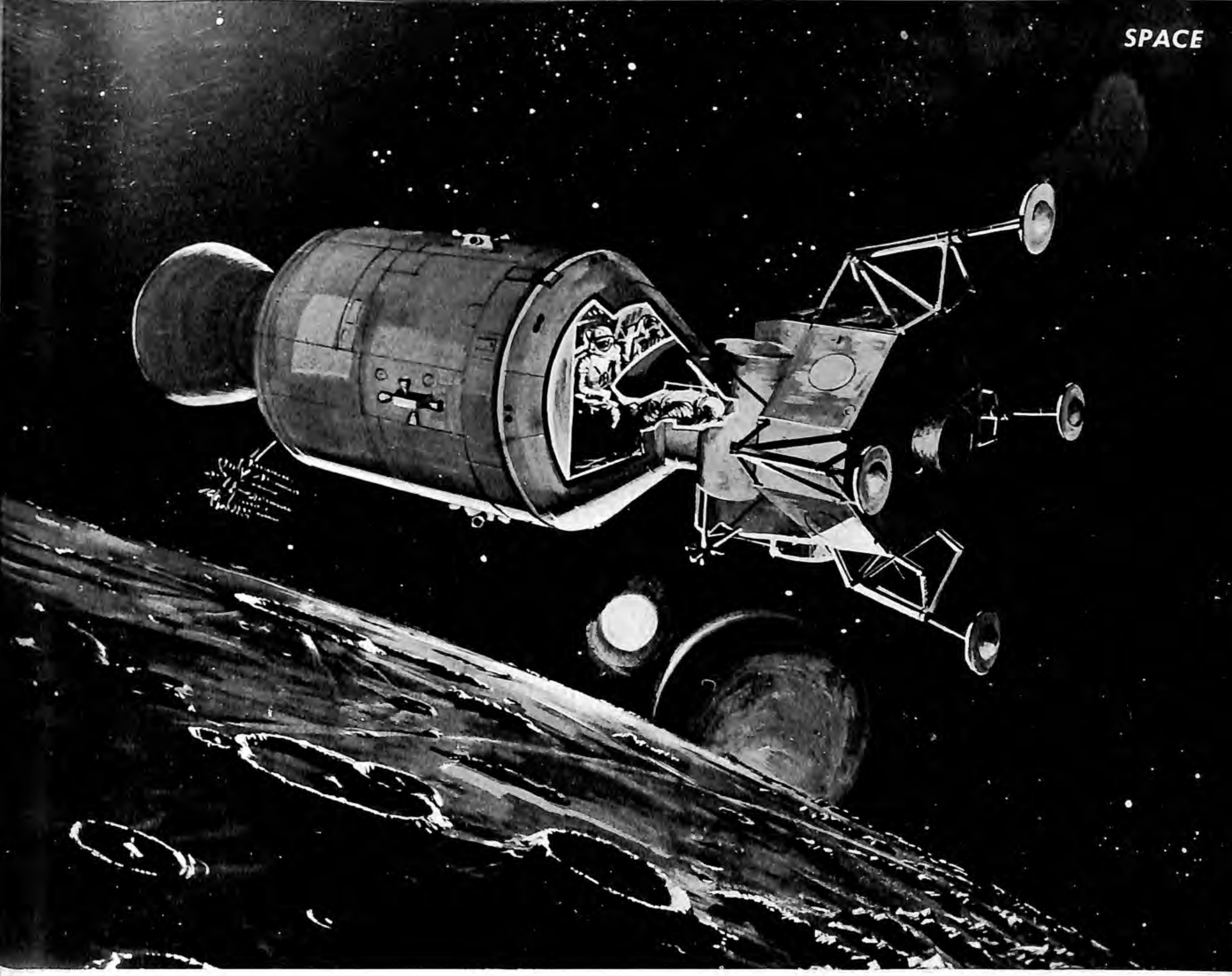
Command Module Specifications

Shape, conical; height 12 feet; diameter (at the base), 13 feet; launch weight 11,000 pounds (approx.); outer structure: stainless steel honeycomb bonded between aluminum alloy sheets; inner compartment: primarily aluminum honeycomb bonded between aluminum alloy sheets; insulation: a two-layer microquartz fiber insulation separates the walls of the inner and outer structures; environment: shirt-sleeve temperature of about 75 degrees, and 100 per cent oxygen; couches: aluminum and titanium padded with plastic encased nylon webbing.

The Service Module houses the main propulsion motor and its propellants for return from the moon and for midcourse corrections. It contains the electrical system, reaction control engines and part of the environmental control system. Propellants and various 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 re-entry.

Service Module Specifications

Shape, cylindrical; height 22 feet (including engine); diameter 13 feet; construction: mostly aluminum alloy; the outside skin is honeycomb bonded between aluminum sheets; launch weight 50,000 pounds (approx.).



The Launch Escape System is located atop the Apollo command module. Its purpose is safe recovery of the command module and its occupants in the event of a catastrophic booster failure before or during launch. In addition to the tower, the system has three primary components: The launch escape and pitch control motors and the tower jettison motor.

The Lunar Excursion Module permits two astronauts to descend to the lunar surface and return to rendezvous with the waiting Command and Service Modules.

Lunar Excursion Module Specifications

Cab diameter 10 feet; length 19 feet; weight 15,000 pounds.

GEMINI

Prime Contractor: McDonnell Aircraft Corporation

Associate Contractors: Honeywell, Inc. (guidance); Westinghouse Electric Company (rendezvous radar); International Business Machines (computer); AiResearch Division, The Garrett Corporation (environmental control system); Beech Aircraft Corporation (propellant loading systems); Rocketdyne, A Division of North American Aviation (spacecraft propulsion); General Electric Company (fuel cell).

Remarks

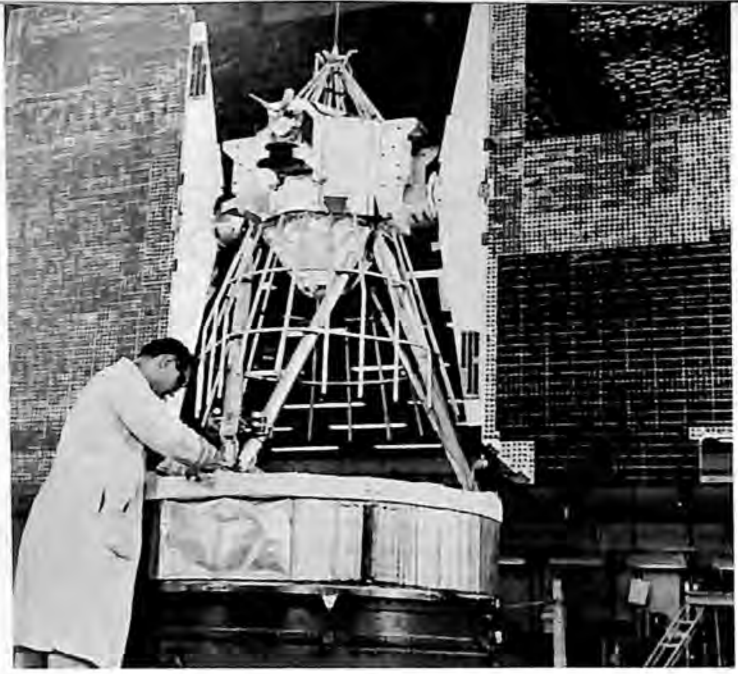
Gemini is a two-man spacecraft for use in a NASA program for long-duration space physiological studies and for development of rendezvous and docking techniques. Gemini's environmental control system is capable of sustaining two astronauts for two weeks; electrical power is supplied by a combination of batteries and a fuel cell. McDonnell is building 13 flight-rated spacecraft; NASA's program calls for 12 flights (10 manned) into 1967. The spacecraft has two sections, a re-entry module housing the astronauts and an adapter section for equipment. The re-entry module is 11 feet tall, the adapter unit seven and a half feet tall. Spacecraft launch weight is approximately 6,900 pounds. Onboard thrusters permit maneuvering for rendezvous and docking missions; on such missions Gemini mates with a 25-foot Agena target spacecraft.

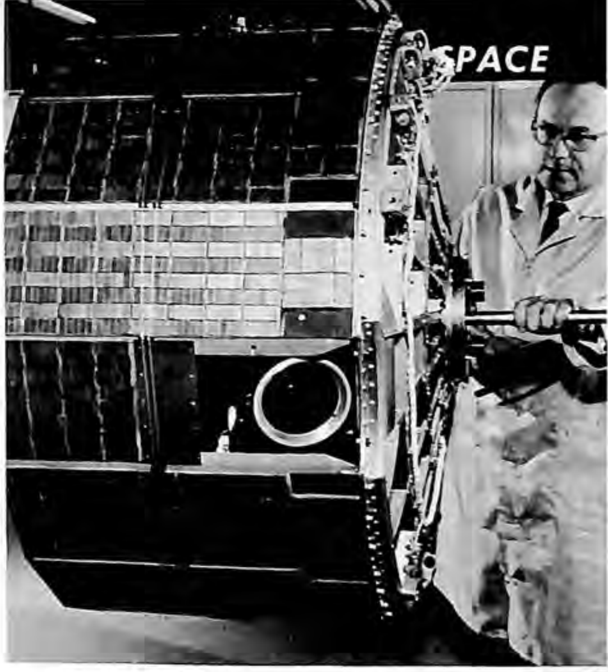
MANNED ORBITING LABORATORY

Major Contractors: Douglas Missile & Space Systems Division (spacecraft); General Electric Company (experiments integration).

Remarks

The Manned Orbiting Laboratory is a project of the Department of Defense, with program direction being handled by the Air Force, aimed at an investigation of the military utility of man in space. The initial program contemplates six manned flights starting in 1968. The spacecraft consists of a modified Gemini capsule employed as a re-entry module and a large cylindrical laboratory canister in which two astronauts will operate in shirt-sleeve environment for periods up to 30 days. The canister will be about 41 feet long and 10 feet in diameter; spacecraft weight, including the modified Gemini, will be on the order of 25,000 pounds. Orbits will be below 350 miles. The program was originally announced in 1963 but it was maintained in study status until August 25, 1965, when formal development was initiated and the major contractors named. The program got under way with about $150,000,000 available in fiscal year 1966 funding. Schedule calls for the first unmanned launch of a Gemini/canister spacecraft in 1967.





NIMBUS

Prime Contractor: General Electric Company, Spacecraft Department
Associate Contractors: Radio Corporation of America (cameras and solar power subsystems, data acquisition facility); Radiation, Inc. (PCM telemetry); ITT (infrared radiometers); California Computer (command and verification telemetry); Control Data Corporation (data processing computer); Collins Radio Company (antenna and receiving facilities).

Remarks

Nimbus is a second-generation research and development meteorological satellite developed by the National Aeronautics and Space Administration's Goddard Space Flight Center. The weather satellite is capable of a wide range of geophysical, communications and scientific payloads. The windmill-shaped spacecraft is approximately 10 feet tall, 11 feet wide and weighs about 830 pounds. Nimbus I was the first earth-oriented weather satellite in the sense that its camera and radiometer systems always pointed toward the earth. Nimbus II, an advanced version of the same spacecraft, is scheduled to be launched in 1966. Nimbus III will include further improvements, including a SNAP 19 RTG nuclear power supply. All Nimbus spacecraft will be earth-oriented and stabilized in all three axes. A Thor Agena B was the launch vehicle for Nimbus I, which was placed in polar orbit August 28, 1964. Nimbus I provided both real time and readout telemetry from its three Advanced Vidicon Camera Systems, one Automatic Picture Transmission system and infrared radiometer system for nighttime photographs.

TIROS

Prime Contractor: Radio Corporation of America, 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. There were 10 successful launches through late 1965. Newest version is the Tiros "wheel," which can be maneuvered to roll in orbit like a drum rolling downhill; its two TV cameras are positioned radially so that with each half turn of the wheel either camera will look down at earth. Four more "wheel" launches planned.

Specifications

Diameter 42 inches; weight approximately 300 pounds.

EARLY BIRD

Prime Contractor: Hughes Aircraft Company

Remarks

The world's first communications satellite, Early Bird was launched April 6, 1965 by the U.S. Communications Satellite Corporation as agent for a world consortium of more than 40 participating nations. The satellite was injected into a synchronous orbit 22,300 miles above the equator over the Atlantic Ocean. The 85-pound spacecraft has capacity for 240 two-way telephone channels or simultaneous two-way television between Europe and North America on a 24-hour basis. It can also handle teletype and facsimile at the same time it carries telephone conversations. Power is supplied by some 6,000 solar cells. The satellite is a later version of the NASA-Hughes Syncom.

SYNCOM

Prime Contractor: Hughes Aircraft Company

Remarks

A second-generation active-repeater communications satellite, Syncom is a synchronous orbiting spacecraft, one whose orbital speed just matches that of the earth's rotation, so that the satellite remains in a fixed position with respect to a point on earth. To achieve the proper velocity, the satellite is sent into orbit at an altitude of 22,300 miles. From that altitude, more than a third of the earth can be "seen," so three such spacecraft can form a TV-telephone network providing 24-hour service. Syncom I, launched February 14, 1963, was unsuccessful. Syncom II, launched July 26, 1963, was completely successful and was the first spacecraft to achieve synchronous orbit. Syncom III, launched August 19, 1964, was placed in stationary orbit over the International Date Line and it relayed the Olympic Games to the U.S. from Japan.

RELAY

Prime Contractor: Radio Corporation of America

Remarks

Relay is a communications satellite of the active-repeater type, in which signals from one ground station are picked up and re-broadcast 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 two 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

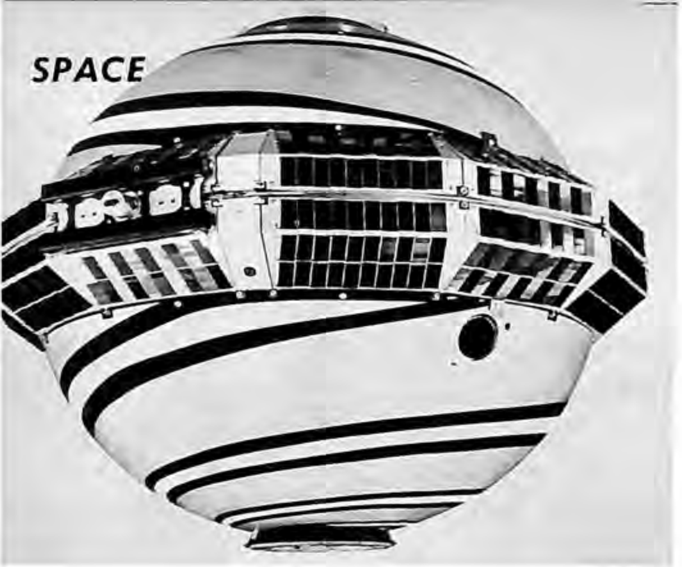
The first active-repeater communications satellite, Telstar demonstrated the feasibility of transmitting television images, telephone, telegraph and radio messages on a global basis. Launched by a Delta booster, Telstar first went into orbit on July 10, 1962. Telstar II was orbited on May 7, 1963. Both satellites were highly successful. NASA provided launch vehicles and tracking facilities on a reimbursable basis.

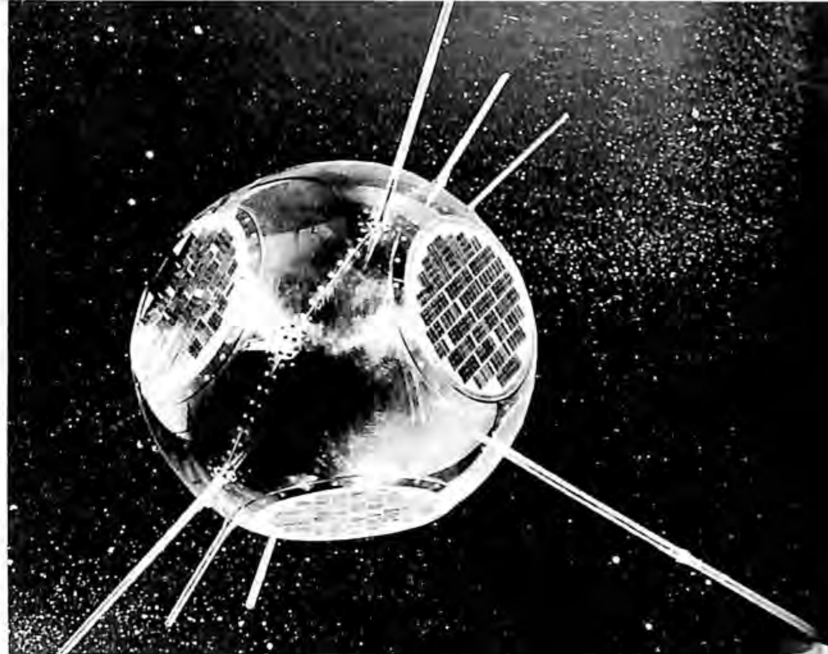
MILITARY COMSAT

Prime Contractor: Philco Corporation; systems engineering and technical direction by Aerospace Corporation

Remarks

The Department of Defense initiated, in 1964, a developmental program for an interim system of communication satellites for purely military use. The system envisions 24 satellites operating in random orbit, each satellite weighing approximately 100 pounds. The comsats will orbit at 18,300 miles; they will be launched in three groups of eight by the Titan III-C booster. The system is to be operational in 1966. DOD is also conducting studies on an Advanced Communications Satellite System.





NAVIGATION SATELLITE (TRANSIT)

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory
Associate Contractors: Westinghouse Electric Company (shipboard navigation receivers); Martin Company (SNAP power generators).

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 four satellites, each weighing less than 100 pounds, in near-circular orbits at 600 miles altitude. The satellite, once known as Transit, is supplied with electrical power by a SNAP-9A nuclear generator. The satellites are launched by the Scout booster.

GEODETIC SECOR (SEQUENTIAL COLLATION OF RANGE) SATELLITE SURVEYOR

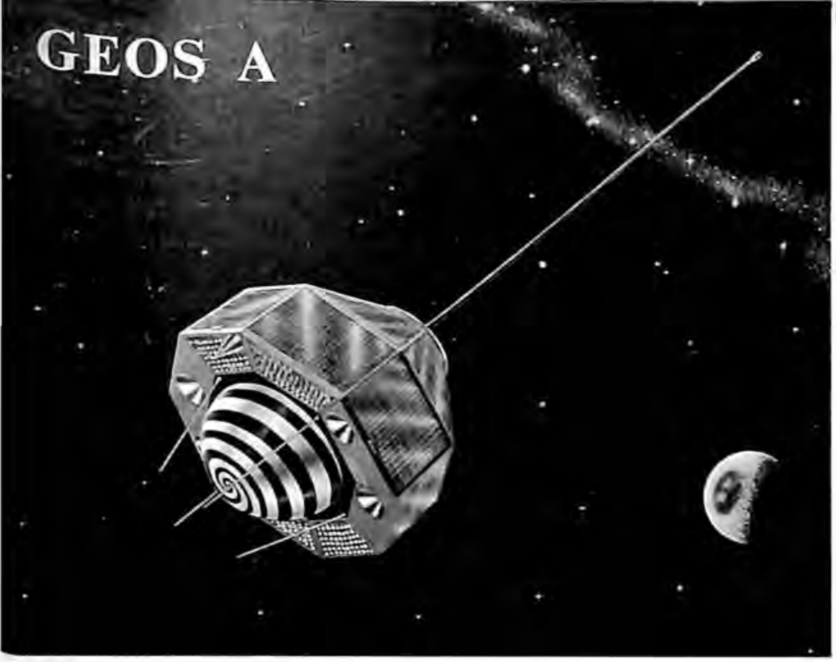
Prime Contractor: Cubic Corporation
Associate Contractor: ITT Federal Laboratories (satellite vehicle)

Remarks

Geodetic SECOR is an all-weather geodetic surveying system. It is capable of using 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 four ground stations, three 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 three 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, for the first time, will allow continents and islands to be brought within the same geodetic global grid.

Specifications

Each ground station is entirely portable and contains three units: a radio frequency shelter, a data handling shelter and a storage shelter. Inside the satellite, which is 20 inches in diameter, are a transponder or receiver-transmitter, a telemetry system to measure temperatures and operating voltage and power system comprised of solar panels and batteries.



GEOS-A

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

The primary objective of GEOS-A, is to provide global geodetic measurements for determining the positions of fiducial control points on the Earth to an accuracy of 10 meters in an Earth center of mass coordinate system, and to determine the structure of the Earth's gravity field to five parts in 10^8. Secondary objectives are to determine accurately the geometry of geodetic triangulation networks and the locations of isolated islands and to evaluate new high-precision satellite tracking techniques. GEOS-A is a 385-pound 32-inch top-shaped satellite; it is 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 will be obtained from solar cells that cover most of the exterior of the satellite. The program is directed by NASA's Goddard Space Flight Center.

PAGEOS

Prime Contractor: G. T. Schjeldahl Company

Remarks

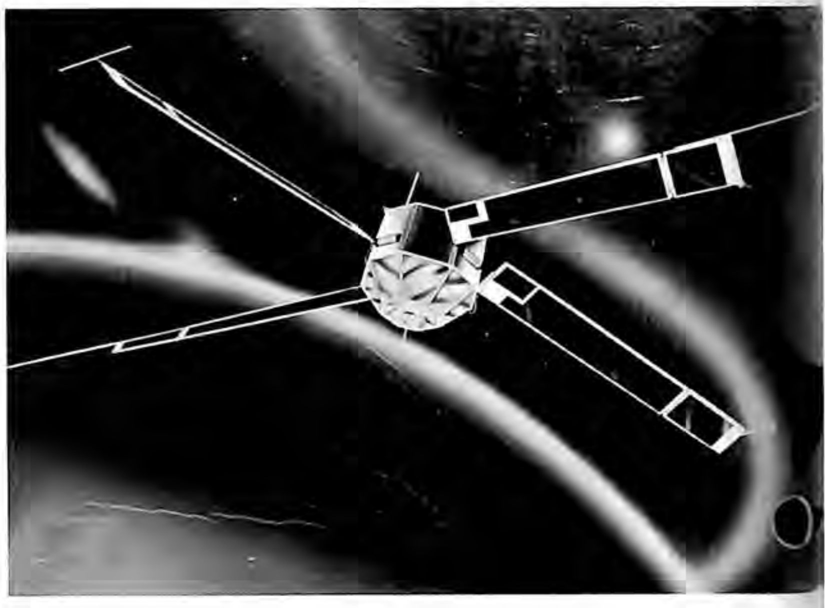
PAGEOS is a passive geodetic satellite of the inflatable type. Originally developed by NASA's Langley Research Center, it is scheduled for 1966 launch.

NUCLEAR DETECTION SATELLITES (VELA)

Prime Contractors: TRW Systems and Space Systems Division, Air Force Systems Command

Remarks

The Nuclear Detection Satellites, also known as Vela, are launched in pairs into high altitude orbits to detect nuclear explosions in space. The project is directed by the Adanced Research Projects Agency of the Department of Defense; Aerospace Corporation has payload responsibility. A single satellite weighs slightly less than 500 pounds and has 20 sides, or detection faces; orbital altitudes range upward from 50,000 miles. The first pair of satellites was launched in October, 1963, the second in July, 1964. Three more dual-launches are contemplated under the present program.



ADVANCED TECHNOLOGICAL SATELLITE

Prime Contractor: Hughes Aircraft Company

Remarks

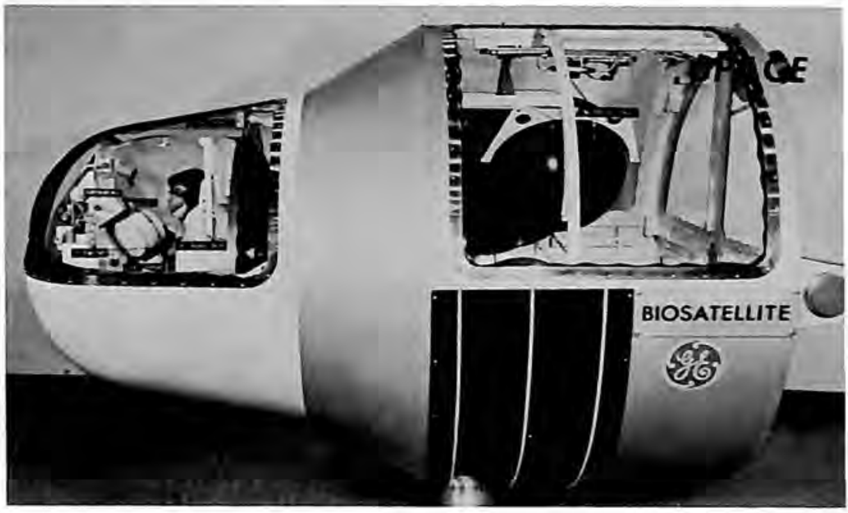
The Advanced Technological Satellite is a spacecraft whose mission is to improve other satellites, specifically to enhance the ability of existing and future satellites to provide weather, and communications data and air/sea navigation aids. Three types of missions are planned for ATS: a 6,000-mile earth orbit to experiment with the gravity gradient stabilization system; two synchronous (22,300-mile) orbits for meteorological, communications and navigation investigation; and two 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. In the program, managed by NASA's Goddard Space Flight Center, Hughes will build eight spacecraft, five of which will be flight vehicles.

EXPLORER SERIES.

Program Direction: National Aeronautics and Space Administration

Remarks

Explorer is not a specific spacecraft but a code name given a series of scientific satellites of different configurations and with varying payloads and assignments. In photo is Explorer XXVII, launched April 29, 1965, from NASA's Wallops Island, Virginia, facility by a four-stage Scout booster. The primary mission of this spacecraft was to provide radio doppler measurements for refining knowledge of the size and shape of the earth. Secondary objectives included study of the earth's ionosphere through worldwide radio measurements of the Faraday effect and of doppler refraction. Explorer XXVIII, built by The Johns Hopkins University Applied Physics Laboratory, weighs 126 pounds and is powered by four solar blades. Latest member of the Explorer series is the Owl, to be built by Rice University's Department of Space Science. The Owl is designed to extend studies of near-earth atmospheric phenomena, particularly auroral activity. Rice will build two spacecraft with first launch planned for 1967.



ENVIRONMENTAL RESEARCH SATELLITES

Prime Contractor: TRW Systems

Remarks

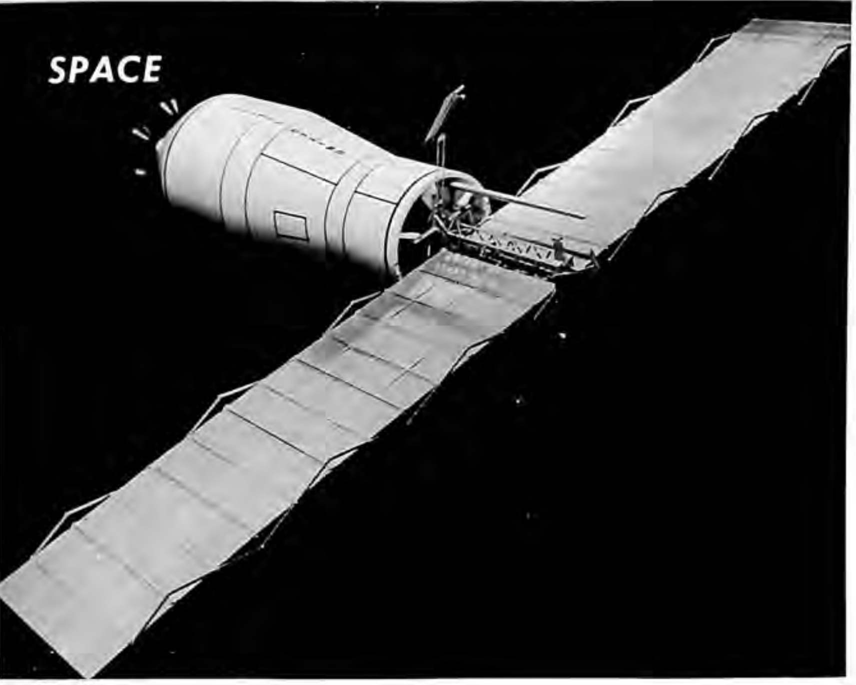
The Environmental Research Satellites were especially designed for piggyback launching from large primary mission vehicles. Ranging in weight from 1.5 to 9 pounds, and carrying from 5 to 14 experiments, these ERS "hitch-hiker" spacecraft provide an inexpensive, flexible vehicle capable of making scientific and engineering measurements in space. A major role of the ERS satellites is to act as a test bed to determine the reliability of unproven components and subsystems destined for use in later generations of spacecraft. A unique feature of the system is its capability to function without a battery. The key to this advantage is the design which permits solar cells, fastened to all exterior surfaces of the vehicle, to maintain constant exposure of about 15 percent of the sun. The ERS is a tiny satellite, measuring in one version only 6.5 inches on a side and weighing 1.5 pounds; a larger version weighs 4.5 pounds. The Space Systems Division of the Air Force Systems Command handles program management.

BIOSATELLITE

Prime Contractor: General Electric Company, Reentry 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 has selected General Electric to develop and build six Biosatellite vehicles, with the first flight scheduled in 1966. 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. Missions of three, 21 and 30 days are expected. All payloads will be recovered. Payload weights will range from about 900 to 1,150 pounds depending on the specific mission. An Improved Delta DSV-3E booster will be the launch vehicle. Rate gyros and cold gas jets will provide attitude control in all three axes; telemetry will be real time and tape recording readout; power will be by batteries and Gemini-type fuel cells; an ablating heat shield will protect the vehicle through re-entry, with recovery planned by air snatch. Biosatellite also has water recovery capability as backup.



PEGASUS

Prime Contractor: Space Systems Division, Fairchild Hiller Corporation

Remarks

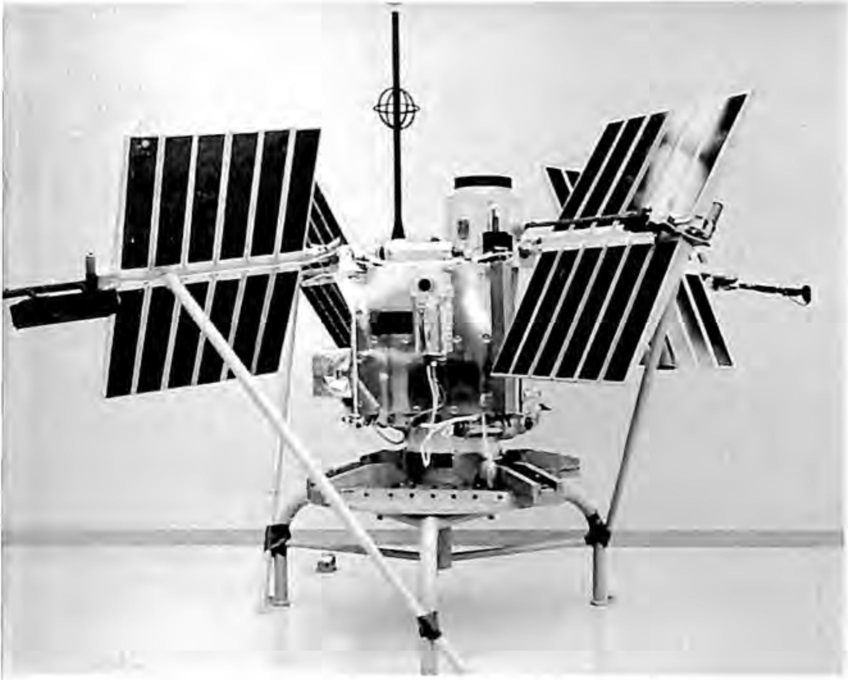
The mission of Pegasus, the Meteoroid Technology Satellite, is to define the magnitude and direction of medium size meteoroids in the near earth space environment. Three Pegasus spacecraft are in varying orbits, 300 to 500 miles high, transmitting this meteoroid detection information on a daily basis to the FHC operated Satellite Control Center at Cape Kennedy. The spacecraft weighs 3200 pounds, with a deployed wing 96 feet long and 14 feet high. Its 416 capacitor detectors of varying thickness provide over 2,000 square feet of area designed to count meteoroid hits for at least one year in space. It contains 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.

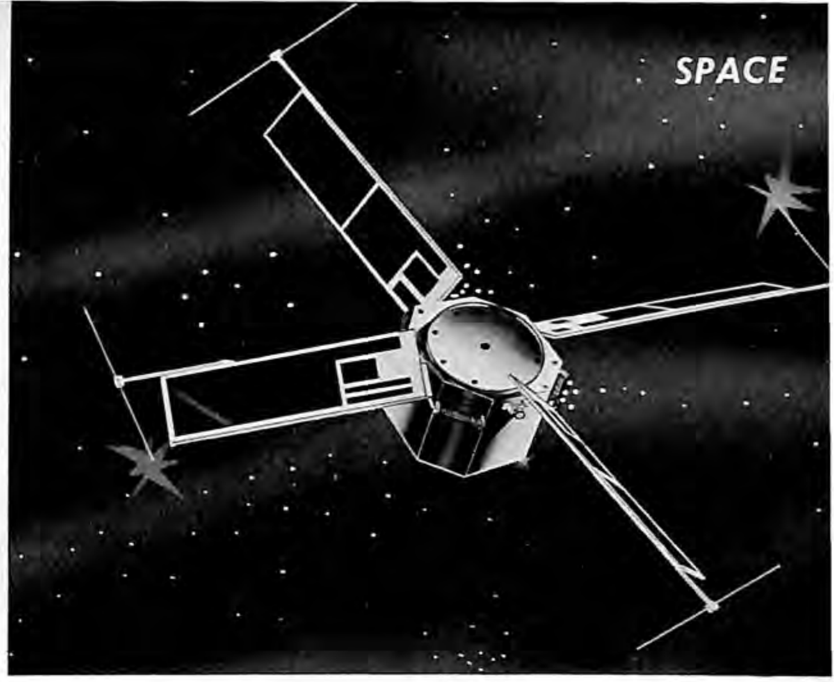
OV-1 (AEROSPACE RESEARCH SATELLITE)

Prime Contractor: Convair Division of General Dynamics Corporation
Associate Contractor: Allegany Ballistics Laboratory (propulsion system)

Remarks

The OV-1, formerly called SATAR, was designed to carry a variety of scientific experiments into orbit in a special pod on the Atlas booster when the lift capability of the Atlas is not fully utilized by other experiments, thus providing an economical satellite with "bonus" experiments. The OV-1 has its own propulsion system which is fired after the satellite is ejected from the booster vehicle. The OV-1 remains inside the Atlas-retained structure during the Atlas flight to protect it from aerodynamics loading and heating. The space vehicle coasts for about 8 minutes in space as preprogrammed attitude control maneuvers are performed on command of the propulsion module guidance system to position it for firing of its solid-fueled motor. OV-1 can be launched singly on the side of Atlas or in dual pods on the booster nose. Once in space, it can perform near-circular or highly elliptical earth orbits, high altitude probes or high velocity re-entry missions. Each OV-1 can carry an 80-pound payload. Total weight on the Atlas is 2,455 pounds for the dual pod load. The satellite is 54.6 inches long and 27 inches in diameter. Contracting agency is the USAF's Office of Aerospace Research.





OV2 SATELLITE

Prime Contractor: Northrop Space Laboratories

Remarks

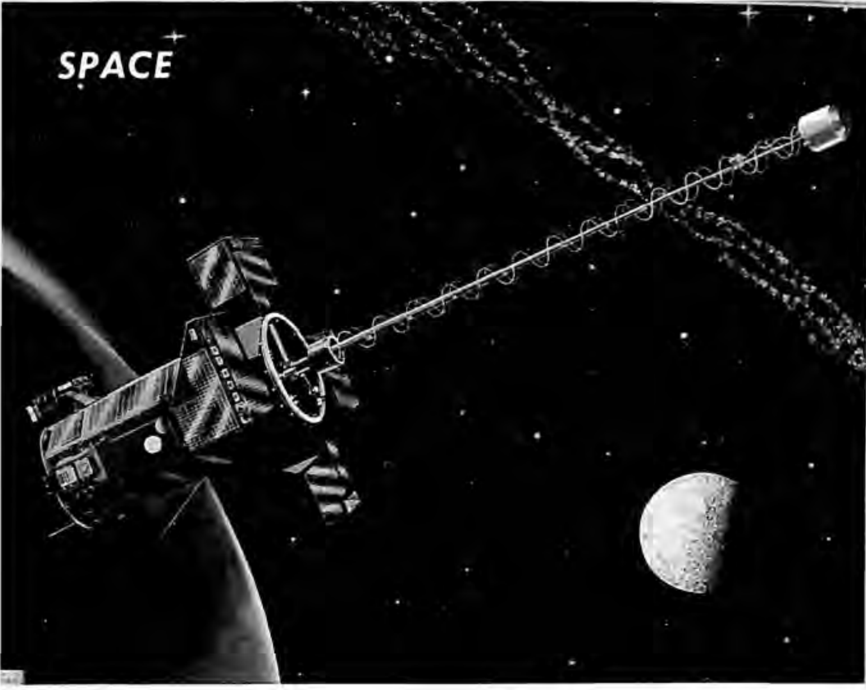
Northrop Space Laboratories (NSL) is currently developing low cost, near-earth space research satellites for the USAF Office of Aerospace Research. On-board experimentation is provided by Air Force Cambridge Research Laboratories (AFCRL), Air Force Weapons Laboratory (AFWL), and Air Force Space Systems Division, Aerospace Corporation (SSD/Aerospace). Three of these satellites were designed, each having somewhat diverse applications. The satellites are secondary payloads for Titan III-C test flights. The first satellite, OV2-1 failed to orbit. The OV2-2 was defined but subsequently cancelled as a result of changes in the Titan III flight test schedule. The OV2-3 was scheduled for launch in the winter of 1965-66. The orbit for the OV2-3 will be near synchronous at 18,200 nautical miles or true synchronous at 19,323 nautical miles. The lifetime of the satellite in orbit will be one year. Northrop Space Laboratories designs, fabricates, integrates, assembles, and tests these vehicles. Most subsystem equipment used on these spacecraft has been demonstrated on previous programs and is readily available for other experiment applications. The spacecraft is a rectangular box 23 by 23 by 24 inches; it weighs 371.5 pounds and carries 129 pounds of scientific equipment. It is powered by four solar paddles; span with paddles extended is 12 feet.

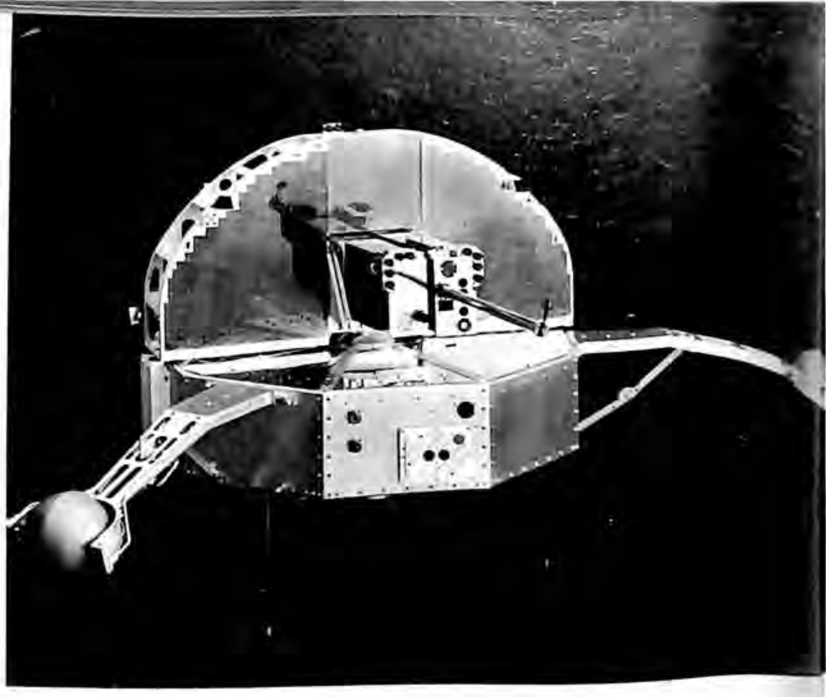
SATELLITE 1963 38C

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

The missions of Satellite 1963 38C are to measure omnidirectional flux of protons and electrons at various energy levels, radiation effects on transistors, and the effectiveness of thermal coatings. The satellite was launched together with a classified Department of Defense spacecraft on September 28, 1963. Its orbit is apogee 1120 kilometers (609 nautical miles), perigee 1070 kilometers (582 nautical miles), inclination 88.9 degrees. The satellite weighs 137 pounds; its body is in the shape of an 18 inch x 10 inch octagonal prism. It is powered by four solar blades and transmits on 136, 162, and 324 mcs. The spacecraft was built for the Bureau of Naval Weapons.





SATELLITE 1964 83C

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

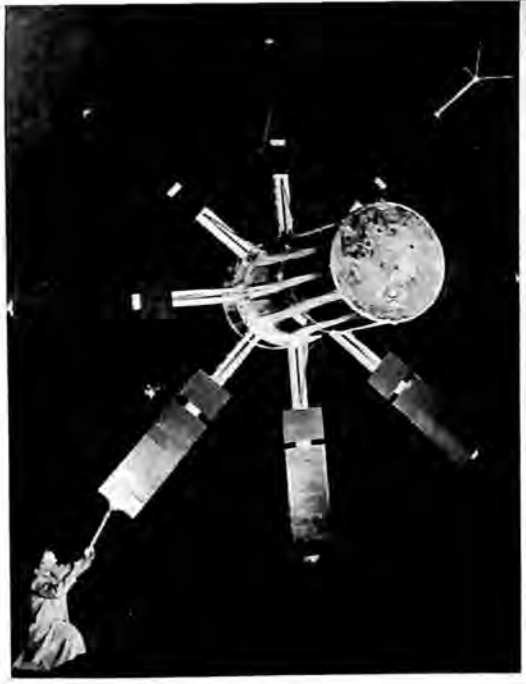
The primary mission of the research satellite 1964 83C is to map the Earth's magnetic field and the celestial field in the ultraviolet region. The satellite also contained experiments to demonstrate the operation of a new solar attitude detector and to determine the sublimation rates of a number of metallic samples. The satellite was launched, together with a classified Department of Defense spacecraft, on December 12, 1964. Its orbit is apogee 1070 kilometers (582 nautical miles), perigee 1027 kilometers (558 nautical miles), inclination 89.93 degrees. The satellite weighs 172 pounds; its body is a 36 inch x 18 inch octagonal prism. It is powered by four solar boxes, plus eight solar panels mounted on the body, and transmits on 136, 162, and 324 mcs. The spacecraft was built for the Bureau of Naval Weapons.

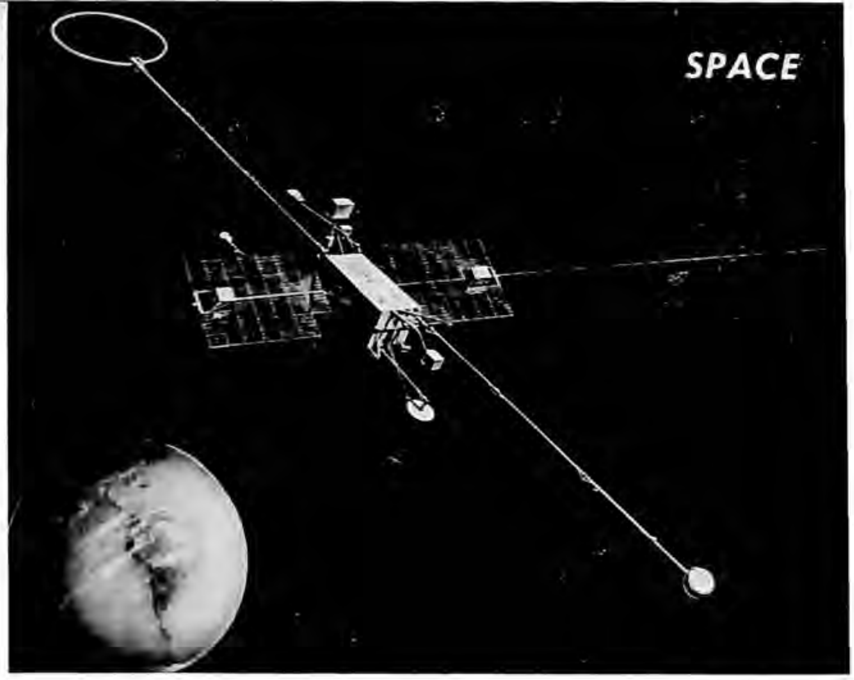
ORBITING SOLAR OBSERVATORY

Prime Contractor: Ball Brothers Research Corporation

Remarks

The Orbiting Solar Observatory, developed for NASA, is designed primarily as a stabilized platform for solar-oriented scientific instruments. Using the gyroscopic properties of a spinning body for stability, the lower "wheel" section spins at an almost constant rate of 30 revolutions per minute. Instruments housed in this wheel scan the sun every 2 seconds. Continuously pointed, solar-oriented experiments are contained in the upper "sail" section which is mounted on top of the wheel by a connecting shaft. Photoelectric solar sensors provide signals to orient the wheel and the pointed experiments in the sail. OSO's are placed 300 to 350 nautical miles above the earth, where they orbit approximately every 96 minutes; spacecraft gross weight is 450-620 pounds. Mission is to map the solar system and to investigate various solar, coronal, and radiation activities. Of the 8 planned OSOs, two are presently in orbit. OSO-I was launched March 7, 1962. Experimenters: Goddard Space Flight Center; University of Minnesota; University of Rochester; Ames Research Center; University of California. OSO-II was launched February 3, 1965. Experimenters: Harvard College Observatory; Naval Research Laboratory; Goddard Space Flight Center; University of Minnesota; University of New Mexico; Ames Research Center. OSO-III did not achieve orbit. OSO-IV is scheduled for 1966 launch. Experimenters: Harvard College Observatory; Naval Research Laboratory; American Science and Engineering; University College, London; University of Leicester; Lawrence Radiation Laboratory. A fifth OSO is in hardware status.





ADVANCED ORBITING SOLAR OBSERVATORY (AOSO)

Prime Contractor: Republic Aviation Corporation
Associate Contractors: Honeywell, Inc. (stabilization and control system); Texas Instruments (communications and data handling subsystems).

Remarks

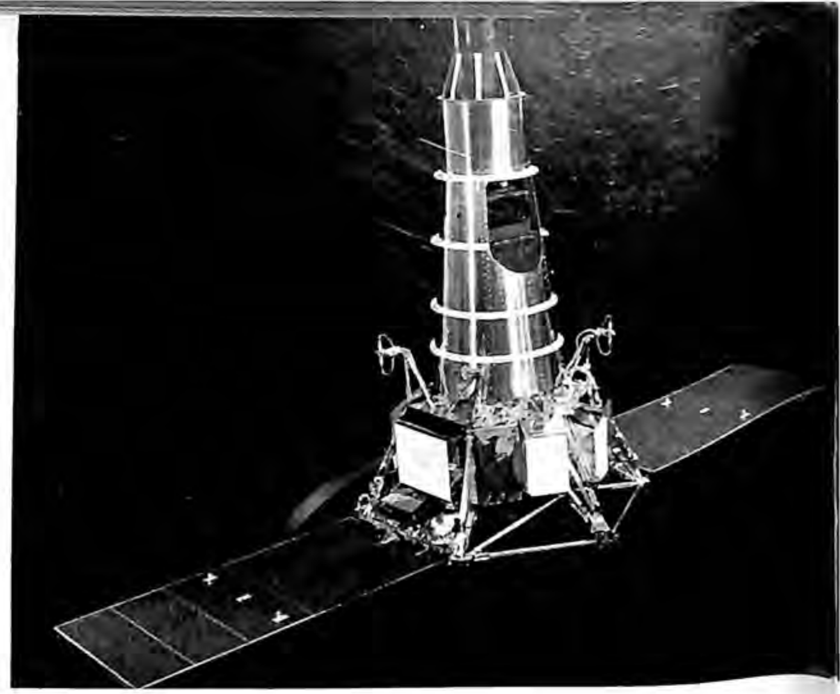
The Mark II AOSO represents technical advances orders of magnitude over present solar observatories. Its pointing accuracy of 5 arc seconds, mission life of one year, and payload capacity will substantially increase its mission capability. The Mark II AOSO spacecraft is designed to gather more than 60 million bits of solar radiation data during each two orbits. The spacecraft will be launched by the increased lifting power of the Thrust Augmented Thor Agena D (TAT). Consequently, the Mark II AOSO will weigh 1400 pounds, 500 pounds heavier than the Mark I vehicle. An increase of four additional solar paddles for a total of eight will provide power supply growth capability. Launch plans call for initial polar orbit in 1969 to provide solar data useful to the Apollo mission. Altitude will be approximately 330 miles. Four tracking stations will monitor and control the spacecraft and retrieve the data. The AOSO Mark II is designed so that the front end of the spacecraft points continually at the sun, and power is derived from solar cells mounted on paddles. The solar array is fixed after erection, since the spacecraft is always solar oriented. These experiments will obtain data at wavelengths which are largely blocked by the earth's atmosphere, and are expected to provide details on the sun never before seen.

ORBITING GEOPHYSICAL OBSERVATORY

Prime Contractor: TRW Systems

Remarks

The Orbiting Geophysical Observatory is a large standardized spacecraft capable of carrying up to 50 different scientific experiments yet utilizing the identical structure and basic spacecraft systems irrespective of mission. The program has two objectives: to conduct large numbers of experiments for making scientific and technological measurements within the earth's atmosphere, the magnetosphere and cislunar space for a better understanding of earth/sun relationships and of earth itself; and to design and develop a standard observatory-type spacecraft of a basic system design that can be used repeatedly for various missions. OGO has a main body 6 feet long, 3 feet wide and 3 feet deep weighing 1,000 pounds. It has two solar paddles each 6 feet wide and 7.5 feet long and six 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. Two OGO's have been launched and four more are planned.



ORBITING ASTRONOMICAL OBSERVATORY

Prime Contractor: Grumman Aircraft Engineering Corporation
Associate Contractors: Westinghouse Electric Company (electronic components); General Electric Company (stabilization and control); Kollsman Instrument Corporation (star trackers); International Business Machines Corporation (data processer); Hughes Aircraft Company and Avco Corporation (communications equipment).

Remarks

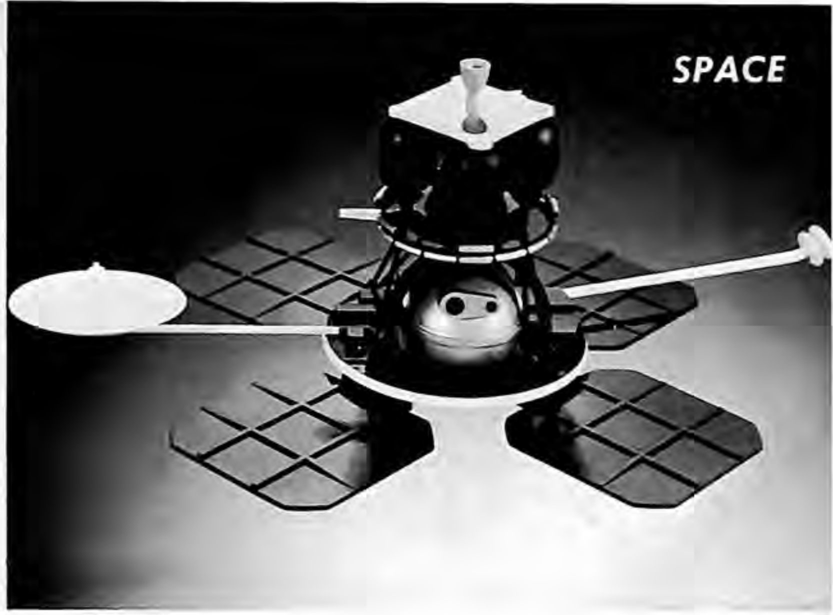
NASA's Orbiting Astronomical Observatory is a large (3,600 pounds) earth-orbiting satellite capable of lifting a number of telescopes above the earth's atmosphere, which obscures cosmic radiations of interest to astronomers. Solar paddles provide 350 watts of power for experiments and for stabilization. Launch vehicle is the Atlas-Agena D; three flights are planned, starting in 1966.

RANGER

Prime Contractor: Jet Propulsion Laboratory, California Institute of Technology
Associate Contractors: Lockheed Missiles and Space Company (prime contractor to Lewis Research Center for launch vehicle system); Astro-Electronics Division, Radio Corporation of America (television system).

Remarks

Ranger is an unmanned, instrumented spacecraft for use in the National Aeronautics and Space Administration program in developing a space technology for transporting engineering and scientific instruments to the moon and for obtaining high resolution pictures of the lunar surface which will be of benefit both to the scientific program and the manned lunar flight program. The spacecraft weighs 809 pounds, and in its flight deployed configuration extends 15 feet across the solar panels and 10 1/4 feet from base to antenna top. On-board equipment includes a central computer and sequencer, command system, telemetry data encoder, attitude control, midcourse propulsion guidance system, solar panels and batteries, high gain and omnidirectional antennas, and a television system consisting of two wide-angle and four narrow-angle cameras, camera sequencers, vidio combiners, telemetry, transmitters and power supplies. Four spacecraft have been successfully launched by Atlas-Agena vehicles using a parking orbit technique. Three successful flight missions have been carried out resulting in over 17,000 high resolution pictures showing details of surface craters as small as 2 1/2 feet in diameter.



SURVEYOR

Prime Contractor: Jet Propulsion Laboratory, California Institute of Technology
Associate Contractors: Hughes Aircraft Company (development and manufacture of spacecraft); General Dynamics/Astronautics (prime contractor to Lewis Research Center for launch vehicle system).

Remarks

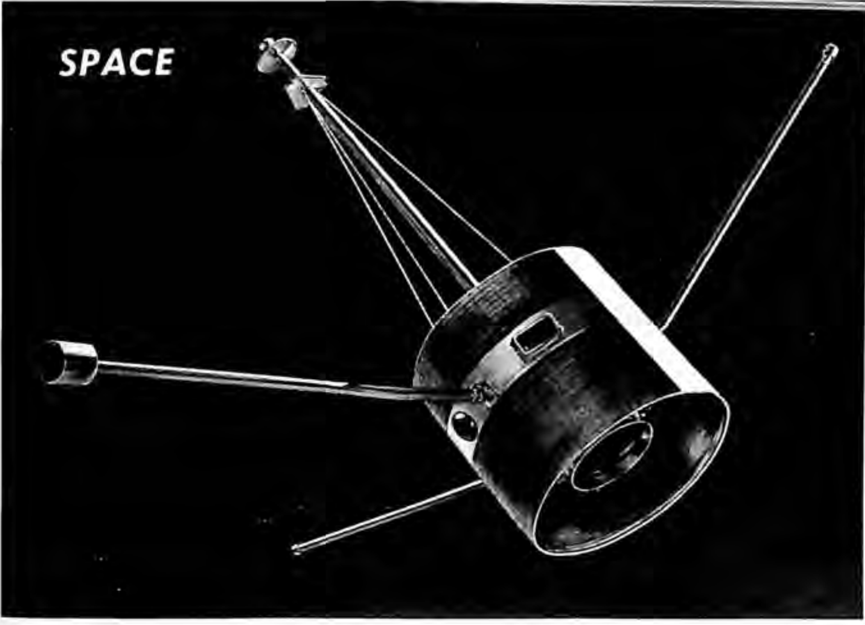
Surveyor is an unmanned, instrumented spacecraft for use in the National Aeronautics and Space Administration program for conducting scientific exploration of the moon and for developing equipment and techniques for soft landing of scientific payloads on the lunar surface. The initial test flights include a survey television system, touchdown instrumentation and diagnostic telemetry for the recovery of engineering data during the launching, in-flight and landing phases; subsequent missions will carry scientific payloads consisting of two camera television, single-axis seismometer, alpha particle scattering, surface sampler and touchdown dynamics experiments to extend knowledge of the lunar surface and to verify the suitability of sites for the Apollo spacecraft landings. The initial Surveyors weigh 2,150 pounds and carry up to 300 pounds of instrumentation; later versions will weigh 2,500 pounds. First moon flights are scheduled for 1966; the spacecraft will be injected into the lunar trajectory by Atlas-Centaur vehicles.

LUNAR ORBITER

Prime Contractor: The Boeing Company
Major Subcontractors: Eastman Kodak (photographic subsystem); Radio Corporation of America (electrical power and communications equipment).

Remarks

Lunar Orbiters will take sharp, close-up pictures of thousands of square miles of the moon and pinpoint safe landing sites for Project Apollo astronauts. Carrying a camera equipped with both a medium and a high resolution lens, each 850-pound spacecraft will pass within 28 miles of the lunar surface as it orbits the moon. The photos will be converted automatically aboard the spacecraft into electrical signals and transmitted to earth. On a typical mission, the high-resolution photos will give scientists a detailed look at an area of the moon roughly equal to a continuous strip one mile wide extending from Los Angeles to New York, and with enough clarity to show objects a yard square. Each Orbiter also will carry instruments to measure radiation near the moon and to detect the presence of micrometeoroids. Boeing will build eight Lunar Orbiters for NASA, three of them for ground tests, five for flight. The program calls for the first launch in 1966. NASA's Langley Research Center is in charge of systems management. The program is under the over-all direction of the Office of Space Science and Applications, NASA.



PIONEER

Prime Contractor: TRW Systems

Remarks

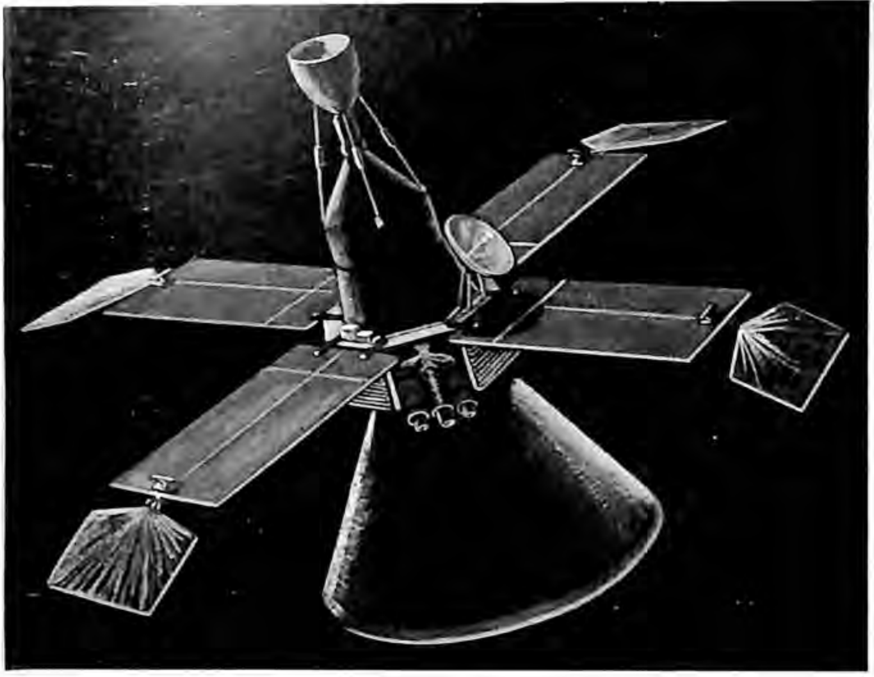
Pioneer is an interplanetary spacecraft designed to operate in solar orbit and send data on interplanetary magnetic fields, radio propagation effects of the "quiet sun," plasma spectrometry, ionization levels and solar, high-energy and medium-energy particles. Pioneer is cylindrical, 35 inches long and 37 inches in diameter; it weighs 140 pounds. High and low gain antennas are mounted on a boom extending from the top of the satellite and experiments are mounted on other booms projecting from the mid-section and base of the spacecraft. A nitrogen gas jet attitude control system, with input from four sun sensors, orients the spin-stabilized spacecraft normal to the ecliptic plane. More than 10,000 solar cells provide 60 watts of electrical power. Four Pioneer flights, beginning in 1965, are scheduled.

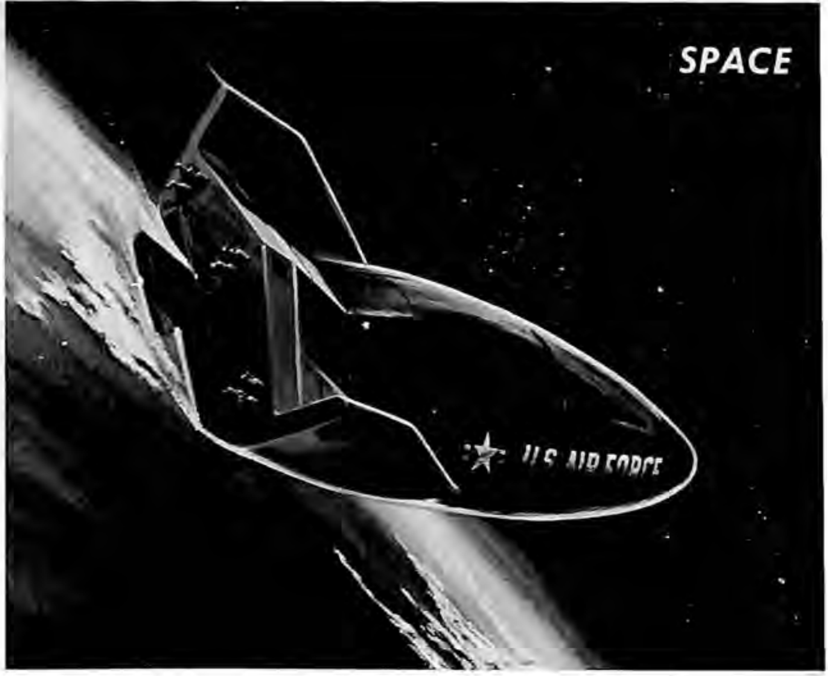
MARINER-MARS

Prime Contractor: Jet Propulsion Laboratory, California Institute of Technology
Associate Contractors: Lockheed Missiles and Space Company and General Dynamics/Astronautics and Lockheed Missiles and Space Company (prime contractors to Lewis Research Center for launch vehicle systems.)

Remarks

Mariner-Mars is an unmanned, instrumented spacecraft for use in the National Aeronautics and Space Administration program in conducting scientific observations of the planet Mars, for developing equipment and techniques for carrying out planetary explorations, and for making scientific measurements of the interplanetary environment. The spacecraft weighs 575 pounds and in its flight-deployed configuration extends 22 feet across the solar panels and stands 9 feet high from base to antenna tip. On-board equipment includes a mid-course propulsion guidance system, a central control and sequencer system, solar panels and battery, attitude control system utilizing sun and star sensors, a digital telemetry system employing omnidirectional and high gain antennas, a digital television system for taking pictures of Mars and instruments for measurement of the fields and particle environments in interplanetary space and the vicinity of the planet. The spacecraft was launched by an Atlas-Agena vehicle system and passed within 6118 miles of Mars in mid-July, 1965, following a 228-day flight. Closeup pictures of the Martian surface were successfully transmitted to earth over a distance of 150 million miles.





VOYAGER

Prime Contractor: Jet Propulsion Laboratory, California Institute of Technology

Remarks

Voyager is an instrumented space vehicle for use in the National Aeronautics and Space Administration program in conducting experiments on the surface of, and in orbit about, the planet Mars during the 1971, 1973, and subsequent opportunities in order to obtain information on the existence and nature of extraterrestrial life, the atmospheric, surface and body characteristics of the planet, and the planetary environment. Two first Voyager space vehicles are expected to be launched during the 1971 Mars opportunity. Each space vehicle will probably consist of an orbiting flight spacecraft carrying a capsule designed for landing on the Martian surface. The spacecraft will also provide the capsule with services such as power, timing and sequencing, telemetry, and command during the transit portion of the missions and may also serve as a communications relay. The capsule will be designed for entry into the Martian atmosphere, descent to the surface, impact survival, and surface lifetimes of as much as six months and will contain the power, guidance, control, communications, and data handling systems necessary to complete its mission. The space vehicles are expected to be launched by vehicles of the Saturn class. In photo, one concept of Voyager, which has not yet been designed.

SV-5D PRIME (PRECISION RECOVERY INCLUDING MANEUVERING ENTRY)

Prime Contractor: Martin Company, Baltimore

Remarks

PRIME is a lifting body class vehicle, a wingless, V-shaped spacecraft with a flat bottom, rounded top and vertical tail fins. The PRIME vehicles will be constructed using conventional aluminum aircraft structure, covered with a Martin-developed, ablative heat shield material. Two movable flaps on the underside of the tail will provide control in pitch and roll axes during atmospheric flight, and reaction jets will be used in space. The vehicles are being built for the Air Force for hypersonic, maneuvering flight tests over the Western Test Range following suborbital launches from Vandenberg AFB by Atlas SLV-3 standard launch vehicles. Parachute recovery of the PRIME spacecraft will begin once they slow to approximately Mach 2. The spacecraft will be "snatched" in the air by a plane near Kwajalein. PRIME is one portion of the broader USAF program START, which includes about a dozen separate areas of investigation and a number of different types of vehicles.

M2-F2 LIFTING BODY VEHICLE

Prime Contractor: Northrop Norair, a Division of Northrop Corporation

Remarks

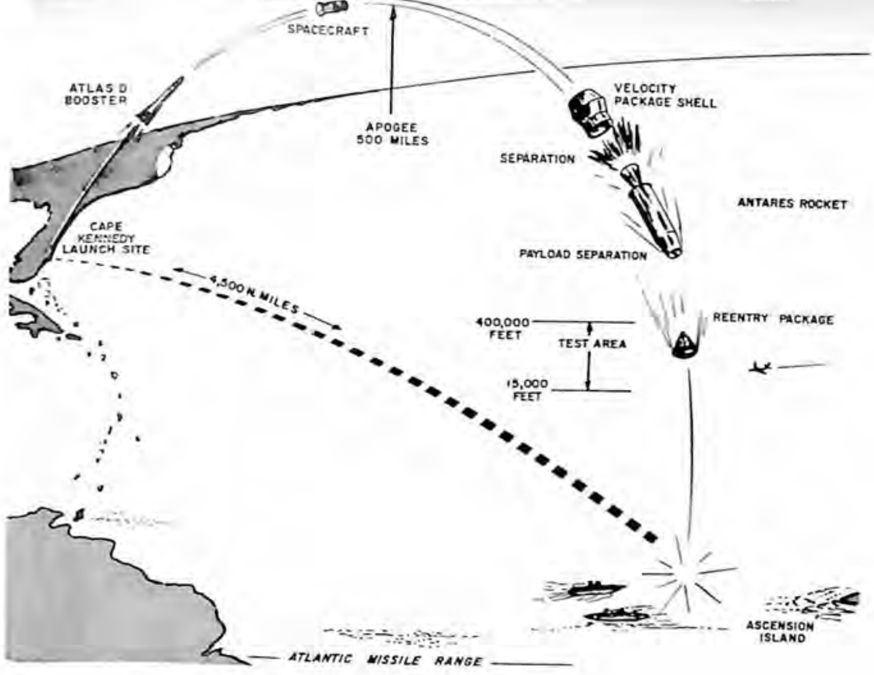
Not specifically a spacecraft, yet part of a space research program, the M2-F2 is an experimental, wingless lifting body designed for flights within the earth's atmosphere. From its flight test program NASA hopes to gain vital information in the art of controlling future manned spacecraft in the earth's atmosphere, in the critical terminal approach and landing phase. M2-F2 is 22 feet 2 inches long, 9 feet 7 inches wide and 8 feet 10 inches high. Maximum weight, including water ballast for tests, is 8,000 pounds. The vehicle is launched from a modified B-52 at about 45,000 feet and Mach 0.8 speed, then it maneuvers and descends to a conventional airplane-type landing. Northrop Norair is building a second lifting body vehicle designated HL-10. Where M2-F2 has a flat top, HL-10 has a flat bottom, and the latter craft has three tail fins instead of M2-F2's two. M2-F2 was delivered to NASA in June, 1965 and it started its flight tests late in 1965. The HL-10 is scheduled for completion and test in 1966.

ASSET

Prime Contractor: McDonnell Aircraft Corporation

Remarks

ASSET is an acronym for Aerothermodynamic/elastic Structural Systems Environmental Test, a non-orbital flight test program to investigate environmental effects on vehicles employing the lifting or glide concept of re-entry from space. Concluded in 1965, its primary objectives were to verify aerodynamic theories and investigate vibration conditions, materials, design and structural concepts for use in advanced hypersonic craft being contemplated by the Air Force. Fabricated of refractory metals (molybdenum, colombium, graphite and zirconium oxide), the vehicle was able to withstand the extreme temperature conditions generated by air friction at hypersonic velocities by radiating heat to the surrounding atmosphere. The flight program consisted of 6 flights in which the delta-shaped ASSET payload (6 feet long, 5.5 foot span, 1,100-1,200 pounds) was placed in the re-entry glide path by Thor and Delta boosters. Separation velocities ranged from Mach 12 to 19 at altitudes up to 200,000 feet. Each vehicle was heavily instrumented to provide aerodynamic and thermodynamic data, which was telemetered to ground stations of the Air Force Eastern Test Range.



FIRE RE-ENTRY SPACECRAFT

Prime Contractor: RAC Corporation

Remarks

Project FIRE is a program of NASA's Langley Research Center, Hampton, Virginia, designed to obtain critically needed information on the heat transfer, materials behavior and radio signal attenuation of spacecraft re-entering the earth's atmosphere at hyperbolic (25,000 mile per hour) velocities. Republic designed and built the 200 pound heavily instrumented prototype and two flight models both of which were successfully launched some 5,000 miles downrange from Cape Kennedy on April 14, 1964, and May 22, 1965 by Atlas D boosters. NASA is presently evaluating the wealth of data (more than 100,000 telemetered bits) which has been reduced for analysis by RAC.

Specifications

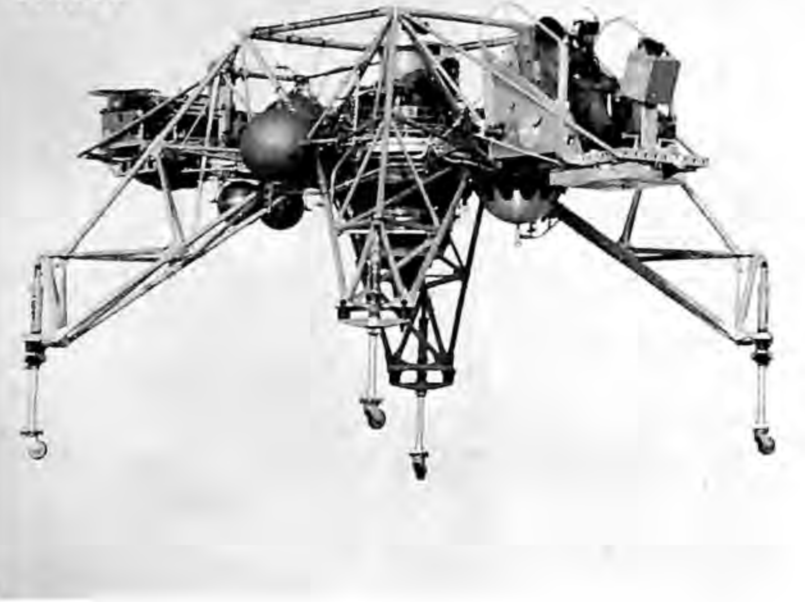
Re-entry velocity 37,000 feet per second; Re-entry vehicle heat shield diameter, 2 feet; overall height, 1.5 feet; weight, approximately 200 pounds; heat shield construction: alternate layers of metallic and oblating shields; instrumentation: thermocouples to measure temperature throughout the flight, radiometers to measure radiation intensities of the plasma sheath, and equipment to measure the onset and decay of radio blackout.

SCANNER

Prime Contractor: Honeywell, Inc.

Remarks

Scanner is a spacecraft to be used in horizon definition experiments being directed by NASA's Office of Advanced Research and Technology. It is being built by Honeywell under a contract with the Langley Research Center. Electronic equipment aboard the vehicle is designed to take readings of the infrared radiation emitted from the earth's atmosphere when viewing the horizon. Suborbital launches to an altitude of about 550 miles are planned from NASA's Wallops Station, Wallops Island, Virginia. Horizon definition and measurement are being studied because of their importance to spacecraft stabilization and guidance techniques.



LUNAR LANDING RESEARCH VEHICLE (LLRV)

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

A space trainer rather than a flyable spacecraft, the Lunar Landing Research Vehicle was designed and built by Bell Aerosystems for the National Aeronautics and Space Administration. It is a non-aerodynamic VTOL craft being flown at the NASA Flight Research Center, Edwards, California, to train astronauts in lunar landing techniques here on earth. With this vehicle, a pilot can simulate in earth environment, actual approach, hover and touchdown procedures required on the moon. A variable stability autopilot enables the pilot to achieve the same reactions and sensations as if he were operating in a lunar environment. The LLRV is designed so various sections can be removed and replaced by actual hardware of the Apollo Lunar Excursion Module. Two LLRVs were delivered to NASA in mid-April, 1964. NASA Test Pilot Joseph A. Walker made the first free flight at Edwards on October 30, 1964.

Specifications

Height 10 feet, 6 inches; four truss legs spread 13 feet, 4 inches; power plants single gimballed, vertically-mounted General Electric CF700-2V axial flow aft fan engine (4,200 pounds thrust), eight 500-pound thrust hydrogen peroxide lift rockets, 16 reaction control hydrogen peroxide rockets. Gross takeoff weight 3,710 pounds.

RADIO ASTRONOMY EXPLORER

Prime Contractor: Goddard Space Flight Center

Remarks

The Radio Astronomy Explorer, scheduled for first launch in 1967, will investigate radio emissions in space. To weigh about 275 pounds, the spacecraft will have four very long (750 feet) extendable antennas. Goddard SFC will build two of the spacecraft and an industrial firm will be selected to build an additional four.

SYNCHRONOUS METEOROLOGICAL SATELLITE

Prime Contractors: RAC Corporation, Hughes Aircraft Company, Radio Corporation of America Astro-Electronics Division

Remarks

An synchronous or 24-hour satellite, the SMS is an advanced type of weather satellite, a follow-on to Tiros and Nimbus. In 1965 the program was still on a study basis; when hardware development is approved NASA will select one of the three study contractors. SMS booster will be either Atlas-Agena or Atlas-Centaur.

SAMOS/ALARM

Prime Contractor: Lockheed Missiles and Space Company

Remarks

SAMOS is an acronym for Satellite and Missile Observation System, a spacecraft for surveillance of enemy territory. SAMOS equipment is contained within an Agena spacecraft; the whole stage goes into orbit. The system is operational, but details are classified. A companion program for development of a system to detect enemy missile launches by means of infrared devices is under way; once called MIDAS, it is now known as Alarm.

ECHO II

Prime Contractor: G. T. Schjeldahl Company

Remarks

A passive communications satellite which carries no internal transmission equipment but relays signals by the "bounce" technique, Echo II is a 135-foot-diameter rigidized sphere. The balloon is launched in a compact package and inflated in space. Two tracking beacons make up the spacecraft's electronic payload.

STAR TRACKER FOR ORBITING ASTRONOMICAL LABORATORY

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

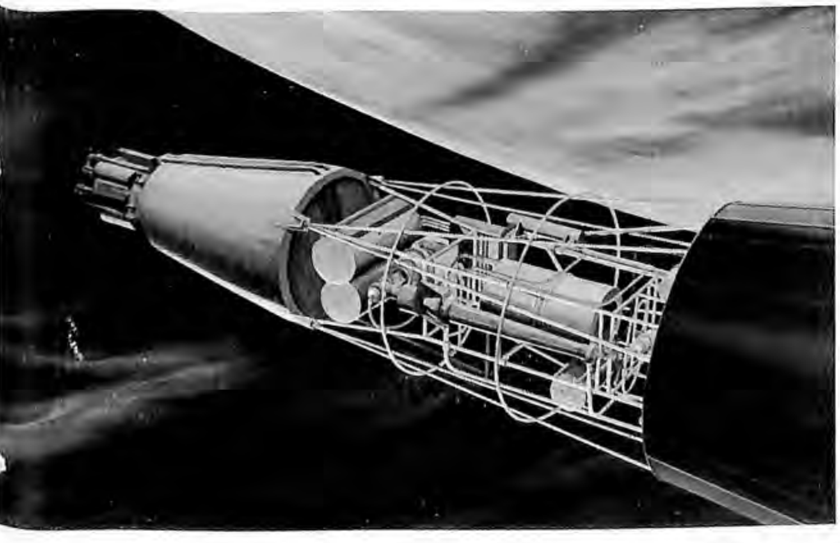
The Bendix Star Tracker has been contracted for use on NASA's Orbiting Astronomical Observatory (OAO) Spacecraft. Once the vehicle has been launched into orbit, the Star Tracker will seek out and "lock" onto an appointed star. It will continuously track the star as the spacecraft orbits the earth and feed the vehicle's control system with signals that represent the position and attitude of the vehicle in relation to the star. The control system uses this information, on command, either to hold the vehicle in a fixed attitude or to change its attitude, as, for example, when a new sighting path for the radiation detection equipment is desired. The Star Tracker assembly consists of a telescope supported by precision pitch and roll gimbals, each with ±60 degree authority. This telescope utilizes a refractive optical system which focuses the star image on the photo cathode of a photo multiplier tube. This phototube is electronically scanned and generates x and y coordinate d-c error signals proportional to the angle between the telescope boresight axis and the star line. The telescope housing, support structure and gimbals are precision machined parts that permit mechanical alignment of the optical axis to within 5 arc seconds.

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 unattended for 10,000 hours (nearly 14 months). Photo shows conceptual use of the SNAP-8 system on a Mars fly-by mission: Heat from a nuclear reactor (far left) is used to operate conversion equipment (center) and generate enough electricity to power the spacecraft for 14 months.



STABILIZED PLATFORM SYSTEM FOR SATURN ROCKET

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

The Saturn rocket's ST-124 stable platform, successfully used on Saturn I SA-5 through SA-10, is scheduled to steer Saturn IB and V vehicles in orbit. It provides guidance and second stage cutoff information, and velocity and attitude control signals starting from about 16 seconds after ignition of the second stage engine. The Saturn stabilized platform operates in conjunction with two 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 three-gimbal or four-gimbal platforms, depending upon the particular Saturn mission. The spherical ST-124 platform measures 21 inches across, and weighs about 110 pounds in a three-gimbal configuration. Addition of a fourth gimbal adds another 15 pounds. The system requires peak power of 200 watts dc and normal running power of about 63 watts dc and is designed to withstand thrust levels in excess of 20 g's. Mounted to the stable inner element, or inertial gimbal, are three single-degree-of-freedom gyros, three pendulous-gyro-accelerometers, and two pre-flight leveling pendulums. Gyros and accelerometers are gas floated. The gyro wheel is supported in the beryllium cylinder, which, in turn, is supported by the hydrostatic gas-bearing, with both radial and axial centering. All platform structural members and most of its components are made of beryllium, thereby affording considerable weight saving as well as greatly improved stability over a wide range of temperatures.

INERTIAL GUIDANCE SYSTEM FOR PERSHING MISSILE

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

The inertial guidance system for the Army's Pershing selective range artillery missile contains six gyros which provide directional references for hitting a target the size of a football field from a distance of several hundred miles. The actual spinning parts of the gyros are sealed-in miniature cylinders (two inches long and one inch in diameter) which, in turn, are "floated" in an outer cylinder, leaving an airspace of just a few thousandths of an inch at all points. Microscopic, bell-shaped air jets in the outer cylinder "float" the gyros on an air cushion—with no metal-to-metal contacts except for pin-point electrical contacts at each end of the gyro cylinders. Contours of gyro components are checked optically for flatness to within 11.5 millionths of an inch. The self-contained, jam-proof guidance system contains a computer that "stores" target information, compares it with flight attitude and acceleration data provided by the gyro system, and aims the missile in flight. It cuts off the rocket engine at the exact point, and the missile becomes an atomic-age "howitzer shell" of fantastic range. The precision of the system is matched by its ability to perform in flight, and there has never been a recorded in-flight malfunction of the guidance system.

PENDULOUS INTEGRATING GYRO ACCELEROMETER FOR MINUTEMAN MISSILE

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

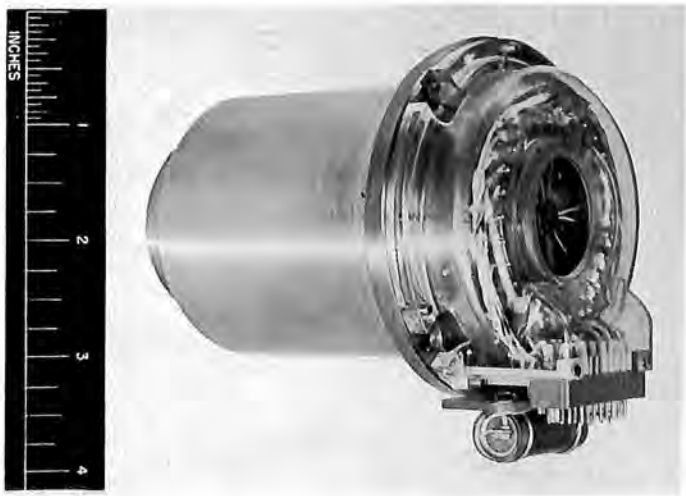
The Bendix 16 PIGA Pendulous Integrating Gyro Accelerometers are the key acceleration-sensing elements in USAF's improved Minuteman ICBM guidance system. The 16 PIGA provides the most accurate velocity-measuring device in existence, precisely measuring accelerations in sensitivities as small as mill-minus g to as large as 30 g's. It is a sensitive, liquid-floated, single-degree-of-freedom gyro instrument rugged enough to operate in vibrational and thermal environments of any application where precise velocity information is required. An outstanding feature of the unit is the low threshold level of the gimbal rotation, resulting from floating the gyro gimbal in viscous fluid of the same density as the average density of the gimbal and maintaining proper gaps between rotating and stationary assemblies. The structural material is beryllium. The weight is approximately one pound, 2 ounces; the size is two and one-half inches in diameter by four inches long. The size of a large percentage of the miniature parts incorporated in the unit are precise to within 50 millionths of an inch or better.

RANGE INDICATOR FOR LUNAR EXCURSION MODULE

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

The Lunar Excursion Module (LEM) range indicator will provide LEM astronauts with altitude and rate-of-altitude change information during descent from NASA's Apollo command and service module to the lunar surface. During the return ascent and rendezvous with Apollo spacecraft, it will display distance between the two 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 four-pound indicator incorporates the latest features of integrated micro-circuit design and has an accuracy of better than one mile at its maximum range and better than five feet during the lunar landing maneuver.



GUIDED MISSILE SYSTEM RADAR SIMULATOR STATIONS FOR NIKE HERCULES MISSILE

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

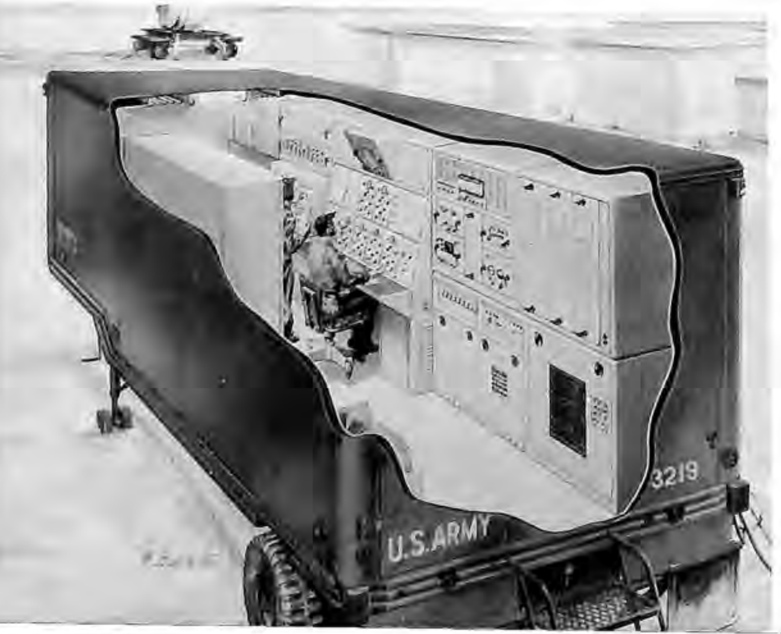
Guided Missile System Radar Simulator Stations, designated AN/MPQ-T1, supply simulated targets and electronic counter measures (ECM) environment for Nike Hercules Radar Systems and are used for the training of Army personnel assigned to Nike installations. The simulator equipment is connected to the Nike Hercules Radar System and may be used either in the field or in a classroom situation for training purposes. Any conditions encountered in actual operation are simulated. The simulator consists of the Operators Console, ECM Cabinet, Chaff Cabinet, Power Supply Cabinet, Passive Interference Generator Cabinet, and Auxiliary Cabinet, all installed in a semi-trailer. The Target Coordinate Generator in the Operators Console independently controls six targets variable in range, speed, heading, elevation, turn rate, climb rate, dive rate, target size and target aspect. The Missile Motion Generator in the console controls rate of fire, type of missile (either Ajax or Hercules), fire command, burst command, guidance command, launcher parallax, lethal radius, missile beacon strength, and missile malfunctions. The ECM Cabinet supplies signals to simulate all forms of electronic jamming to which the Nike radars are likely to be exposed under actual combat conditions. The Chaff Cabinet enables the simulator operator to make fifteen chaff drops. He may also make a corridor drop. The chaff is presented on any of the radars in a realistic manner. It is normally affected by wind and time. The Power Supply Cabinet regulates voltages for all systems in the simulator.

PRECISION APPROACH AND LANDING SYSTEM

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

The Precision Approach and Landing System is the first and, thus far, only automatic landing system to receive U. S. Federal Aviation Agency approval to permit large commercial jet aircraft to make fully automatic landings in scheduled service. It is also the first to receive FAA approval for use in Category II conditions or weather affording only 100-foot ceilings and 1,300 feet forward visibility. A complete system for automatic landings is comprised of an improved autopilot coupler (which locks the aircraft's autopilot to the instrument landing system beam at the airport) and amplifier computer, two radio altimeters, dual flare computers, a standby gyro-horizon, and improved yaw damper and a series of monitors to check the operation of the autopilot and instruments. An automatic throttle control is optional. The sensitivity of the auto-pilot coupler permits a longitudinal dispersion of only plus or minus 500 feet from the intended touch-down point and a lateral dispersion of plus or minus 50 feet from the beam. The equipment also automatically compensates for wind conditions. Each of two radio altimeters provides height-above-terrain signals for the autopilot and the indicator on the pilot's panel. At an altitude of 60 feet, the flare computer takes control of the airplane. Upon receiving the appropriate signals from the altimeters it puts the airplane in the landing attitude and reduces its rate of descent to two feet per second for the touchdown. The yaw damper and new automatic throttle system also are tied into the autopilot system to provide precise lateral and airspeed control. The operations of all of the system's components are constantly checked during the final approach by a series of monitors. Should there be any error, the monitor disconnects the autopilot.



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

MICROVISION

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

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 contracted by the Federal Aviation Agency for installation at its research center in Atlantic City, N. J. Microwave radio signals—beamed to the plane from both sides of the landing strip—puts an electronic image or "picture" of the runway on a semi-transparent screen in the cockpit. The pilot "sees" the runway through his normal line of vision from a distance of about ten miles with the plane at an altitude of some 5,000 feet. At a distance of about seven miles from touchdown, the runway, appearing as a pattern of separate beacons resembling runway lights, comes into focus on the screen and becomes increasingly defined as the distance decreases. The system comprises a series of ground-based microwave beacon-transmitters, airborne direction finding equipment, and the head-up display. The beacons, along each side of the runway, form a pattern similar to runway lights. Each beacon transmits one-microsecond pulses approximately 400 times per second to small, fixed, wide-angle microwave antennas installed in the aircraft nose. The airborne direction finding receiver determines the immediate angular position of all the beacons with respect to the longitudinal and lateral axes of the aircraft, and simultaneously presents these positions, in true perspective, 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.

VERTICAL SCALE FLIGHT INDICATORS FOR F-111

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

Vertical Scale Flight Indicators for the F-111 use moving tapes, command indices and a common reference line to display vital flight parameters at a glance. Familiarization time is quick and displays during flight are rapidly and precisely interpreted by the pilot. The indicators, which receive inputs from a central data computer and a source of command data in the form of synchro or potentiometer signals, present information such as vertical speed, mach number, indicated airspeed, and maximum safe speed. Indicator tapes provide greatly improved scale factors for better readability. Scale limits are not restricted to 360 degrees, and yet require less panel space and fewer components than round dial indicators. The new reference-line concept of the vertical scale instruments eliminates the often tedious and less accurate method of reading round dials with pointers. Command information is set either manually or remotely from a ground station via data link. When all commands are executed, a continuous horizontal bar appears across the indicator grouping, instantly showing the pilot that the aircraft is correctly performing the necessary tasks.

ADC-600 AIR DATA COMPUTER FOR F-111

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

The ADC-600 Air Data Computer for the supersonic F-111 immediately and precisely converts information on the physical properties of the air through which the plane is flying into data for operation of such subsystems as autopilots, flight instruments, and navigation systems. The highly refined, analog, central air data computer exhibits controlled dynamic response, high accuracy, and static probe error compensation capability in providing the F-111 aircraft systems with a wide range of information. The basic computing mechanism and repeater modules provide shaft rotations for 88 electromechanical devices such as conductive plastic potentiometers, synchros, encoders, and switches. Shaft outputs include altitude, mach number, true airspeed, total pressure, dynamic pressure, indicated air speed, true temperature, pressure altitude, and angle-of-attack, all corrected for probe errors. Of 88 output provisions, 66 are implemented and 22 are reserved for growth potential. The unique design philosophy applied to the ADC-600 makes the sensors and the whole computer relatively immune to position and acceleration errors. Consequently, the computer provides precision outputs of fine sensitivity, particularly required at high altitudes. The computer is flexible in design, reliable, easily maintained, and incorporates monitoring and self-test capabilities. It achieves good balance between the weight and size economy of single packaging, on the one hand; and the design flexibility of modular construction and separate packaging, on the other hand. The air data system is the same—except for a few internal differences due to mission requirements—on both the USAF's F-111A and USN's F-111B.

PB-60 AUTOMATIC FLIGHT CONTROL SYSTEM FOR C-141

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

The PB-60 Automatic Flight Control System on the C-141 aircraft is the world's most advanced automatic flight control system for transport use. It features a triple redundant yaw damper system which is entirely fail operative. No single failure can cause loss of control. By means of an electronic voter circuit that uses majority logic, the performance of three separate yaw channel electronic circuits is continuously compared and the optimum circuit is automatically switched in as the working circuit. If a malfunction occurs in it, one of the two remaining circuits automatically takes over. The yaw damper system also has a self-checking feature which continuously alerts the crew to its GO or NO-GO condition. The PB-60 also allows the human pilot to keep in the control loop when the autopilot is engaged. In addition to the conventional pedestal-mounted controller through which the aircraft is maneuvered when on autopilot, the human pilot has the same type of maneuvering control in his control wheel. This control wheel steering enables the pilot, at any time the autopilot is engaged, to maneuver his aircraft in conventional manner but with the advantage of stabilization from the autopilot system. The system also employs solid state electronics in all control switching functions. Among its more conventional functions, the automatic flight control system will maintain the attitude, altitude and heading of the aircraft and has the ability to track automatically VOR, ILS, and glide slope beam references. PB-60 Automatic Flight Control System is also used on commercial aircraft

BANC-660 NAVIGATION COMPUTER SYSTEM

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

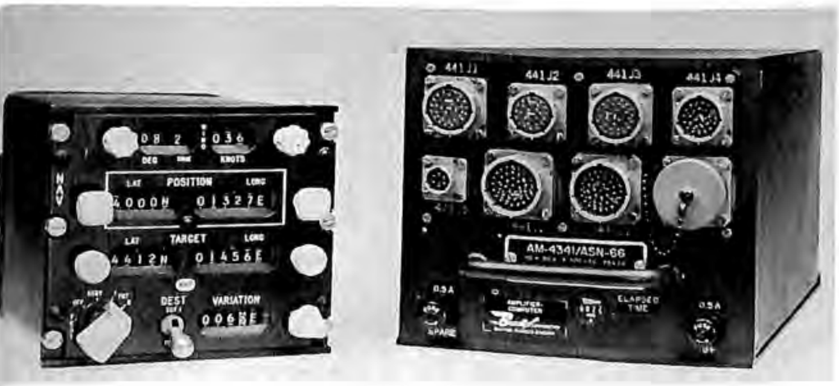
The BANC-660 Navigation Computer System provides continuous automatic dead reckoning in latitude and longitude coordinates, computes the precise great circle course and distance to either of two destinations, and solves wind magnitude and direction, independent of ground-based aids and free of any outside interferences. Designated as AN/ASN-66 for military use, the system incorporates three computers—Present Position, Course and Distance, and Wind Memory—in two compact units: the Computer Amplifier and the Computer Control. The units are completely modular and provide for integral self-testing. Electrical outputs of bearing, distance, and ground track are compatible with standard Bearing-Distance-Heading indicators or Horizontal Situation Indicators. Twelve other outputs of navigational data are provided, in addition to the displays of present position and computed wind. The Wind Memory Computer Section provides for three modes of operation that are automatically actuated, as required: Doppler, Wind Memory and Air Mass. The console-mounted computer control unit is divided into six sub-assemblies, all mounted within a dust-tight cover. The modules are easily removable from the chassis frame. The compact computer amplifier unit houses six electromechanical modules, removable for easy servicing, and the system's electronic circuitry. The electronics include a plug-in power supply at the rear wall of the amplifier unit, and the eight printed circuit cards, also readily removable. All system primary power is applied to the computer amplifier.

WIND MEMORY COMPUTER

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

The Bendix Wind Memory Computer, Type BAWC 200, augments the navigational performance of automatic dead reckoning systems used with Doppler radar. The computer compares ground speed and drift angle from the Doppler radar with true airspeed from an air data computer or an airspeed transmitter and with heading from a magnetic compass or a guidance system. The resulting computation is the vector difference—N-S and E-W wind components—used as auxiliary outputs. The wind memory computer continuously transmits ground speed and ground track to the automatic dead reckoning computer, eliminating manually set wind parameters. During periods of temporary Doppler radar dropout, the wind memory computer stores the last radar-derived computed wind vector components and combines them with current air-speed and heading to compute outputs of ground speed and ground track. In the event of Doppler radar dropout for an extended period, the wind memory computer retransmits the true airspeed and heading information to the automatic dead reckoning computer for computation with wind direction and wind velocity, which must then be set in manually, to provide ground speed and ground track.

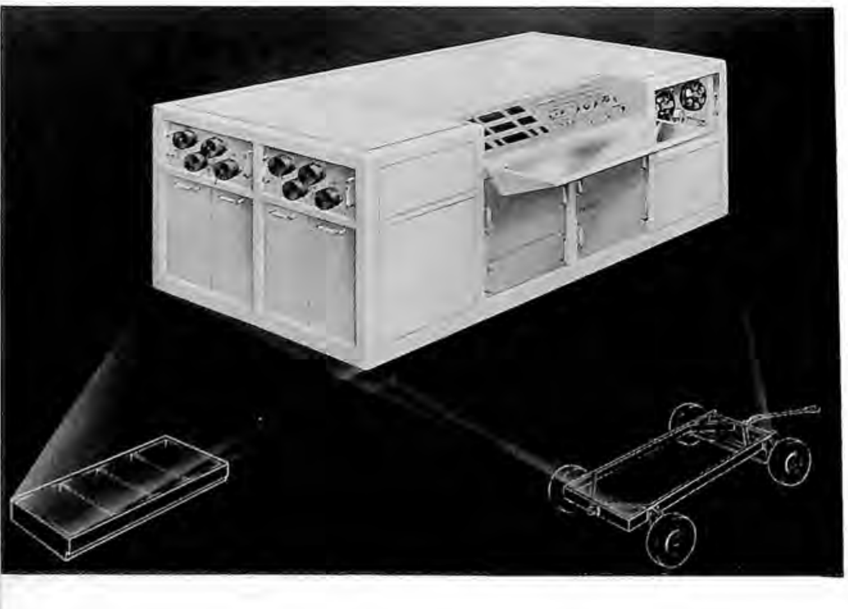


AN/GSM-133 PROGRAMMER COMPARATOR

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

The AN/GSM-133 is an automatic, versatile, programmable testing system that will, for the first time, provide consistent automatic checking of avionic systems for aircraft, missiles and space vehicles at all levels from factory and depot to flight line and on-site maintenance. This second generation programmer-comparator incorporates micrologic techniques that reduce its size by 30 percent and weight by 50 percent over current models. It can be transported either by air or overland. The system performs serial type evaluations on both analog and digital signals, utilizing integrated (micrologic) elements for all logic functions. It evaluates voltage levels and measures time, events, frequencies, and resistances to high orders of accuracy and it is compatible with testing requirements anticipated through 1975. The wide interfacing capability of the set permits the direct coupling of alternate programming sources, manual controls, displays, recorders, and measurement devices, as well as providing all of the basic input/output lines for connections with computational devices in either on-line or off-line configurations. The general purpose configuration of the set can be readily altered for special applications. The set provides for a variety of multiple, independent, and simultaneous evaluations. This capability greatly enhances the versatility of the set and allows for combining continuous monitoring techniques with sequential evaluations of related parameters and for directly accommodating a variety of dynamic test procedures.



AN/FPS-85 SPACE TRACK RADAR SYSTEM

Prime Contractor: The Bendix Corporation, Bendix Radio Division

Remarks

This radar facility, located at the Eglin Air Force Base, Florida, will become a major element of the United States aerospace surveillance and warning system. The building housing the space track radar is 13 stories high and more than a city block long. The radar system uses an electronic scanning technique called "phased array," a method of scanning large volumes of space with radar beams without any mechanical movement of the radar. Space track radar has thousands of small individual receivers and transmitters fixed in the face of the antenna structure. Through the high speeds available with electronic—rather than mechanical—beam steering, it is possible to track many satellites up to altitudes of several thousand miles in one "glance." Design, technical and contractual direction of the project is by the Air Force Systems Command's Rome Air Development Center. The development has been under the sponsorship of the Electronic Systems Division but will be operated by the Air Defense Command.

AN/MRC-98 TROPOSPHERIC SCATTER COMMUNICATIONS SYSTEM

Prime Contractor: The Bendix Corporation, Bendix Radio Division

Remarks

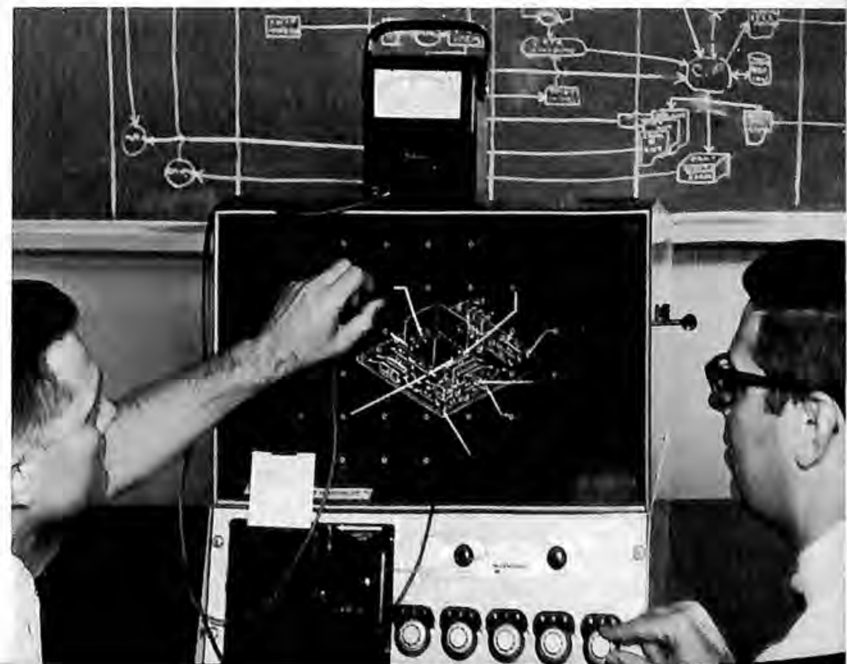
This mobile air transportable communications system is used by the Air Force for long distance point-to-point voice and teletype contact. The system is composed of three 31-foot trailers plus two multichannel microwave antennas having quadruple diversity capability. Bendix furnished complete systems to the armed forces in activities recently encountered in the Dominican Republic. Scatter communications technique is accomplished by bouncing radio waves off the troposphere and used where the distances between sites are too great for line-of-sight communications or where terrain conditions do not permit the use of multiple station hops that are required in line-of-sight systems. Scatter propagation reduces substantially the number of relay steps in a communication network. During Project Watermark, Bendix provided technical assistance to assure prompt and proper erection of antennas as well as final testing and checkout for the required reception and transmissions, both at Ramey Air Force Base in Puerto Rico and San Isidio, Santo Domingo.

SAVAC

Prime Contractor: Chrysler Corporation Missile Division

Remarks

SAVAC is an electronic problem simulator being used by the Air Force to simplify training of technical personnel who man the complex electronic, electric or mechanical circuitry used in today's missile and fire control systems, radar equipment and automated devices. SAVAC stands for Simulates, Analyzes, Visualizes, Activated Circuitry. A 35mm slide projects circuit diagrams onto the screen of SAVAC, which resembles a television set. Punch cards, fed into the unit, are used to create malfunctions or problems in the projected circuit. The system allows students to work on malfunctioning circuits and to learn intricacies of complex systems without using the actual equipment which is often expensive and highly sensitive. SAVAC units range in size from a table model to a 78-inch high floor demonstrator which can be used for group training. The units are assembled at Chrysler Missile Division's Florida Operations Plant near Cape Kennedy, Florida.



PYROLYTIC GRAPHITE ROCKET NOZZLES

Prime Contractor: Wright Aeronautical Division, Curtiss-Wright Corporation

Remarks

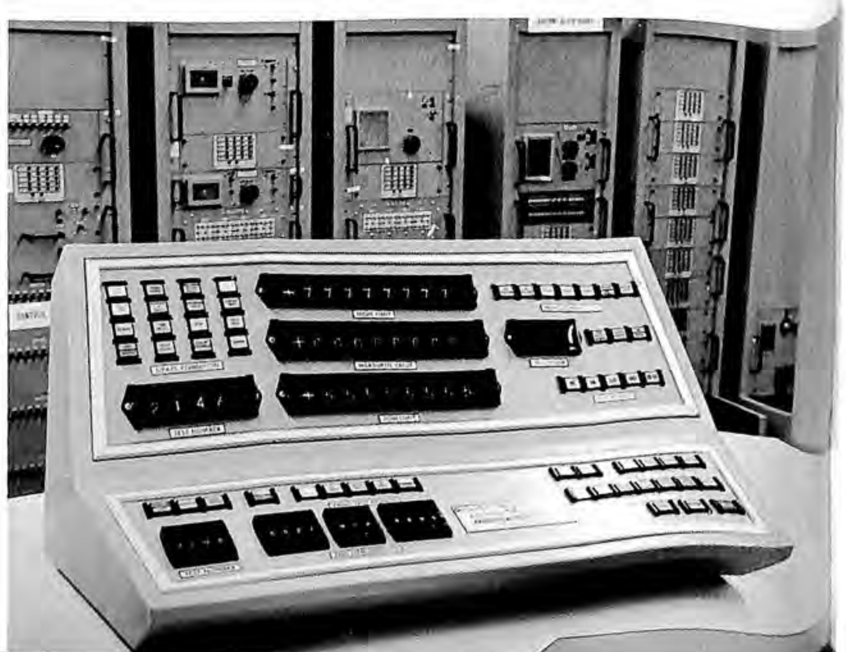
Under contract with the USAF Rocket Propulsion Laboratory, Wright Aeronautical Division of Curtiss-Wright Corporation is developing pyrolytic graphite rocket nozzles for use in space propulsion systems. A testing program for high temperature nozzles is currently under way, its aim being to improve non-eroding characteristics and the utilization of advanced high energy propellants. No detailed specifications are available.

GENERAL PURPOSE AUTOMATIC TEST SYSTEM (GPATS)

Prime Contractor: Electronics and Space Division, Emerson Electric Company

Remarks

The General Purpose Automatic Test System (GPATS) consists of a central programmer-controller mated with any number of selectable functional building blocks (i.e. programmable stimulus generators, response monitors, switching units, simulated loads, and power supplies) which can be interconnected in hundreds of different ways to perform desired test programs on any given system. A Universal Decoder Memory Unit (UDMU) is an integral part of each building block to provide a common interface and capability for standard decoding and memory of programmed information. GPATS offers the following overall benefits: reduced test equipment design cost, reduced test equipment hardware cost, test uniformity, accuracy consistency, increased reliability of tested unit, increased testing rate, improved use of skilled manpower, reduced operator training, greater logistics control, and improved physical flexibility and utility. GPATS is being developed under USAF contract.



AUTOMATIC PICTURE TRANSMISSION GROUND STATION

Prime Contractor: Fairchild Hiller Electronic Systems Division

Remarks

The Automatic Picture Transmission (APT) Ground Station receives, records and provides terrestial pictures including the cloud cover as transmitted by Weather Satellites for interpretation by meteorologists. More than 50 stations are now in service throughout the world, reproducing weather pictures sent by the APT Systems aboard TIROS and NIMBUS satellites. A new improved system featuring reduced size and proprietary photorecorder to produce actual 8 inch by 8 inch photographs is under development. The new WeatherPix APT Ground Station comprises a pedestal-mounted antenna (in photo), antenna control system, receiver and photographic facsimile display unit. In normal operation mode, the directional ground antenna is oriented to begin receiving when the satellite reaches a point 10 degrees above the station's horizon. Operating at distances up to 150 feet from its associated equipments, the antenna can be rotated 270 degrees clockwise or counter-clockwise. The pedestal houses a motor-driven azimuth positioner, and the console mounts all operating controls for speed and direction of antenna rotation. The received signal is fed to a low-noise preamplifier and then through a coaxial cable to the receiver. Here the receiver amplifies and demodulates the signal, extracting the AM subcarrier from the FM carrier and producing a 2400 cps output that carries video data to the photo recorder. Using a line-by-line scan technique the photo recorder reproduces the transmitted APT picture on photographic paper. A clear gray-shade print is ready for use within 15 seconds after completion.

AUXILIARY DATA ANNOTATION SET

Prime Contractor: Fairchild Hiller Electronic Systems Division

Remarks

The Auxiliary Data Annotation Set provides mission-pertinent data annotation capability to airborne reconnaissance photo cameras. Pertinent flight information, such as time, latitude, longitude, speed, barometric and radar altitude, heading, pitch, roll, drift, date, sortie number, detachment, radar mode, correlation counter, sensor/station identification, and taking unit identification can automatically be marked on the sensor film. The ADAS equipment is adaptable by means of system component selection to a particular aircraft installation and mission requirements, thus insuring high commonality for reduced logistics support. The AN/ASQ-90 consists of the Auxiliary Data Translator Unit, six Recording Head Assemblies, a Time Insertion Unit, and a Test Display Unit. The AN/ASQ-90 systems have been installed on the RF-4B and RF-4C aircraft. A modified ADAS system configuration is used on the McDonnell RF-101 aircraft, and consists of the Auxiliary Data Translator Unit, and four Recording Head Assemblies. Information is recorded on film by means of a cathode ray tube contained in each Recording Head Assembly. The Auxiliary Data Translator Unit (ADTU) contains a logic module and a power supply module. A Fixed Programmer Card Assembly which provides a means of changing the fixed data (date, sortie number, etc.), is inserted in the ADTU just-prior to flight. An earlier alphanumeric ADAS system was designed for the AN/USD-5 Reconnaissance Drone, AN/USQ-28 Mapping System, as well as RF-101 and RF-4C aircraft applications.

VAPOR CYCLE AIR CONDITIONERS FOR GROUND SUPPORT

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

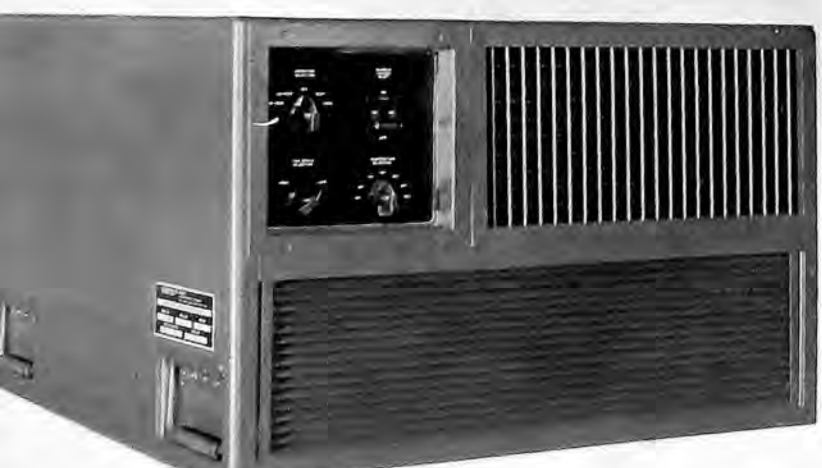
A new line of air conditioners was developed for ground support van and shelter use, designed to meet the rigid requirements of the military services. Eleven different models were developed ranging in capacity from 9000 to 60,000 BTU per hour, with 60-cycle and 400-cycle power options available on all units. All models are of a compact, low-silhouette design, completely self-contained, and readily adaptable to any installation requirement. Developed for use in tactical and support organizations, the air conditioners can meet the cooling, heating, and ventilation requirements of communications facilities, field command posts, electronic equipment shelters, medical facilities, field repair shops, photo processing shelters, and others—in general, for any van or shelter that requires a compact, lightweight, reliable, high-performance air conditioner.

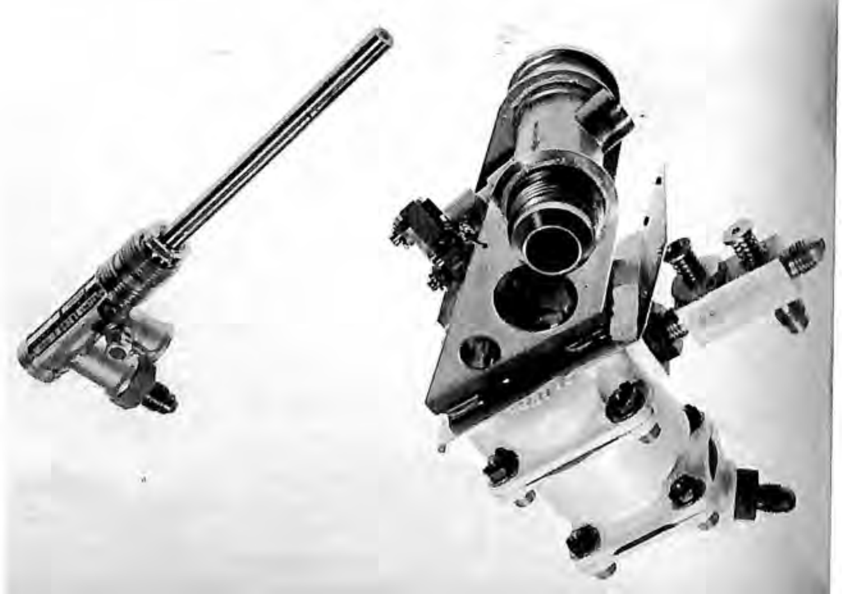
TEMPERATURE CONTROL SET MODELS CTS25-1, CTS26-1, CTS27-1, AND CTS28-1

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

A series of temperature control sets are used on the Series F-111 aircraft to control the flow of air to various systems of the aircraft in response to the temperature requirements of the systems. The CTS25-1 controls the cooling airflow into the aircraft electronics bay and has a temperature set point of 150 ± 10 degrees F; the CTS26-1, which is a low-limiting temperature control set, controls the flow of refrigeration air to the aircraft cooling system and has a temperature set point of 65 ± 5 degrees F; the CTS27-1 controls the flow of air to the aircraft rain-removal and anti-icing system and has a temperature set point of 390 ± 10 degrees F; and the CTS28-1 controls the flow of cooling air to the AMCS equipment and has a temperature set point of 65 ± 5 degrees F. Each temperature control set consists of a butterfly modulating valve assembly, and a temperature sensor assembly. The temperature sensor, which is located at the point where temperature control is required, senses the temperature of the air and, as required, varies the pneumatic control pressure which positions the modulating valve butterfly. In photo, Model CTS28-1.



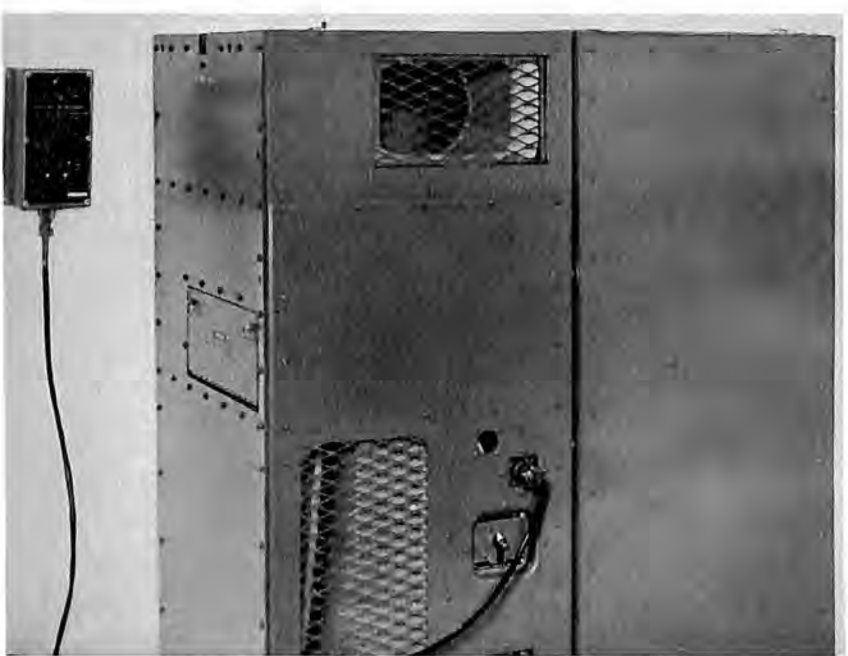


AIR CONDITIONER MODEL VEA4-6

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

Air Conditioner Model VEA4-6 is a lightweight, air transportable, vapor cycle air conditioning package specifically designed to provide conditioned air for a guided missile system. The unit is presently being used in other applications having similar personnel and equipment cooling and heating requirements. After initial installation, the unit is capable of an air cooling load capacity of 50,000 BTU per hour and a heating capacity of 35,800 BTU per hour. It uses Refrigerant 12 for cooling and operates on 208-volt, 3-phase, 400-cycle power. The unit is winterized to allow operation in ambient temperatures down to -65 degrees F. It discharges conditioned air at a flow rate of approximately 1100 cubic feet per minute at a temperature of 65 degrees F, automatically controlled. The air conditioner consists of two equal size enclosures that are easily interconnected and can be operated remotely from each other. The enclosures are of compact, sturdy construction and are built to rigid military specifications and standards. One enclosure, the Condenser Section, contains the compressor, condenser fan, and high-pressure refrigerant controls. The other enclosure, the Evaporator Section, contains the evaporator, evaporator fan, expansion valve, heaters, electrical controls, and temperature controls. They can be easily separated and interconnected through suitable refrigerant and electrical lines for applications in which such arrangement is preferred. Functionally, the VEA4-6 consists of a cooling subsystem and a heating subsystem regulated by either automatic or manual controls from an adjacent control panel.

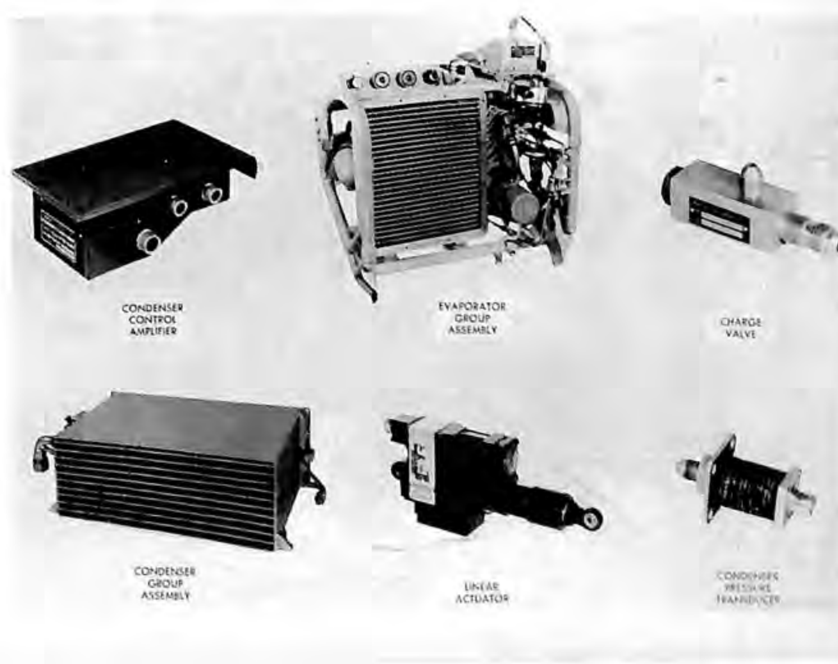


VAPOR CYCLE REFRIGERATION SYSTEM MODEL VEA6-1

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks:

The Vapor Cycle Refrigeration System Model VEA6-1 is used to cool, dehumidify, and recirculate air used for cooling aircraft electronic equipment. It is presently being used on Navy Model E2-A aircraft. The VEA6-1 is the equivalent of a 5.4-ton air conditioning system, and can absorb heat produced by the electronic equipment at a rate of 64,800 BTU per hour under maximum load conditions. The system uses Refrigerant 12 as the cooling medium. This refrigerant absorbs heat from the electronic equipment cooling air flowing through the condenser. A manually controlled switch places the system in operation when the aircraft is on the ground with the engines operating. The system can be operated with the aircraft on the ground and the engines shut down if an external source of electrical power, hydraulic pressure, and cooling air is available. When the aircraft is airborne, the system will automatically compensate for varying flight conditions. It does not require engine bleed air for operation.



GROUND AIR CONDITIONER MODEL GEA50-1 (A/M32C-10)

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

The Ground Air Conditioner Model GEA50-1 (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 discharge air is delivered directly into the air-duct system of the aircraft at temperatures ranging from 47 degrees F to 200 degrees F, discharge pressures to 3 psig, and airflow rates as high as 50 pounds per minute. Discharge temperatures are selectable through the entire operating range and are regulated by a simple and reliable control system, which maintains the selected temperature, once established, independent of changes in delivery flow rate and back pressure. The airflow rates can be selected from 5% to 100% of full delivery load and are automatically controlled. The unit is all-pneumatic in operation and receives its sole source of energy, turbine bleed air, from an external gas turbine compressor. 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, on which are also mounted pneumatic gages to monitor the performance of the unit. Two discharge ports in the unit allow servicing of two aircraft simultaneously.

URINE DISPOSAL LOCK

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

The Urine Disposal Lock (UDL) was designed for the Apollo spacecraft to provide a means for storing urine during the mission and permitting ejection of the stored urine by the opening of a dump port to space vacuum. The UDL is basically a spherical vessel containing a butyl rubber bladder encompassing a liquid collection sponge to absorb and retain the urine. The unit is extremely compact. It has a 6-inch spherical diameter and the surface of the unit is electro-polished to a surface finish with an emissivity of 0.07. The unit weighs under 3 pounds, and holds a total of 950 cc of urine. During use, gas and liquid urine flow into the vessel through an inlet port at a pressure of 5 psia at a gas flow rate of 1.2 cfm at ambient temperature and a liquid flow rate of 375 cc in 30 seconds. As the gas and liquid flow into the UDL, the liquid is absorbed by the sponge material contained within the rubber bladder. The gas passes through the sponge material and flows through a gas outlet port. The internal pressure of 5 psia keeps the system in equilibrium so that there are no differential pressures creating forces on the sponge. After the liquid waste has been accumulated in the UDL, the unit can be evacuated by operation of a selector valve within the vehicle that opens a dump port and closes the inlet and gas outlet ports. The dump port is opened to space vacuum, creating a pressure differential between this port and the vent port pressure. This results in a compression or squeezing effect on the rubber bladder which in turn squeezes the sponge forcing the liquid out at an average rate of 375 cc in 15 seconds, aided by the pressure differential.

COLD GAS SUPPLY UNIT MODEL GTU-1

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

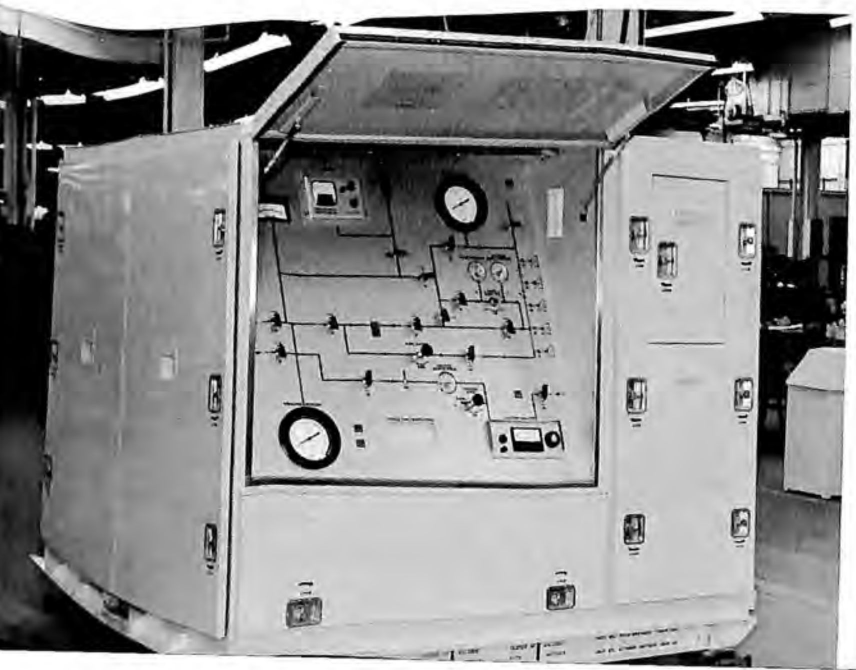
The Cold Gas Supply Unit Model GTU-1 is capable of evacuating tanks or pressure vessels to remove air, moisture, and contaminants. The tanks can then be charged with clean, dry Refrigerant 14 at pressures higher than the normal bottle pressure. In addition to the normal complement of pressure and temperature gages found on gas transfer units, the cold gas supply unit is equipped with a moisture analyzer for determining the moisture content of the refrigerant supply and the refrigerant charge. Provisions are also included for reading the temperature of the tanks being charged. The unit contains a motor driven compressor, a motor driven vacuum pump, filters, compressor and refrigerant cooler, electrical components, and the various valves, fittings, and tube assemblies that make up the system. Also enclosed in the unit is a rack that will accommodate five 195-pound refrigerant storage bottles, each containing 70 pounds of Refrigerant 14.

AIR CONDITIONER MODEL VEA4-5

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

Air conditioner Model VEA4-5 is a lightweight, air transportable, vapor cycle air conditioning package specifically designed to provide conditioned air for guided missile systems. The unit is presently being used in the Pershing missile system, but can be used in other applications having similar heating and cooling requirements. After initial installation in a trailer, the unit is capable of an air cooling load capacity of 38,000 BTU per hour and a heating capacity of 35,800 BTU per hour. It can operate in an ambient temperature down to –65 degrees F. The unit discharges conditioned air at a flow rate of 300 cubic feet per minute at a temperature of 59 degrees F, automatically controlled. The air conditioning unit consists of two equal size enclosures that are easily interconnected and can be operated remotely from each other. The enclosures are of compact, sturdy construction and are built to rigid military specifications and standards. One enclosure, the Condenser Section, contains the compressor, condenser fan, and high-pressure refrigerant controls. The other enclosure, the Evaporator Section, contains the evaporator, evaporator fan, expansion valve, heaters, electrical controls, and temperature controls. They can be easily separated and interconnected through suitable refrigerant and electrical lines for applications in which such arrangement is preferred. Functionally, the VEA4-5 consists of a cooling subsystem and a heating subsystem regulated by either automatic or manual controls from an externally mounted control panel.



GROUND PRELAUNCH COOLING UNIT MODEL GLC-1

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

The Ground Prelaunch Cooling Unit Model GLC-1 is a trailer mounted unit which provides ground support for the Gemini spacecraft during ground tests and prior to launching. A special transport fluid is cooled, pressurized, and circulated by the mobile cooling unit. The unit is designed to provide a flow of transport fluid from 0.2 to 1.0 gallons per minute with a constant discharge temperature of –85 degrees F. Spacecraft flow requirements will vary with ambient temperatures. The unit will provide sufficient cooling to absorb a spacecraft heat load of 5,000 to 14,000 BTU per hour. For prelaunch operation, the transport fluid, MCS 198 coolant, flows through insulated flexible tubing to the gantry and from the gantry through an umbilical tube to the spacecraft, where the coolant circulates through the spacecraft heat exchangers to provide cooling for special purpose equipment. The coolant returns through an umbilical tube to the gantry, and from the gantry to the cooling unit. During ground test procedures, the insulated flexible tubing is connected directly to the umbilical package. The cooling unit continually recools and recirculates the fluid.

TEMPERATURE CONTROL SYSTEM MODEL CTS65-1

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

The Temperature Control System Model CTS65-1 is used on the McDonnell RF-4C reconnaissance aircraft to control the temperature of air used for cooling electronic and photographic equipment. Temperature control is accomplished by mixing the cold air output of the aircraft air cycle machine with a quantity of engine bleed air. The unit consists of three independent subsystems. Each subsystem (or circuit) has an independent source of hot and cold air and a complete temperature control system to provide cooling airflow in response to the requirements, respectively, for electronic component cooling, infrared equipment cooling, and photographic equipment cooling. Basically, the subsystems are identical with the exception of the temperature set point. Each cooling subsystem consists of a temperature control valve, temperature sensors, temperature anticipator, solenoid valve, and temperature switch. The electronic component cooling subsystem is capable of maintaining either of two temperature set points. When the aircraft is operating at altitudes below 25,000 feet, the temperature set point is 85 ± 5 degrees F. Above 25,000 feet the temperature set point is shifted to 40 ± 5 degrees F. The infrared equipment cooling subsystem is capable of maintaining a set point temperature of 95 ± 5 degrees F, and the photographic equipment cooling subsystem is capable of maintaining a set point temperature of 75 ± 10 degrees F.

AIR CONDITIONER MODEL VEA4-3

Prime Contractor: Fairchild Hiller Corporation, Stratos Division

Remarks

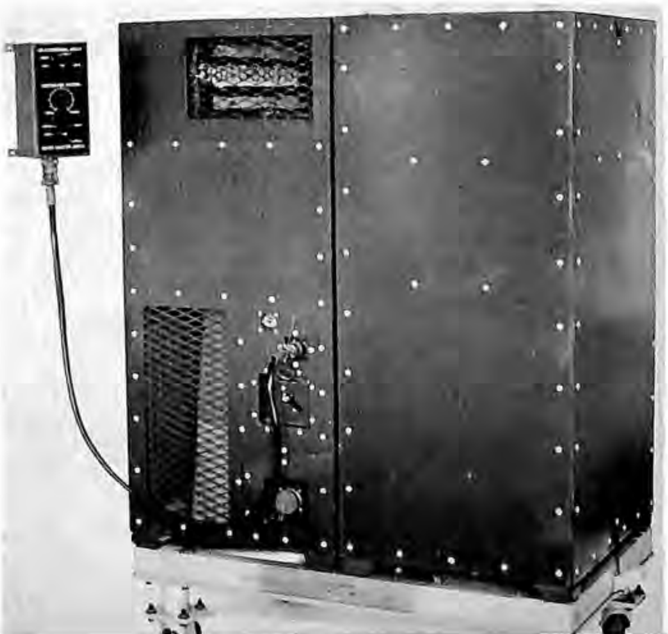
Air Conditioner Model VEA4-3 is a lightweight, air transportable, vapor cycle air conditioning package specifically designed to provide contitioned air for guided missile ground support shelters. The unit is presently being used in the HAWK missile ground support system, but can also be used in other applications having similar personnel and equipment cooling and heating requirements. After initial installation in a trailer or shelter, this unit is capable of an air cooling load capacity of 50,000 BTU per hour when using a 208-volt, 4-pole motor, 11,500 rpm, 13-hp motor compressor, and an air cooling load capacity of 38,000 BTU per hour when using a 416-volt, 6-pole motor, 7500 rpm, 8-hp motor compressor. The unit has a heating capacity of 35,800 BTU per hour (10.5 kilowatts). It discharges conditioned air at a flow rate to 1300 cfm, within a temperature range from 60 degrees F to 90 degrees F, automatically controlled. The air conditioning unit consists of two equal size enclosures that are easily interconnected and can be operated remotely from each other. The enclosures are of compact, sturdy construction and are built to rigid military specifications and standards. One enclosure, the Condenser Section, contains the compressor, condenser fan, and high-pressure refrigerant controls. The other enclosure, the Evaporator Section, contains the evaporator, evaporator fan, expansion valve, heaters, electrical controls, and temperature controls. They can be easily separated and interconnected through suitable refrigerant and electrical lines for applications in which such arrangement is preferred.

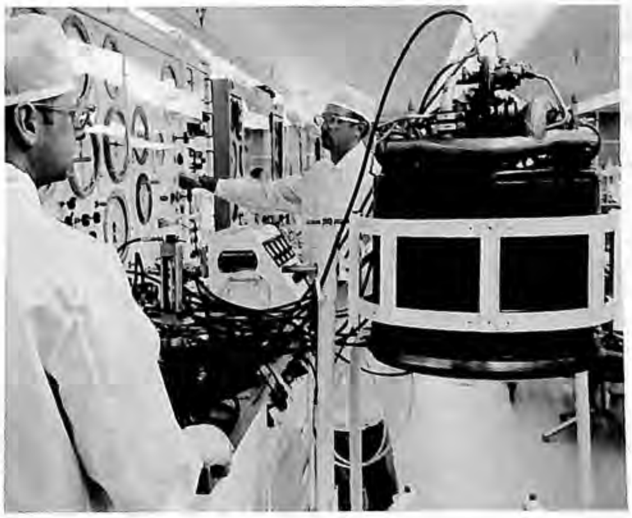
GEMINI ENVIRONMENTAL CONTROL SYSTEM

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Division.

Remarks

The environmental control system (ECS) developed and produced for the Gemini spacecraft, is designed to provide a safe and comfortable gaseous atmosphere for two astronauts for duration up to two weeks in earth orbit. The ECS provides the astronauts with fresh oxygen and water; it removes carbon dioxide, odors, waste water and solids from the gas stream, cools the gas and regulates the suit and cabin pressure levels. The ECS also regulates the flow of coolant required for equipment cooling. Components providing these functions are located in both the re-entry module and adapter sections of the spacecraft. The Gemini spacecraft is pressurized with a pure oxygen atmosphere at 5.5 pounds per square inch. Primary oxygen for breathing, ventilation and pressurization is stored at cryogenic temperatures and supercritical pressures. A secondary (re-entry and emergency) supply is high pressure gaseous oxygen. Primary cooling is accomplished by means of an intermediate heat transport fluid which absorbs heat in heat exchangers and dissipates this heat through a space radiator. A water boiler cooling system is used in launch, re-entry and emergency phases. Though basically an automatic system the ECS also includes manual overrides for controlling temperature and pressure.





GEMINI FUEL CELLS

Prime Contractor: General Electric Company, Direct Energy Conversion Operation

Remarks

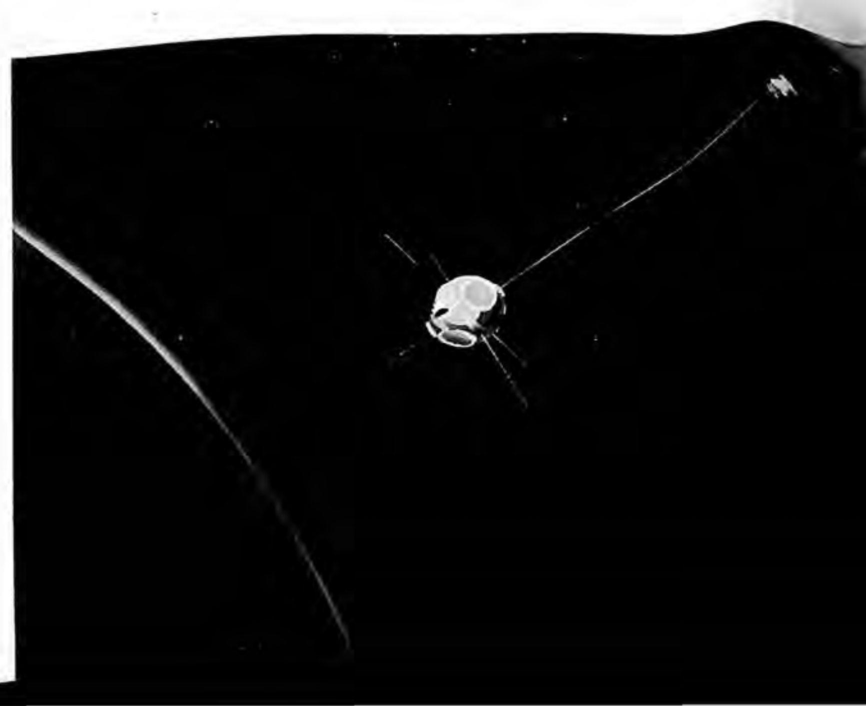
Two fuel cell batteries, each with a rated output of 1 kilowatt, power spacecraft equipment on the long Gemini missions 5, and 7 through 12. Using hydrogen as fuel and oxygen as a reactant gas, the fuel cells convert the chemical energy of the gases into electricity, producing water at the rate of about one pint per kilowatt hour, as a byproduct. Each fuel cell battery weighs 68 pounds, is 25 inches long and 12.5 inches in diameter. Total fuel cell system weight, including gas supply, piping and accessory equipment external to the fuel cells proper, is about 450 pounds. Each Gemini fuel cell battery contains 96 individual fuel cells, separated into three stacks of 32 cells each. Each stack can be individually controlled by the astronauts and can be turned on and off, as needed. Current production Gemini-type fuel cell batteries are designed to provide power for the longest Gemini mission, 14 days, but on test have run as long as 46 days. Advanced fuel cells, now under development, are expected to extend fuel cell life expectancy four or five times.

GRAVITY GRADIENT SYSTEMS

Prime Contractor: General Electric Company, Spacecraft Department

Remarks

Gravity gradient satellite stabilization systems have been extensively developed by General Electric. Gravity gradient systems use the natural gravitational field surrounding the earth to make a satellite constantly point to the earth. They are lightweight, use little or no power for operation and have very few parts. They have virtually unlimited life and can be designed for two and three-axis stabilization. GE is developing two Gravity Gradient Test Satellites for the Air Force and will provide gravity gradient systems for NASA's GEOS and Applications Technology Satellite programs. A GE system also has stabilized a Naval Research Laboratory satellite since its launch in January, 1964.



PLASMA PROPULSION

Prime Contractor: General Electric Company, Space Sciences Laboratory

Remarks

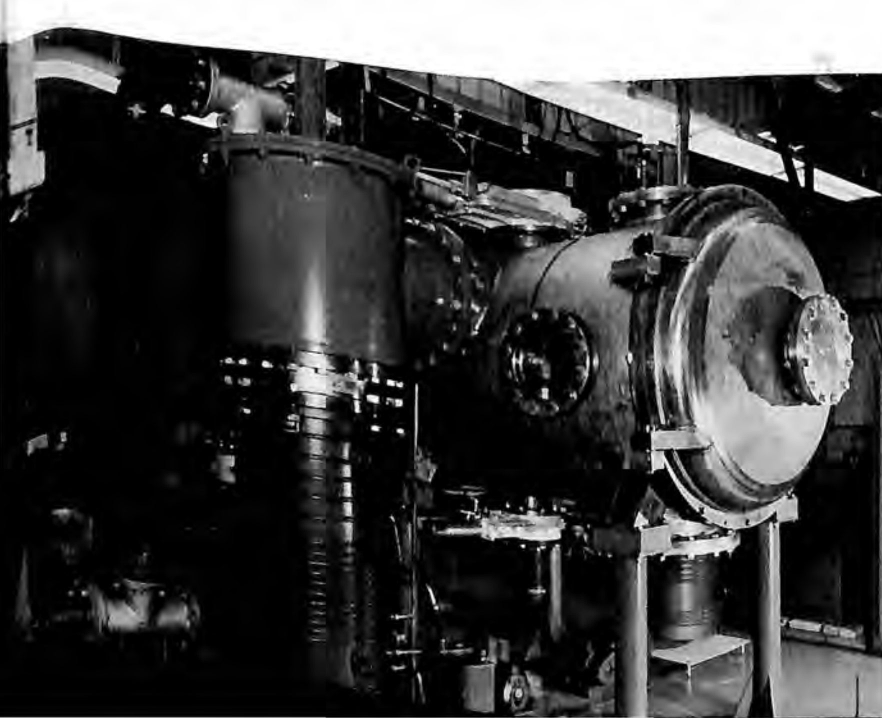
The GE Space Sciences Laboratory has been conducting investigations into plasma propulsion. There is particular interest in electric thrusters as space propulsion engines, and much of the work has been conducted under contract to NASA's Lewis Research Center. The Repetitively Pulsed Plasma Accelerator (REPPAC) produces thrust by electromagnetically accelerating a low density gas. The small amount of propellant needed to produce thrust makes this an attractive form of space vehicle attitude control and propulsion. The laboratory is working toward devices with high specific impulse for propulsion in interplanetary environments. Another laboratory development is a continuous-wave, cyclotron-resonance plasma accelerator nicknamed "Cyclops." At higher thrusts, a plasma engine that runs continuously can be made lighter and more efficient than pulsed devices. In photo, the Continuous Plasma Engine Test Facility.

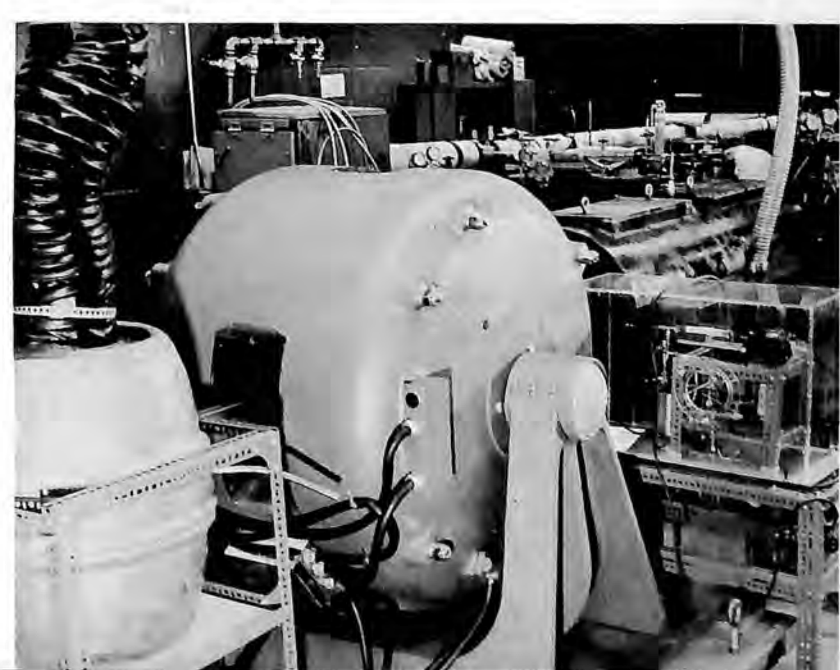
MHD POWER GENERATION

Prime Contractor: General Electric Company, Space Sciences Laboratory

Remarks

Magnetohydrodynamic (MHD) power generation is a process of extracting electrical power directly from an ionized gas as it moves through a magnetic field. In an MHD generator, a conducting gas flows past a magnetic field, generating an electromagnetic force within the gas. The electrical power is extracted from the flowing gas by electrodes. General Electric is investigating this concept under a contract from NASA's Lewis Research Center. The reduced weight, high reliability and high efficiency of the MHD concept make it a promising source of space power. GE scientists have successfully operated an MHD generator at 2,200 degrees Fahrenheit, which is considerably lower than that used most frequently with other MHD techniques. As a result, the previously unsolved critical problem of finding materials capable of reliably containing the hot reactive gas for periods commensurate with those required for planetary space flight have been virtually eliminated. In photo, GE's Gas-seeded MHD Blowdown Facility.





ACCEPTANCE CHECKOUT EQUIPMENT

Prime Contractor: General Electric Company, Apollo Support Department

Remarks

GE's Apollo Support Department is building 10 sets of Acceptance Checkout Equipment—Spacecraft, dubbed ACE S/C, for the National Aeronautics and Space Administration. Each ACE system is an automated checkout and test system for the Apollo spacecraft. The ACE system is basically a combination of 110 control, communications and display consoles, power panels, patchboards and computers functionally arranged in Control, Computer and Terminal Facility rooms. ACE stations are or will be installed at North American Aviation, Grumman Aircraft Engineering Corporation, NASA's Manned Spacecraft Center and NASA's Kennedy Space Center in the Merritt Island Launch Area. ACE systems can interrogate and test environmental control systems, fuel cell and associated cryogenic reservoirs, power and sequential systems, stabilization and control, service module propulsion and instrumentation and communications for the Apollo Command, Service and Lunar Excursion Modules to provide immediate evaluation of the spacecraft's flight readiness. The GE Apollo Support Department also makes Electrical Support Equipment (ESE) for checkout of the Saturn launch vehicles; Launch Support Equipment, for checkout of launch facilities; and related test, measurement and calibration equipment.

AN/APN-153 DOPPLER NAVIGATION RADAR

Prime Contractor: GPL Division, Aerospace Group, General Precision, Inc.

Remarks

The AN/APN-153 Doppler Navigation Radar is a velocity sensor giving extremely accurate aircraft ground speed and drift angle. The system operates in the Ke Band, occupies 1 cubic-foot of space and weighs only 48 pounds. The equipment consists of three units: Receiver-Transmitter, Control-Indicator and Antenna Assembly. Its flexible design provides both analog and digital outputs making it universally compatible with all navigation computers and other aircraft equipment requiring velocity and drift information. Its small size and low weight permit the system to be installed in any aircraft. The AN/APN-153 System is currently operational, or due to be installed in the following aircraft: E-2A, A-6A, A-4E, P-3A, S-2E, RA-5C, C-130, C-131, C-123, F-100, Mirage III, B-26, F-27 BAC-111, Comet IV.

VIDEO FILM CONVERTER

Prime Contractor: General Precision, Inc., Link Group

Remarks

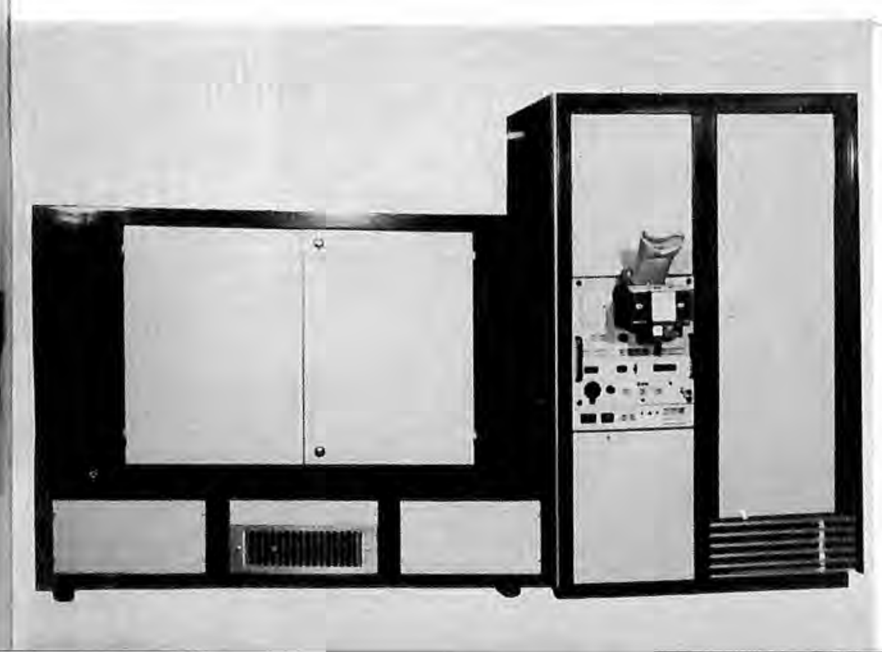
The Video Film Converter, capable of high density recording, permanent storage and slow or fast read-out of video data, can convert time dependent electrical analog or digital signals into space dependent photographic images. Three built-in modes of operation are available. The analog recorder mode records analog picture video onto 35mm or 70mm photographic film using left to right raster scanning. Geometric distortion is held to less than 0.2%. The analog read mode scans 35 millimeter or 70 millimeter film in a horizontal motion using a beam of light from the flying spot scanner. A digital record mode can be employed to record picture data consisting of discrete data points representing gray levels of 64 different intensities. Utilization of the digital read mode affords vertical and horizontal reading of data from photographic film, as the digital raster sequentially moves an electron beam across the face of the flying spot scanner tube. Some of the special features of the device include the capability to adjust lines per frame from 100 to 2500; a flying spot scanner capable of generating spot size on the order of 1 mil (.001 in.), and the scanning raster of the flying spot scanner tube capable of being rotated 180 degrees in either direction. Completely transistorized except for certain power supplies and the cathode ray tube (CRT), the system can also record film in a continuous sweep motion, as opposed to the usual discrete-step motion. Already proven in reconstruction of pictures of the lunar surface during the Ranger missions, the Video Film Converter was selected for ground-data handling in support of the Mariner 4 exploration of Mars.

C-141A AIRCRAFT FLIGHT SIMULATOR

Prime Contractor: General Precision, Inc., Link Group

Remarks

The Link C-141A all-digital flight simulator, using the Mark I digital computer, was designed for the Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio. Its parallel-binary computer design functions in conjunction with peripheral analog equipment to translate digital outputs into realistic control, display, and environmental effects. Ease of programming in communications and navigation, a remote operator's station which allows a centralized station to handle more than one simulator, in addition to microcircuitry and printed circuit boards afford realism and fidelity in the simulator's performance. The cockpit mounted on the three-point motion base has pilot, co-pilot, and flight engineer training stations. The crew is exposed to such flight conditions as engine noise, cockpit motion, wing flap and wing spoiler effects, and tire and brake screech. Navigation and communication characteristics of the simulator are electronically computed and activated. Two air conditioning units are employed to absorb cockpit heat and computer enclosure heat. The C-141A simulator uses a hydraulic control loading system designed expressly for digital flight simulators. Its employment affords realistic simulation of the static and dynamic force characteristics of a single-channel control and loading system, in addition to greater simulation fidelity of a booster system.



F-4C FLIGHT TRAINER

Prime Contractor: General Precision, Inc., Link Group.

Remarks

A new Link Weapons Systems Trainer completely simulates the performance of the Air Force F-4C all-weather, two-man, supersonic aircraft designed for both high altitude interception and long-range attack missions. The WST also provides simulation of fire control, Electronic Counter Measure (ECM), Electronic Counter-Counter Measure (ECCM), navigation and target seeking through the use of radar land mass presentations, and bombing and target intercept equipment duplication. The trainer's motion system simulates sensations of pitch, buffet, rough air, and other effects encountered in maneuvering the F-4C. Engine and aerodynamic noise, lighting effects associated with cloud cover, bomb and rocket blast, and duplication of temperature variations are included in the system providing realism in the training mission. Simulated altitude for the land mass display ranges from 500 feet to over 80,000 feet through radar sweep ranges from 10 to 200 miles. Radar reflectivity and terrain information are duplicated by simulated land mass returns on operational radar scopes. This operation can cover 1250 miles square and it represents 29 different contours in various reflectivity intensities of gray. Training techniques are oriented toward developing pilot familiarity with the tactical mission of the F-4C. Later stages of instruction are geared to insure that pilots can check out an actual radar-tactics mission from start to finish including the variables of climb-out, winds at varying altitudes and radar scope interpretation of navigation check points and target locations.

AF37A-T27 TRAINER

Prime Contractor: General Precision, Inc., Link Group.

Remarks

The Space Flight Simulator designed by General Precision's Link Group for Edwards Air Force Base duplicates motion, images and sounds of space flight. The 15-ton, 32-foot high mechanism of steel girders, optical, electrical, recording and hydraulic equipment provides realistic space flight conditions for extraterrestrial training in the 2,800-pound steel and fiberglass, single-place, roof hatch entrance cockpit. Vibrations, pitching, rolling, yawing, launch and re-entry of a spacecraft in flight are simulated by the 125 horsepower motion system, while star fields, the earth and moon, and rendezvous vehicle are presented in their proper perspectives by the 12 inch optical window display and high resolution TV systems. The more than 2,000-pound visual system consists of highly polished mirrors, lenses, beam splitters and a closed circuit television system. Pilot activities are monitored by two-way radio and the internal television system at a master central station manned by instructors. Abort and emergency conditions can be introduced into the mission at any time during the simulated flight. In addition, astronauts are confronted with recovery problems encountered during land and water setdowns. High-speed, high-capacity digital and analog computers linked together to form a hybrid system perform the lengthy and complex computations of space flight simulation. The system includes the Link Mark II digital computer (68,000 word capacity) and two Electronic Associate PACE analog computers containing a total of 45 amplifiers. The most advanced space simulator presently in use, the T27's basic design includes the flexibility to keep pace with advances in spacecraft developments.

F-106/MA-1 WEAPON SYSTEM

Prime Contractor: Hughes Aircraft Company

Remarks

The MA-1 is an electronic navigation and armament control system developed for the F-106 Convair Delta Dart. It is the Air Defense Command's most automated electronic system for manned aircraft. With a digital computer capable of making 9,600 arithmetical calculations in one second, 6,250 decisions in one minute, the MA-1 system computes SAGE target vectoring information and actually takes control of the Delta Dart on a combat intercept. It flies the interceptor to its target, pinpoints the target's position, launches the attack and brings the interceptor back to base. Or given the projected path and speed of the target, the MA-1 system can program the F-106's course to intercept without any further direction from SAGE. The MA-1 system weighs 2,460 pounds and takes up 43 cubic feet of volume. Its features include a high capacity digital computer, automatic data link reception, and automatic flight control during navigation phases, during radar attacks and during instrument landing approaches. The system also has a 5-minute self-test programmer. In photo, the 200 black boxes which make up the MA-1 system together with the armament it controls (four Falcon missiles and one Genie). Hughes builds a similar system (MG-10) for the Convair F-102 and an MG-13 system for the McDonnell F-101.

IBM DATA PROCESSOR AND DATA STORAGE FOR ORBITING ASTRONOMICAL OBSERVATORY

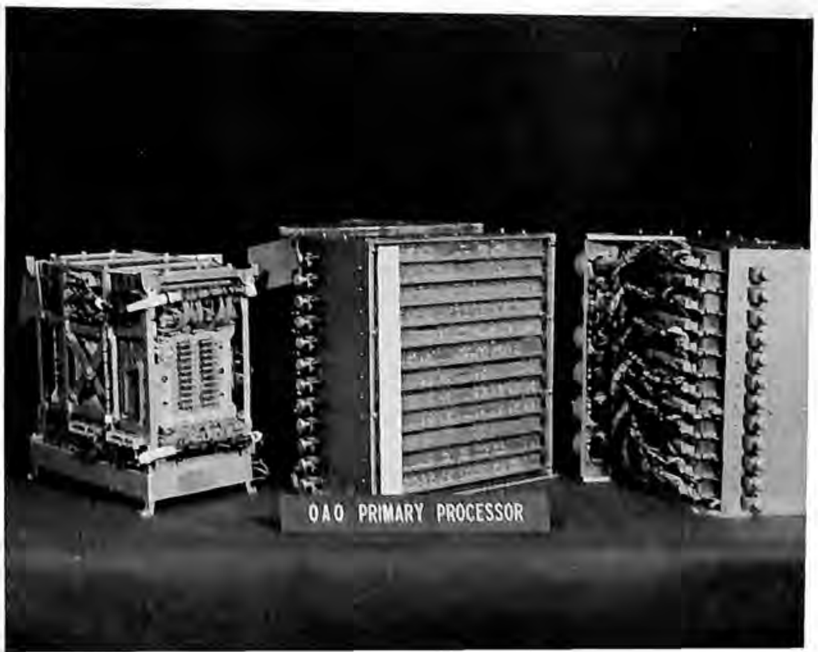
Prime Contractor: International Business Machines Corporation, Federal Systems Division (Grumman Aircraft Engineering Corporation is satellite prime contractor).

Remarks

The advanced IBM OAO data processor with its associated memory is the central command post of the 3600-pound scientific satellite. It will issue commands for satellite orientation, store instructions for experiments radioed up from ground, issue commands for starting and stopping all experiments, store experimental data obtained by scientific instruments and monitor the physical condition of the satellite. Over 200,000 bits of scientific information can be stored on board OAO in the very large IBM system's memory during the experiment portion of each orbit. This information is stored in a non-rotating, non-destructive, random access memory system. It contains two memory modules that can operate in series or as two parallel redundant memory dystems. All experimental information gathered by OAO equipment, as well as satellite status data, can be read out and radioed to the ground in 7.5 seconds. Since data can be taken from the memory over and over without destroying it as in conventional systems, the memory can be read out as many as 80 times during the ten minutes the satellite is in range of a ground station on each orbit. By repetition, complete readout and verification of the OAO's figure-facts can be enhanced.

Specifications

Volume 4.62 cubic feet; power 80 watts.



GUIDANCE COMPUTER FOR TITAN II ICBM

Prime Contractor: International Business Machines Corporation, Federal Systems Division.
Associate Contractor: AC Spark Plug Division of General Motors Corporation (Titan II inertial guidance system prime).

Remarks

The 90-pound IBM computer is the hub of the all-inertial guidance system that keeps the now-deployed Titan II on course by comparing missile attitude and speed with a predetermined target trajectory. The courses to several targets can be stored in the computer's memory for alternate selection at launch time. The computer also performs a prelaunch checkout by monitoring Titan's continual state of readiness in the silo. For high reliability, the circuits have welded connections and are encapsulated into rugged modules. The memory is a thin shell, light-weight magnetic drum that stores over 100,000 bits of information. This information is transferred to and from the drum surface by 82 self-adjusting read-write heads that float above the spinning drum on a cushion of air 1/10,000 of an inch thick.

Specifications

Volume 2.75 cubic feet; power 150 watts.

GUIDANCE COMPUTER FOR SATURN I

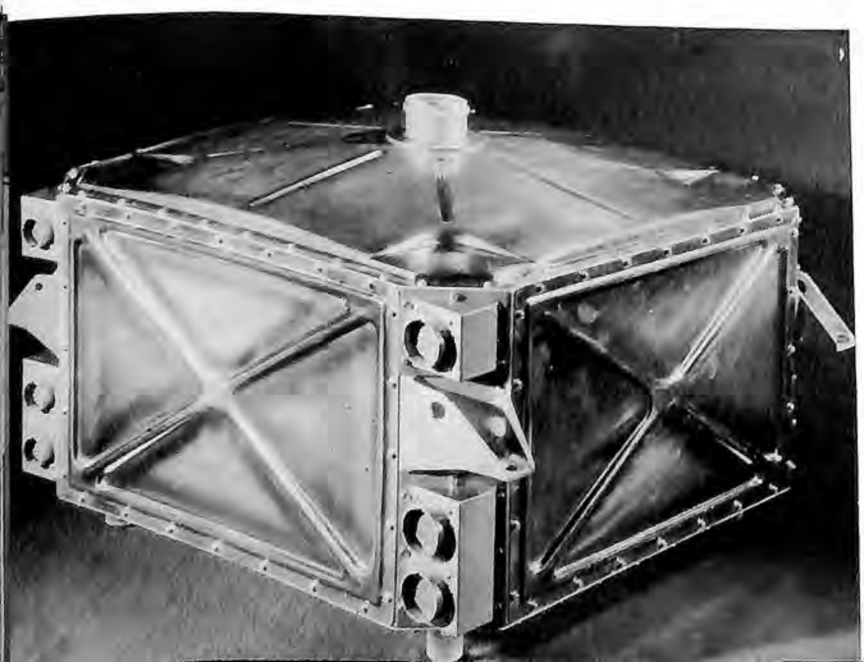
Prime Contractor: International Business Machines Corporation, Federal Systems Division.

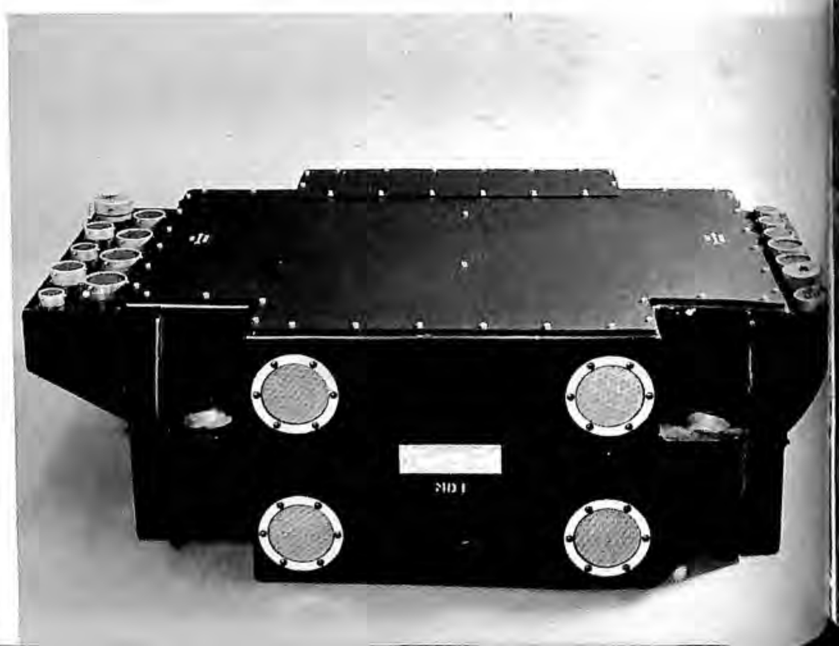
Remarks

The 90-pound IBM guidance computer—a version of IBM's ultrareliable ASC-15 space computers—successfully guided Saturn I vehicles into near-perfect orbits on all of the five flights steered by an on-board system. In this system, computer guidance information is stored on the surface of a thin-shelled magnetic drum memory that spins 6,000 times a minute. This data is read by tiny magnetic heads which float on a layer of air 2 millionths of an inch thick created by the spinning drum. The heads take off guidance data stored on the drum and then send it to the computer. The GSP-24 signal processor takes analog signals, such as roll, pitch and yaw, from the instruments aboard Saturn and converts them to digital impulses the computer can process. The processor carries the computer's guidance signals back to the Saturn's rocket engines to change course.

Specifications

Volume 2.5 cubic feet; storage capacity 100,000 bits of information.





IGM GEMINI GUIDANCE COMPUTER

Prime Contractor: International Business Machines Corporation, Federal Systems Division.

Remarks

The 59-pound guidance computer on board the two-man Gemini spacecraft performs complex calculations to help the astronauts guide and maneuver the craft. Computer tasks are to back-up the ground-based radio launch guidance system in case of failure, to help astronauts adjust and refine their orbit after Titan II second stage shut down, to compute navigation and guidance information and have it displayed to help astronauts rendezvous with another orbiting vehicle, and to calculate and issue commands to return the spacecraft safely to earth at a desired landing point. The computer makes more than 7,000 calculations a second and has a random access, non-destructive memory system (approximately 4 by 4 by 7 inches) containing over 150,000 multi-aperture ferrite cores that permit data to be read out of memory without destroying the core's magnetic state. To allow the astronauts to communicate with the computer, there are two cockpit units called the Manual Data Insertion Unit (in photo) and the Incremental Velocity Indicator. With these, the astronauts can enter new information into the system during flight to adjust the spacecraft's position and velocity or to change the time that a specific flight maneuver should occur.

Specifications

Volume 1.35 cubic feet; power 95 watts; storage capacity over 159,000 bits of information.

REAL-TIME COMPUTER COMPLEX SYSTEMS (RTCC)

Prime Contractor: International Business Machines Corporation, Federal System Division

Remarks

An integral part of ground support operations for Gemini space flights and future Apollo flights is the Real-Time Computer Complex at NASA's Manned Spacecraft Center in Houston, Texas. Through RTCC, IBM personnel are meeting the long-term computing needs of the Gemini/Apollo missions. They are manning and managing the real-time data processing and computational support system for the flights. Chief RTCC purpose is to supply NASA flight controllers with very powerful digital processing capabilities needed in controlling actual or simulated Gemini and Apollo flights. IBM is furnishing hardware equipment, mission and mathematical analysis, programming, equipment engineering and program testing for the system. Equipment selected includes five IBM 7094 Model II data orocessors, magnetic card readers, magnetic tape units, consoles and large-capacity computer memories. During the 1966 calendar year, new IBM System/360 systems will begin to be installed to replace the 7094s. In the historic 14-day Gemini 7/6 flight the IBM RTCC systems performed 850 billion calculations. The systems have over 2.5 million words of data and programming in their memories. More than 550,000 program instructions were written by the IBM/NASA team at Houston. The RTCC systems logged over 600 mission hours by year end 1965.

GUIDANCE COMPUTER FOR NASA'S SATURN IB/V

Prime Contractor: International Buisness Machines Corporation, Federal Systems Division.

Remarks

The flights of Saturn IB/V launch vehicles are directed by an advanced IBM 77-pound computer and a 176-pound data adapter. They ride near the rocket's top in the Instrument Unit—a 3-foot-high, 22-foot-diameter ring (which IBM is integrating under another contract). The digital computer which has a design reliability of 99.8 percent uses a duplex memory design and a triple modular redundancy approach. Once the vehicle lifts off the pad, the computer navigates and steers it. The data adapter gathers signals from instruments such as accelerometers and rate gyros and routes them to and from the computer. After the computer processes the data, using information stored in its memory, it develops steering signals and passes them on to the rest of the system via the data adapter. After directing the vehicle into earth-orbit, the computer checks out the final propulsion stage, sends these test results to the ground for analysis, calculates the lunar transfer trajectory (if it is a lunar exploration mission), and then restarts the S-IVB stage to send the Apollo payload on its way to the moon. This general purpose, serial, binary computer has a random access magnetic core memory system which can be expanded to store 920,000 bits of information—twice as many as will be needed for the presently planned missions. The magnesium-lithium structure, itself a very significant metallurgy innovation, is very light in weight and it acts as its own "cold-plate" to carry off damaging heat.

Specifications

Volume 2.2 cubic feet; power 131 watts.

DEEP SPACE NETWORK

Prime Contractor: Jet Propulsion Laboratory, California Institute of Technology

Remarks

The Deep Space Network (DSN) is a precision communication system which is designed to communicate with, and permit control of, spacecraft developed for deep space exploration. The DSN consists of the Deep Space Instrumentation Facility (DSIF), the Space Flight Operations Facility (SFOF), and the DSN Ground Communication System (GCS). The DSIF utilizes large antennas, low-noise phase-lock receiving systems, and high-power transmitters located at stations positioned around the Earth to track, command, and receive data from deep space probes. DSIF stations are located near Goldstone, California; Woomera and Canberra, Australia; Johannesburg, South Africa; Madrid, Spain; and Cape Kennedy, Florida. The SFOF is located at the Jet Propulsion Laboratory in Pasadena, California, and utilizes operations control consoles, status and operations displays, computers, data processing equipment for analysis of spacecraft performance and space science experiments and communication facilities to control space flight operations. This control is accomplished by generating trajectories and orbits, and command and control data, from tracking and telemetry data received from the DSIF in near real-time. The SFOF also reduces the telemetry, tracking, command and station performance data recorded by the DSIF into engineering and scientific information for analysis and use by the scientific experimenters and spacecraft engineers. The DSN Ground Communication System consists of voice, normal and high data rate teletype circuits between each station and the SFOF, and a microwave link between the SFOF and Goldstone. In photo, the Goldstone antenna.

AN/USQ-28 AERIAL SURVEYING AND MAPPING SYSTEM

Prime Contractor: Kollsman Instrument Corporation

Remarks

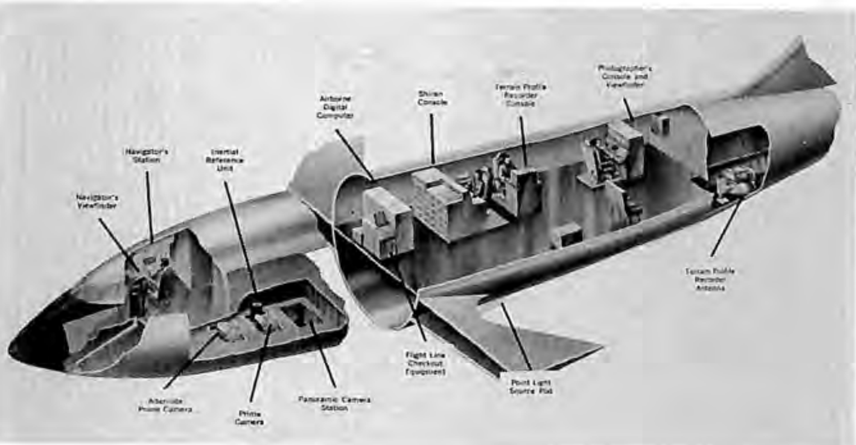
The AN/USQ-28 is the first of a new class of advanced airborne electronic photography systems that completely integrates aerial surveying and photomapping techniques with computer control. Made up of 12 subsystems integrated to provide the fastest and most accurate means ever available to obtain raw geodetic and photomapping data, the AN/USQ-28 is capable of mapping 30,000 to 40,000 square miles a day and collect data about where the photos were taken, from what altitude and from what angle. The system, developed under USAF direction, will be installed in a Boeing RC-135A transport/reconnaissance aircraft. Kollsman delivered a prototype system and three production models in 1965.

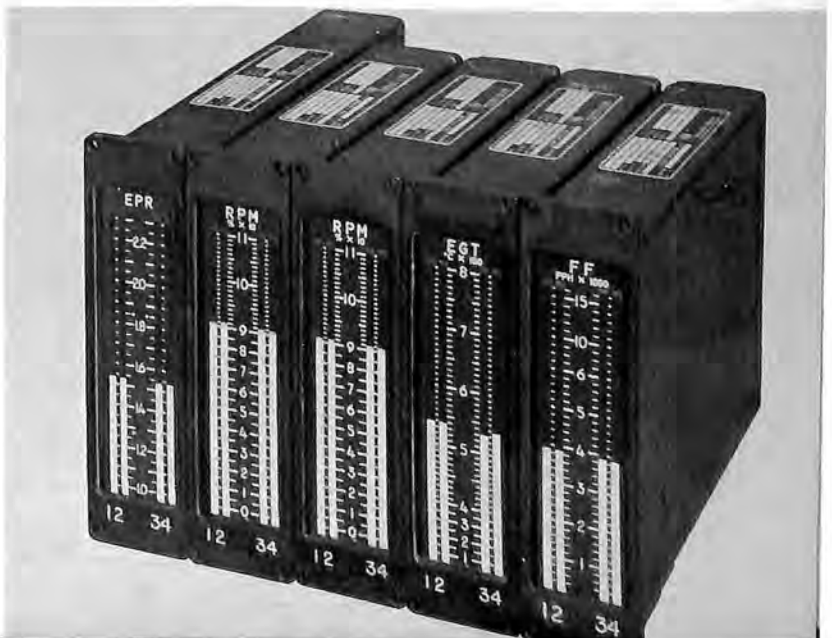
VERTICAL SCALE ENGINE INSTRUMENT SYSTEM

Prime Contractor: Lear Siegler, Inc., Instrument Division

Remarks

Currently in production for the Air Force C-141, the Vertical Scale Engine Instrument System permits the aircraft operator to make a rapid and accurate evaluation of vital engine parameters. Parameters for all four engines are shown on the indicator, making any variation instantly apparent. The four basic indicators are engine pressure ratio, exhaust gas temperature, turbine speed in rpm, and rate of fuel flow. A converter completes the system. Vertical Scale Engine Instrument Systems can also be provided for two-engine, six-engine and eight-engine aircraft, and are adaptable to measure other parameters such as nozzle position, fuel quantity, oil pressure, oil temperature and torque. In the C-141 system, the engine pressure ratio indicator displays engine thrust by indicating ratio of turbine outlet pressure and compressor inlet pressure. The indicator scale range is 1.0 to 2.5 engine pressure ratio units. Exhaust gas temperature indicator displays turbine discharge temperature with scale ranges from 0 degrees to 700 degrees Centigrade. Turbine or compressor speed is indicated by the revolutions per minute indicator in a scale range of 0 to 110% rpm (100% rpm is equal to 4,200 rpm). Fuel flow is shown in pounds per hour per engine. Scale ranges are from 0 to 16,000 pounds per hour. The converter, designed to accept signals from sensors currently in use, is composed of 16 circuit boards with each board containing the conversion elements and two amplifiers. A failure in any electronic channel can be repaired by quick removal and replacement of the appropriate circuit board.





TACTICAL AIRCRAFT SYSTEM

Prime Contractor: Lear Siegler, Inc., Instrument Division

Remarks

The Tactical Aircraft System provides all-attitude roll and pitch information, all-attitude heading information, pilot display of the roll, pitch and heading information and the mechanization required for bomb delivery. Designed under a building block concept, the Tactical Aircraft System has four separate self-contained component groups, each completely independent of the circuitry and mechanization of the others. Depending on tactical requirements, the entire system or any combination of attitude reference, heading reference, display or bombing functions can be used. The Tactical Aircraft System is produced as the AN/AJB-7 Attitude Reference and Bombing Computer Set for the F-4C aircraft and is used in part or in whole on the F-105D/F, F-106A/B, A-4E, F-4B, and A-7A aircraft. The attitude reference group serves as a central gyroscopic reference subsystem with outputs for all aircraft systems requiring roll, pitch and azimuth information. An all-attitude gyroscope provides gyro-stabilized pitch and roll data referenced to the earth's gravitational field through use of liquid-level-type gravity sensors. These sensors are disconnected during turns by a switching rate gyroscope. Azimuth reference signal is obtained from a vertically-stabilized directional gyroscope in the three-axis unit. The heading reference group has been designed to supply synchro outputs of heading and to provide manual control of the heading subsystem. Heading outputs can be either magnetic or great circle with magnetic north reference furnished by a magnetic detector. The display group provides a visual cockpit display of aircraft roll, pitch and heading.

GEOCENTRIC VERTICAL REFERENCE SYSTEM

Prime Contractor: Lear Siegler, Inc., Instrument Division

Remarks

A Geocentric Vertical Reference System provides verticality data with less than 0.5 degrees of error under a wide range of flight conditions. Scheduled for use in the Navy's F-4J and F-4K fighter bombers, the system supplies accurate, gyro-stabilized roll and pitch synchro outputs during dynamic conditions by compensating for acceleration errors which affect ordinary gravity-sensing erection systems. In addition, the system—designated GVR-10—provides outputs of vertical acceleration, vertical velocity and flight path angle. In flight tests, verticality errors of less than 0.5 degrees were obtained when the patented GVR-10 system was used as compared with up to four degrees error experienced with a conventional vertical gyro system. The output accuracy for the GVR-10 flight path angle is within three percent of the aircraft's flight path angle. The GVR-10 system consists of two units, the LSI Model 7428A Geocentric Pendulum Reference and the LSI Model 6315A Geocentric Reference Computer. The Model 7428A is a gyroscopic unit containing a vertical gyroscope and a geocentric pendulum control in a redundant roll gimbal. The geocentric pendulum control is stabilized in pitch by a pitch gimbal servoed to the vertical gyro. The geocentric pendulum control provides the necessary erection signals to the vertical gyro torquers to maintain the gyro at true vertical. A roll and pitch stabilized vertical accelerometer, mounted in the Model 7428A, provides a vertical acceleration output which is available to other subsystems and is also used in the Model 6315A for computation of flight path angle.

ASTRONAUT MANEUVERING UNIT

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.

Remarks

The Astronaut Maneuvering Unit is a back pack designed to permit an astronaut to leave his orbiting capsule and perform useful tasks in space. It will be used in NASA's Gemini program as part of Air Force Experiment D-12, a project to prepare the way for man to assemble and service spacecraft in orbit, transfer from vehicle to vehicle or move equipment. The AMU equips the astronaut for space excursions with a complete propulsion system for maneuvering, an automatic stabilization system, a two-way communications system linking him to his parent craft and ground stations, plus oxygen, pressure and temperature systems for survival in space. The 150-pound pack has sufficient fuel and oxygen to permit excursions of as long as 150 minutes outside the parent spacecraft. The astronaut controls his maneuvers in space by activating thrusters from controls on arm rests. The pack has 12 reaction jets, four firing forward, four downward, two up and two down. The system is being tested under weightless conditions in flights on KC-135 aircraft flying ballistic trajectories to achieve up to 30 seconds of zero-gravity. LTV is building a number of test units and three flight models of the AMU for the Air Force.

SPACE ENVIRONMENT SIMULATOR

Prime Contractor: LTV Aerospace Corporation, A Subsidiarv of Ling-Temco-Vought, Inc.

Remarks

This cylindrical simulator, 12 feet in diameter and 11 feet deep, permits testing of space equipment and vehicles at extreme heat and cold to simulate actual space flight. It can simulate orbital altitude up to 200 miles, space thermal radiation levels, solar radiation, intensity and spectral distribution and orbital motion relative to the "sun". Gemini and Apollo astronauts' space suits have been tested in this simulator under heat and cold conditions. Liquid nitrogen flowed through coils permits tests at as low as minus 320 degrees Fahrenheit. Twenty xenon-mercury high pressure lamps of 2500 watts each permit solar simulation temperatures.

MANNED AEROSPACE FLIGHT SIMULATOR

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.

Remarks

The manned aerospace flight simulator enables an astronaut to make realistic orbital, lunar and interplanetary "flights," view the movement of his vehicle in "space" and experience problems and stresses like those an actual space vehicle would encounter—all while remaining safely on earth. Developed by LTV, the simulator has been employed by a number of U.S. astronauts to practice abort lunar landings and other space missions. Together with its computer facility, the simulator represents a value of more than $2,000,000. The simulator consists of a single-place gondola with a complete set of working controls, instruments and visual aids tied into a huge bank of computers, making possible all types of aerospace missions. The simulator is mounted on a pivoted yoke permitting pitch, yaw and roll movements. Surrounding the gondola is a 20-foot fiberglass sphere on which projections of earth, lunar and star field views can be seen. It can produce approximately 5 G's for short duration in both pitch and yaw. In roll it is limited to 15 G's. The pilot is under observation at all times by closed circuit television in the control room.

ALOTS AIRBORNE LIGHTWEIGHT OPTICAL TRACKING SYSTEM

Prime Contractor: Nortronics Division of Northrop Corporation
Aircraft Modification Subcontractor: Lockheed Aircraft Service Company

Remarks

Lockheed Aircraft Service Company in 1965 installed an advanced airborne optical tracking system in a KC-135A aircraft to provide surveillance coverage of missile flights for the Air Force Eastern Test Range. Designed to provide precision photographic coverage of missiles during the early launch, stage separation and re-entry phases of flight, ALOTS will be operated at an altitude of 40,000 feet to eliminate interference from cloud cover and other atmospheric conditions which frequently inhibit ground based camera systems. The Nortronics-developed ALOTS system can photograph and resolve a 12-foot target at a distance of 200 miles. The heart of ALOTS, an integrated automatic tracking and photographic system, was installed by LAS in an external pod and mounted on the aircraft's cargo door (in photo).

LOCKHEED EJECTABLE RECORDING SYSTEM

Prime Contractor: Lockheed Aircraft Service Company

Remarks

Lockheed Aircraft Service Company was awarded a \$4.5 million contract in 1965 for installation of the Lockheed Ejectable Recording System in the Military Air Transport Service fleet of 42 C-133 aircraft. The system retains a 15-hour, continuous record of critical aircraft engine and system operations. A four-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.

RADA (RANDOM ACCESS DISCRETE ADDRESS)

Prime Contractor: Martin Company, Orlando.

Remarks

In advanced status, RADA is a project directed toward phase development of a dial telephone system with the mobility of the vehicular radio in battlefield communications. Under project management of Army Materiel Command, RADA is envisioned as being able to handle voice, teletype, facsimile, and data transmission within an Army combat division without use of heavy, fixed, switching centers or the time-consuming and dangerous laying of wire during battle. RADA would provide for priority service among selected subscribers, conference calls, and area warning. It would provide complete privacy of communication between sender and receiver. Intended to be extremely portable and adaptable to all military vehicles, RADA is a radio system in which simultaneous transmissions could occur within a common frequency band without mutual interference. The subscriber set (photo), which has the features of a portable touch-tone telephone automatically selects an available frequency within the allotted band and broadcasts the address of the called party. Distant subscribers are reached automatically through range extension units.

SNAP-19 RADIOISOTOPE THERMOELECTRIC GENERATOR

Prime Contractor: Martin Company, Baltimore.

Remarks

Martin Company is developing SNAP-19 for the National Aeronautics and Space Administration's Nimbus weather satellite program. As now planned, two SNAP-19 generators will supply part of the electrical power to a Nimbus B weather satellite orbiting the earth (photo, generators on forward rim). The bulk of the power will be supplied by solar cells. Future Nimbus satellites may be powered solely by nuclear energy. Early in 1965, Martin delivered to NASA the first pair of SNAP-19s for system qualification tests with a Nimbus B satellite mockup. These generators were electrically-heated prototypes and contained no fuel. They will be followed by a number of fueled units for further integration tests and actual flight. Nimbus B will be NASA's first satellite to use a nuclear power source. Martin is working under direction of the Atomic Energy Commission.

Specifications

Finned cylinder shape, 11 inches high, 22 inches in diameter; fueled with plutonium-238; electrical output 30 watts (each generator); design life 5 years.

Method of Operation

The generator has no moving parts. Spontaneous decay of the plutonium-238 generates heat in the containment block surrounding it. The heat is transformed directly into electrical energy by a series of thermoelectric elements grouped around the fuel core.

SNAP RADIOISOTOPE THERMOELECTRIC GENERATOR

Prime Contractor: Martin Company, Baltimore

Remarks

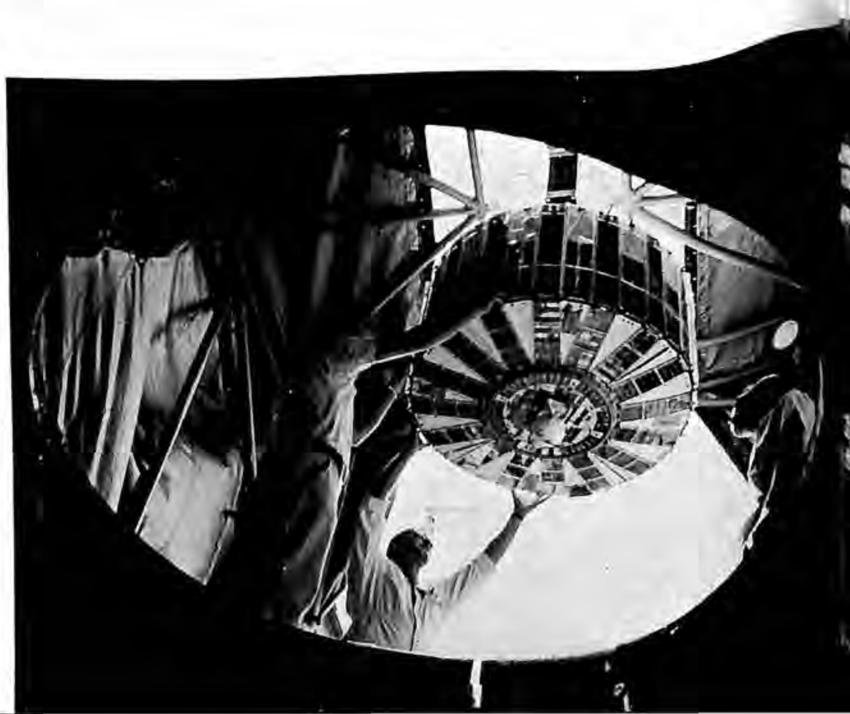
The first use of nuclear power in space occurred June 29, 1961 when the United States orbited Navy experimental navigational satellite 4A with a small radioisotope power supply on board (photo, SNAP is small white ball on bottom of satellite). The grapefruit-sized generator called SNAP (Systems for Nuclear Auxiliary Power) marked its fourth anniversary in space June 29, 1965, still functioning aboard the satellite, which Navy officials said was signalling loud, clear and regularly to a string of tracking stations around the world. The SNAP nuclear generator is supplementing solar power on the 175-pound satellite, built by The Johns Hopkins University Applied Physics Laboratory. The satellite became the oldest operating U.S. satellite in May, 1964, when signals of the Vanguard I were heard by tracking stations for the last time.

Specifications

Elongated sphere shape about 5 inches in diameter and 5 1/2 inches high; fueled with plutonium-238; power output 2.7 watts; generator's design life 5 years.

Method of Operation

The generator has no moving parts. The spontaneous decay of the plutonium-238 generates heat in the containment block surrounding it. The heat is transformed directly into electrical energy by a series of thermoelectric elements grouped around the fuel core.



SNAP–9A RADIOISOTOPE THERMOELECTRIC GENERATOR

Prime Contractor: Martin Company, Baltimore

Remarks

Two SNAP-9A radioisotope thermoelectric generators are currently in orbit aboard Navy navigation satellites (in photo, SNAP-9A is finned cylinder). The first "proof-of-principle" generator, launched in September, 1963, represented the first all-nuclear power system to be used on a satellite. The second nuclear-powered satellite, launched in December, 1963, is part of a three-satellite navigational system that enables fleet units to pinpoint their location anywhere on earth. The satellite is the only one in the system to be powered by the atom. The other two are powered by solar cells. Atomic Energy Commission is cognizant agency.

Specifications

Finned cylinder shape, 20 inches in diameter, 9 1/2 inches high; fueled with plutonium–238; weight 27 pounds; electrical output 25 watts; design life 5 years.

Method of Operation

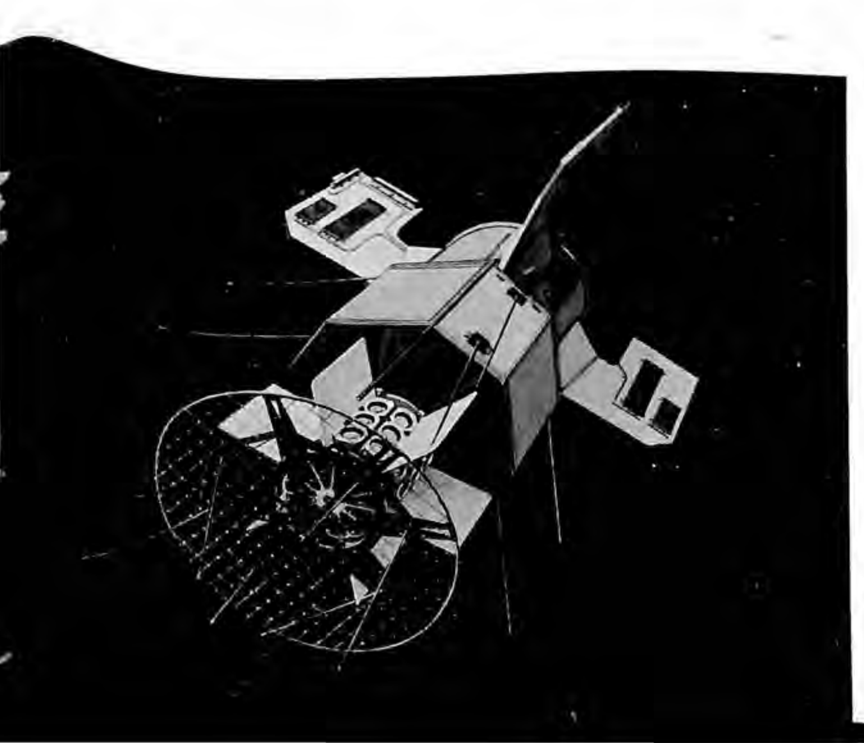
The generator has no moving parts. The spontaneous decay of the plutonium–238 generates heat in the containment block surrounding it. The heat is transformed directly into electrical energy by a series of thermoelectric elements grouped around the fuel core.

LUNAR MISSION SIMULATOR

Prime Contractor: Martin Company, Baltimore

Remarks

The lunar mission simulator is designed to accurately forecast pilot performance and reliability for Apollo space missions and other missions of equal or longer duration having similar tasks. Under a NASA study contract, real-time, simulated flights are "flown" by three-man crews who are graduates of the Air Force's Aerospace Research Pilots School, Edwards AFB, California. Each crew spends seven days on the simulated round trip to the moon following five weeks of classroom work, physical conditioning and simulator training. The Apollo mission was chosen for the studies because it represented a system already well defined and requiring a variety of tasks to be performed by the pilots. Major elements of the simulator include a full-scale Apollo spacecraft and lunar excursion module (LEM), incorporating much the same configuration and instrumentation of the spacecraft that will be used in the Apollo project. Adding realism to the simulator are visual out-the-window displays for the benefit of the space pilots, including a huge shell-like parabolic screen measuring 24 feet in diameter. It envelops the Apollo and LEM spacecraft in a field of some 2300 major stars and constellations projected on its surface. The screen also is used to project a view of the moon's surface in the lunar landing phase of the missions. Included in the simulator complex is an extensive group of analog computers, flight control and monitoring decks, utilizing closed circuit TV and other communications equipment in the spacecraft. Data collection equipment provides a continuous transmission of over 550 channels of flight data, all of it used to help fly the missions and collect information on the pilot's performance.



BIRDiE (BATTERY INTEGRATION AND RADAR DISPLAY EQUIPMENT)

Prime Contractor: Martin Company, Orlando

Remarks

BIRDiE is an electronic, semi-automatic air defense coordination and fire distribution system which makes optimum use of electronics with human supervision imposed at critical points. BIRDiE provides effective air defense by automatic acceptance, generation, processing and distribution of pertinent target data for guided missiles. It can also monitor and/or direct fire unit activity and can even operate autonomously if higher command inputs are interrupted. One of its features is that all functions of surveillance, entry, tracking, monitoring, and friendly protection are combined into a single situation display console. BIRDiE is transistorized and transportable. The system can be tailored to meet the size of the defense battery requirements.

HAYSTACK 120-FOOT MICROWAVE ANTENNA SYSTEM

Prime Contractor: North American Aviation

Remarks

The Haystack is the first of a new generation of ultra-powerful antenna systems whose purpose is to pioneer the development of techniques and equipment for high-capacity satellite relay systems for worldwide communications. Built by North American for the Air Force Systems Command, it is operated by scientists of MIT's Lincoln Laboratory at a hilltop site near Tyngsboro, Massachusetts. The 680-ton apparatus is the most precise steerable instrument of its kind. Enclosed in a 150-foot high fiberglass and aluminum geodesic radome, the giant antenna is a radio telescope of unprecedented high resolution and sensitivity. It can also be used as a very long range tracking and measuring radar, enabling scientists to accurately locate a pea-sized object a thousand miles out in space. Its 100,000 watt transmitter can be used to communicate with space probes at a distance of a hundred million miles. The Haystack facility became operational in 1965.

MINUTEMAN I (LGM-30B) GUIDANCE AND CONTROL SYSTEM (AN-DJW-16)

Prime Contractor: Autonetics Division, North American Aviation

Remarks

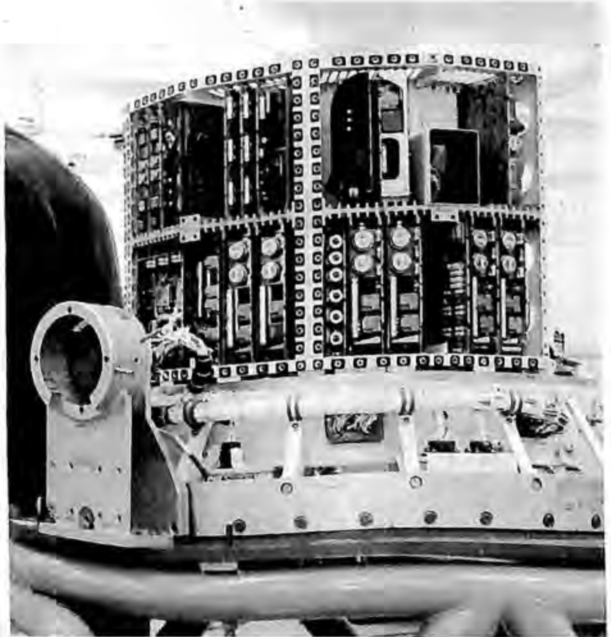
As associate prime contractor for guidance and control (G&C) equipment for the solid-fueled Minuteman I ICBM, Autonetics designed, developed and is producing virtually all this quick-reaction missile's avionics and its supporting ground checkout and alignment equipment. Minuteman I G&C features a degree of long-term reliability once considered impossible. Such reliability was achieved largely by a simplified, integrated avionic system, a rigorous program of reliability improvement of components and subsystems and adoption of new engineering techniques and production methods. Three basic components of this missile's N-10 all-inertial guidance and flight control system are a gyro-stabilized inertial platform, an air-bearing, magnetic-disk memory type of solid-state digital computer and electrohydraulically operated engine nozzle control units. The computer accepts information from velocity meters during flight to generate missile steering, staging and thrust-termination signals. Steering signals move appropriate nozzles to direct engine thrust and control the missile's trajectory. Such movable nozzles constituted a breakthrough in automatic flight control of solid-fueled missiles. Prior to flight, the computer functions as an integral part of the ground checkout equipment, performing regular checks on the missile's readiness for flight, including automatic calibration and alignment of the guidance system. Computer tie-in permits subsystems to perform multiple functions. This, in turn, helps reduce the number and complexity of subsystems and ground support equipment, and also results in a 31-second reaction time for an ICBM originally specified to be launched in 60 seconds.

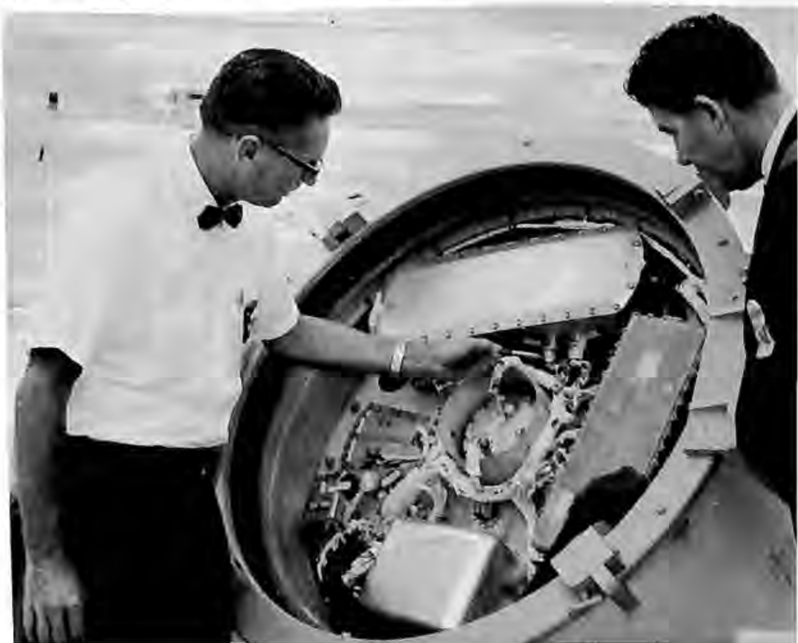
MINUTEMAN II (LGM-30F) GUIDANCE AND CONTROL SYSTEM (AN-DJW-26)

Prime Contractor: Autonetics Division, North American Aviation

Remarks

Microelectronics is the key to major technical improvements being incorporated in the Air Force's new Minuteman II ICBM. The new equipment being furnished by the Autonetics Division, North American Aviation, associate contractor for guidance, flight control and ground checkout equipment, includes: an inertial guidance platform featuring use of pendulous integrating gyro accelerometers and a new gyrocompass azimuth assembly that provides backup to the primary optical reference; microelectronic airborne digital computer with expanded memory capacity, functional capability, greater reliability and reduced size and weight; liquid injection for more efficient Stage II rocket motor flight control. Most of the flight control electronics have been incorporated into the "upstage" portion of the system, housed in the lightweight magnesium/cork guidance body section. The "downstage" portion includes an angular accelerometer unit similar to that in Minuteman I, Stage I and III nozzle control units, two Stage II electro-hydraulic control units, two Stage II electro-hydraulic control units, and all electrical cabling. Key element in the missile's N17 guidance system is the microelectronic computer that accepts information from sensing instruments mounted on the inertial platform and compares it with previously-stored information. When course and speed deviations are noted, the computer signals the flight control equipment, which then directs rocket engine thrust toward the proper trajectory. In pre-flight operational deployment, the computer performs regular checks and reports on missile flight readiness; verifies all targeting, enabling and launch commands; selects the commanded target, controls launch timing, and sequences the missile and ground equipment to first-stage ignition.





POLARIS SHIP'S INERTIAL NAVIGATION SYSTEMS (SINS)

Prime Contractor: Autonetics Division,North American Aviation

Remarks

Ship's Inertial Navigation Systems (SINS) enable Navy Polaris submarines to navigate submerged for long periods of time and to fix precisely their missile-launching positions. This self-contained system basically consists of a digital computer, velocity meters and an inertial platform stabilized by gyroscopes. Automatically and accurately, SINS sense a ship's accelerations, measure them and provide results in the form of continuously available position information, heading and velocity. Autonetics' first production-model SINS were installed in 1959 aboard the George Washington, the nation's first Polaris submarine. Under subsequent contracts, Autonetics became SINS supplier for the balance of the Navy's currently-programmed 41-ship Fleet Ballistic Missile force and those being built in the United Kingdom for the Royal Navy. As Polaris submarines return for overhaul, their early-model SINS are being replaced with improved versions. The Navy's last 12 Polaris submarines and those for the British Royal Navy are each being equipped with two Mk-2 Mod-3 SINS. This model includes an additional gyro that monitors and corrects the drift rates of other gyros to increase overall system accuracy. Other versions of the Autonetics' SINS are operational aboard U.S. Navy attack submarines, three attack carriers (USS Enterprise, USS Independence and USS Ranger) and two range tracking ships—the USS Twin Falls Victory in the Eastern Test Range, and the USNS Range Tracker in the Western Test Range.

REINS (RADAR EQUIPPED INERTIAL NAVIGATION SYSTEM) AUTOMATIC BOMBING NAVIGATION SYSTEM (AN-ASB-12)

Prime Contractor: Autonetics Division, North American Aviation

Remarks

The AN-ASB-12 REINS provides the North American-built Navy Vigilante carrier-based attack bomber with precision guidance, all-weather terrain avoidance for low-altitude missions, air-to-ground ranging, and contour and ground mapping capabilities. REINS target identification and automatic navigation free the aircraft's pilot and navigator-bombardier for concentration on the critical attack phases of the mission. The system includes an inertial autonavigator, digital computer, analog bombing computer, radar, television, wide-angle display projector and tie-in equipment. Eastman Kodak Company and General Dynamics/Electronics, respectively, produced and supplied the system's closed-loop TV and radar. Other Autonetics' systems integrated into the Vigilante include automatic flight control electronics and the shipboard automatic checkout equipment to monitor performance and perform preflight, line and shop maintenance. Released for design in 1959, the first REINS engineering model was produced 14 months later. The first Navy squadrons of REINS-equipped A-5 Vigilantes were operationally deployed in February, 1963.

F-105/R14A MULTIMODE, MONOPULSE RADAR

Prime Contractor: Autonetics Division, North American Aviation

Remarks

Under subcontract from Republic Aviation Division, the Autonetics Division of North American Aviation, Inc., has produced the R14A multimode, monopulse radar system now operationally deployed in F-105 Thunderchief fighter-bombers of the Air Force's Tactical Air Command. Integrated with missile-launching and air-data computers, bombing and gun-firing systems, an optical sight and a stable platform, the R14A radar makes the F-105 one of the most versatile of USAF aircraft. It performs all radar functions on both low and high level missions and gives the F-105 capability for air-to-air search and automatic tracking, ground mapping, terrain avoidance, contour mapping and air-to-ground ranging. Autonetics has delivered almost 800 of these radar systems.

HOUND DOG GUIDANCE AND CONTROL SYSTEMS

Prime Contractor: Autonetics Division, North American Aviation

Remarks

Inertial guidance and flight control systems produced by Autonetics Division automatically guide the air-launched, operational Hound Dog air-to-ground missile (AGM-28A/B) on a pre-selected path to its target, including evasive action en route. Basic mission of the Hound Dog is to increase the capabilities of the Strategic Air Command's intercontinental B-52 manned bomber. Launched from the high-flying B-52, the Hound Dog can fly low-level to escape radar, or high up at supersonic speeds to avoid ground fire. It can fly a dog-leg evasive course to confuse enemy defenses, then dive to its target to explode at any programmed time. Finally, the Hound Dog can act as a front runner for the B-52 or deal its own blow on a primary target hundreds of miles from its airborne launch point. Hound Dog's G&C system allows new cruise altitudes or new targets to be programmed after the B-52 is airborne, so that target, launch point, trajectory, flight pattern or burst height can be changed as needed. Also, the Hound Dog's guidance system can supplement the B-52 bomber's navigation equipment.

MARINE STAR TRACKER

Prime Contractor: Northrop Nortronics' Marine Equipment Department

Remarks

The Northrop Marine Star Tracker is a Vidicon type tracker that will be installed as a component of Sperry Ships Inertial Navigator/Star Tracker systems on Apollo range instrumentation surface ships. The tracker is designed to accept computer data on star position, automatically acquire the star, lock on, and track it until the computer has collected sufficient track data, at which time a second star will be designated. In a secondary mode, the Northrop star tracker can also track an illuminated balloon, receiving synchro deck train and elevation data for acquisition. It offers accuracy to five arc seconds in the automatic mode. The Northrop Marine Star Tracker will provide celestial information to permit calculation of navigational position to an accuracy of less than one-tenth of a mile on the surface of the Earth. (Position-fixing to this accuracy is necessary during the radar-tracking of the Apollo moon shot so that the vehicle trajectory can be controlled precisely and ensure a successful mission.)

GEMINI PARACHUTE LANDING SYSTEM

Prime Contractor: Ventura Division, Northrop Corporation

Remarks

Gemini astronauts are able to operate their own parachute landing sequence, where in the Mercury program parachute operation was automatic. The astronauts deploy the 8.3-foot diameter drogue parachute by mortar at 50,000 to 40,000 feet. At 10,600 feet, the drogue extracts an 18-foot Ringsail pilot parachute. The pilot chute in turn pulls the 84-foot main parachute. For landing, spacecraft attitude is changed from the vertical to a nose-high 35 degree attitude by releasing the single point connection of the main parachute and allowing the spacecraft load to transfer to a two-legged bridle. Landing speed is about 30 feet per second. The main chute weighs 107 pounds, the pilot chute 8 pounds.

APOLLO EARTH LANDING SYSTEM

Prime Contractor: Ventura Division, Northrop Corporation

Remarks

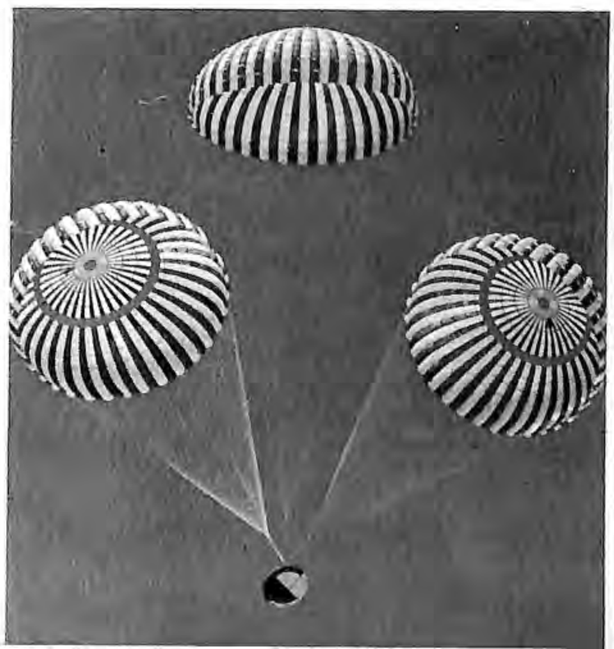
New undergoing test, the Apollo landing system consists of several parachutes: two 13-foot diameter drogue stabilization chutes; three Ringslot 7-foot diameter pilot parachutes; and three Ringsail-type main chutes each having a canopy diameter of 83 feet. Total weight of the system is approximately 540 pounds. An automatic system is provided to perform the recovery operation or can be initiated in its various steps by an astronaut. At 25,000 feet, a barometric pressure switch fires a charge to jettison the apex heat shield over the parachute compartment. Two seconds later, the two drogue chutes are mortar deployed for stabilization and deceleration. At about 10,000 feet, the three 7-foot pilot chutes are deployed, also by mortar, and each pulls out one of the three main chutes. Landing speed is approximately 25 feet per second.

SATURN GROUND COMPUTER SYSTEM

Prime Contractor: Radio Corporation of America, Defense Electronic Products, Van Nuys Facility

Remarks

The Saturn Ground Computer System is an on-line, real time computer system utilized to perform automatic checkout and launch control functions for the Saturn IB and Saturn V launch vehicles. The input/output capabilities are tailored to NASA needs on the Apollo program. The RCA 110A SGCS is very well-suited to meet NASA requirements for increased automatic control, flexibility, checkout capacity, accuracy, speed and reliability. This computer system is the first process control machine to offer a general purpose organization featuring core memory and an automatic priority interrupt system for efficient multi-programming. Unit consists of 19 to 20 cabinets including the following systems or subsystems: data link, discrete, interface to digital data acquisition system, and analog system. The RCA system is used for checkouts in static captive firings, unit tests and actual launch procedures. Twenty-four systems will be placed in use for testing of individual instrumentation units or booster units and actual launch of the Saturn IB or Saturn V. Systems are established in the Launcher Control Center or the Launcher Umbilical Transporter. The input data comes in analog form and goes thru scaling, multiplexing and conversion to digital form when the computer operates upon it. Output data is converted from digital back to analog format with amplification and priority assigned.



ELECTRONIC SWITCHING SYSTEM

Prime Contractor: Radio Corporation of America, Defense Electronic Products, Van Nuys Facility

Remarks

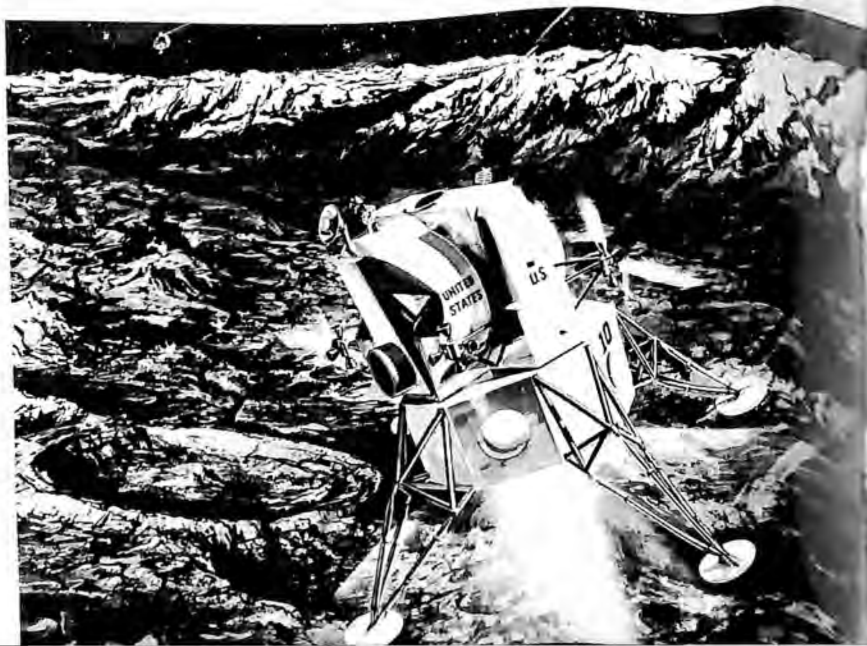
An Electronic Switching System replaces electromechanical switching centers for communication purposes with the use of the electronic computer. This permits "on-line, real-time, full-time," storage and forward type message switching system, utilizing modern electronic components and computer switching techniques to transmit a massive flow of information between widely distributed geographical locations. There is a single switching center for United Air Lines that is supported by a communications network consisting of standard teletypewriter circuits and machines to provide an accurate, reliable and efficient message switching system. The system is "on-line" in the sense that messages from field station, teletypewriter sending machines are transmitted directly to the switching center. It is "real-time" in that the switching center immediately processes the received messages and performs required functions to forward them to addressed stations, and it is "full-time" in the sense that it operates 24 hours a day, 7 days per week. To accomplish message switching, the computer routes and interprets messages by electronically reading control characters within the message. The arrangement of messages in comprehensive formats directs the electronic computer's handling of the message from inception to delivery. Basic features are automatic time-sharing of all programmed switching functions; each function is performed by priority on a demand basis; automatic smoothing of traffic peaks without compromising line utilization; automatic initiation of on-line selfcheck during low traffic periods. Basic elements are: storage, concentrator, line counter, line scanner, expandor, input/output relays and processor interface.

RCA LEM SYSTEMS

Prime Contractor: Radio Corporation of America

Remarks

Radio Corporation has multiple systems responsibilities in connection with NASA's Lunar Excursion 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 LEM 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 LEM 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 LEM, 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 LEM crew to rendezvous and dock with the Apollo for the home trip.



AN/FPQ-6 TRACKING RADAR

Prime Contractor: Radio Corporation of America, Defense Electronic Products

Remarks

Capable of pinpointing an object 32,000 miles away within a few yards of its true position, the AN/FPQ-6 is a tracking radar used in the United States' global tracking network. Built by RCA's Missile and Surface Radar Division, the AN/FPQ-6 and its air transportable version, AN/TPQ-18, are high accuracy, long range, amplitude comparison, monopulse, C-band instrument radars. They supply accurate spherical coordinate information on long range, high velocity targets.

AN/FPS-16 PRECISION INSTRUMENTATION RADAR

Prime Contractor: Radio Corporation of America, Defense Electronic Products

Remarks

First used in downrange missile tracking as early as 1957, the AN/FPS-16 radar is part of the national space tracking network. The AN/FPS-16 and its air transportable version, AN/MPS-25, are C-band radars that can acquire and automatically track passive or active targets with velocities up to 10,000 yards per second. Equipped with a 12-foot dish antenna, the system provides range data to an accuracy of 7 yards at 500 nautical miles. The radars also provide a means of evaluating target performance by supplying precise target position information in the form of digital, synchro and potentiometer data to local or remote computers, visual displays, plotting boards and data recorders.

AN/TSQ-47 AIR TRAFFIC CONTROL SYSTEM

Prime Contractor: Radio Corporation of America, Defense Electronics Products

Remarks

The AN/TSQ-47 is a complete package including terminal area navigation, traffic control, instrument landing and communication facilities, transportable in three C-130's and put into operation within a matter of a few hours. The system consists of six units, each packaged in a separate shelter: the AN/TPS-35 Surveillance Radar, which offers two-dimensional coverage at distances up to 275 miles; the AN/TRN-17 Tacan navigation station (built by International Telephone and Telegraph Corporation); the AN/TPN-14 Precision Approach Radar; the AN/TSW-5 radar approach and traffic control center; the AN/TSW-8 control tower for active runway and VFR approach operations (in photo); and the AN/T-SC-23 communications van, supplied by Adler Electronics. The system has been undergoing test at Eglin AFB, Florida, and is slated for eventual use by the Air Force Communications Service.

AN/TRC-97 TROPOSPHERIC SCATTER RADIO RELAY EQUIPMENT (NO. 1 SY-73E)

Prime Contractor: Radio Corporation of America, Defense Electronic Products

Remarks

The AN/TRC-97 is a solid state radio relay terminal providing tumble microwave, diffraction or tropospheric scatter communications in the military band of 4,400 to 5,000 megacycles. With minimal size, weight and power requirements, it delivers full duplex multichannel voice, data or teletype communications over paths ranging from 1 to 100 nautical miles. With power equipment and antenna in a standard trailer, the entire AN/TRC-97, designed for quick reaction tactical use, is readily transportable by 3/4-ton truck or suitable aircraft, and it can be set up and in operation within an hour after arrival at site. The antenna system consists of two 8-foot parabolic antennas, which can be set up and aligned in less than 40 minutes. The equipment is made by RCA's Communications Systems Division.

DIMATE

Prime Contractor: Radio Corporation of America, Defense Electronic Products

Remarks

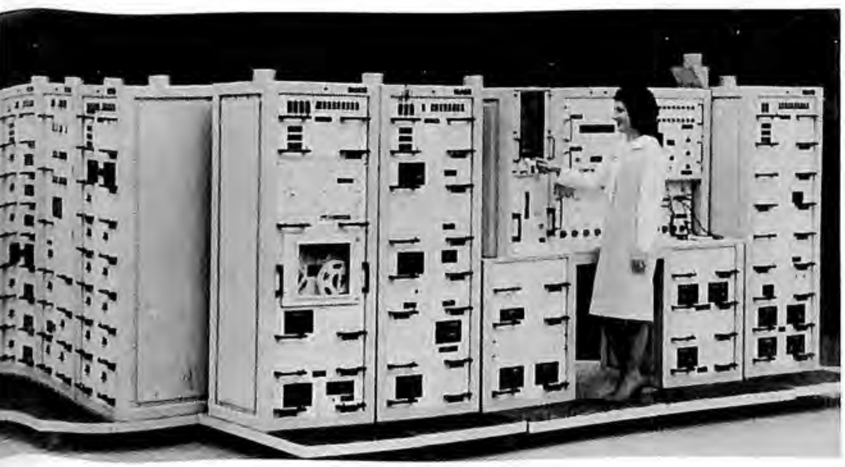
DIMATE, developed for the Army Electronics Command and installed at the Tobyhanna Army Depot, is an acronym for Depot Installed Maintenance Automatic Test Equipment. Designed to check out and fault-isolate communications equipment for which the Electronics Command has maintenance responsibility, DIMATE is computer-controlled, operated by test programs on magnetic or perforated paper tape. The equipment racks contain the controls and display, stimulus, measurement switching and power supply subsystems.

MULTISYSTEM TEST EQUIPMENT

Prime Contractor: Radio Corporation of America, Defense Electronic Products

Remarks

The Multisystem Test Equipment, built by RCA's Aerospace Systems Division, is designed to check out and monitor the electronic assemblies of existing and future Army missile systems. MTE contains measurement and stimuli subsystems controlled by a digital computer. All test programming information and operator instructions are stored on magnetic tape. To test a particular assembly, the operator connects it to MTE (photo) and leaves the rest to the system. Test results, on a Go, No-Go basis, plus operator instructions for any needed adjustments or repairs, are automatically printed out and displayed.



THERMIONIC DIODE

Prime Contractor: Republic Aviation Division, Fairchild Hiller Corporation

Remarks

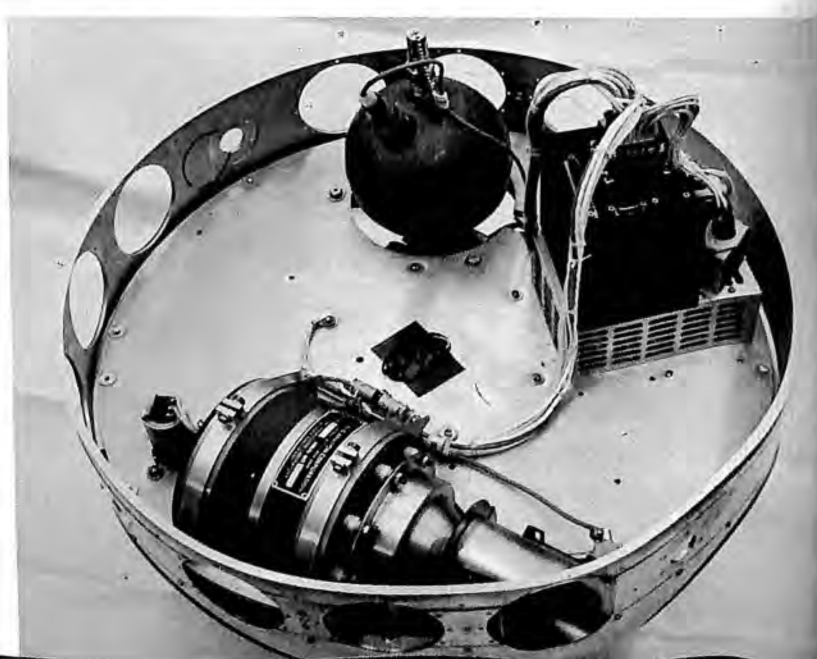
Externally fueled cylindrical cesium diode is capable of producing electrical power in either a reactor or a radioisotope heat source. Complete power systems based upon this diode have low weight and volume. They are well suited for long periods of unattended service. The diode pictured has been operated at one kilowatt.

PLASMA PINCH ENGINE

Prime Contractor: Republic Aviation Division, Fairchild Hiller Corporation

Remarks

Republic's plasma pinch engine is an electric propulsion system designed to provide high specific impulse low thrust for attitude control or propulsion of space vehicles. Units in power ranges from 27 watts to 30 kilowatts have been developed. The 27 watt unit (in photograph) produces 1/10,000th of a pound of thrust at one pulse per second. Its specific impulse is approximately 1,000 seconds.



MICRO-THRUST STAND

Prime Contractor: Republic Aviation Division, Fairchild Hiller Corporation

Remarks

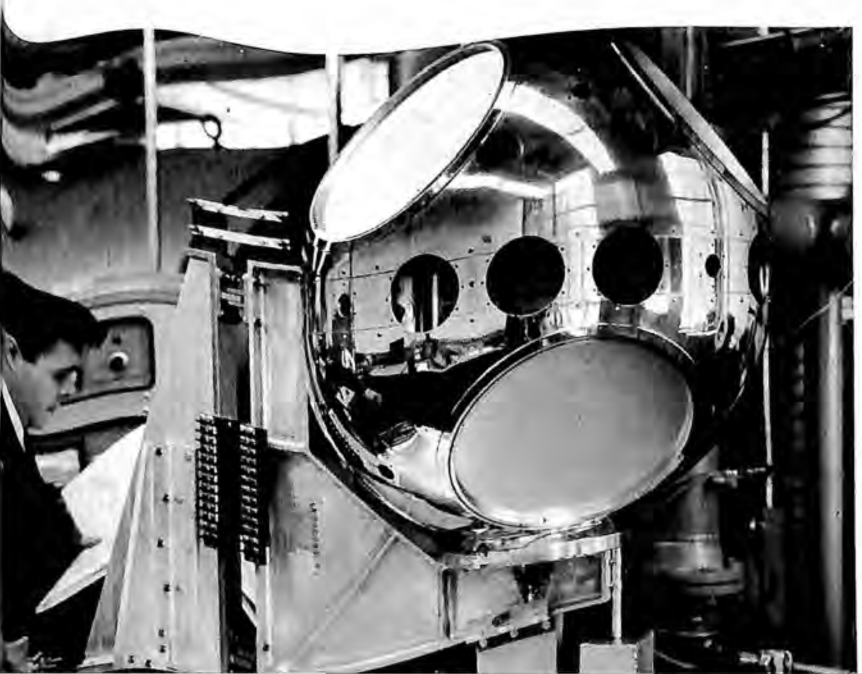
Presently developed thrust stands have been built with resolutions of a micropound (one-millionth of a pound) ranging up to one pound thrust steady state. Stands have been designed to carry as much as 200 pounds of thrustor and instrumentation mass; these stands have provision for a large number of instrumentation leads, power leads carrying several hundred amperes and propellant and cooling lines. In addition, a stand with 1 millipound resolution and 0.5 pound maximum thrust has been built with a system bandwidth of 250 cycles per second permitting accurate measurements to be made of thrust build-up and decay of test engines. All these stands feature built-in automatic levelling and calibration equipment permitting remote calibration in a vacuum chamber, prior to each test. (Photo shows maneuvering satellite mounted on micro-thrust stand.)

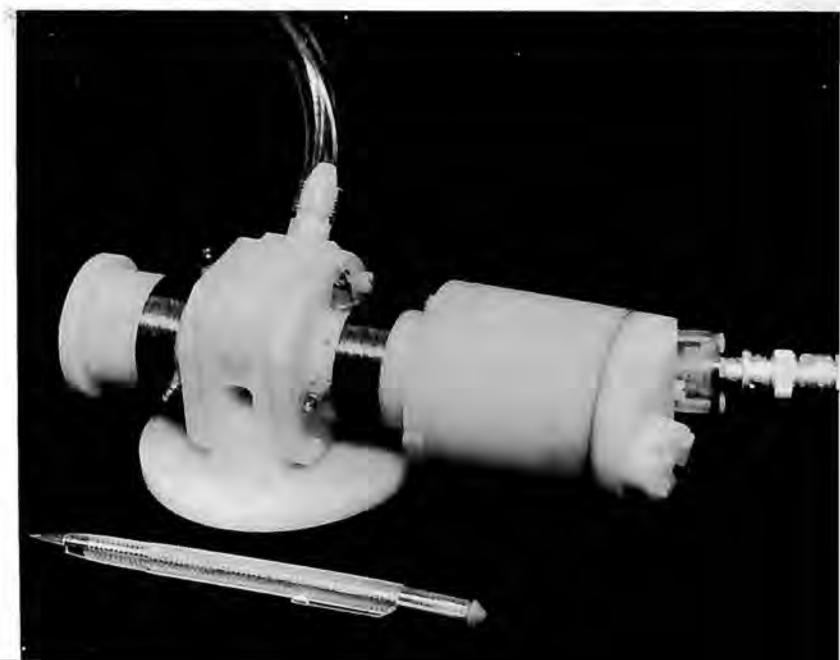
MAGNETOMETER AND MAGNETIC GRADIENT METER

Prime Contractor: Republic Aviation Division, Fairchild Hiller Corporation

Remarks

The Republic air-driven magnetometer is based upon a single short-circuited rotating coil with no wiping contacts. This results in low noise and enables a very low level of magnetic field to be sensed. The rotating coil has an AC circulating current as a result of the presence of the field to be measured. The resulting AC magnetic field links a multi-turn stationary winding and yields an AC voltage proportional to the field to be measured. Sensitivity is one micro-gauss. Dual units on the same shaft have been used to read magnetic field gradients (shown in photo).





SIFTER

Prime Contractor: Republic Aviation Division, Fairchild Hiller Corporation

Remarks

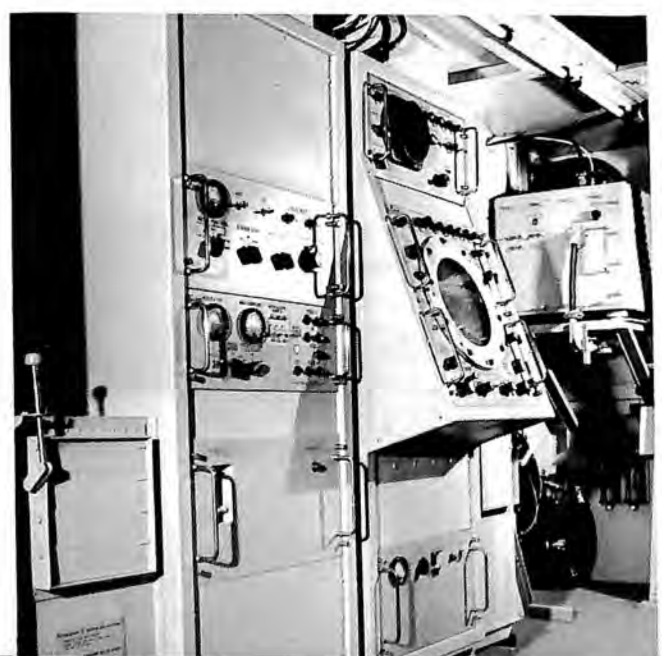
The SIFTER is an automatic pre-flight tester for unattended checking of IFF operations. The aircraft pilot responds to taped instructions which are programmed to the codes of the day. A Go or No-Go decision can be immediately made. The system is adaptable to all tactical and strategic operations as well as to commercial airline checkout operations. This portable equipment requires no special fixtures or power sources to operate unattended from a site up to two miles from the calling aircraft. Four functional sections are packaged as single unit: a standard communications set, an IFF transponder, a programmer and an antenna system.

MOBILE RADAR WEATHER SYSTEM AN/TPS-41

Prime Contractor: Republic Aviation Division, Fairchild Hiller Corporation

Remarks

The Mobile Radar Weather System provides a completely automatic processing, reduction and display system for rapid presentation of fresh meteorological data from a mobile position. Battle commanders can locate and measure precipitation and natural or nuclear clouds for tactical purposes at ranges up to 150 miles. The MWR display system consists of three visual indicators—horizontal or vertical cross section area of precipitation and echo return to measure precipitation rate. First system was delivered to the Army Electronics Laboratories July, 1965. Total weight of this wheeled system is less than 3,500 pounds. The equipment has been designed so that it can be set up in less than 20 minutes on a self-supporting basis.



RADIATING FACILITY (RADFAC)

Prime Contractor: Republic Aviation Division, Fairchild Hiller Corporation

Remarks

Republic has developed a radiating facility (RADFAC) that provides a quick, remote check of the communication, identification, and navigation (CIN) subsystems carried by a majority of aircraft. The RADFAC checks the CIN equipment of an aircraft by radiating programmed signals from its antenna to the CIN equipment antennas located in the aircraft. One technician can determine the proper operation of the aircraft equipment by merely following taped operating instructions transmitted from RADFAC and observing the instruments in the cockpit. These observations provide a confidence check or, in the case of a malfunction, isolate the faulty unit. The various radiation tests are conducted in about 2.5 minutes. The taped voice instructions to the technician are controlled by a magnetic-tape programmer in the RADFAC equipment.

MICRO-VUE

Prime Contractor: Republic Aviation Division, Fairchild Hiller Corporation

Remarks

The MICRO-VUE, 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 film chips, about 4 inches square, that hold 9800 frames (for example, 8 1/2 inch by 11 inch pages) of technical data in a 99-by-99 matrix. For information retrieval, solid state electronic digital loops provide random access to any frame on the hi-density micro image chip. The operator simply dials in the frame number, pushes a button, and the frame is automatically found and displayed on a screen. The film chips on which the hi-ratio reduction micro-photographic data are stored are produced using readily available equipment and films. A page of information can be reduced to 1/300th of its original size. Consequently, a single chip can hold a 75-foot-by-75-foot city map or chart of a utility distribution system. While the 4-by-4 inch film chip for the standard MICRO-VUE holds 9800 frames or the equivalent, the MICRO-VUE can be modified for even greater storage per chip. Access to a particular frame is usually made automatically, but the MICRO-VUE can be set up for 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. Changing chips takes only a few minutes of even an inexperienced operator's time.

METEOROLOGICAL DATA SYSTEM

Prime Contractor: Republic Aviation Division, Fairchild Hiller Corporation

Remarks

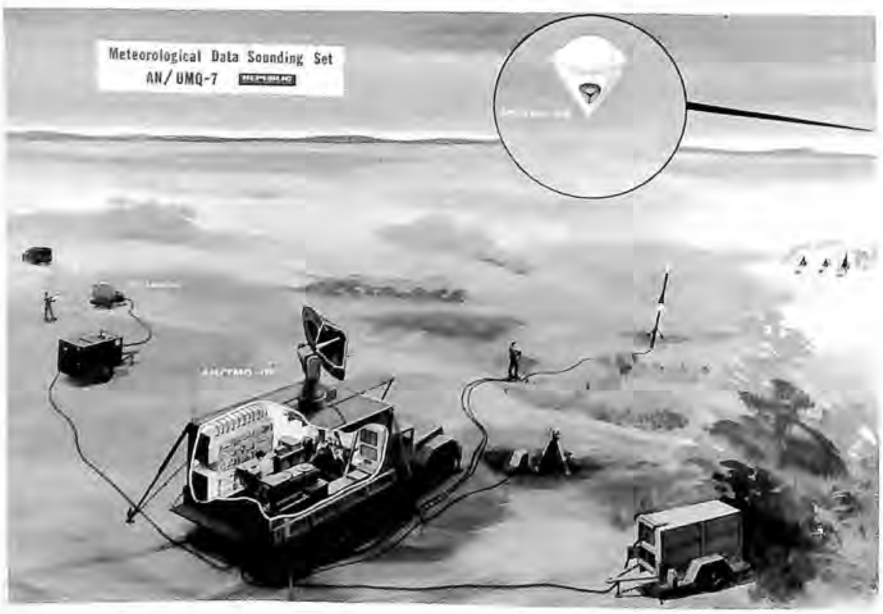
The Meteorological Data System developed by Republic Aviation Division is a light weight, transportable system designed for set-up and operation within 30 minutes. Its primary function is to provide up-to-the-minute meteorological data to Army artillery units by sounding the atmosphere to an altitude of approximately 100,000 feet. It also supplies meteorological information including nuclear fallout and sound ranging to the Air Weather Service and NATO. The Republic Meteorological Data System is made up of a Meteorological Data Sounding Set (AN/UMQ-7) and a Mobile Weather Radar (AN/TPS-41). The Meteorological Data Sounding Set includes the Automatic Atmospheric Sounding Set (AN/TMQ-19) and the Atmospheric Meteorological Probes (AN/AMQ-22 and AN/AMQ-23) in addition to ancillary items such as the power generator, hydrogen generator and the balloon or rocket launcher. The AN/TMQ-19 Automatic Atmospheric Sounding Set has the capability of accurately tracking and receiving data transmitted from airborne balloon and rocket probes. The complete system is housed in a mobile type shelter suitable for field operation. High accuracy and rapid data processing and reliability are the outstanding features of this system. The first system was delivered to the Army in September, 1965. It is 12 feet long, 7 feet wide and weighs 5,000 pounds with the shelter.

MAGNETRON TUNING SYSTEM

Prime Contractor: Vickers Incorporated Division of Sperry Rand Corporation

Remarks

The magnetron tuning system is an electrohydraulic control system that provides tuning capabiity to frequency-agile magnetron radar transmitters. The system is comprised of a self-sufficient hydraulic power supply; electrohydraulic, linear servoactuators; and electronic controls. The use of this system permits rapid change of transmitter frequency with both manual and programmed commands. This, in turn, reduces susceptibility of the radar transmitter to jamming. A linear output of up to ± .235 inches at a maximum rate of 10 cycles per second is transmitted to the magnetron tubes. Completely portable, the total weight of the system is 245 lbs. This is divided into five major self-contained assemblies. The system will be integrated into the TPS-34 radar system; the actuators mechanically coupled to the magnetron tubes, hydraulic power supply and servo amplifier integrated into the radar boom structure and the electronic frequency programmer integrated into the over-all radar control network. Design life of the magnetron tuning system is 2,000 hours. Vickers is currently building three systems for the Sperry Gyroscope Company.



RADAR SIMULATOR

Prime Contractor: Sperry Rand Corporation, Sperry Microwave Electronics Company Division

Remarks

This new line of radar simulators is designed to test pre-flight operational readiness of missile beacon transponders, on the range or in the laboratory. A full portable, battery operated instrument with a tripod mounted 18 inches standard gain directional antenna, the new simulator is light weight and compact. The equipment can be conveniently transported and set upon the site in a matter of minutes. The two units presently available are capable of interrogating conventional C- and S-band transponders at distances of up to several thousand yards. Readout of the beacon reply is viewed on a 3-inch oscilloscope. In the field, the unit may be operated continuously for about an hour using its internal rechargeable battery. For longer operating time, it can be connected to a standard 12-volt vehicle battery or a conventional 115 VAC supply. Radar simulators were delivered in the summer of 1965 to White Sands Missile Range, NASA Flight Research Center at Edwards AFB, California and the Sandia Corporation at Albuquerque, New Mexico.

SGN-10 INERTIAL NAVIGATION SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Gyroscope Company Division

Remarks

The Sperry SGN-10 is the first inertial navigation system for commercial airlines. It is an outgrowth of such Sperry-designed navigation systems as those that enable the Navy's submarines to navigate under polar ice caps and those for the USAF's B-58 supersonic bomber. The SGN-10 is entirely independent of external aids, such as radio or visual landmarks, and will enable airlines to shorten the distance flown between terminals, reduce operating costs, and increase safety. It will be particularly useful to airlines flying intercontinental routes and to supersonic transports. Delivery was begun in late 1965 to Pan American World Airways of the SGN-10 for installation on its entire fleet of 707 jets. Two systems have been purchased by Germany for testing by Deutsche Lufthansa A.G.

LORAN-D RADIO NAVIGATION SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Gyroscope Company Division

Remarks

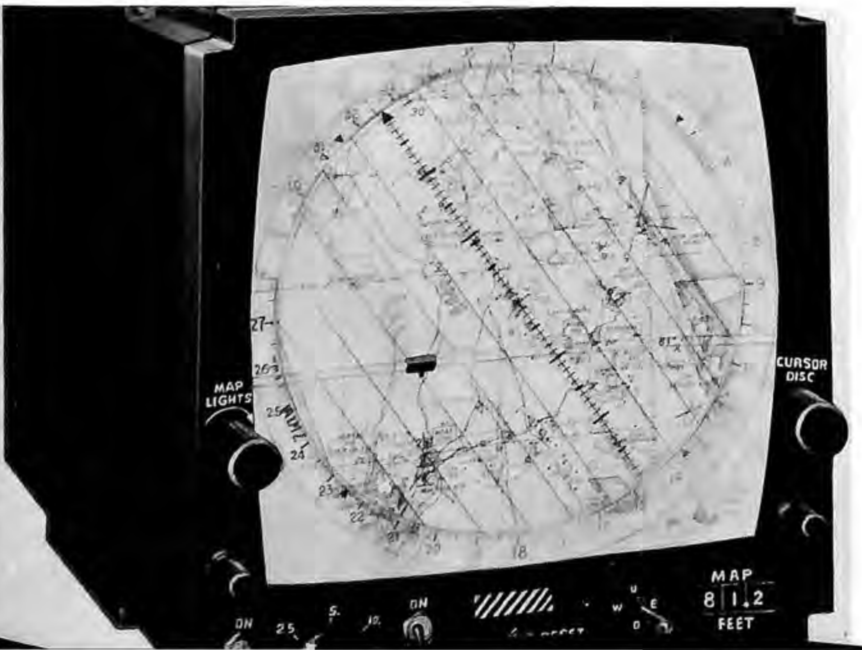
The Loran-D portable radio navigation system consists of navigation receivers for both ground and air vehicles plus transportable ground stations which broadcast position signals. It will enable these forces to operate from the same, exact position information, particularly important in a limited warfare operation where battle lines are fluid and pinpoint navigation is essential. Loran-D is an outgrowth of Loran-C, which enables a navigator to determine his position by timing the arrival of simultaneously broadcast signals from different transmitting stations. Loran-D transmitters are air transportable and can be quickly set up. Loran-D is on order for the U.S. Air Force. It will also be used in a radar system being built for the Canadian Navy.

LORAN-C NAVIGATION SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Gyroscope Company Division

Remarks

Loran-C, like standard Loran, is a navigation system which determines position by timing signals from master and slave transmitters around the world. It is more accurate than standard Loran, however, and its 100 kc frequency makes the signals usable over land. The microcircuit Loran-C receivers are three times more reliable than conventional Loran-C receivers and yet are smaller, require less power and are simpler to operate. Prototype Loran-C receivers, developed under the sponsorship of the Navy Bureau of Weapons, were extensively flight tested by the Air Force. The Air Force Aeronautical Systems Division accepted delivery of a number of receivers in April, 1965. The Air Force is planning to use the precision navigator for Apollo recovery aircraft.



HEAD-UP ELECTRONIC WINDSHIELD DISPLAY

Prime Contractor: Sperry Rand Corporation, Sperry Gyroscope Company Division

Remarks

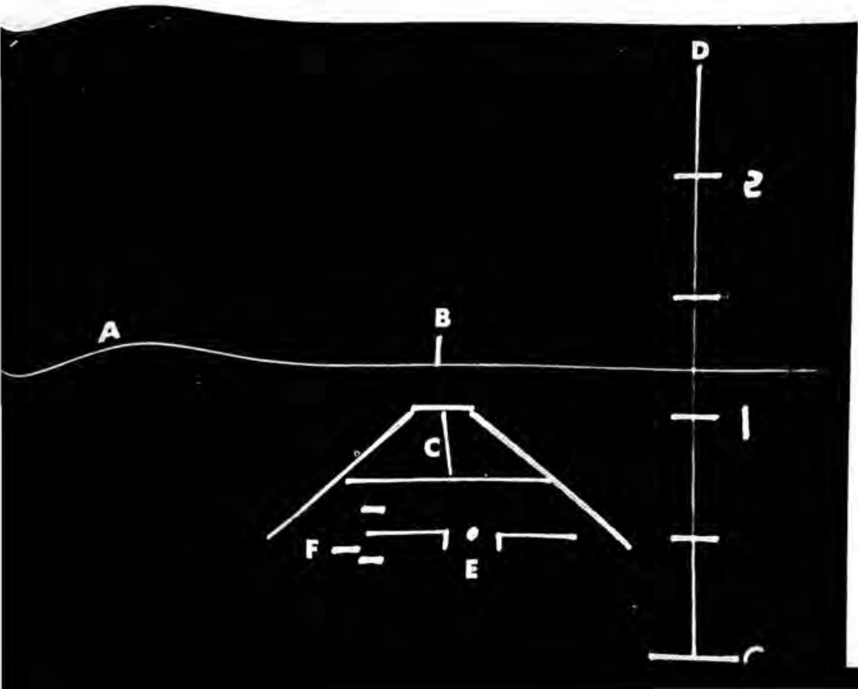
The head-up electronic windshield display projects an outline of the runway in colored lights and tells the pilot where his aircraft is in relation to the runway. A red path marker symbol represents the airplane; bars of light form the runway and the horizon. The pilot stays on the proper path by maintaining alignment with the runway's center line and keeping the path marker aimed at the end of the runway. Sperry has been working on the concept since 1956 with military and company funds. Test versions have been flown in several types of aircraft.

AN/FPQ/10 RADAR SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Gyroscope Company Division

Remarks

This radar is being developed for the Navy as a general purpose precision tracking radar to acquire and track missiles and aircraft. The design will incorporate solid state circuits throughout, with the exception of the transmitter, to provide high reliability. Approximately 35 per cent of the circuits will be microcircuited, making this radar a first in this field.



AIRPORT SURVEILLANCE RADAR

Prime Contractor: Texas Instruments Incorporated

Remarks

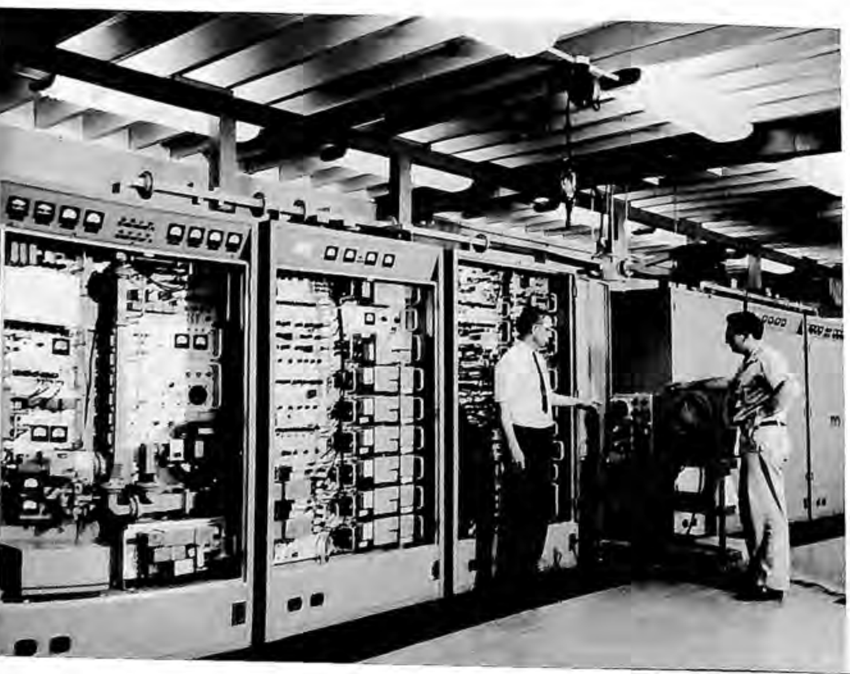
Texas Instruments Airport Surveillance Radar, designated ASR-4, ASR-5, ASR-6 and AN/FPN-47, is an all-weather, long-range system used to control air traffic in the vicinity of major metropolitan airports. The ASR is a dual redundant system (except for antenna) and is designed to operate continuously 24 hours a day with a design life of 20 years. TI designed, developed, manufactured and installed more than 125 systems at major domestic airports, and Air Force bases and foreign airfields around the world. Maximum range of the ASR-4 is 60 nautical miles. It has MTI capability, automatic performance monitoring, and automatic fault protection.

ROLLER DRIVE AND ROLLER GEAR DRIVE

Prime Conctractor: TRW Systems, Accessories Division

Remarks

The TRW Roller Drive and Roller Gear Drive are simple, bearingless, light-weight, high-speed ratio planetary transmission systems which use roller friction to transmit torque quietly with high efficiency, without lubrication. Essentially, the drive consists of a sun roller and clustered two-step planets, on each of which is maintained a three-line preload in such a manner that almost pure rolling is obtained between all contacting elements. Unlike conventional transmission systems, all stages of the TRW drive are placed in a single plane approximately the same diameter and thickness of one stage of a multistage planetary drive. Thus the savings in volume and weight over conventional transmission systems is represented in the roller drive by approximately the number of stages eliminated. Bearings have been eliminated from all but the output ring of planets, where they are required to resist output torque reaction. Absence of bearings increases efficiency of each step and eliminates a cause of failure. Contracts have been received by TRW from the government to develop roller drive transmission for Army helicopters and marine silent power transmission systems for the Navy. Other applications currently under development by TRW include torque amplifier systems, high-speed centrifugal drives, aircraft accessory drives and aircraft utility pneumatic actuator systems.



X-22A PROPELLER SYSTEM

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

The X-22A aircraft has four propellers mounted in ducts, two in the forward and two in the aft section of the aircraft. The ducted propellers swing vertically and horizontally for vertical and forward flight. To cut down on weight, the seven-foot diameter propellers have fiberglass blades (a fiberglass sleeve bonded to a steel, load-carrying core) and integral gear boxes. The lightweight blade design alone makes each X-22A propeller 25 per cent lighter than metal-bladed propellers of comparable size. Further weight reduction is achieved by attaching the gear box directly to the propeller. An interconnected shaft system transmits power from the four turboshaft engines mounted on a wing in the aircraft's aft section. The right-hand propellers rotate clockwise, the left-hand propellers counterclockwise. A master governor controls the rotational speed of the propellers by automatically changing the blade angles. Hamilton Standard manufactured the fiberglass-bladed, integral gear box propellers for Textron's Bell Aerosystems.

XC-142A PROPELLER SYSTEM

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

The XC-142A's four 15-1/2 foot main propellers and single eight-foot tail propeller have lightweight blades made out of fiberglass shell bonded to a steel, load-carrying core. This design makes the propellers 25 per cent lighter than metal-bladed propellers of the same size. Additional weight-savings are achieved by integrating the propeller with the reduction gearing which is normally mounted on the engine. The integral gear box propeller eliminates duplicate shafting and reduces the weight and size of many gear and propeller components. During hover and transition between vertical to forward flight, the pilot controls the XC-142A by varying the pitch of the main propeller blades instead of wing and tail ailerons. He does this by increasing the pitch of the propellers on one side of the aircraft and decreasing pitch on the other side. The tail propeller is also used for attitude control during hover and flight transition. It is disengaged and braked in forward flight. Cross-shafting in the wing interconnects the propellers, and clutch mechanisms are used to transfer power of one turboprop powerplant to the propeller of another engine which has been shut down. Hamilton Standard is producing the propellers for Hiller Aircraft which is responsible for the V/STOL transport's power transmission system, gearing, shafting and propellers, flaps and ailerons.

LEM ENVIRONMENTAL CONTROL SYSTEM

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

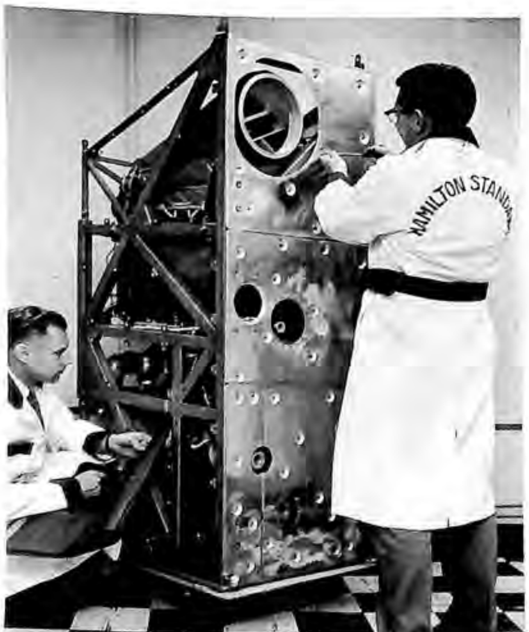
The environmental control system for the lunar excursion module (LEM) supplies oxygen, pressurization and ventilation for the cabin and space suits worn by the two astronauts. It also removes carbon dioxide, odors and other contaminants from the cabin atmosphere. Thermal control includes the temperature of the ventilating gas for the cabin and space suits, electronic equipment and warming cryogenic fluids. During normal operation, the cabin and space suits are maintained at 5 pounds per square inch, permitting the crew to open the face plates and remove their gloves. When the cabin is depressurized, the astronauts seal their space suits and pressure is reduced to 3.5 pounds per square inch. The pressurizing gas is 100 per cent oxygen. The major portion of this oxygen is stored cryogenically, but the environmental control system also includes a small gaseous oxygen accumulator for high-flow demands of short duration. Sufficient oxygen is stored for six cabin repressurizations, two fills and four refills of the oxygen tanks on the portable life support system to be worn by the space-suited crew when they explore the moon's surface, plus normal crew consumption and vehicle and suit leakage. The thermal control function employs an ethylene glycol-water mixture as a heat transport fluid, circulated through a closed loop. Waste heat from this loop is rejected to a self-regulating porous plate sublimator which discharges vapor to the vacuum of space. A positive expulsion tank is used for storage of water required for evaporation and for supplying the metabolic needs of the crew. The tank also stores sufficient water for two fills and four refills of the life support pack's water tanks.

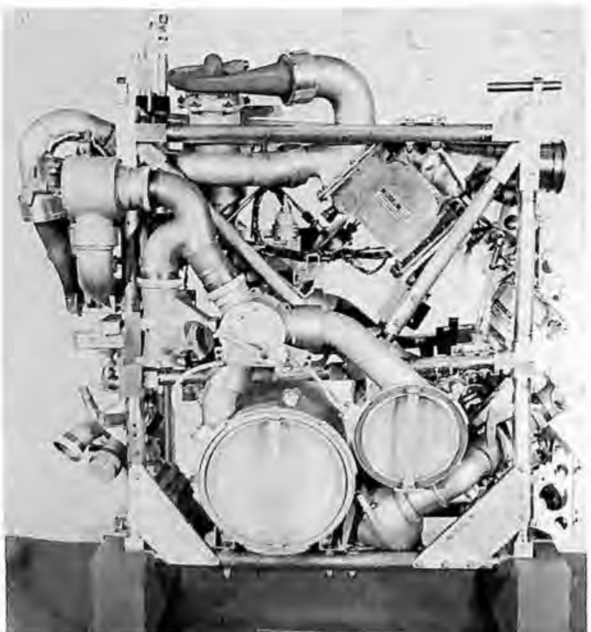
XB-70 ENVIRONMENTAL CONTROL SYSTEM

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

The XB-70's environmental control system is designed to provide a shirt-sleeve environment for the crew as the aircraft flies at subsonic and supersonic speeds, including Mach 3 when skin temperatures are more than 600 degrees Fahrenheit. The recirculating system cools, pressurizes, ventilates and controls the relative humidity inside the crew and electronic equipment compartments. It also supplies cooled air in the hollow space between the fuselage's inner and outer walls. Compartment pressure is regulated to an 8,000-foot altitude. The heart of the system is a 33-ton capacity Freon refrigeration package. A controlled airflow from the aircraft's jet engines supplies makeup air for leakage in the air supply used for ventilation and pressurization. Temperature of the engine bleed air is approximately 800 degrees Fahrenheit before it enters the system. Hamilton Standard manufactured the environmental control system for North American Aviation.





PORTABLE LIFE SUPPORT SYSTEM FOR APOLLO SPACE SUIT

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

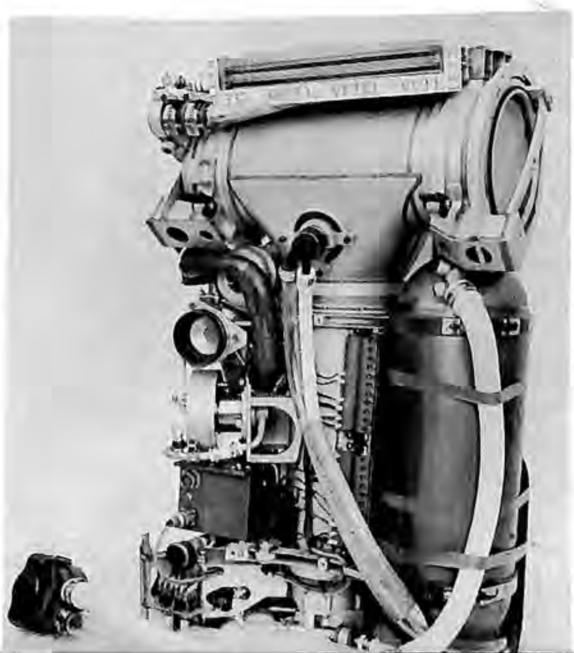
The Portable Life Support System (PLSS) is designed to be worn by space-suited astronauts when they explore the lunar surface. Weighing 60 pounds, it will supply oxygen, pressurization and control the temperature, relative humidity, carbon dioxide and other contaminants of the ventilating gases in the suit. The PLSS also recirculates and recools the water that flows through the tubing of the liquid-cooling garment worn under the Apollo space suit. This water removes the astronaut's body heat. The life support pack will permit four-hour extravehicular expeditions. Its expendables can be recharged in the lunar excursion module (LEM) for the pack's reuse. A two-way radio and telemetry unit provides voice communications and the transmission of astronaut physiological and space suit data to the LEM or to the command module for relay to earth. Hamilton Standard developed the PLSS for NASA's Manned Spacecraft Center.

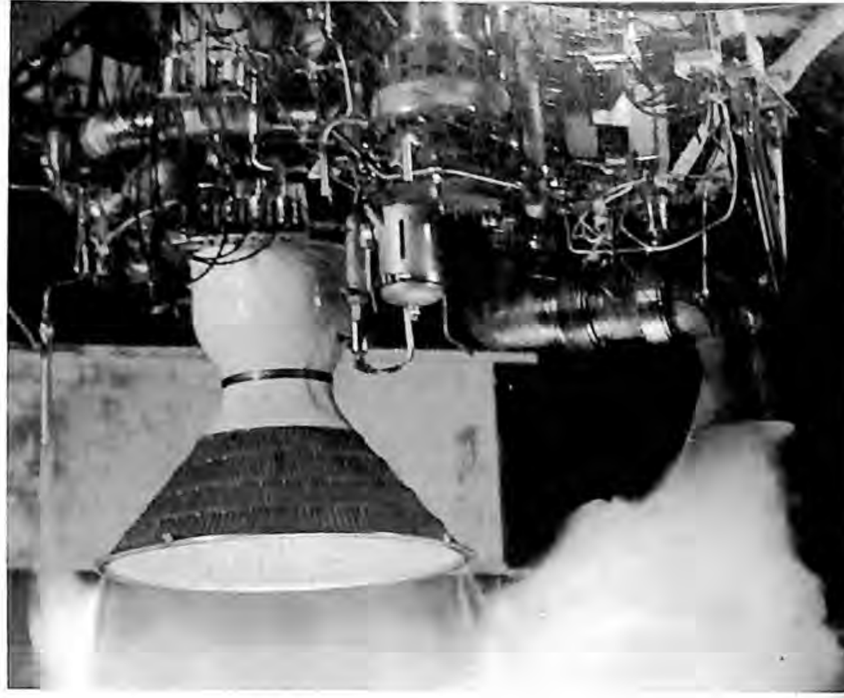
LUNAR TELEVISION CAMERA

Prime Contractor: Westinghouse Electric Company, Defense and Space Center

Remarks

The Westinghouse Aerospace Division is building a molecular electronic lunar television camera to be used by astronauts on the moon's surface (photo). Thirteen of the cameras will be built under contract to NASA, seven of them flight models which will be used on Apollo missions. The scenes taken by the astronaut will be televised "live" over commercial TV networks. Transmission from the moon will be at 10 frames per second with 320 lines resolution; this signal will be converted to commercial frame and scan rates at earth receiving stations. The camera is designed to be completely automatic, maintenance-free and 99.9 per cent reliable for 14 days. Weighing 5 1/2 pounds (without the lens), it operates on only six watts of power. It has a highly sensitive low-light-level Vidicon imaging tube and can be used in almost total darkness.





TITAN II FIRST STAGE ENGINE SYSTEM

Prime Contractor: Aerojet-General Corporation

Remarks

The liquid rocket engine system which boosts Gemini astronauts into orbit is the simplest pump-fed propulsion system yet devised. The Titan II first stage engine system is produced by Aerojet-General Corporation's Liquid Rocket Operations. In combination with the second stage engine which ignites at altitude and goes into orbit with the Gemini capsule, the Aerojet engine system for Gemini contains only 111 moving parts, fewer than an automobile engine. A feature of Aerojet's propulsion system for the Gemini launch vehicle is storable propellants; the fuel is a blend of hydrazine and UDMH (unsymmetrical dimethyl hydrazine) and the oxidizer is nitrogen tetroxide. These hypergolic propellants require no ignition system since they ignite on contact; they are the key to the quick reaction time of the Gemini launch vehicle and the simplicity of its engine system.

Performance

Thrust 430,000 pounds.

TITAN II SECOND STAGE ENGINE

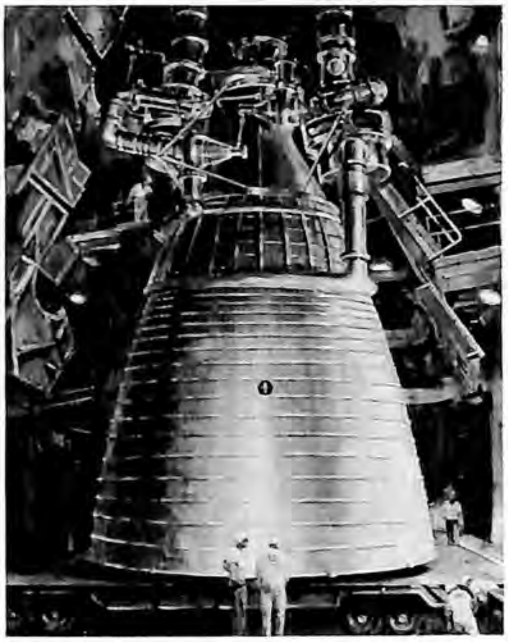
Prime Contractor: Aerojet-General Corporation

Remarks

Like the lower stage Titan II propulsion system, the second stage engine burns hypergolic propellants; fuel is a combination of hydrazine and UDMH, oxidizer is nitrogen tetroxide. In photo, exhaust from the single roll nozzle is shown at the right, and a fuel "overboard" line, which discharges the small amounts of fuel used to actuate various valves and controls, is at the left. For flight, where the engine will operate at high altitude, an ablative skirt is added to the thrust chamber, extending the ratio area from 31:1 to 45:1.

Performance

Thrust 100,000 pounds.



M-1 LIQUID HYDROGEN ROCKET ENGINE

Prime Contractor: Aerojet-General Corporation

Remarks

M-1 is a liquid hydrogen rocket engine which was planned for use as an upper-stage propulsion unit for future space projects. The engine was in the early development stages when the program was canceled. The picture is an artist's concept.

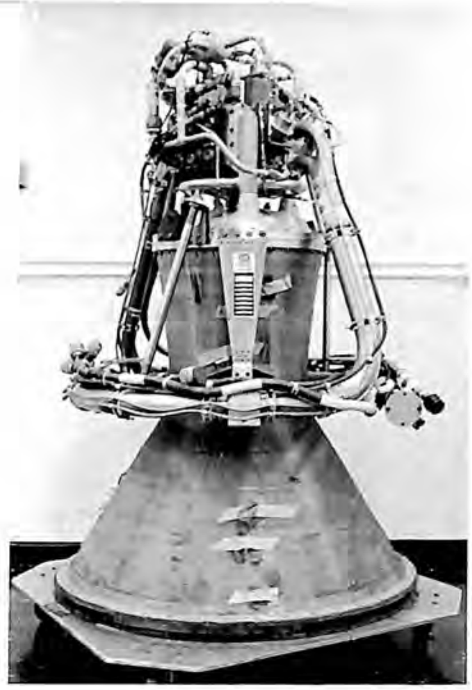
NERVA (NUCLEAR ENGINE FOR ROCKET VEHICLE APPLICATION)

Prime Contractor: Aerojet-General Corporation

Principal Subcontractor: Westinghouse Electric Company (nuclear reactor)

Remarks

NERVA is under development by Aerojet-General Corporation for the Space Nuclear Propulsion Office of the Atomic Energy Commission and the National Aeronautics and Space Administration. America's first nuclear rocket propulsion system, the engine uses liquid oxygen -423 degrees Fahrenheit which is heated to thousands of degrees by a nuclear reactor and exhausted as gas to provide thrust. The operational NERVA will have a 5 billion watt reactor and will produce 250,000 pounds of thrust for an upper-stage vehicle application.



MINUTEMAN II SECOND STAGE ENGINE

Prime Contractor: Aerojet-General Corporation

Remarks

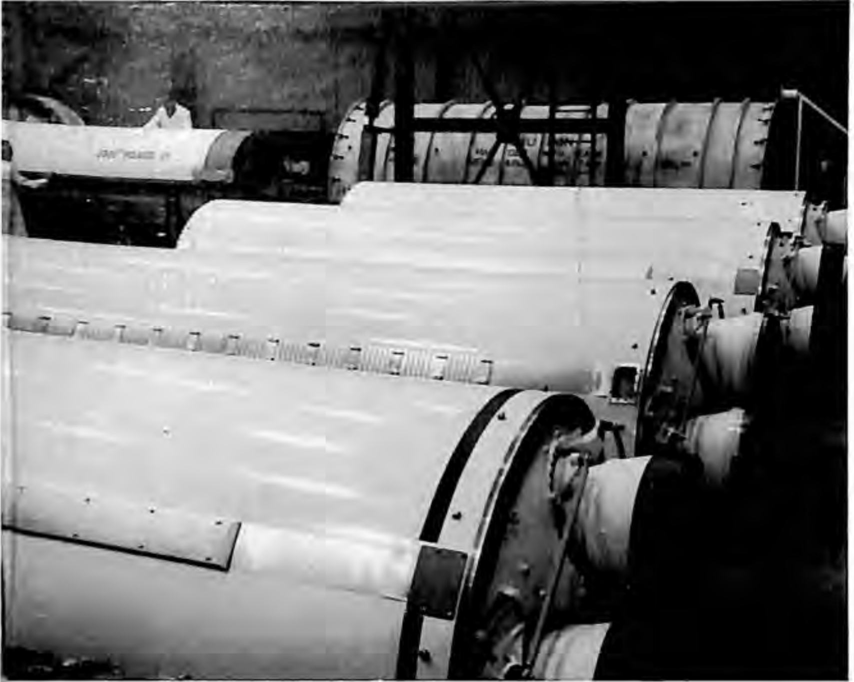
The new second-stage solid-propellant rocket motor for the Air Force Minuteman II ICBM is 50 percent more powerful than its predecessor, increasing the missile range from Minuteman I's 6,300 to 7,000 miles. The advanced motor is equipped with a large single nozzle instead of the 4 smaller nozzles that move in pairs on the other 2 stages to guide the vehicle during flight. The new 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.

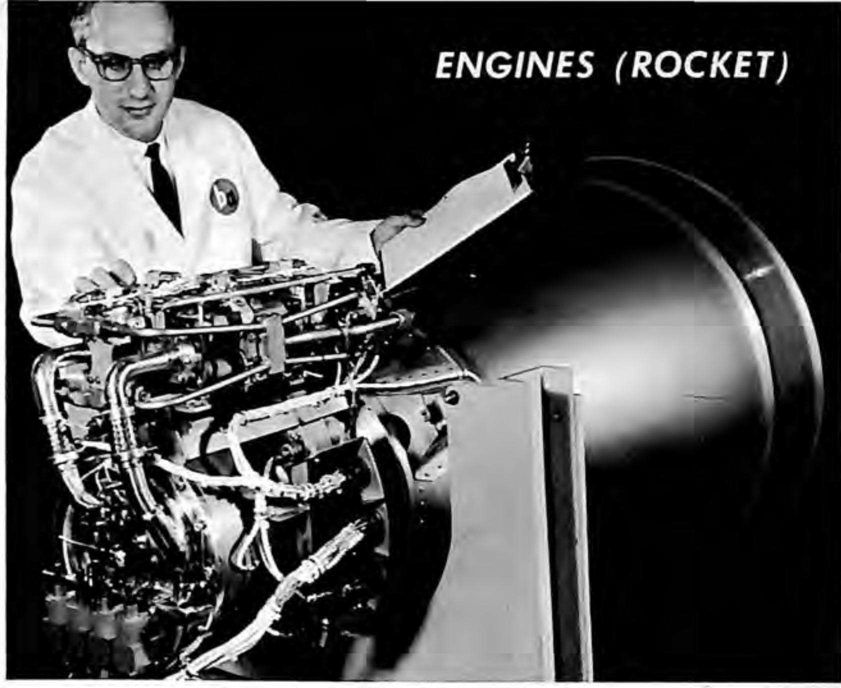
APOLLO SERVICE MODULE ENGINE

Prime Contractor: Aerojet-General Corporation

Remarks

The Apollo Service Module engine is one of the newest manned space flight rocket engines. It may be turned on or off at will, burn for long and short durations, and it has no complicated pumps, cooling systems or ignition devices. It provides propulsion of the 3-man Apollo space capsule to and from the moon, places the capsule in the correct moon orbit and ejects it back into the correct re-entry window for return to earth. In addition to power for emergencies, it provides rocket power to help hook up with the lunar excursion module on the 2 astronauts' return from exploring the moon's surface. A special 9-foot extension skirt of titanium and columbium permits more effective utilization of rocket gases in the vacuum of space. In photo, the first production type Service Module engine designed, developed and produced at Aerojet-General's Liquid Rocket Operations.





POLARIS MOTORS

Prime Contractor: Aerojet-General Corporation

Remarks

In photo, the 2,000th solid propellant rocket motor produced by Aerojet-General for the Navy's Polaris Fleet Ballistic Missile. While details of the power plant are classified, the engine shown is designed for use in the Polaris A-3, the 2,500 nautical mile range model and the latest to go into service. Aerojet-General started production of Polaris motors in 1959. The company produced all of the first and second stage motors for the 1,200 nautical mile range A-1 version, the first stage units for the 1,500-mile A-2, and is now producing the first stage engine for the A-3.

LUNAR EXCURSION MODULE ASCENT ENGINE

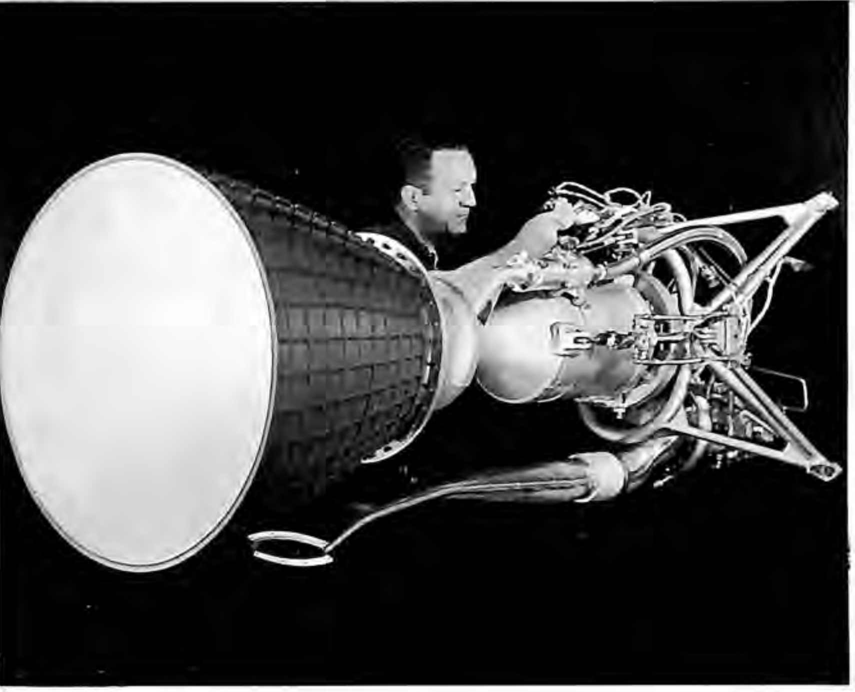
Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The ascent rocket engine will propel the Project Apollo Lunar Excursion Module from launch on the lunar surface into a trajectory leading to a rendezvous with the orbiting Command and Service modules. The engine is under test at Manned Spacecraft Center's White Sands Operation.

Performance

Average thrust 3,500 pounds.



AGENA ENGINE

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The Agena engine is a liquid bi-propellant system used in a number of Air Force and NASA programs including Ranger, Mariner, Nimbus, Echo, OGO, POGO, AOSO and OAO. A multiple restart version of the engine is used to propel the Agena target vehicle for Project Gemini rendezvous missions. In production at Bell Aerosystems since 1958, 7 years, the Agena engine orbited more than 80 percent of the Air Force and NASA satellites launched through 1965 and placed approximately 60 percent of the free world's functional unmanned payloads in space. Fired in space well over 200 times by the end of 1965, the Agena engine has a reliability record exceeding 99.3 percent.

Specifications

Length 7 feet; width 3 feet; weight 300 pounds.

Performance

Thrust 16,000 pounds average.

HERCULES SOLID ROCKET SERIES

Prime Contractor: Hercules Powder Company

Remarks

Hercules Powder Company 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 Sidewinder. In addition, the company manufactures these motors:

X248 ALTAIR: Incorporated into Thor, Delta, Scout, Argo and other programs, the Altair was the first rocket to feature a glass fiber filament-wound case structure.

Specifications

Length 58 inches; diameter 18 inches; weight 500 pounds.

Performance

Thrust 3,100 pounds; time 38 seconds.

ANTARES: A scale-up of the X248 Altair built specifically for Scout, Antares is also used in several other space vehicles. It has a mass fraction of 0.93.

Specifications

Length 113 inches; diameter 30 inches; weight 2,285 pounds.

Performance

Thrust 14,000 pounds; time 36 seconds.

RANGER RETRO: This motor was designed to lower the Ranger payload on the moon at reduced impact speeds; it also places the twin Nuclear Detection Satellites into precise orbits.

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 SOLID PROPELLANT SOUNDING ROCKET MOTOR

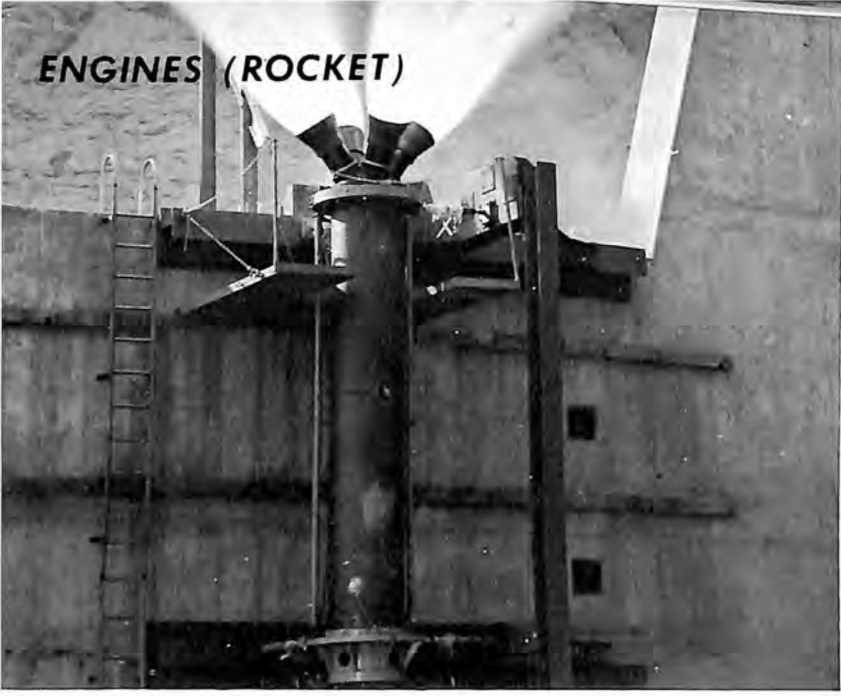
Prime Contractor: Lockheed Propulsion Company

Remarks

The Hydac solid propellant motor is in wide operation as a single stage motor and in various second, third and fourth stage configurations of the Terrier, Honest John and Nike systems.

Specifications

Length 145 inches; diameter 9 inches; weight 563 pounds.



APOLLO LAUNCH ESCAPE MOTOR

Contractor: Lockheed Propulsion Company

Remarks

The Apollo Launch Escape motor Subsystem consists of 2 solid-propellant rocket motors designed to pull the Apollo Command module away from the Saturn booster in the event of malfunction during launch. A solid-fuel motor (1) supplies the main impulse. The escaping spacecraft is put into an arching trajectory by a smaller pitch control motor (2) mounted in the forward section of the assembly.

Specifications

Length (1) 15 feet, (2) 2 feet; diameter (1) 26 inches, (2) 9 inches; weight (1) 4,700 pounds, (2) 50 pounds.

Performance

Thrust (1) 155,000 pounds, (2) 2,800 pounds.

LOCKHEED 156-INCH SOLID MOTOR

Prime Contractor: Lockheed Propulsion Company

Remarks

Lockheed is building two versions of the 156-inch diameter solid rocket motor for feasibility demonstrations. Motor Number One has a thrust of 3,000,000 pounds; it is 75 feet long and carries 700,000 pounds of high-performance rubber-based solid propellant. It has a segmented steel case and a liquid injection thrust vector system. Motor Number Two is 35 feet long with a monolithic steel case and carries 300,000 pounds of propellant. In photo, Motor Number One, first fired in 1964.

MA109

Prime Contractor: The Marquardt Corporation

Remarks

MA109 rocket engines are being used for attitude control in the following NASA programs: Project Apollo Service Module, Lunar Excursion Module (each with 16 engines per module) and Lunar Orbiter.

Specifications

Length 13.4 inches; diameter 5.6 inches; weight 5.4 pounds; propellants: oxidizer, nitrogen tetroxide; fuel, a blend of nitrogen tetroxide and unsymmetrical dimethyl hydrazine; radiation-cooled chamber.

Performance

Thrust 100 pounds nominal vacuum.

MA118

Prime Contractor: The Marquardt Corporation

Remarks

The MA118 rocket engine was developed for NASA as an ullage and Delta-V rocket, originally for application on the Saturn IV-B vehicle.

Specifications

Length 38.7 inches; diameter 17 inches maximum; weight 70 pounds; propellants: oxidizer, nitrogen tetroxide; fuel, a blend of nitrogen tetroxide and UDMH; ablative chamber.

Performance

Thrust 1,750 pounds nominal vacuum.

MA124-XAA

Prime Contractor: The Marquardt Corporation

Remarks

The MA124-XAA engine was developed as a Delta-V and roll control rocket engine for NASA's Syncom Mark II satellite.

Specifications

Length 5.2 inches; diameter 3.95 inches; weight 1.27 pounds; propellants: oxidizer, MON-15, fuel monomethylhydrazine; chamber radiation-cooled.

Performance

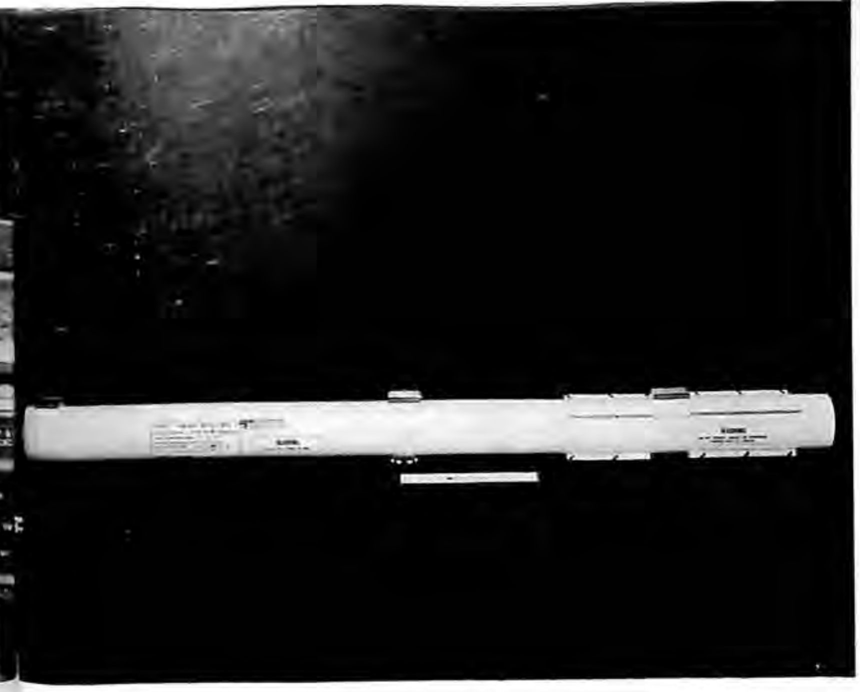
Thrust 5 pounds nominal vacuum.

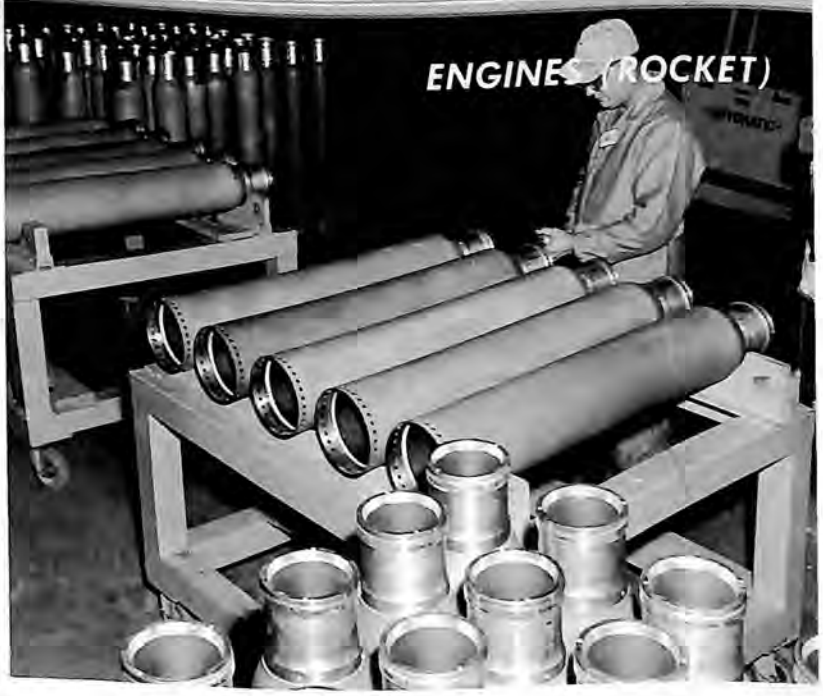
MARK 2/3 TARTAR/TERRIER GAS GENERATORS

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

The electrical and hydraulic system turbines in the Tartar and Terrier surface-to-air missiles are powered by 2 Rocketdyne solid propellant gas generators. High operational reliability has been demonstrated by the MK 2 gas generator and its twin unit MK 3, developed for the Navy. Unique feature of the generators is a boost disc of fast-burning propellant. Cemented to the starting end of the main propellant, it provides the instantaneous burst of power needed to start the hydraulic and electrical system turbines. Both units use a clean burning extruded ammonium nitrate propellant. The propellant charge has been designed to achieve control of the high boost pressure and its leveling off within 1 second of firing. The MK 2 unit boosts the electrical system on both Tartar and Terrier to rated output in approximately .5 second; the MK 3 boosts the hydraulic turbine to rated speed within 1 second.





MARK 36, MOD 2 SIDEWINDER ROCKET MOTOR

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

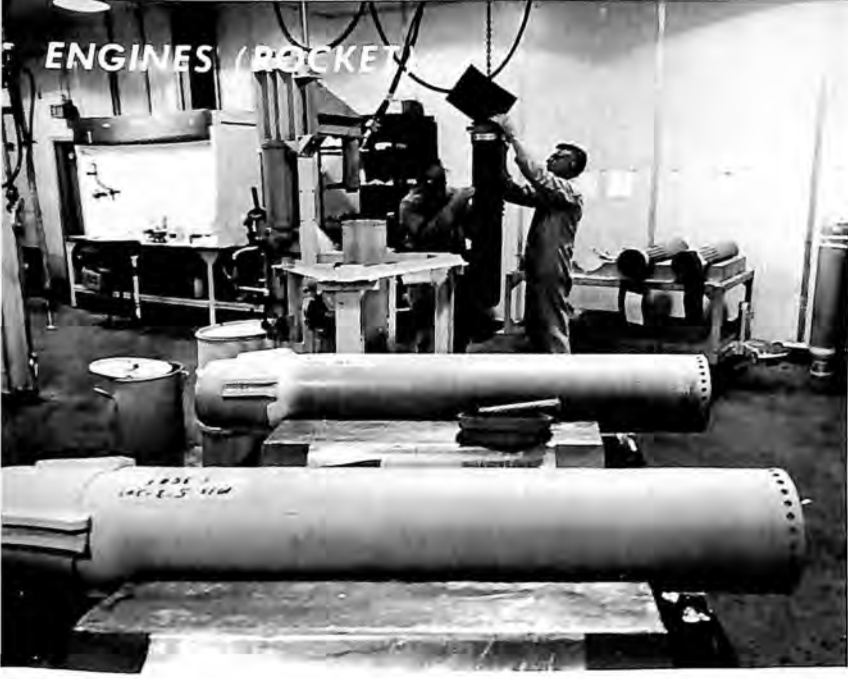
Greater speed and range, plus improved operational characteristics have marked the second generation of Sidewinder with its advanced solid propulsion system under development at Rocketdyne since 1963. This Navy air-to-air missile mounted on F-8's and F-4B's was designed to destroy high-performance fighter aircraft and bombers. The rocket motor measures 72 inches long, 5 inches in diameter, and contains 60 pounds of improved Flexadyne propellant. Loaded with fuel, the motor was subjected to extensive vibration, shock, drop tests simulating extremes of operational use, and temperature extremes ranging from sub-zero to over 300 degrees Fahrenheit. In over 200 firings during development and evaluation the motor showed 100 percent reliability. Sidewinder is the first guided missile to destroy an enemy aircraft in actual combat (during the Quemoy crisis used by Chinese Nationalist forces). Original versions developed by the Naval Ordnance Test Station became operational in 1953.

SPARROW III ROCKET MOTOR

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

The solid propulsion system for Sparrow III, one of the Navy's most advanced air-to-air missiles, has been under development 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 contract approval. Specifically designed to propel the electronically-controlled Sparrow III 6-b, primary armament on the Navy's F4-B aircraft, the new rocket motor increases the missile's operational temperature range as well as its total power and firing range. To qualify for supersonic missions, the advanced motor completed test firings at temperatures from sub-zero to over 300 degrees Fahrenheit; survived several days of continuous vibration; passed drop tests from heights up to 40 feet, and special shock tests simulating aircraft carrier catapult and arrested landing conditions. The Sparrow III motor is the first to combine a unique free-standing propellant charge (grain) with Flexadyne, an improved solid propellant which increases performance and operating temperature range, and resists cracking or tearing at extremely low temperatures.



SHRIKE ROCKET MOTOR

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

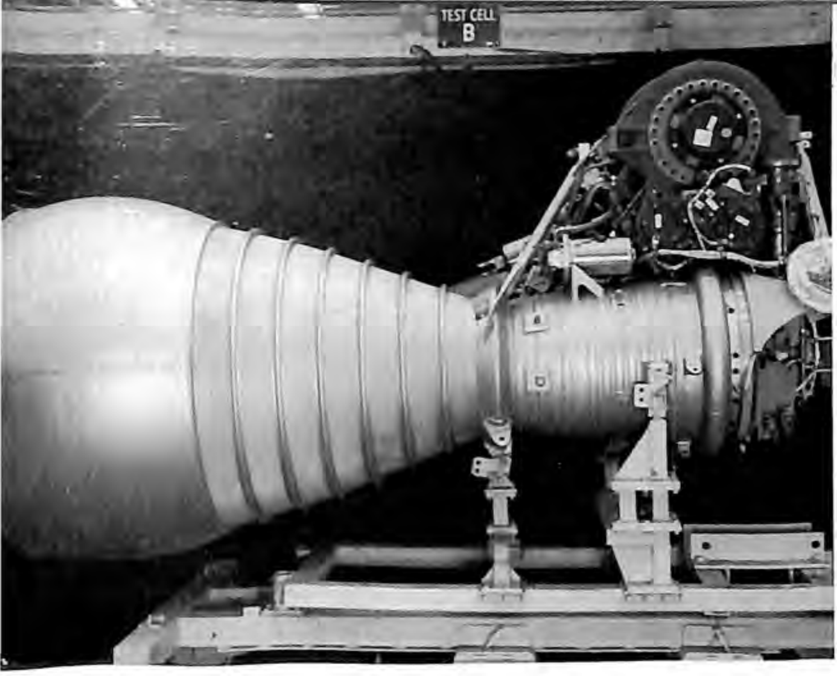
First in a new generation of tactical weapons, the Navy's Shrike air-to-ground missile is powered by a solid-propellant rocket motor similar in design and performance to the propulsion system of Sparrow III. Both motors combine a unique free-standing propellant charge (grain) with Flexadyne, an improved solid propellant providing substantial performance increase and wider operating temperaturre 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. The missile was developed by the Naval Ordnance Test Station with engineering and manufacturing support by Texas Instruments, Inc.

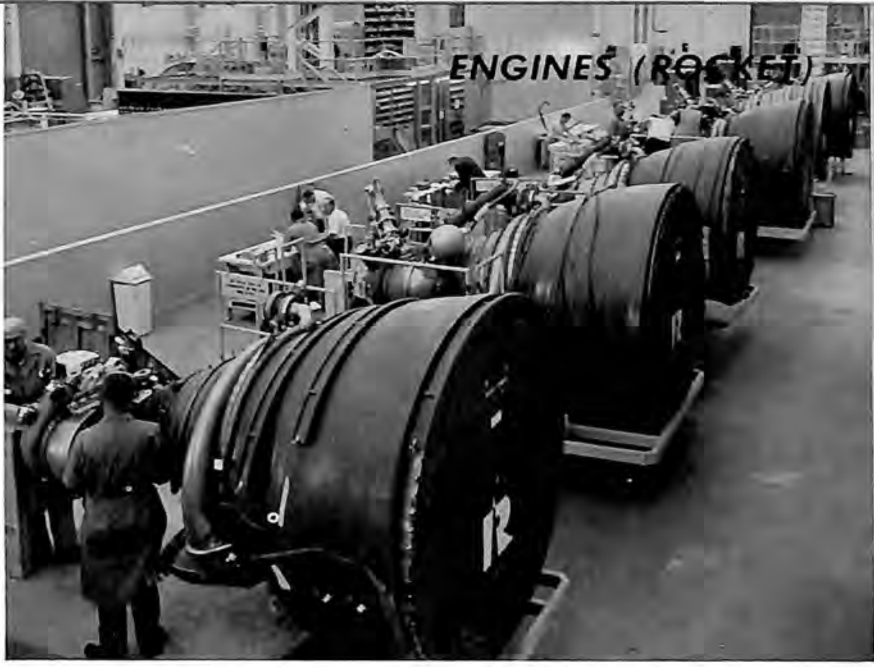
ROCKETDYNE SOLID MOTORS

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

Rocketdyne's Solid Rocket Division at McGregor, Texas, produces a number of motors for specialized applications. Among them are the ullage motors for the S-II second stage of the Saturn V launch vehicle. These motors, attached in clusters of eight 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 Mark 47 for the Phoenix missile, the Redhead-Roadrunner launch booster, the RS-B-105 booster for the MQM-15A drone, the RS-B-202 zero launch booster for the F-104G, and turbine starters for the MA-3 and H-1 liquid rocket engines. In photo, solid propellant samples undergo test at the division's research laboratory.





H-1 ENGINE

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

A key engine in the U.S. national space program, the H-1 in a cluster of eight units develops first stage thrust of 1,600,000 pounds for the Saturn I and IB vehicles. Regeneratively cooled, it burns a combination of RP-1 fuel and liquid oxygen oxidizer. Engines are tested singly at Rocketdyne's Propulsion Field Laboratory in California and at the company's Neosho, Missouri, plant prior to delivery to NASA's Marshall Space Flight Center and the Chrysler assembly plant at Michoud, Louisiana.

Specifications

Maximum envelope length 104 inches; maximum envelope diameter 46 inches at nozzle exit.

Performance

Thrust 200,000 pounds.

J-2 ENGINE

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

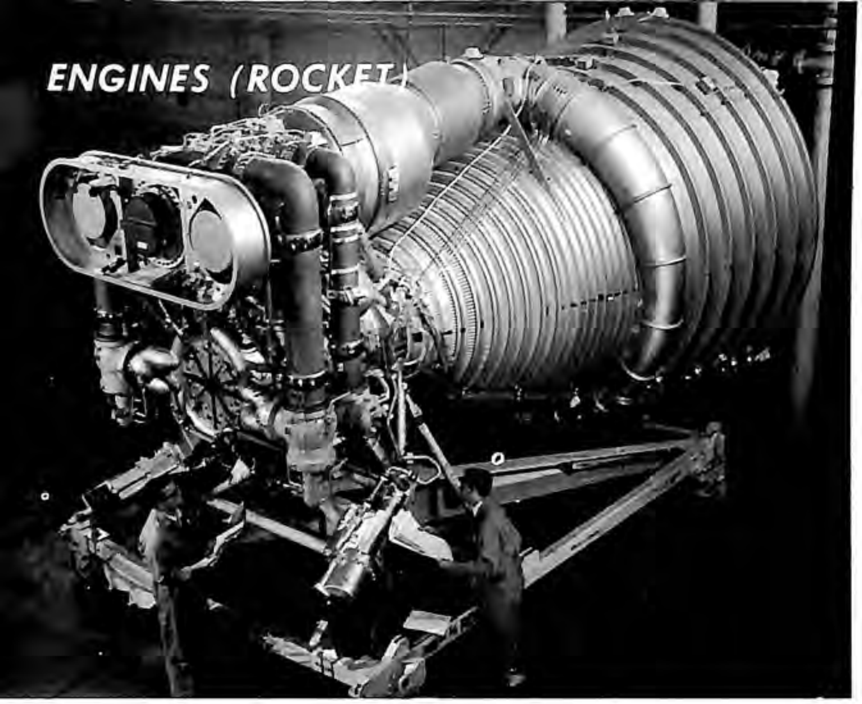
One of the major engines in NASA's manned space flight program is the J-2, which burns liquid hydrogen fuel with a liquid oxygen oxidizer and is the largest hydrogen-burning engine to reach test status (in photo, J-2 production line at Rocketdyne's Canoga Park, California, plant). The regeneratively-cooled engine plays an important role in the nation's two 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 five as the second stage and in the S-IVB as the third stage, which will send Apollo astronauts into a lunar trajectory. J-2 is being developed under the technical direction of NASA's Marshall Space Flight Center.

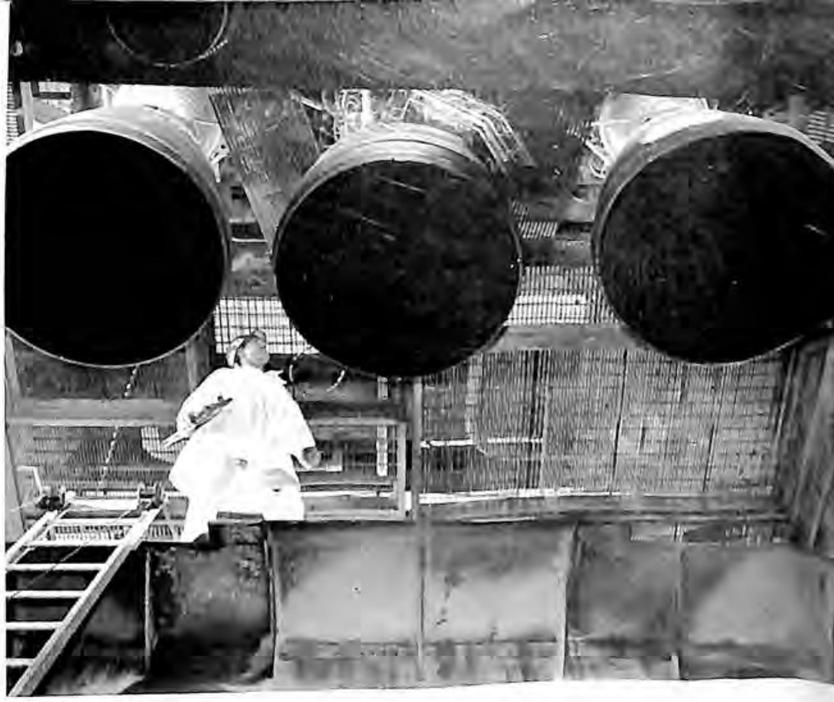
Specifications

Maximum envelope length 116 inches; maximum envelope diameter 80 1/2 inches at nozzle exit.

Performance

Thrust 200,000 pounds.





F-1 ENGINE

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

The primary engine in the U.S. manned space flight program, the F-1 is the most powerful liquid-fueled engine in the U.S. inventory. Being developed under the technical direction of NASA's Marshall Space Flight Center, it is regeneratively-cooled and it burns a combination of RP-1 fuel and liquid oxygen oxidizer. A cluster of five F-1's, with a total thrust of 7,500,000 pounds, makes up the propulsion system of the S-IC, basic stage of the huge Saturn V launch vehicle which will send Apollo astronauts to the moon.

Specifications

Maximum envelope length 18 feet; maximum envelope diameter 12 feet at nozzle exit.

Performance

Thrust 1,500,000 pounds.

ATLAS MA-5 SYSTEM

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

The MA-5 system is the propulsion package for the SLV-3 launch vehicle. Generating 360,000 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 intercontinental ballistic missile propulsion system includes 2 small vernier or stabilizing engines mounted on the missile frame to prevent roll.

Specifications

Length (booster package including 2 engines) 136 inches, sustainer 94.7 inches; diameter booster package 168 inches; fuel RP-1: oxidizer liquid oxygen.

Performance

Thrust 389,000 pounds total, including: boosters 330,000, sustainer 57,000, 2 verniers 1,000 each; cooling regenerative.

THOR MB-3

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

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 prevent roll. More space vehicles have been boosted by Thor than by any other propulsion system.

Specifications

Length 141 inches; diameter 66.7 inches; fuel RP-1; oxidizer liquid oxygen.

Performance

Thrust 170,000 pounds.

AR2-3

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

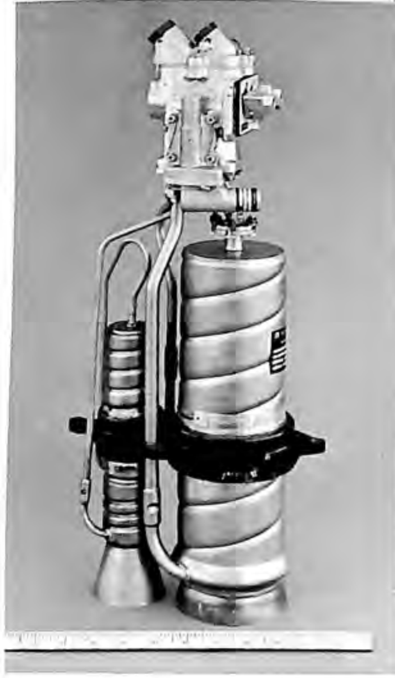
A supplemental propulsion unit for manned aircraft, the AR2-3 provides extra thrust for the Lockheed NF-104A Starfighter to augment its turbojet engines and enable it to attain altitudes up to 130,000 feet for aerospace training missions. The liquid-propellant rocket engines boost thrust by more than 6,000 pounds.

Specifications

Length 32 inches; diameter 15 inches; weight 235 pounds; fuel JP-4 or 5; oxidizer hydrogen peroxide.

Performance

Thrust throttlable from 50 percent to maximum of 6,600 pounds at 35,000 feet.



P4-1 DRONE ENGINE

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

The P4-1 storable liquid propellant powers Navy XKD2B and Air Force Q-12 target missiles produced by Beech Aircraft Corporation. It is a small compact system having both sustainer and booster and producing over 600 pounds of thrust to power the target missile to Mach 2 at 70,000 feet.

Specifications

Length 21 inches; diameter 6.6 inches; fuel hydyne (MAF-4); oxidizer inhibited red fuming nitric acid.

Performance

Thrust sustainer 106 pounds at 70,000 feet, booster 550 pounds at 25,000 feet.

SE-6 CONTROL THRUSTER

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

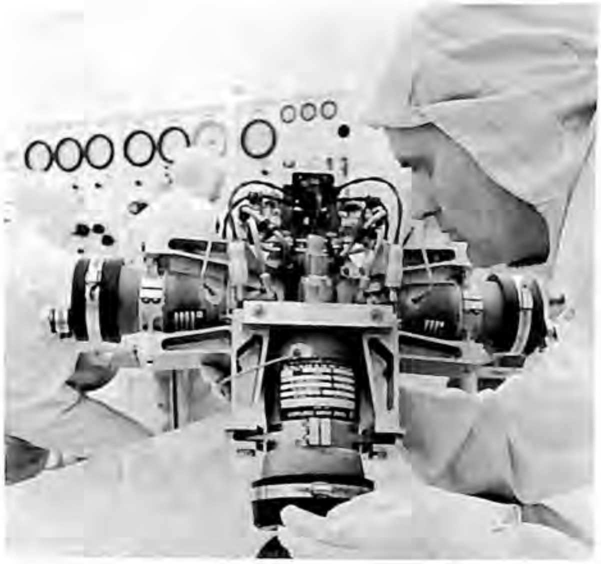
The SE-6, employed in multiple units, provides onboard propulsion for the Gemini spacecraft. It is part of the RCS (Re-entry Control System) for Gemini, used for maneuvering during re-entry phase. RCS has two eight-engine systems, one of which is redundant. It is positioned in the small end of the Gemini in front of the pilot's compartment.

Specifications

Fuel monomethylhydrazine; oxidizer nitrogen tetroxide.

Performance

Thrust 25 pounds per engine; cooling ablative.



SE-7, SE-8, SE-9

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

SE-7,-8,-9 are small liquid propellant thrusters burning a combination of monomethylhdrazine fuel and nitrogen tetroxide oxidizer. SE-7 is used for corrections of orbital attitude and maneuvering in the Gemini spacecraft; SE-8 for the attitude re-entry control system in the Apollo command module; SE-9 for attitude control of the Titan III-C transtage. The units are employed in multiples, 16 in the SE-7 system including 6 of 100 pounds thrust, 2 of 85 pounds and 8 of 25 pounds. SE-8 has two sets of six engines each, one set redundant, all engines 93 pounds thrust. SE-9 consists of two 3-engine modules plus 2 single engines, with 4 of the engines producing 45 pounds thrust and the other four 25 pounds. In photo, a 3-engine module of the SE-9 system.

RL10 ROCKET ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

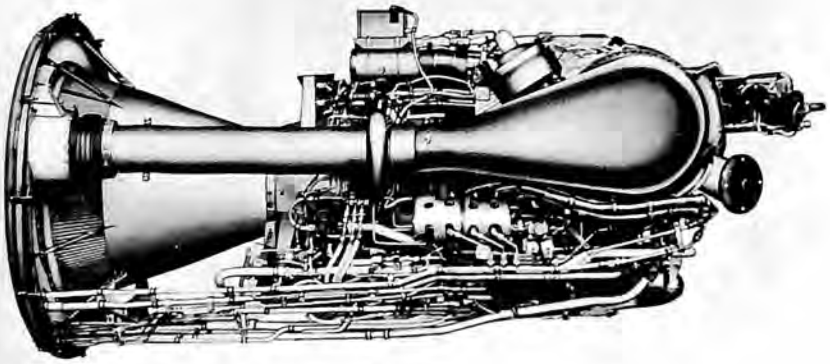
The RL10A-3-1 was the world's first operational liquid hydrogen rocket engine. It was developed for NASA as powerplant for the Centaur and for the Douglas S-IV stage of Saturn I. The latter, a developmental stage leading to larger hydrogen-powered space vehicles, was phased out after 6 successful flights. Centaur was designed to carry unmanned scientific payloads to the moon, Mars and other planets. An advanced model of the RL10, the 10A-3-3, is under development for future Centaur application on Saturn IB and Atlas boosters.

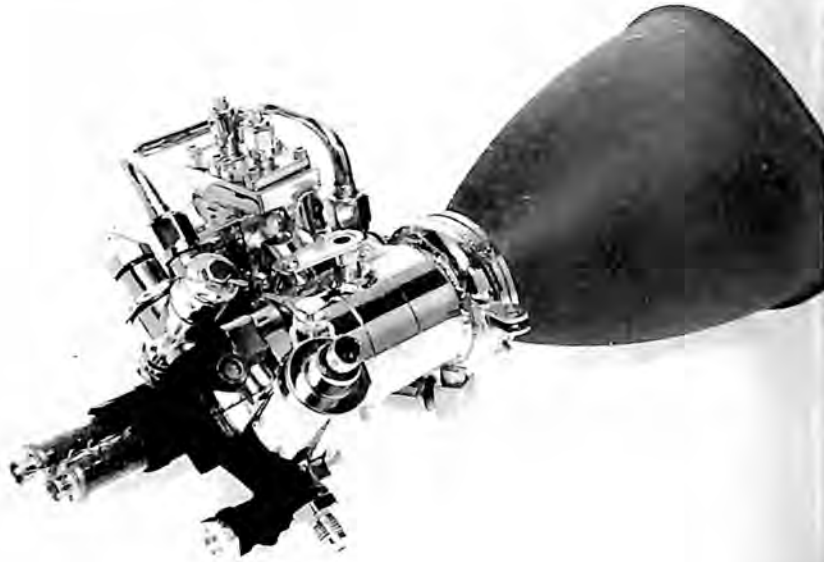
Specifications

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 44 seconds.





YLR99-RM-1 TURBOROCKET

Prime Contractor: Thiokol Chemical Corporation

Remarks

The YLR99-RM-1 throttlable turborocket engine was developed by Thiokol Reaction Motors Division to provide propulsion for the X-15 hypersonic manned research aircraft. It fulfills the manned safety requirements of MIL-E-5149 and incorporates extensive malfunction self-monitoring features. The engine operates on liquid oxygen and anhydrous ammonia 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.

Specifications

Length 82.03 inches; diameter 39.31 inches; weight 910.0 pounds; operational life between overhauls one hour.

Performance

Thrust continuously throttlable from 15,000 to 57,000 pounds (altitude); rated duration 180 seconds at full thrust; total propellant flowrate 212.5 pounds per second.

TD-339 SURVEYOR VERNIER ENGINE

Prime Contractor: Thiokol Chemical Corporation

Remarks

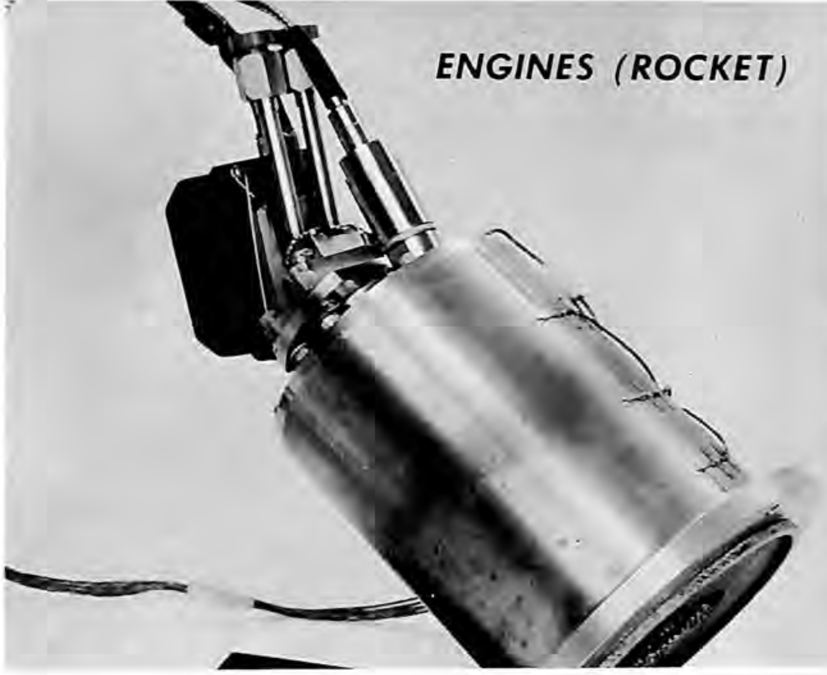
Developed for the Surveyor soft lunar landing vehicle, TD-339 vernier engines will provide power for mid-course trajectory correction, final soft landing velocity and stability control. The TD-339 is a small regeneratively-cooled liquid system operating on pressure-fed nitrogen tetroxide monomethylhydrazine propellants. Basic elements of the engine are the thrust chamber and injector assembly, dual propellant throttle 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 respective engines (3 per spacecraft).

Specifications

Weight 5.9 pounds.

Performance

Thrust continuously throttlable for 30 to 104 pounds; 3 restarts capability.



THIOKOL SOLID ROCKETS

Prime Contractor: Thiokol Chemical Corporation

Remarks

Thiokol manufactures a varied line of solid rocket motors over a wide thrust range. Its largest motors are two varieties of 156-inch diameter, the 156-1C-1 and the 156-2C-1. The former has a maximum envelope length of 939 inches and a loaded weight of 777,000 pounds. The latter has a maximum envelope length of 1,206.1 inches. Both motors burn aluminum-hydrocarbon fuel and ammonium perchlorate oxidizer. Thrust values are 1,400,000 pounds for the 1C and 3,000,000 pounds for the 2C. Other Thiokol motors include the XM100 booster for the Sergeant missile (length 195.3 inches, diameter 32 inches, weight 6,910 pounds); the M16E1 Matador booster; the 34,000 pound thrust Recruit rocket (length 102.22 inches, diameter 9 inches, weight 352 pounds); the M30 Nike-Hercules sustainer (length 174 inches, diameter 28.44 inches, weight 2,660 pounds); the 64,000 pound thrust Caster rocket (length 244.12 inches, diameter 40 inches, weight 8,746 pounds); the TX-33-36 Little Joe rocket, which produces 53,850 pounds thrust (length 237.44 inches, diameter 31 inches, weight 8,796 pounds); the 200,000 pound thrust M-55 (TU-122) Minuteman Stage 1/Wing 1 motor and the M-55E1 Wing 2 motor of unannounced thrust; the XM-15 Bemare booster; the TX-135 Nike Zeus booster (length 203 inches, diameter 43.12 inches); the XM-105 Pershing first stage motor (length 78.55 inches, diameter 40 inches); the XM-106 Pershing second stage motor (length 63.28 inches, diameter 40 inches); and motors for various other missiles.

C-1 MULTIPURPOSE ENGINE

Prime Contractor: TRW Systems

Remarks

Under contract to NASA, TRW Systems is engaged in the competitive Phase I development of the multipurpose liquid fuel C-1 engine. The engine features the same basic single element concentric injector successfully used, in the MIRA 150A. Dribble volumes have been reduced to give short reproducible pulses and a minimum impulse bit of 2 pound-seconds. Ablatively cooled, the C-1 burns nitrogen tetroxide and monomethylhydrazine.

MIRA 180 SURVEYOR ENGINE

Prime Contractor: TRW Systems

Remarks

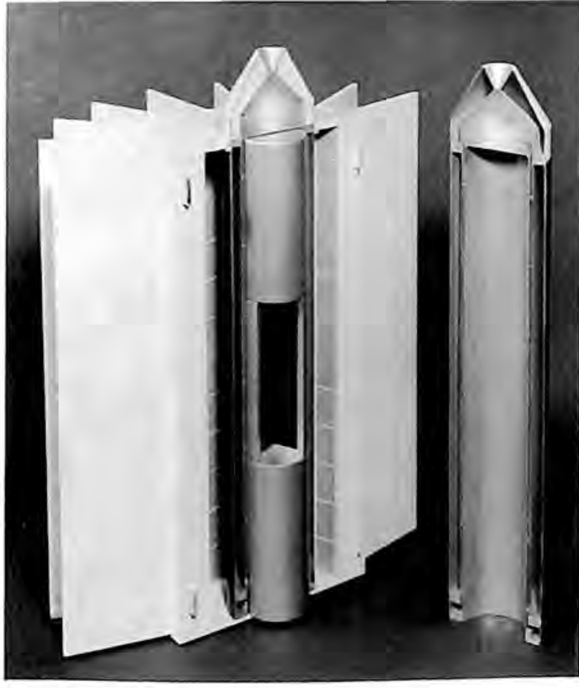
The MIRA 180 engine is the alternate landing and midcourse guidance engine for the unmanned NASA Surveyor spacecraft. It will feature a vastly increased throttle range continuously variable between 20 and 180 pounds of thrust, a 9:1 ratio. The present contract calls for integration of 3 MIRA 180's into a vernier propulsion system for maneuvering and landing of the Surveyor. The MIRA engines were developed under a TRW independent research program; an engine similar to the 180 but with greater thrust is being developed for use on the Lunar Excursion Module of the Apollo.

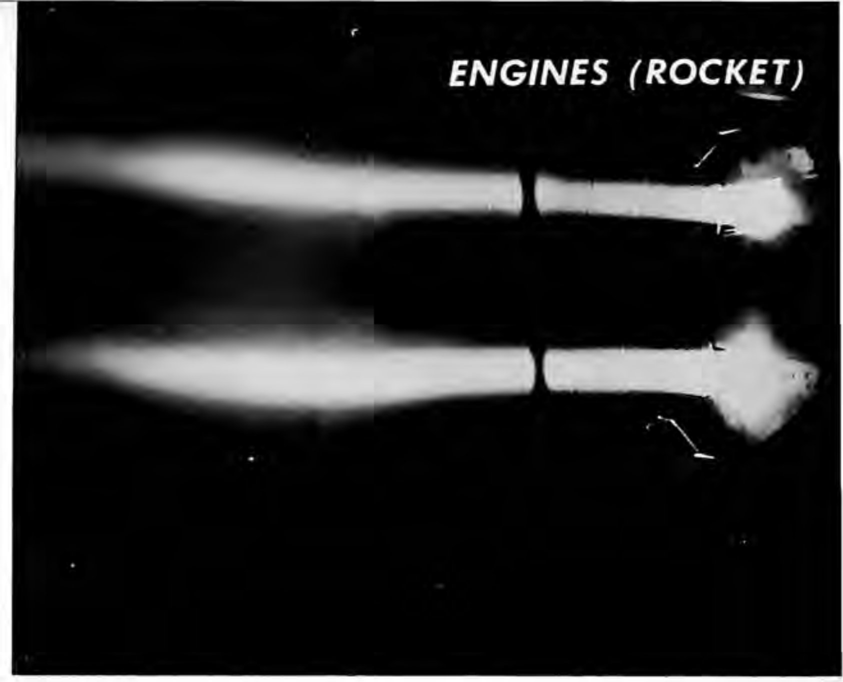
LUNAR EXCURSION MODULE DESCENT ENGINE

Prime Contractor: TRW Systems

Remarks

TRW Systems is developing a LEM descent engine under a parallel program for Grumman Aircraft Engineering Corporation. The TRW engine concept uses a variable area, coaxial injector and cavitating venturi flow control valves to achieve a highly reliable and stable engine smoothly variable over a range of 10 to 1 (the LEM descent engine is designed to land the module and its two astronauts on the surface of the moon in the Apollo program).





SNAPOODLE RADIOISOTOPE THRUSTER

Prime Contractor: TRW Systems

Remarks

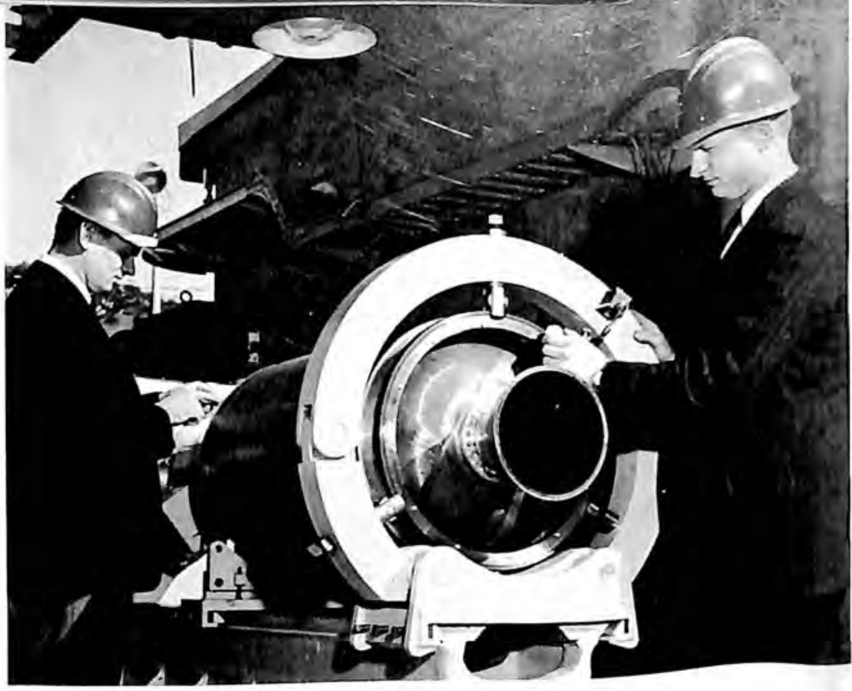
A radioisotope-fueled space engine capable of generating simultaneously thrust and usable electrical power, the Snapoodle is a development of TRW Systems in cooperation with the Air Force. It is a self-contained unit using heat from a radioisotope source for acceleration of gaseous hydrogen to create thrust and to generate electricity through a thermoelectric converter. Snapoodle's primary propulsive element is the Poodle thruster consisting mainly of a pair of concentric cylinders with an overall diameter of 4 inches, length 17 inches and weighing about 30 pounds. It generates about a quarter of a pound of thrust—suitable for sustaining a spacecraft in a low altitude orbit, transferring the vehicle from one orbit to another, or for providing maneuverability. The radioisotope is polonium-210, sealed within the core cylinder of the thruster. As it decays, fast-moving alpha particles are stopped by the metal container which becomes heated to temperatures in excess of 2,500 degrees Fahrenheit. Thermal energy normally radiated into space has been harnessed by means of a thermoelectric converter (which converts heat directly into electricity). Some of the radiated heat is thus converted into usable electrical power. The Snapoodle can deliver 70 watts of electric power while thrusting and a range of 200 to 250 watts with no propellant flow. Record heats approaching 3,000 degrees Fahrenheit have been attained. In photo Snapoodle (left) and Poodle (right).

TRW ION ENGINE

Prime Contractor: TRW Systems

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.



F720L8.0K ADVANCED UPPER-STAGE LIQUID ENGINE

Prime Contractor: United Technology Center

Remarks

The high performance, liquid fuel F720L8.0K was developed for advanced upper-stage applications requiring space life of about 30 days. Capable of multiple restart, it features a silica phenolic combustion chamber and columbium alloy nozzle extension.

Specifications

Length 84 inches; weight 180 pounds; nozzle expansion ratio 40:1; propellant nitrogen tetroxide and a 50/50 mixture of hydrazine and unsymmetrical dimethylhydrazine; duty cycle about 500 seconds.

Performance

Thrust about 8,000 pounds.

FW-4S UPPER-STAGE SOLID-PROPELLANT ROCKET

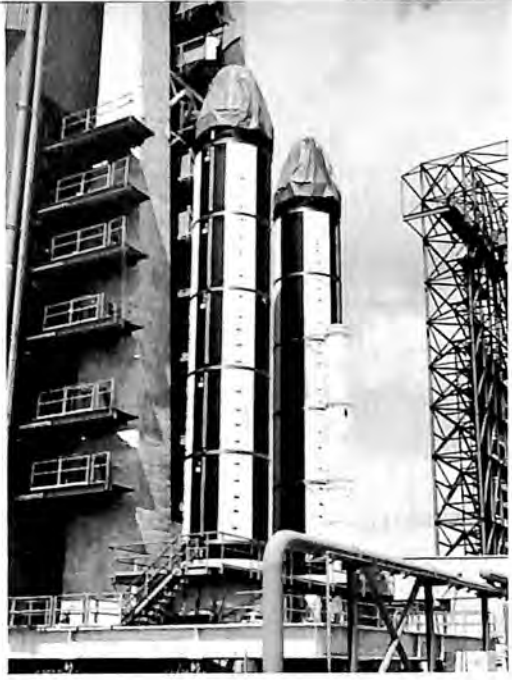
Prime Contractor: United Technology Center

Remarks

The FW-4S was developed under contract to Air Force Space Systems Division as an improved fourth-stage motor for the Scout vehicle and for other high-performance, upper-stage applications including Thor/Delta. Motor spins at 200 revolutions per minute during firing. Case is of lightweight fiberglass-epoxy.

Performance

Thrust about 6,000 pounds.



UA 1205 SEGMENTED SOLID PROPELLANT ROCKET

Prime Contractor: United Technology Center

Remarks

Two 1205's make up the booster stage of the Air Force's Titan III-C. The first large segmented solid-propellant motors to demonstrate successful flight performance, they are attached on opposite sides of the vehicle's liquid-fuel core. Each motor consists of 5 center segments, 2 end closures, nose fairing, nozzle, liquid injection TVC and thrust termination and destruct system.

Specifications

Height 86 feet; diameter 120 inches; weight 250 tons; burn time about 115 seconds.

Performance

Peak thrust about 1.2 million pounds.

R1820-84 ENGINE (C9)

Prime Contractor: Curtiss-Wright Corporation

Remarks

A 9-cylinder single row radial reciprocating engine, the C9 is manufactured for use in military H-34 series helicopters.

Specifications

Dry weight 1,427 pounds; length 52.0 inches; length 55.74 inches; fuel grade 115/145.

Performance

Take-off power at sea level 1,525 brake horsepower.

R3350-32W ENGINE (TC18)

Prime Contractor: Curtiss-Wright Corporation

Remarks

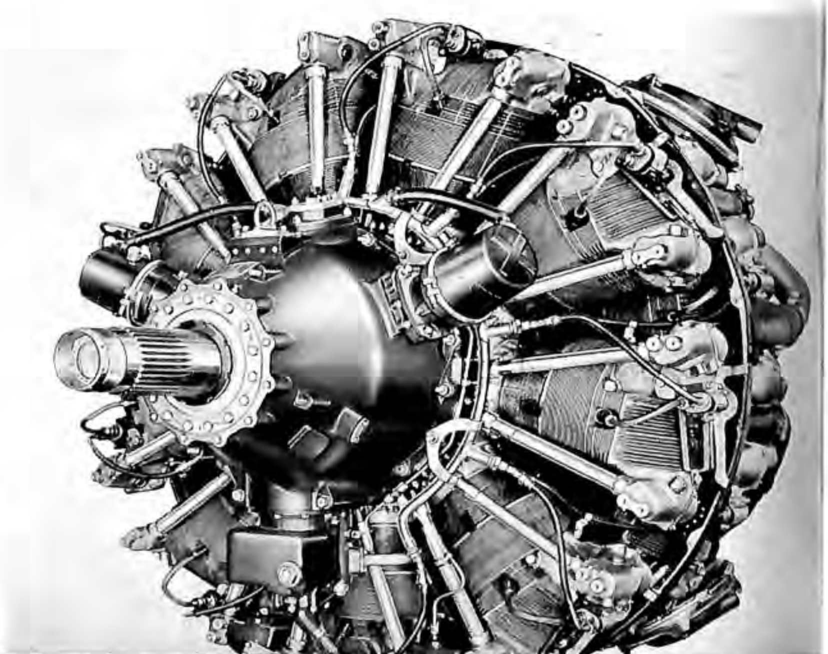
The TC18 is an 18-cylinder double row radial turbo compound reciprocating engine used by the military services in P-2 and P-5 series aircraft.

Specifications

Dry weight 3,560 pounds; length 91.8 inches; diameter 56.59 inches; fuel grade 115/145.

Performance

Take off power at sea level 3,700 brake horsepower.

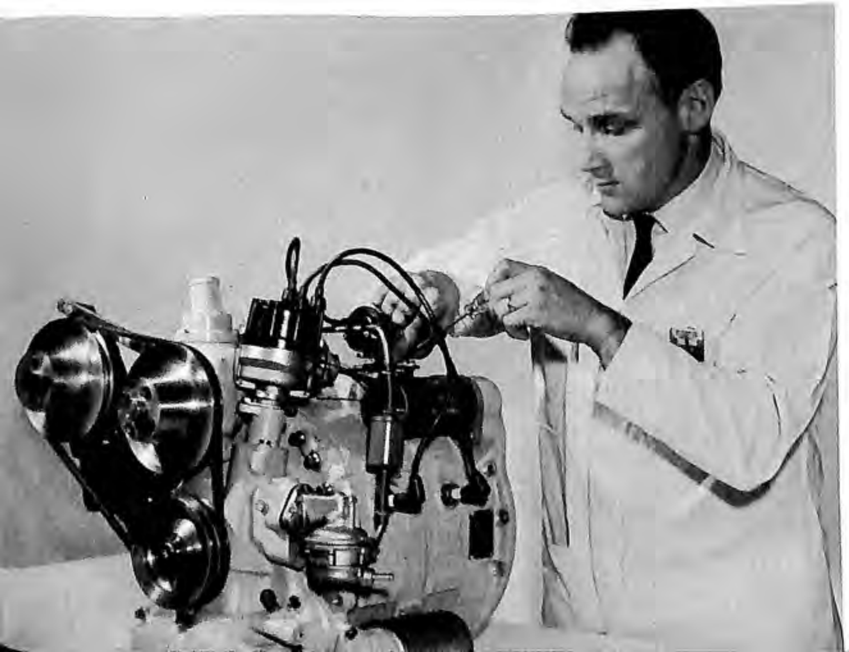


RC2-60 ROTATING COMBUSTION ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

This is one of the models developed by Curtiss-Wright for automotive, aircraft, marine and industrial applications. Basic operation of the RC2-60 consists of 2 moving parts, the rotor and crankshaft. There are no reciprocating parts. The intake, compression, ignition, expansion and exhaust sequence is practically continuous because this engine turns with the rotor. Fuel enters through an intake port on one side of the chamber and exhausts through a port on the opposite side of the chamber eliminating the use of valves, springs, tappets and camshafts. Other models of the rotating combustion engine, including air-cooled versions, are presently under development for light plane applications.



R985 MILITARY-COMMERCIAL RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

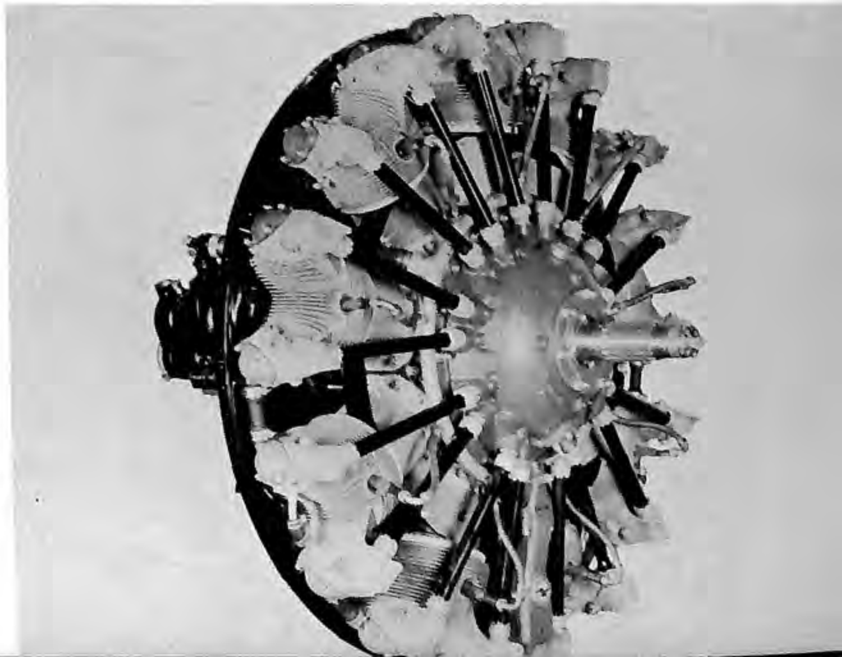
Like its famous predecessor, the Wasp, R985 Wasp Junior is a 9-cylinder radial air-cooled piston engine no longer in production but still in wide use. It powers the Beech 18, the deHavilland Beaver, the Sikorsky S-51 helicopter and other aircraft. A total of 39,037 R985's were built.

Specifications

(Model A): Length 41.06 inches; diameter 45.75 inches; compression ratio 5:1; dry weight 565 pounds. (Model B5): Length 42.43 inches; diameter 46.10 inches; compression ratio 6:1; dry weight 682 pounds.

Performance

Rating 300 brake horsepower (Model A); 450 brake horsepower (Model B5).



R1830 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

First installed in the famous Pan American Airways' Martin China Clipper, in the early 1930's, 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-3's. This engine, also the powerplant for the Lockheed Lodestar and other aircraft, was manufactured in greater numbers than any other Pratt & Whitney model between 1932 and 1947.

Specifications

Length 61.16 inches; diameter 48.19 inches; bore 5.5 inches; stroke 5.5 inches; displacement 1,830 cubic inches; compression ration 6.7:1; dry weight 1,467 pounds.

Performance

Rating 1,200 brake horsepower.

R1340 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

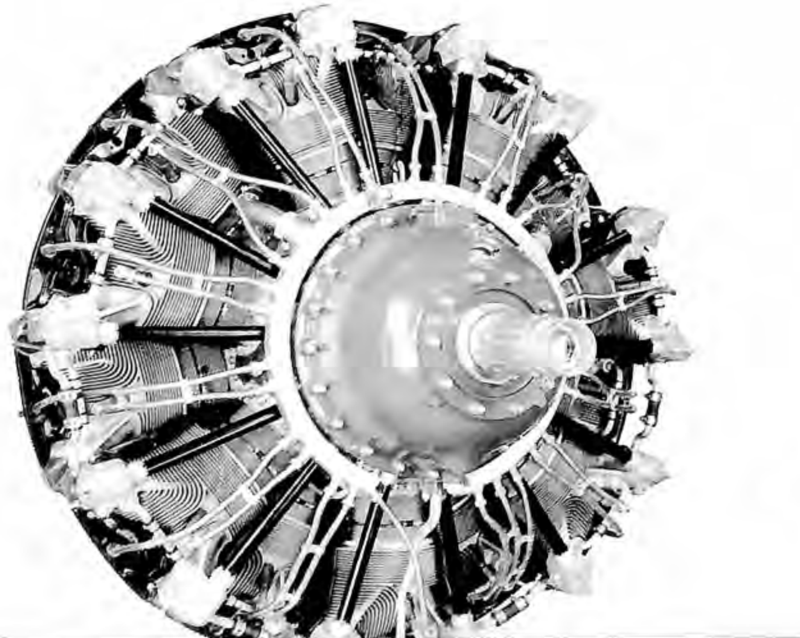
Still in use, the R1340 Wasp was produced in numerous configurations for 35 years—longer than any other Pratt & Whitney engine. It powered many military and commercial airplanes in aviation's pioneering days. Among the planes still flying with R1340 engines are the deHavilland Otter, the Grumman Mallard and various helicopters.

Specifications (Model A)

Length 42.63 inches; diameter 51.44; dry weight 745 pounds.

Performance

Rating 410 brake horsepower.



R2000 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

Out of production but still in use, the R2000 Twin Wasp is a 14-cylinder radial air-cooled piston engine. It powered the Douglas C-54 Skymaster, workhorse of World War II, the Berlin Airlift and the trans-Pacific airlift supporting the Korean campaign. Presently in Viet Nam, it powers the Army's CX-2B or deHavilland DHC-4 Caribou.

Specifications (Model 2SD13-G)

Length 59.66 inches; diameter 49.10 inches; bore 5.75 inches; stroke 5.5 inches; displacement 2,004 cubic inches; compression ratio 6.5:1; dry weight 1,605 pounds.

Performance

Rating 1,450 brake horsepower at 2,700 revolutions per minute.

R2180 RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

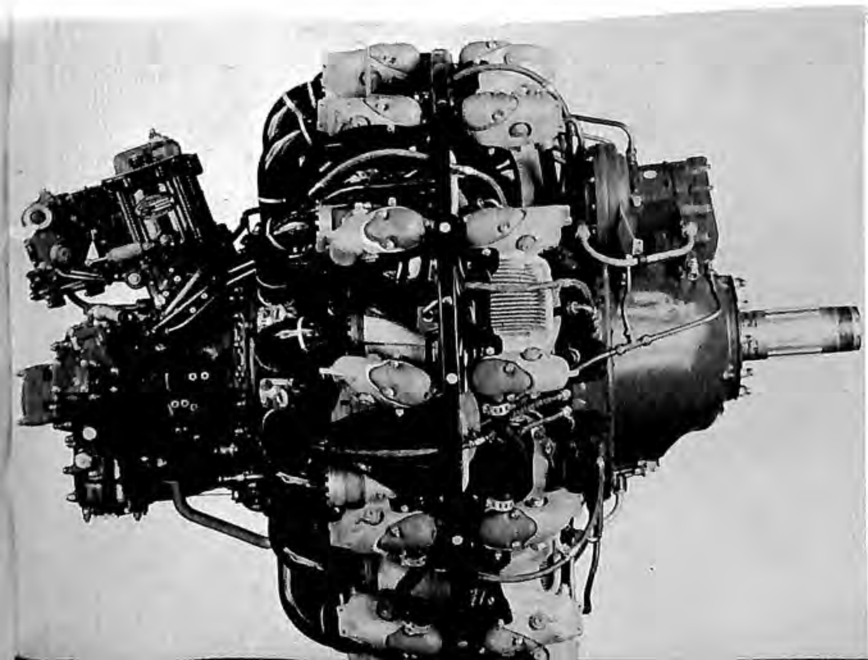
The R2180 Twin Wasp, 14-cylinder radial air-cooled piston engine was developed after World War II but had a short production life. It is used in the SAAB Scandia transport.

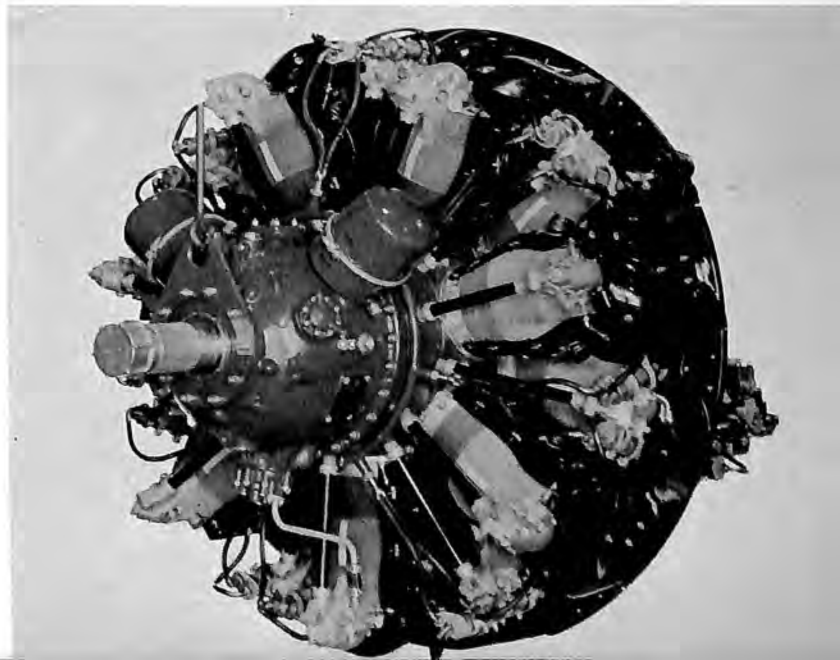
Specifications

Length 76.20 inches; diameter 54 inches; bore 5.75 inches; stroke 6 inches; displacement 2,181 cubic inches; compression ratio 6.7:1; dry weight 1,870 pounds.

Performance

Rating 1,800 brake horsepower.





R2800 MILITARY-COMMERCIAL RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

Still in military and commercial service, the R2800 Double Wasp is an 18-cylinder radial air-cooled piston engine which powered many military aircraft in World War II. Between 1939 and 1960, 125,443 of these engines were manufactured.

Specifications (CB16)

Length 78.40 inches; diameter 52.80 inches; bore 5.75 inches; stroke 6 inches; displacement 2,804 cubic inches; compression ratio 6.76:1; dry weight 2,350 pounds.

Performance

Rating 2,500 brake horsepower.

R4360 MILITARY-COMMERCIAL RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

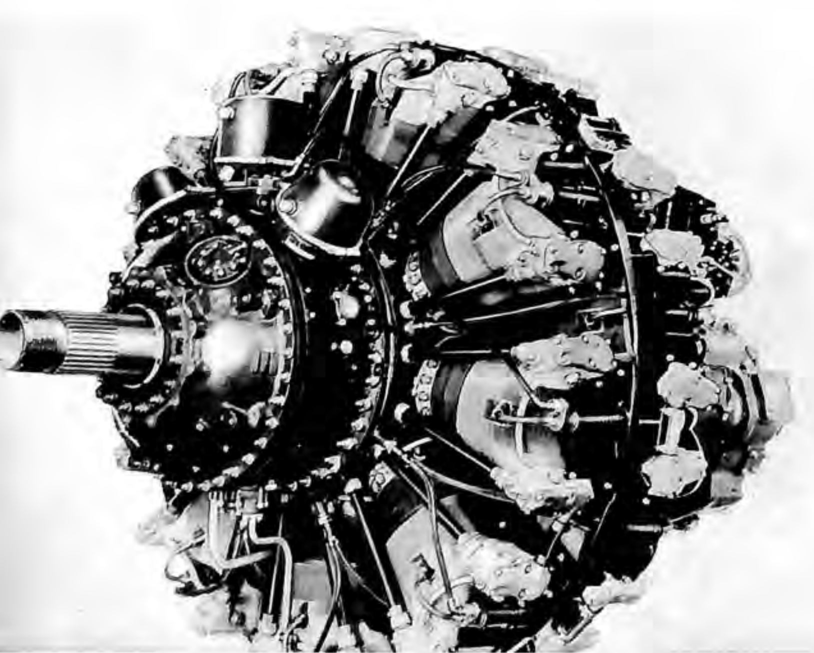
A 28-cylinder radial air-cooled piston engine, the R4360 was the most powerful engine of its type produced. It was developed during World War II and still powers the Boeing C-97, Fairchild C-119, Douglas C-124 Globemaster transports and the Boeing 377 Stratoliner.

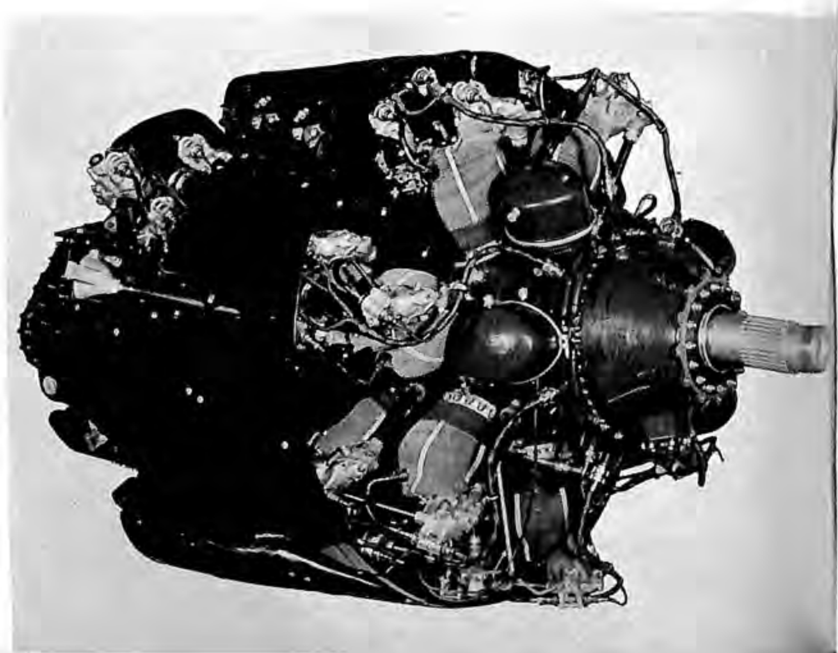
Specifications (Model TSB3-6)

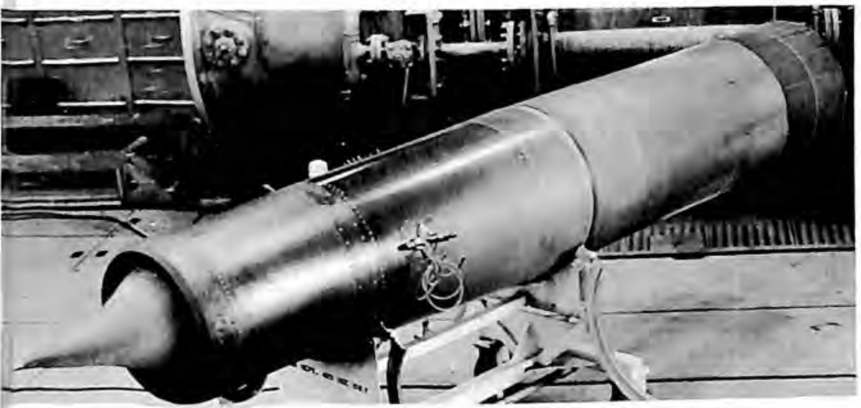
Length 96.50 inches; diameter 54 inches; bore 5.75 inches; stroke 6 inches; displacement 4,363 cubic inches; compression ratio 6.7:1; dry weight 3,482 pounds.

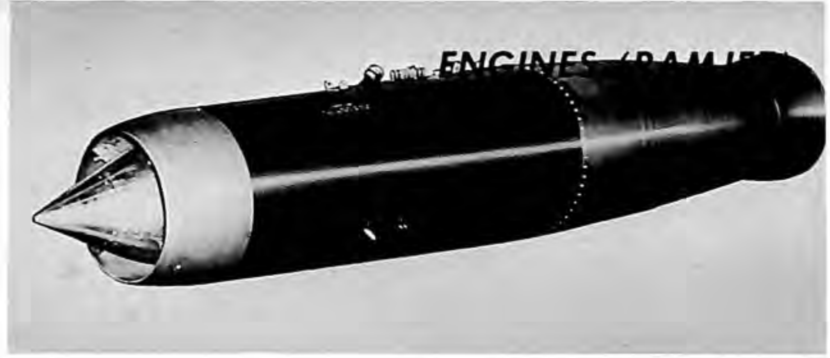
Performance

Rating 3,500 brake horsepower (with water injection).









RJ-43-MA-3 MILITARY RAMJET

Prime Contractor: The Marquardt Corporation

Remarks

Developed for the Air Force, the RJ-43-MA-3 engine is a complete nacelle-type supersonic ramjet engine with a conical shock inlet. Cruise propulsion for the currently operational Boeing Bomarc A interceptor missile is provided by 2 of these ramjet engines.

Specifications

Length 173.4 inches; diameter 28.1 inches; conical spike; external compression ram inlet; weight 503 pounds; fuel 80/87.

Performance

Cruise thrust 1,650 pounds net jet; maximum thrust 7,500 pounds net jet.

RJ-43-MA-11 MILITARY RAMJET

Prime Contractor: The Marquardt Corporation

Remarks

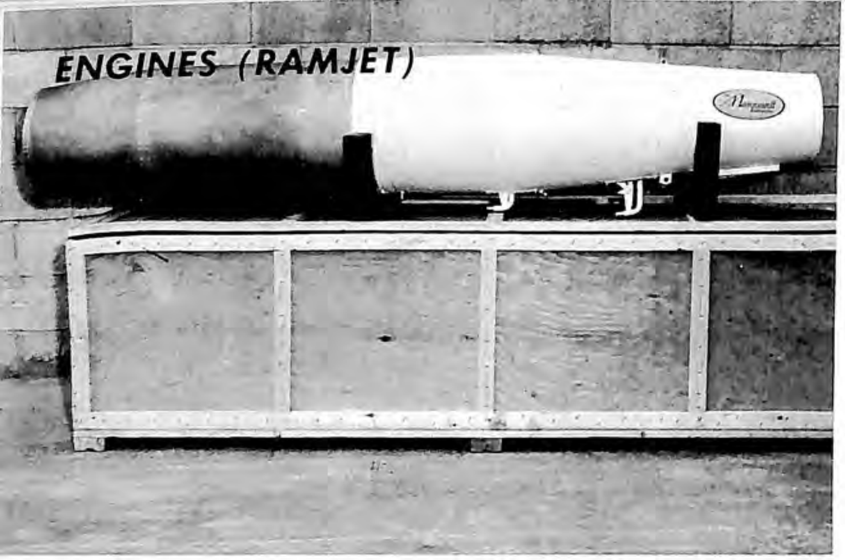
The RJ-43-MA-11, produced for the Air Force, is a complete nacelle-type supersonic ramjet engine with a high compression inlet spike. This engine (2 units) provides the cruise propulsion source for the Boeing Bomarc B interceptor missile.

Specifications

Length 171.8 inches; diameter 28.1 inches; semi-isentropic spike, external compression ram inlet; weight 525 pounds; fuel JP-4.

Performance

Cruise thrust 1,685 pounds net jet; maximum thrust 13,300 pounds.



MA74-ZAB RAMJET

Prime Contractor: The Marquardt Corporation

Remarks

Developed for Army use, the MA74-ZAB is a nacelle-type subsonic and supersonic ramjet engine with normal shock inlet. It is the cruise propulsion source for the North American Redhead/Roadrunner target missile system for low altitude application.

Specifications

Length 90.7 inches; diameter 16.5 inches; weight 110 pounds; fuel JP-4; convergent sonic exit.

Performance

Thrust 1,790 pounds net jet.

MA150-XAA RAMJET

Prime Contractor: The Marquardt Corporation

Remarks

The MA150-XAA is a nacelle-type subsonic and supersonic ramjet engine with normal shock inlet. It provides the cruise propulsion for the Army's North American Advanced Redhead/Roadrunner target missile system for high and low altitude application.

Specifications

Length 104.5 inches; diameter 19.0 inches; weight 165 pounds; fuel JP-4; convergent sonic exit.

Performance

Thrust 2,300 pounds net jet at low altitude; 575 pounds net jet at high altitude.

T53 TURBOSHAFT GAS TURBINE ENGINE

Prime Contractor: Lycoming Division, Avco Corporation

Remarks

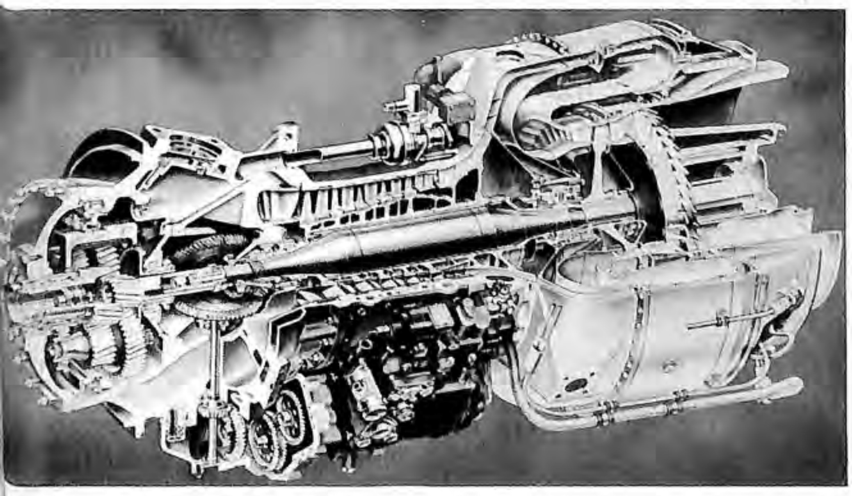
With over 1,500,000 hours of flight experience under all environmental conditions, accumulating more than 11,000 hours monthly in Vietnam alone, the T53 turboshaft engine is the most experienced in its class in the world. Configurations of this engine power the Army's versatile Bell UH-1 "Huey" tactical helicopter and the Air Force's Kaman HH-43B "Huskie" rescue helicopter, as well as the Canadair CL-84 tilt-wing V/STOL aircraft under development. All T53's are designed under a modular construction concept which facilitates rapid simple field maintenance.

Specifications

Length 48 inches; diameter 23 inches; weight 496 pounds; compressor stages 5 axial, 1 centrifugal, pressure ratio 6:1; turbine stages 1, axial free turbine combustor.

Performance

Rating 1,100 shaft horsepower; specific fuel consumption .68 pounds per horsepower per hour.



T53 TURBOPROP GAS TURBINE ENGINE

Prime Contractor: Lycoming Division, Avco Corporation

Remarks

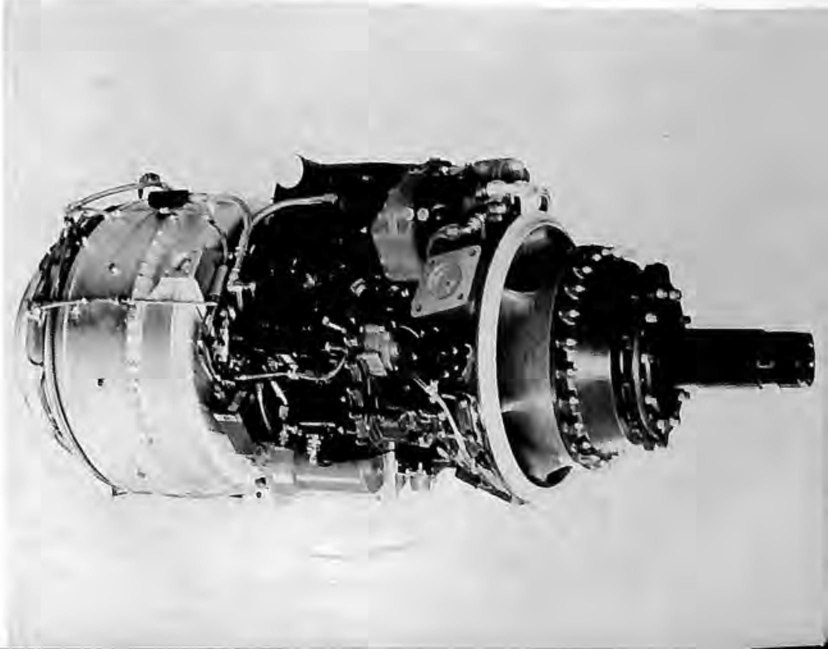
The latest version of the turboprop T53, designated the L-7, powers the Army's twin engine Grumman OV-1 "Mohawk" high speed observation aircraft which has a capability for short field operation. Growth versions of the engine are in advanced development.

Specifications

Length 59 inches; diameter 23 inches; weight 555 pounds; compressor stages 5 axial, 1 centrifugal, pressure ratio 6:1; turbine stages 1, axial free turbine compressor. (The advanced version has a 2-stage gas producer and a 2-stage power turbine.)

Performance

Rating 1,100 shaft horsepower; specific fuel consumption .67 pounds per horsepower per hour.



T55 TURBOSHAFT GAS TURBINE ENGINE

Prime Contractor: Lycoming Division, Avco Corporation

Remarks

The same design configuration philosophy as the proven T53 was maintained in the T55, the higher powered of Lycoming's 2 gas turbine engine families. Twin T55's power the Army's Boeing-Vertol CH-47A "Chinook" medium transport helicopter and the Curtiss-Wright X-19 tri-service VTOL aircraft. The L-7 version provides the highest power-to-weight ratio in its class. Current development will increase output of the basic engine to approximately 3,400 shaft horsepower. Another advanced T55 development is the design of a 6:1 high bypass ration turbofan in the 5,200-pound-thrust class for subsonic long range mission applications.

Specifications

Length 44 inches; diameter 24 1/4 inches; weight 580 pounds; compressor stages 7 axial, 1 centrifugal, pressure ratio 6:1; turbine stages 2, axial free turbine combustor.

Performance

Rating 2,650 shaft horsepower; specific fuel consumption .61 pounds per horsepower per hour.

T55 TURBOPROP GAS TURBINE ENGINE

Prime Contractor: Lycoming Division, Avco Corporation

Remarks

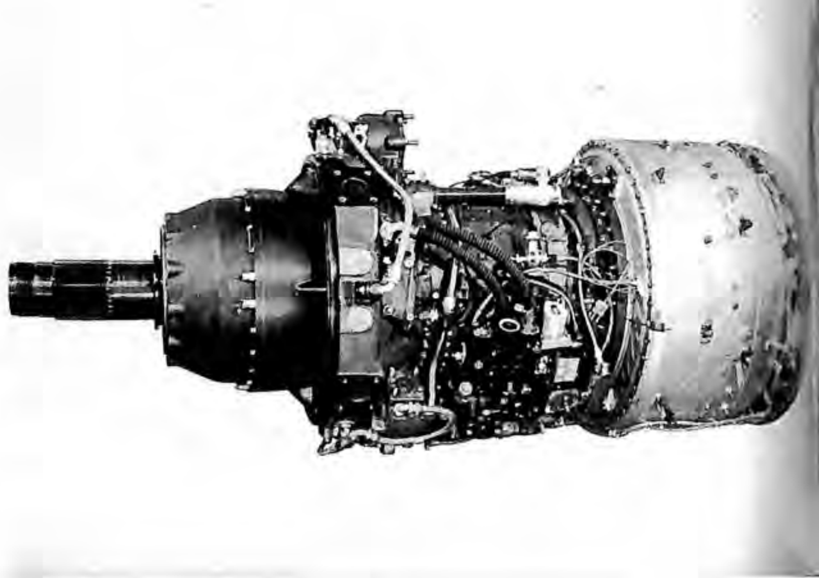
Among the turboprop T55-powered aircraft is the North American YAT-28E, now being evaluated by the Navy for trainer missions. Advanced-stage development will provide this engine with output in the 3,400 shaft horsepower class.

Specifications

Length 62 inches; diameter 24 1/4 inches; weight 795 pounds; compressor stages 7 axial, 1 centrifugal, pressure ratio 6:1; turbine stages 2, axial free turbine combustor.

Performance

Rating 2,445 shaft horsepower; specific fuel consumption .62 pounds per horsepower per hour.



T50 MILITARY TURBOSHAFT

Prime Contractor: The Boeing Company

Remarks

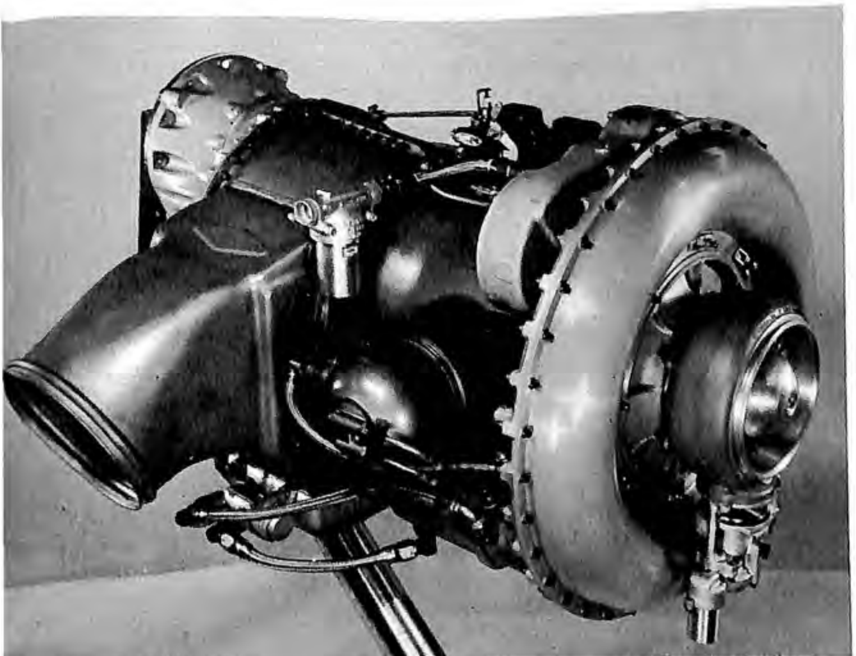
Configurations of the T50 military turboshaft engine power the Navy/Gyrodyne QH-50 series drone anti-submarine helicopters.

Specifications (T50-BO-10)

Length 37.5 inches; diameter 22.5 inches; weight 244 pounds; compression ratio 5.74:1; axial flow 2-shaft engine; compressor 1 axial, 1 centrifugal; turbine stages 2, 1 gas producer, 1 power output

Performance

Rating 330 shaft horsepower at 90 degrees Fahrenheit sea level (-10 model); 300 shaft horsepower at 60 degrees Fahrenheit sea level (-8A model).



J65-W-7 ENGINE

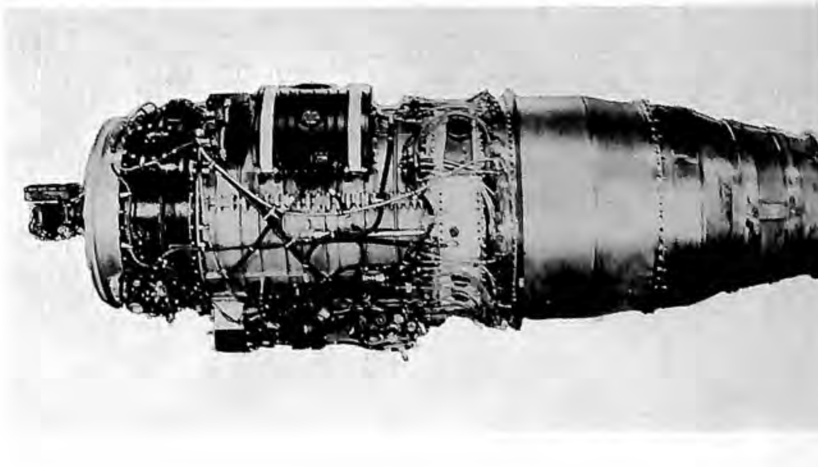
Prime Contractor: Curtiss-Wright Corporation
The J65-W-7, used by the military in the F/RF84F aircraft, is a single spool axial flow compressor type jet power plant.

Specifications

Dry weight 2,795 pounds; length 115.0 inches; diameter 37.5 inches; type fuel JP-4.

Performance

Take-off power at sea level 7,800 pounds thrust.



J65-W-18 MODEL ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

A single spool, axial flow compressor type jet power plant with afterburner, the J65-W-18 powers the F-11 series military aircraft.

Specifications

Length 181.0 inches; diameter 37.5 inches; weight approximate dry 3,485 pounds; fuel JP-4.

Performance

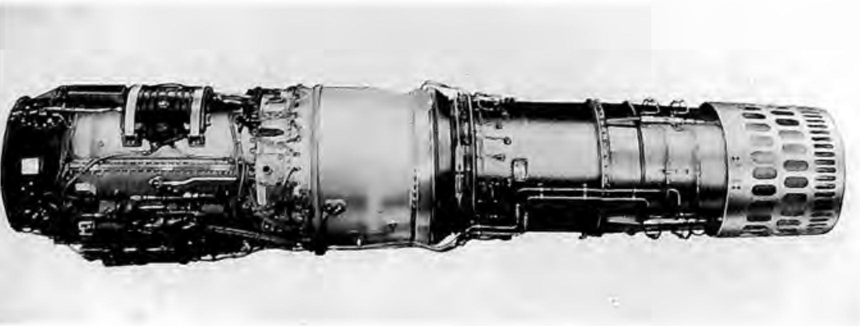
Take-off rating at sea level 10,500 pounds thrust.

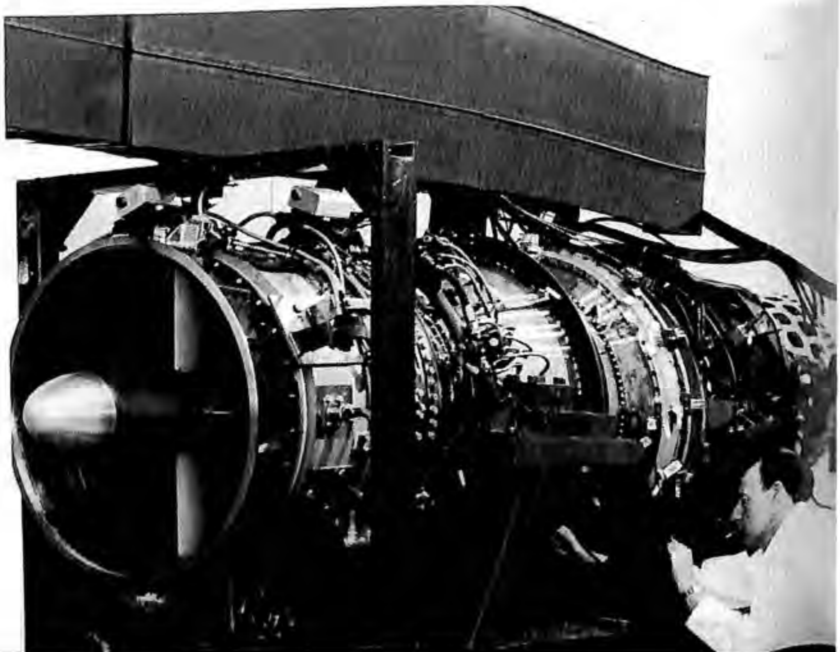
TJ60 GAS TURBINE ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

Called the "building block" for a new generation of jet engines to boost both range and payload of subsonic and supersonic aircraft, the TJ60 is a new experimental gas turbine engine under development for the USAF's Aero Propulsion Laboratory. The basic power plant can be adapted and used as a turbojet or turbofan engine for cruise and lift applications. Features of the new TJ60 concept to increase efficiency and performance are transpiration-cooled turbine blades, a new compressor, a new combustor and variable turbine stator blades.





T76 MILITARY TURBOPROP

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Division of Arizona

Remarks

The T76 is a military turboprop engine in initial production and flight testing for use on the North American OV-10A (COIN) aircraft. A commercial version designated TPE-331 is being produced for the Aero Commander-Turbo Commander, the Mitsubishi MU-2, Volpar Beech 18 modification and the Fairchild Hiller Turbo-Porter. Among the features of this engine are rapid thrust reverse; counter-rotating props for dual engine installations; landing and take-off at constant engine speeds; and immediate response to load requirements.

Specifications

Length 46 inches; width 21.10 inches; height 24.7; weight 286 pounds; compressor 2-stage centrifugal; turbine 3-stage axial.

Performance

Rating 660 shaft horsepower (T76); 605 shaft horsepower (commercial version).

YJ93 MILITARY TURBOJET

Prime Contractor: General Electric Company

Remarks

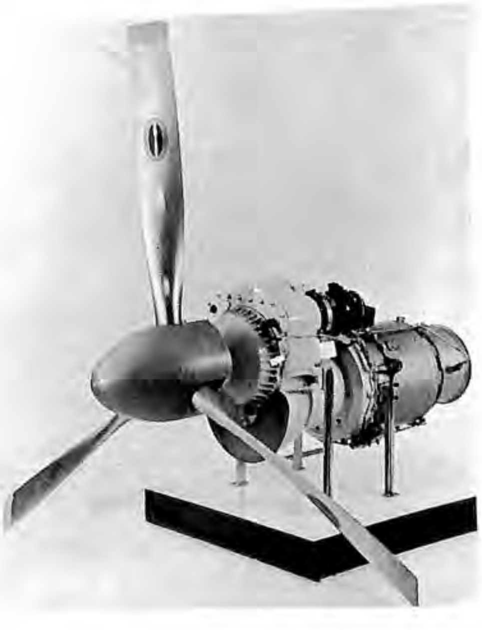
The YJ93 is a Mach 3 engine designed to power the Air Force XB-70 (North American Aviation) at a speed of 2,000 miles per hour above 70,000 feet.

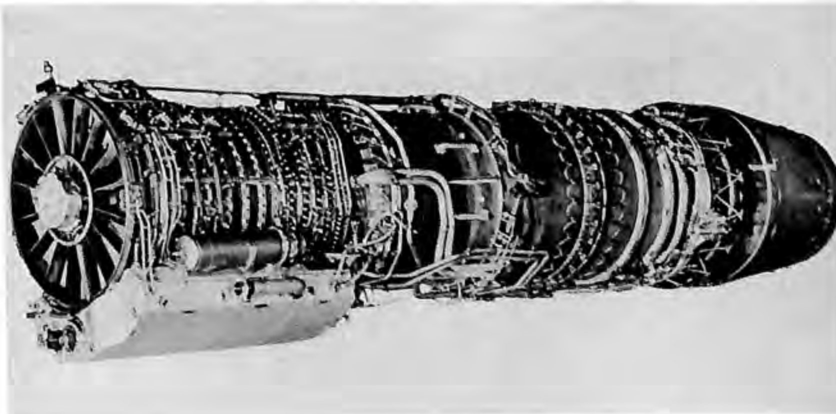
Specifications

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; speed capability sustained Mach 3.





J79 MILITARY TURBOJET

Prime Contractor: General Electric Company

Remarks

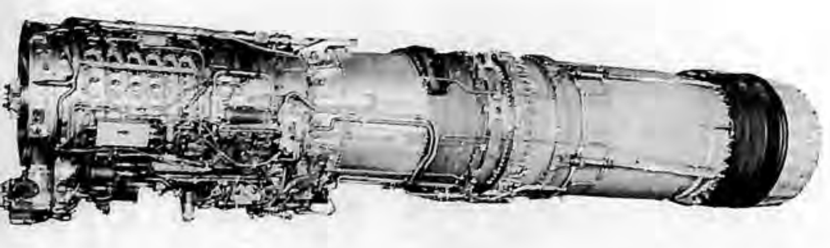
A military turbojet engine, the J79 is widely used on Air Force, Navy and NATO aircraft—the Lockheed F-104, Convair B-58, North American RA-5C and the McDonnell Phantom operational J79-8 and J79-15 operational engines.

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 TURBOJET

Prime Contractor: General Electric Company

Remarks

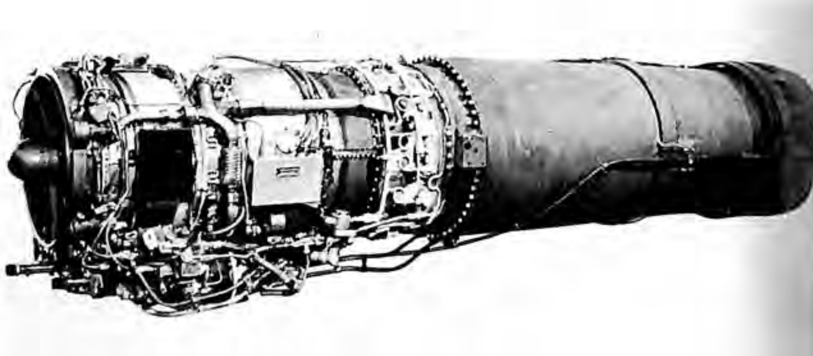
Powerplant for high performance aircraft and air breathing missiles, the J85 turbojet is available in both afterburning and non-afterburning configurations. It has the highest power-to-weight ratio of any production engine in its class in the free world. This engine provides power for Northrop's F-5 and T-38A and Fiat's G91Y. An advanced version, with 5,000 pounds of thrust, is designated J85/J1A.

Specifications (J85-13)

Length 108.9 inches; flange diameter 21 inches; weight 587 pounds; thrust to weight ratio 6.95:1; compressor stages 8; turbine stages 2.

Performance

Maximum thrust 4,080 pounds.



CF700 COMMERCIAL TURBOFAN

Prime Contractor: General Electric Company

Remarks

An aft fan version of the J85/CJ610 turbojet family, the CF700 is now being produced in volume for commercial aircraft. Applications include the Dassault Mystere 20/Fan Jet 10 passenger business jet aircraft. It is also used in the Bell lunar landing research vehicle to equalize the forces of gravity and rockets for pilot control movements.

Specifications

Length 53.6 inches; fan diameter 33.1 inches; weight 710 pounds; compressor stages 8, axial flow; turbine stages 2, axial flow.

Performance

Take-off thrust 4,200 pounds; maximum continuous thrust 4,000 pounds.

CJ610 COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

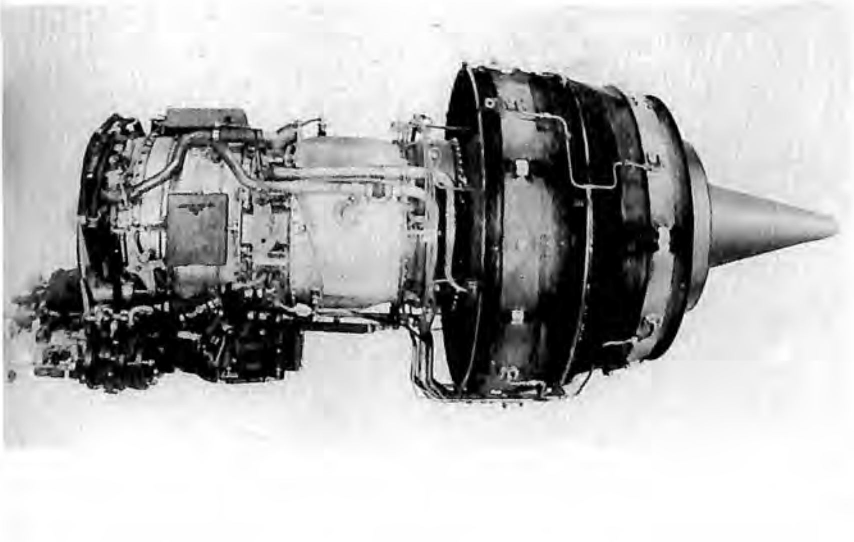
The CJ610 is a derivative of the J85 turbojet and is available in 2 configurations. Twin CJ610 engines power the Aero Commander Jet 1121, HFB 320 Hansa and the Lear Jet business aircraft.

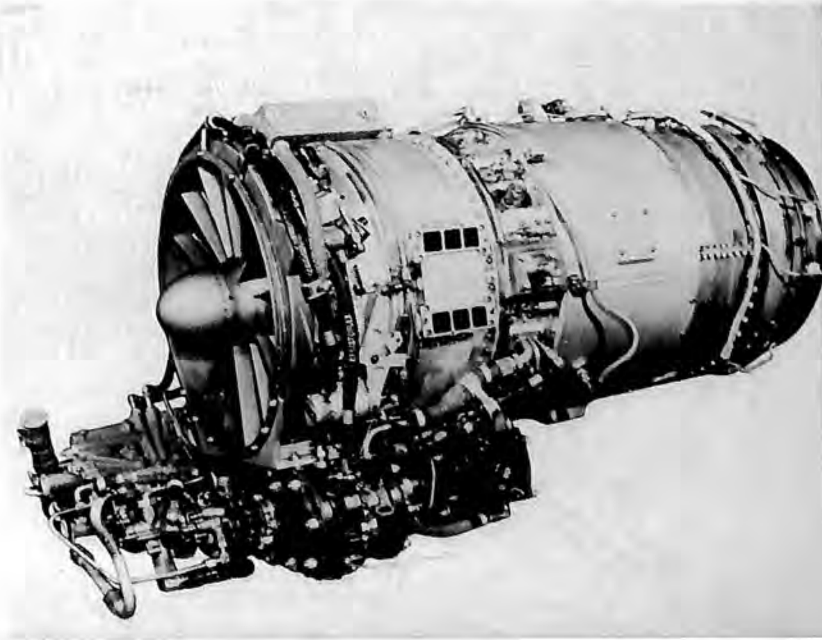
Specifications (CJ610-1)

Length 51.1 inches; flange diameter 17.7 inches; weight 339 pounds; thrust to weight ratio 7.14 : 1; compressor stages 8; turbine stages 2.

Performance

Take-off thrust 2,850 pounds.





CT64 COMMERCIAL TURBOPROP/DIRECT DRIVE

Prime Contractor: General Electric Company

Remarks

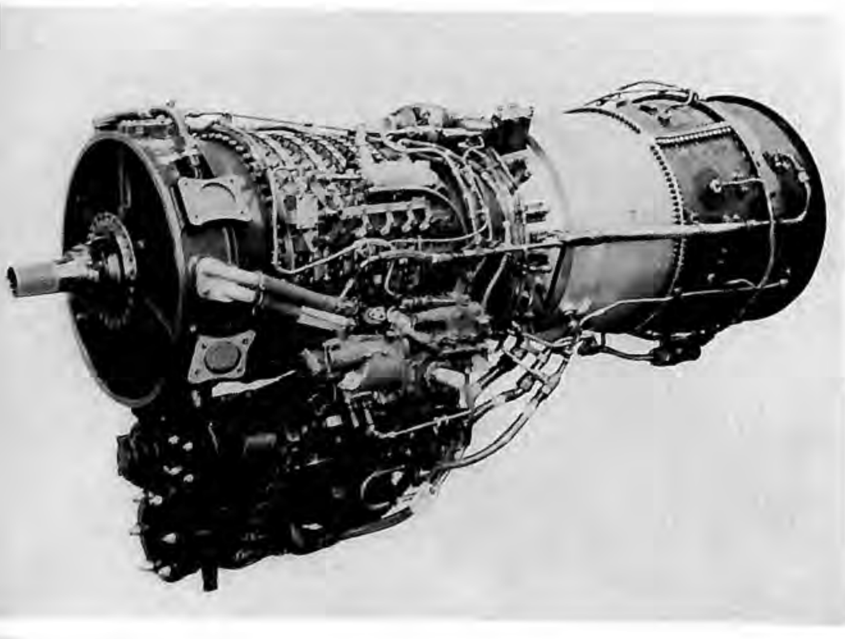
Configurations of the T64 commercial turboprop and direct drive engines are in production and certified for civil use. The CT64-410-1 and CT64-810-1 are turboprop engines and the CT64-610-1 is a direct drive powerplant.

Specifications (CT64-810-1 Turboprop)

Length 112.9 inches; maximum height 46 inches; weight 1,167 pounds; compressor stages 14; turbine stages 4.

Performance

Maximum shaft horsepower 2,850.



T64 MILITARY TURBOSHAFT/TURBOPROP

Prime Contractor: General Electric Company

Remarks

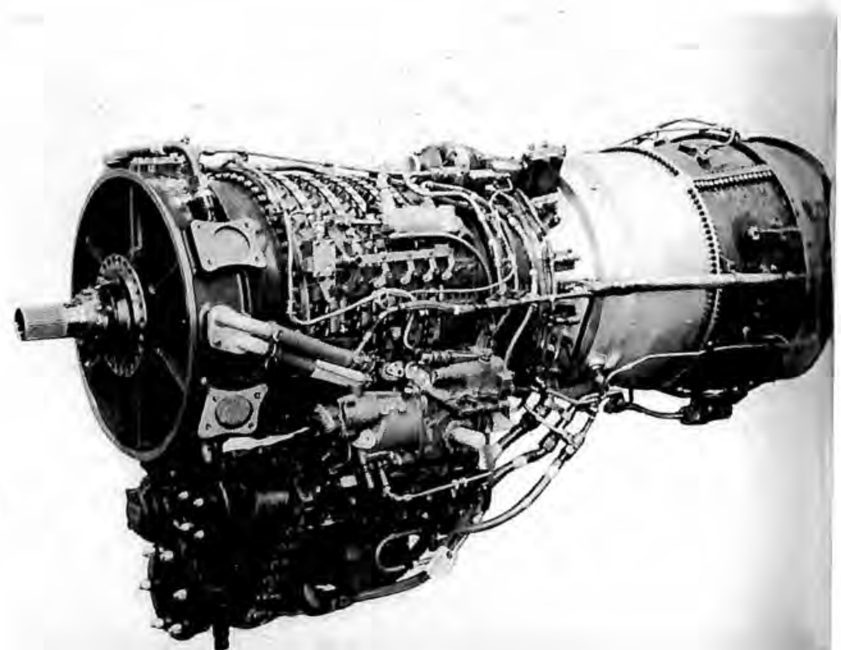
The T64 is a free turbine power plant for helicopter and V/STOL aircraft. The basic engine is designated T64-6. With a single reduction gearbox added it is the T64-2. Addition of a planetary reduction gear creates the turboprop configuration with the T64-4 two stage gearbox below the engine centerline and the T64-8 gearbox above the engine centerline. Military applications of the T64 include: deHavilland CV-7A, Sikorsky CH-53A, Vought/Hiller/Ryan XC-142A and Hughes XV-9A.

Specifications (T64-8)

Length 112.9 inches; maximum height 46 inches; horsepower/weight ratio 2.45:1; compressor stages 14; turbine stages 4; weight 1,161 pounds.

Performance

Maximum equivalent shaft horsepower 2,850.



T58 MILITARY TURBOSHAFT

There are currently in production several configurations of the T58 turboshaft engine, powerplant for a wide variety of helicopters and VTOL aircraft. Applications include Sikorsky SH-3A, Kaman UH-2A, Boeing-Vertol CH-46A, Sikorsky HH-52A, Sikorsky CH-3C, Bell UH-1F, Piasecki 16-1A, Kaman UH-2, Bell 204-B and Bell X-22A. The CT58-110 configuration powers a variety of commercial helicopters and production of the higher rated CT58-140-1 is under way.

Specifications

Length 59 inches; maximum width 18.8 inches; weight 335 pounds; compressor stages 10; turbine stages 3.

Performance

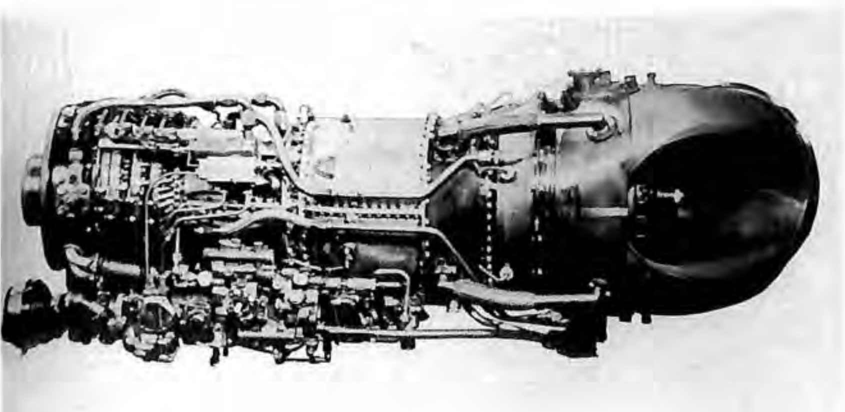
Rating 1,500 horsepower (military application); take-off horsepower 1,250 (CT58-110), 1,400 (CT58-140).

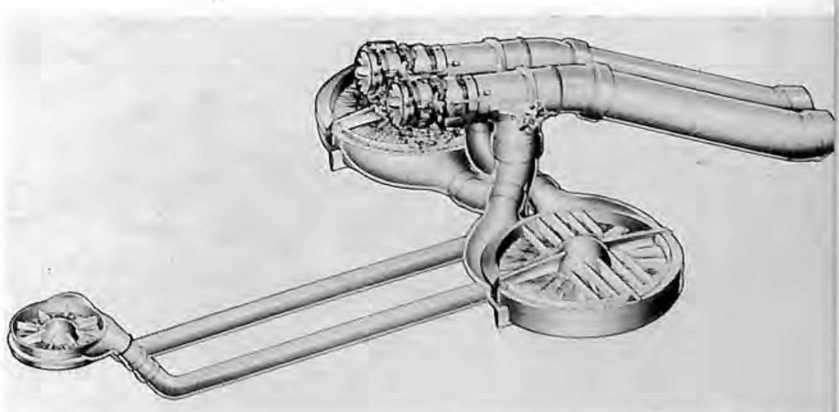
X353-5B LIFT FAN SYSTEM

Prime Contractor: General Electric Company

Remarks

A convertible propulsion system, the X353-5B is designed to power highspeed Vertical Take-Off and Landing aircraft. The fan system consists of 2 wing-mounted lift fans and a nose fan to control pitch of the aircraft. The Lift Fans installed in the XV-5A Army VTOL research aircraft treble the gas generator thrust of the twin J85 power plants.





CJ805-3/-23 COMMERCIAL TURBOJET/TURBOFAN

Prime Contractor: General Electric Company

Remarks

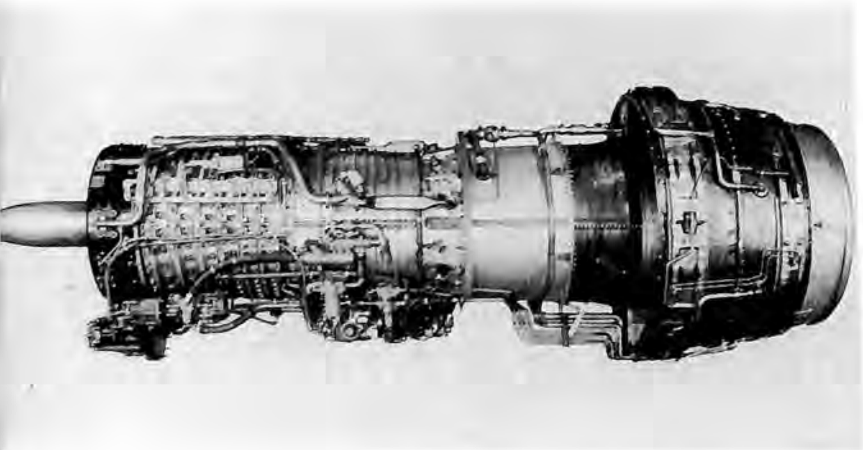
The CJ805-3 turbojet powers the Convair 880 transport in service with 10 airlines; the CJ805-23 aft-fan version is in commercial service with 7 airlines using the Convair 990 transport.

Specifications

CJ805-3: length (with reverser) 181.93 inches; diameter 31.6 inches; weight 2,817 pounds; axial flow jet; compressor stages 17; turbine stages 3. CJ805-23: length 149.6 inches; maximum fan diameter 53.34 axial flow fan; weight 3,776 pounds; compressor stages 17; turbine stages 3/1.

Performance

CJ805-3: thrust 11,650 pounds.
CJ805-23: thrust 16,100 pounds.



GE1 MILITARY/COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

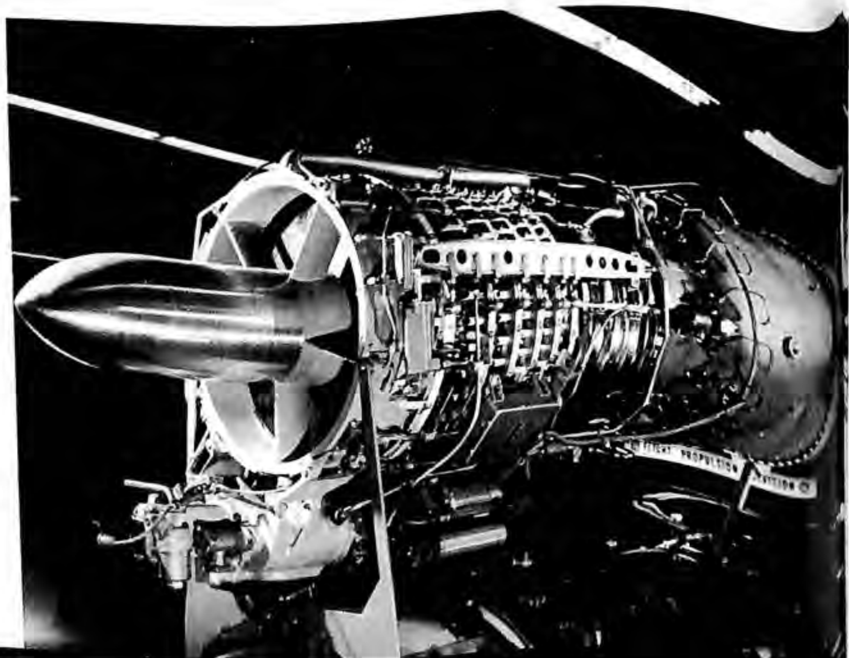
The GE1 Building Block approach provides for one gas generator as the basis of a family of advanced propulsion systems. Building Block components—turbofans, afterburners, thrust vectoring devices—are added to the GE1 gas generator to provide performance and configurations tailored to specific aircraft 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 per cent reduction in length, 79 per cent reduction in volume plus reduced weight and fuel consumption.

Performance

The GE1 is in the same thrust class as the J47 (6,000 pounds) and has a versatility of thrust size spanning a range of almost six times the basic gas generator thrust.



GE4/J5 COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

The GE4/J5 is a supersonic transport engine incorporating design features of the J79 and YJ93 engines and advanced technology. Full-scale engine testing will begin in mid-1966.

Specifications (Preliminary)

Length 328 inches; maximum diameter 71 inches; weight (for Mach 2.7) 8,100 pounds.

Performance

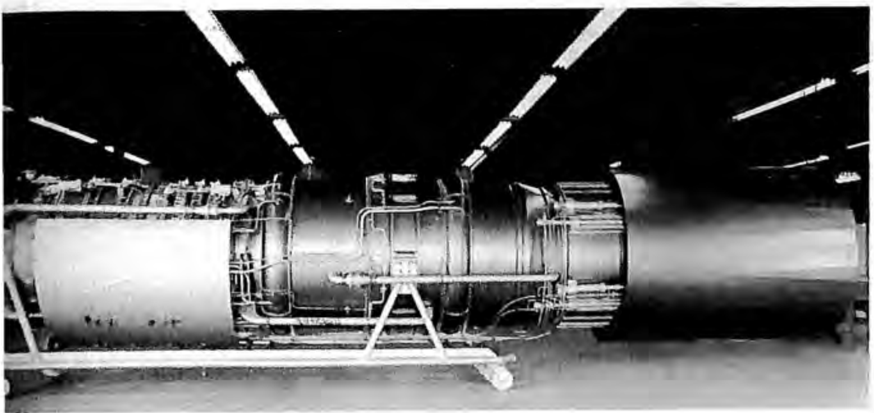
Thrust class 50,000 pounds.

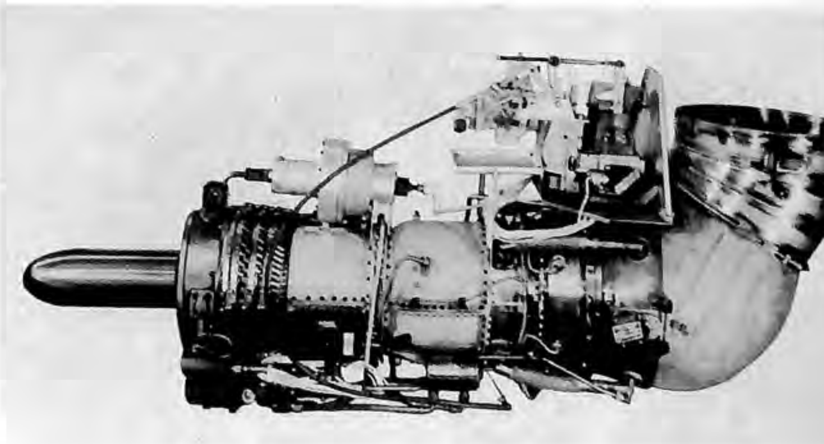
LM100 GAS TURBINE

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. At sea the LM100 provides maneuvering and docking power for the H.S. Denison hydrofoil ship of the Maritime Administration and the H.S. Victoria passenger hydrofoil. Industrially, it drives a liquid pump for oil well, fracturing treatment, provides emergency generating power for a telephone company, and drives a gas pipeline compressor.





LM175 GAS TURBINE

Prime Contractor: General Electric Company

Remarks

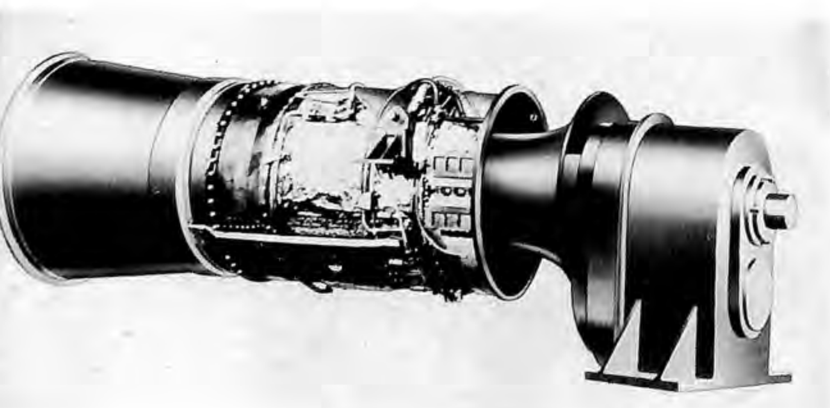
A jet engine for emergency generator packages developing 1,000 kilowatts of emergency power, the LM175 is a 1,750 horsepower class, lightweight turboshaft engine suitable for marine and industrial applications similar to those of the LM100.

LM1500 GAS TURBINE

Prime Contractor: General Electric Company

Remarks

Available as a shaft power engine or a gas generator, the LM1500 is derived from the J79 aircraft engine. It supplies main propulsion for the Maritime Administration's 60-knot H.S. Denison hydrofoil, powers a 300-ton Navy hydrofoil; provides launching power when used as an aircraft catapult, boost propulsion for Navy patrol gun motorboats, and reserve electrical power.



501-D13D COMMERCIAL TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

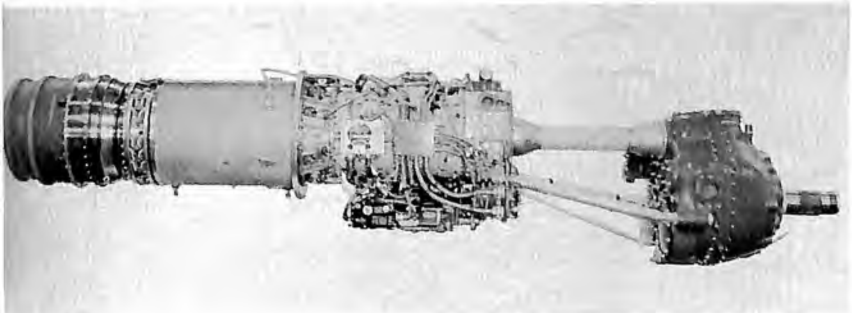
The 501-D13D is the powerplant for the Convair 580 operating with 3 airlines, 13 corporations and the Federal Aviation Agency. A similar engine powers the Lockheed Electra.

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 shaft horsepower.



250-C18 COMMERCIAL TURBOSHAFT

Prime Contractor: Allison Division of General Motors

Remarks

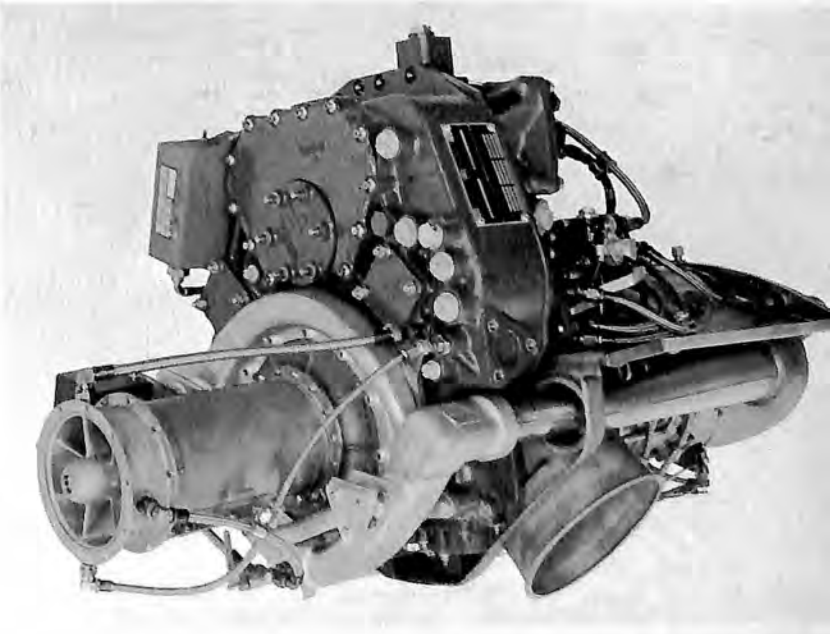
Model 250 powers the Hiller FH-1100 and Hughes 500 light helicopters.

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.



501-D22 COMMERCIAL TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

The 501-D22 turboprop engine powers the Lockheed 382 B, commercial version of the military Hercules.

Specifications

Length 146 inches; width 27 inches; height 39 inches; weight 1,833 pounds; compression ratio 9.65:1; compressor stages 14; turbine stages 4.

Performance

Rating 4,050 shaft horsepower

T63-A-5A MILITARY TURBOSHAFT

Prime Contractor: Allison Division of General Motors

Remarks

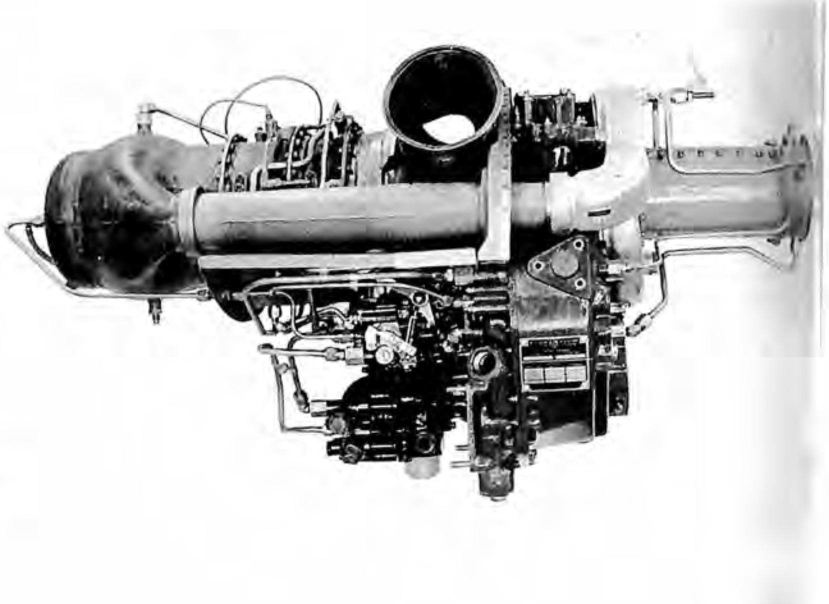
The T63-A-5A powers the Army OH-6A light observation helicopter.

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.



T56-A-7 MILITARY TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

The T56-A-7 is a military engine operational in various versions of the Lockheed C-130 Hercules serving the Air Force, Coast Guard, Marine Corps, Military Air Transport Service and the Navy, as well as governments of 11 foreign nations. T56-A-8 is used in the Grumman E2A and C2A aircraft.

Specifications

Length 146 inches; width 27 inches; height 39 inches; weight 1,833 pounds; compression ratio 9.65:1; compressor stages 14; turbine stages 4.

Performance

Rating 4,050 shaft horsepower.

T56-A-10W MILITARY TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

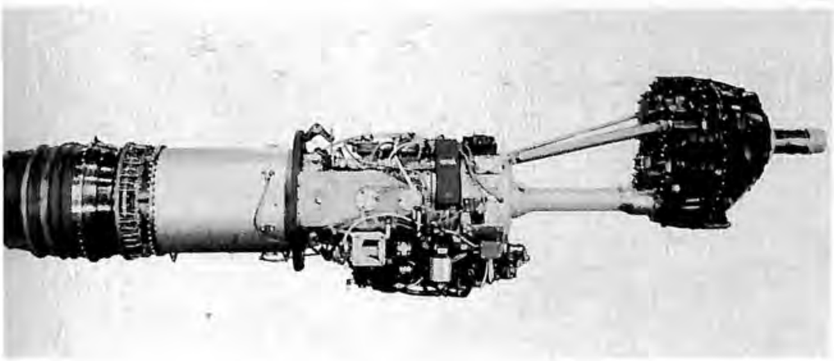
The T56-A-10W is the powerplant of the Lockheed P3A anti-submarine warfare plane in Navy service.

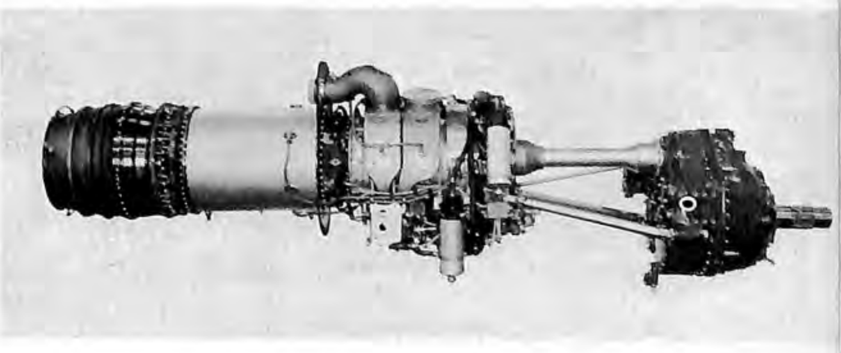
Specifications

Length 147 inches; width 27 inches; height 44 inches; weight 1,853 pounds; compression ratio 9.65:1; compressor stages 14; turbine stages 4.

Performance

Rating 4,050 shaft horsepower dry; 4,500 shaft horsepower augmented.





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 P3A anti-submarine warfare plane.

Specifications

Length 147 inches; width 27 inches; height 44 inches; weight 1,895 pounds; compression ratio 9.65:1; compressor stages 14; turbine stages 4.

Performance

Rating 4,910 shaft horsepower.

T56-A-15 MILITARY TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

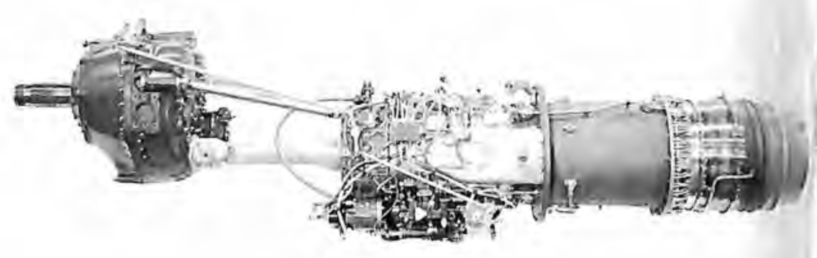
The T56-A-15 is in Air Force service as powerplant for the Lockheed HC-130H search, rescue, recovery aircraft.

Specifications

Length 146 inches; width 27 inches; height 39 inches; weight 1,825 pounds; compression ratio 9.65:1; compressor stages 14; turbine stages 4.

Performance

Rating 4,910 shaft horsepower.



T56-A-18 MILITARY TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

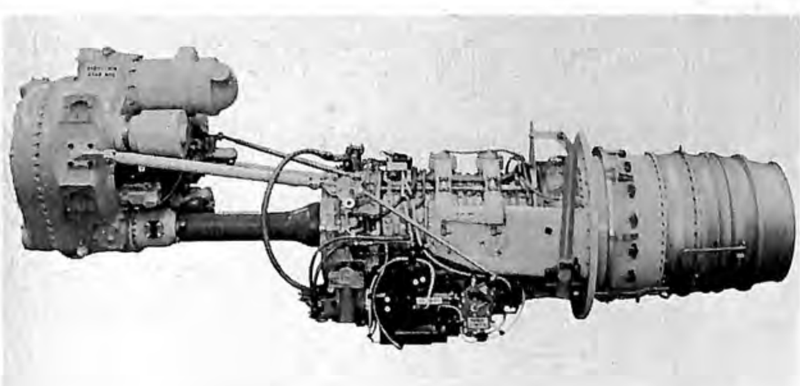
A growth version of the T56 engine, T56-A-18 is being developed for Navy use.

Specifications

Length 115 inches; width 29 inches; height 45 inches; compressor ratio 9.65:1; compressor stages 14; turbine stages 4 with air-cooled first and second stage blades and vanes.

Performance

Rating 5,000 shaft horsepower.



T78-A-2 REGENERATIVE MILITARY TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

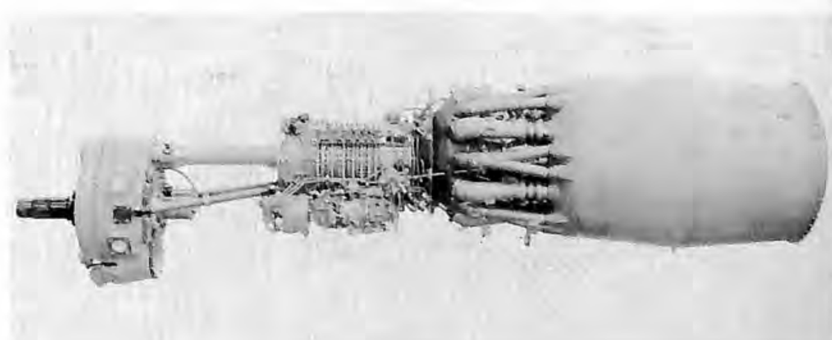
The first United States regenerative turboprop engine for Navy antisubmarine warfare applications, T78-A-2 is in developmental status.

Specifications

Length 160 inches; maximum diameter at regenerator 35 inches; weight 1,565 pounds; compressor stages 14 with variable geometry vanes; turbine stages 4.

Performance

Rating 4,125 shaft horsepower.



T34 MILITARY TURBOPROP

Prime Contractor: Pratt & Whitney Aircraft

Remarks

Development of the T34 (PT2) axial flow turboprop engine began in 1945. The engine was put into production in 1953. It powers the Douglas C-133 Cargomaster.

Specifications

Length 155.12 inches; diameter 34.06 inches; weight 2,870 pounds; compression ratio 6.25:1; axial flow, single rotor; compressor stages 13; turbine stages 3.

Performance

Thrust 7,500 shaft horsepower wet, 6,500 dry.

JFTD12 COMMERCIAL TURBOSHAFT

Prime Contractor: Pratt & Whitney Aircraft

Remarks

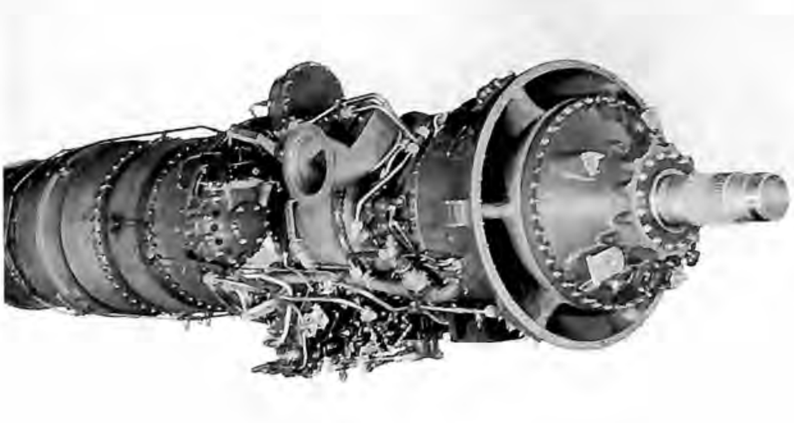
A turboshaft adaptation of the JT12 engine, the JFTD12 has a 2-stage free turbine added in the rear. Two of these engines power the Sikorsky S-64 Skycrane, an all-purpose heavy-lift transport helicopter.

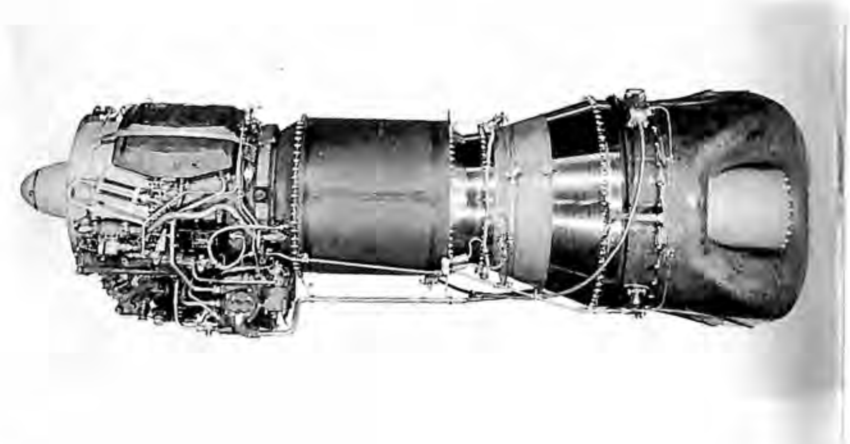
Specifications

Length 108 inches; diameter 21.9 inches; weight 882 pounds; compression ratio 6.5:1; free turbine drive; compressor stages 9; turbine stages 4.

Performance

Rating 4,050 shaft horsepower.





J48 MILITARY TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

In 1950 Pratt & Whitney completely redesigned and re-engineered the Rolls-Royce Tay engine, producing under license the most powerful jet powerplant developed at that time. The engine is out of production but still used in the Grumman F-9J and F-9F Cougars. A total of 4,108 J48's were built.

Specifications

Length 109.75 inches; diameter 50.50 inches; weight 2,080 pounds; compression ratio 3.5:1; centrifugal-flow single rotor; compressor stages 1; turbine stages 1.

Performance

Thrust 7,250 pounds.

J58 MILITARY TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

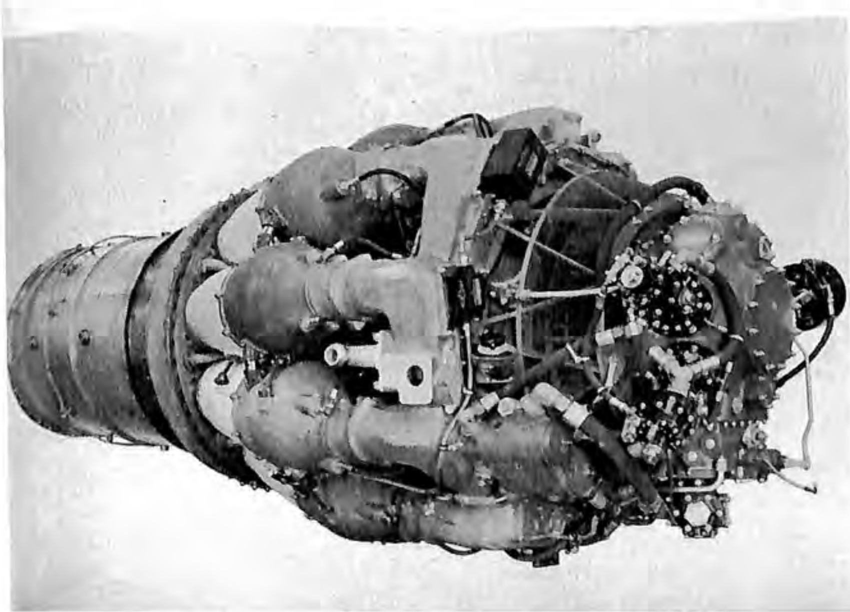
The J58 powers the twin-engine Mach 3 Lockheed YF-12A interceptor and the SR-71 strategic reconnaissance aircraft.

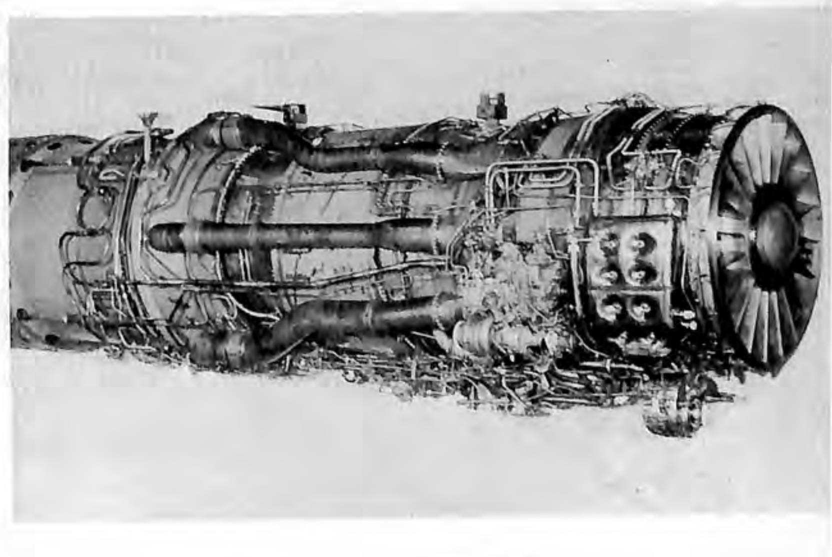
Specifications

Classified.

Performance

Thrust in the 30,000-pound class.





J57 MILITARY TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

The J57 turbojet which put American military aircraft into supersonic flight was produced from 1951 to 1965. Winner of the 1952 Collier Trophy, it was also the first engine to reach 10,000 pounds of thrust. Among the craft it powers are: the Boeing B-52 bomber, KC-135 tanker-transport and C-135A transport; the North American F-100, McDonnell F-101, Convair F-102, Ling-Temco Vought F-8, Douglas F-6 and A-3. Over 33,000,000 operating hours have been accumulated by the more than 21,000 J57's produced.

Specifications (J57-P-43 WB)

Length 167.3 inches; diameter 38.9 inches, compression ratio 13; weight 3,870 pounds, axial flow, dual rotor; compressor stages 16; turbine stages 3.

Performance

Thrust 13,750 pounds; afterburning versions 18,000 pounds.

J75 MILITARY TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

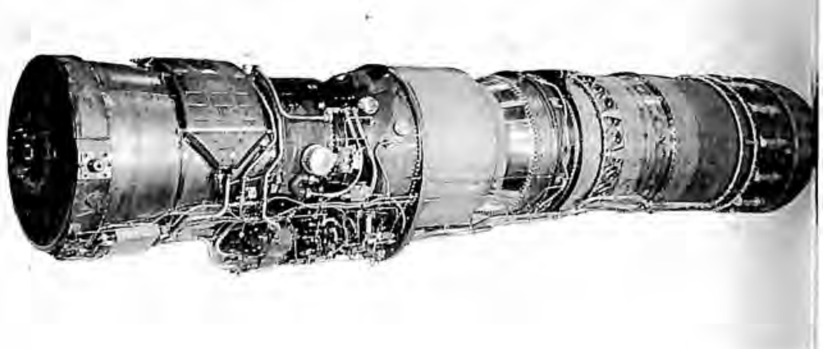
Design work on the J75 (JT4 commercial) began in 1952. To design an engine with 50 per cent more output but only slightly larger than the similar J57 (JT3) at the time, engineers took the advanced step of increasing the hub to tip ratio. This essentially reduced the diameter of the hub which reduced weight and increased the airflow. The engine is used in the Republic F-105 and GD/Convair F-106. More than 1,500 engines were shipped between April, 1957, and July, 1964.

Specifications

Length, J75-P-17, 237.6 inches; P-19W, 259.3 inches; diameter 43 inches; compression ratio 12:1; axial flow, dual rotor; compressor stages 15; turbine stages 3; total weight, P-17, 5,875 pounds; P-19W, 5,960 pounds.

Performance

Thrust, afterburning P-17, 24,500 pounds; afterburning plus water injection P-19W, 26,500 pounds.



J52 MILITARY TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

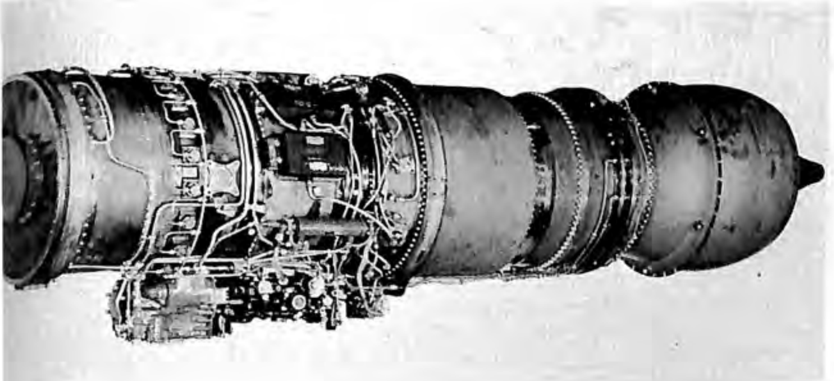
Similar in design to the larger J57 and J75, the J52 was introduced in 1957. Configurations of this engine power the Douglas A-4E Skyhawk and TA-4E, the Grumman A-6A and the North American Hound Dog missile.

Specifications

Length 116.9 inches; diameter 30.15 inches; weight (P-8A) 2,118 pounds; axial flow, dual rotor; compressor stages 12; turbine stages 2.

Performance

Thrust (P-8A) 9,300 pounds.



JT3 COMMERCIAL TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

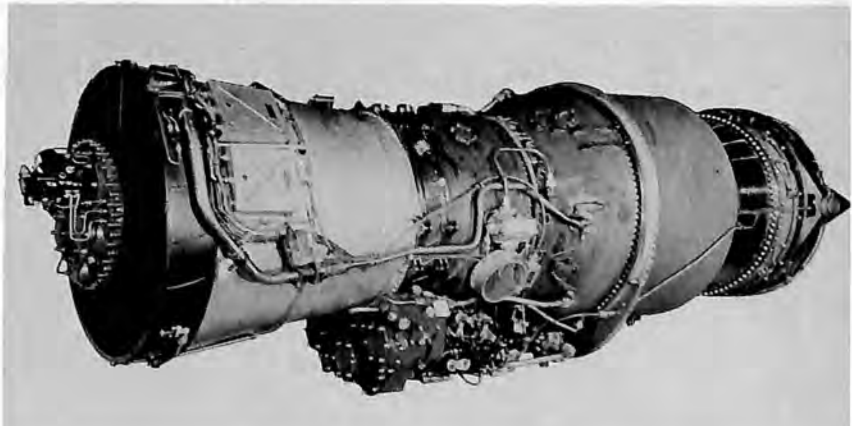
On October 26, 1958, the JT3 Turbo Wasp ushered in the American commercial jet age. A commercial version of the J57, this engine was produced from 1958 to 1961. Configurations are in wide service on the Boeing 707-120 and 720, and the Douglas DC-8-10.

Specifications (JT3C-6)

Length 128 inches; diameter 38.8 inches; weight 4,234 pounds; compression ratio 13; axial flow, dual rotor; compressor stages 16; turbine stages 3.

Performance

Thrust 13,500 pounds with water injection.



JT4 COMMERCIAL TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

A larger, advanced configuration of the JT3, the JT4 (military version J75) is used in the long-distance Boeing 707-320 and Douglas DC-8-20, -30 airliners. Built between 1959 and 1961, it attained the longest time between overhaul (TBO) ever authorized any engine by the Federal Aviation Agency—6,400 hours.

Specifications (JT4A-9)

Length 144.1 inches; diameter 43 inches; weight 5,050 pounds; compression ratio 12; axial flow, dual rotor; compressor stages 15; turbine stages 3.

Performance

Thrust 16,800 pounds.

JT12/J60 TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

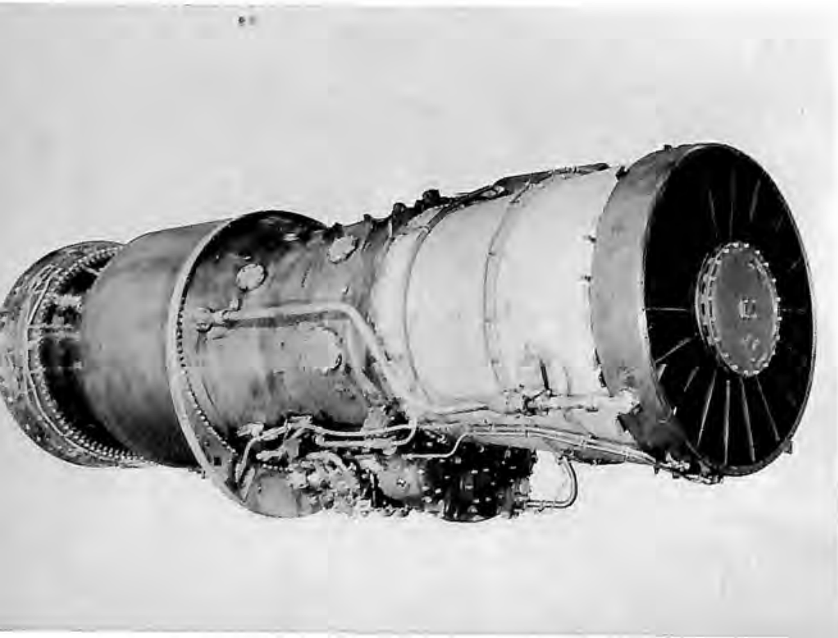
The JT12A-6A (military designation J60), smallest in the company's jet engine family, powers the 4-engine Lockheed JetStar and twin-engine North American Sabreliner business aircraft. J60 also powers the XV-4A VTOL.

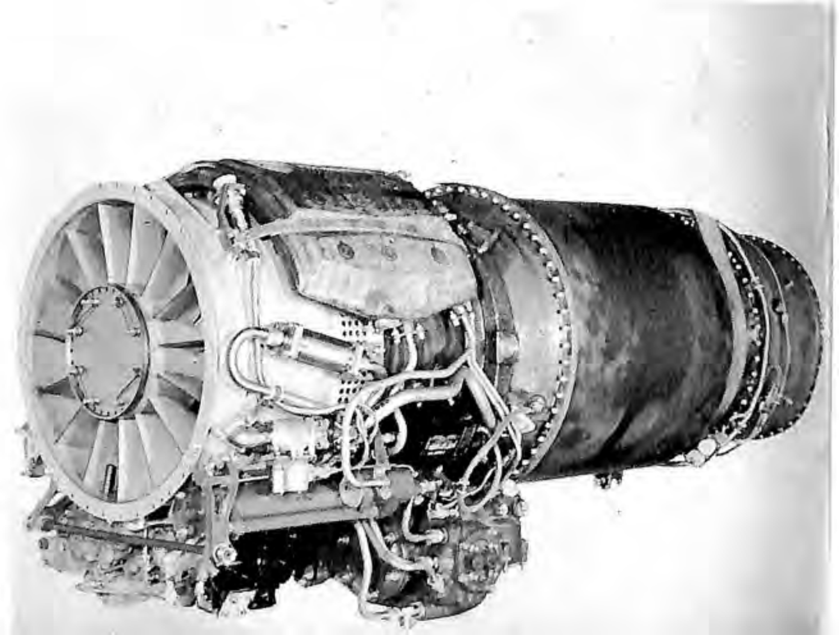
Specifications (JT-12)

Length 78 inches; diameter 21.9 inches; weight 448 pounds; compression ratio 6.5:1; axial flow, single rotor; compressor stages 9; turbine stages 2. J60 same except for length: 77.9 inches in P-3-5 versions, 70.6 inches in P-6, -4.

Performance

Thrust 3,000 pounds, either version.





JT3D COMMERCIAL TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

The world's most widely used turbofan engine, winner of speed and endurance records, the JT3D evolved from the J57. It features improved thrust ratings and lower fuel consumption. Configurations of this engine power the Boeing 707-120B, 720B, 707-320B and C; the Douglas DC-8-50, DC-8-60, and DC-8F. The most advanced model is scheduled as powerplant for Lockheed's projected L-300B, commercial version of the C-141 military transport.

Specifications (JT3D-3, -3B)

Length 134.4 inches; diameter 53 inches; weight 4,190 pounds; compression ratio 13; axial flow, dual rotor; compressor stages (including fan) 15; turbine stages 4.

Performance

Thrust 18,000 pounds.

JT8D COMMERCIAL TURBOFAN

Prime Contractor: Pratt & Whitney

Remarks

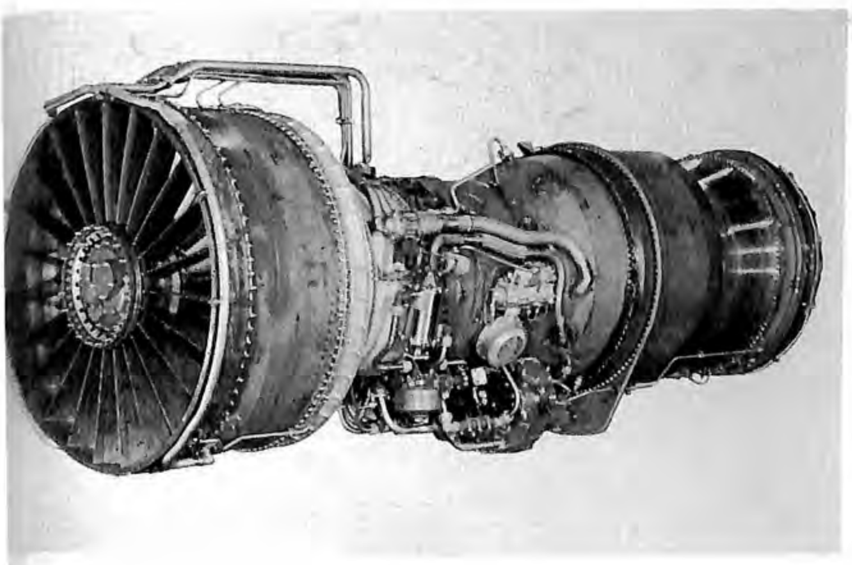
The company-financed JT8D was designed and developed from the outset for application to short and medium range aircraft. Approximately a year and a half after entering commercial service, it reached a time between overhaul (TBO) of 3,200 hours. The JT8D turbofan engine powers the Boeing 727 and 737, the twin-engine Douglas DC-9 and the Sud Aviation Super Caravelle 10B and 10R.

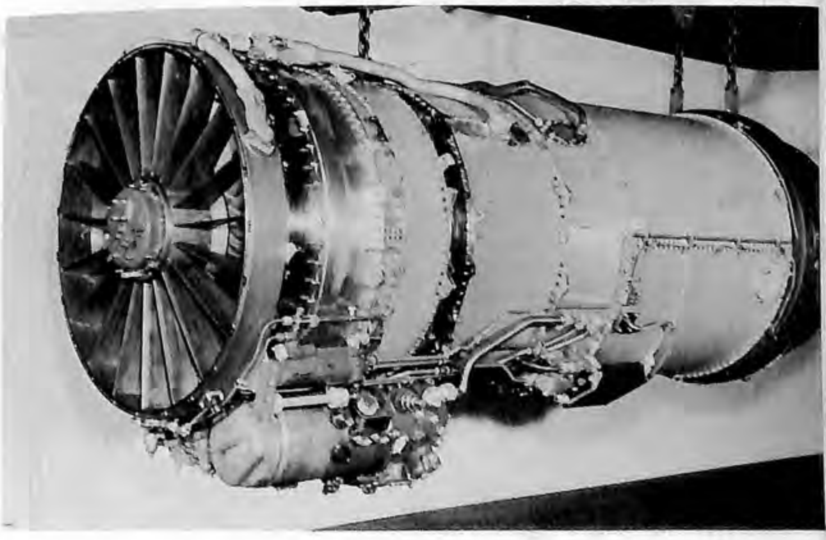
Specifications

Length 119.8 inches; diameter 44 inches; weight 3,096 pounds; compression ratio 16:1; axial flow, dual rotor; compressor stages including fan 13; turbine stages 4; full-length fan duct.

Performance

Thrust 14,000 pounds.



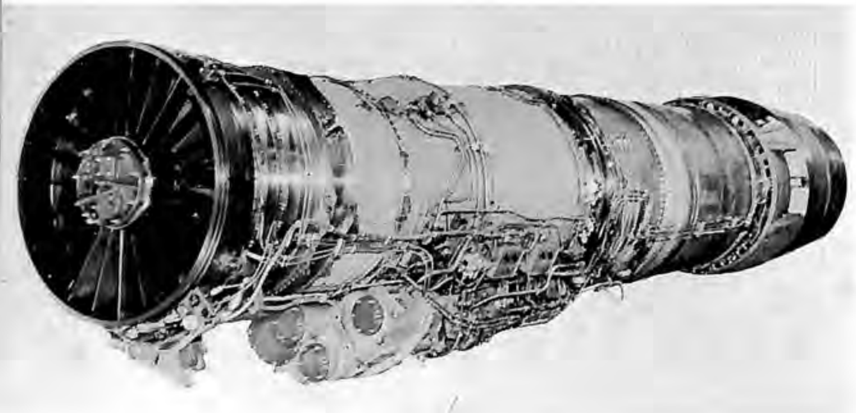


TF30 MILITARY TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

The 20,000-pound-thrust 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 F-111A variable sweep wing supersonic fighter developed for the Air Force, and the Navy F-111B produced by Grumman. A non-afterburning version is the powerplant for Ling-Temco-Vought's new light attack Navy craft. Specifications are classified.



TF33 MILITARY TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

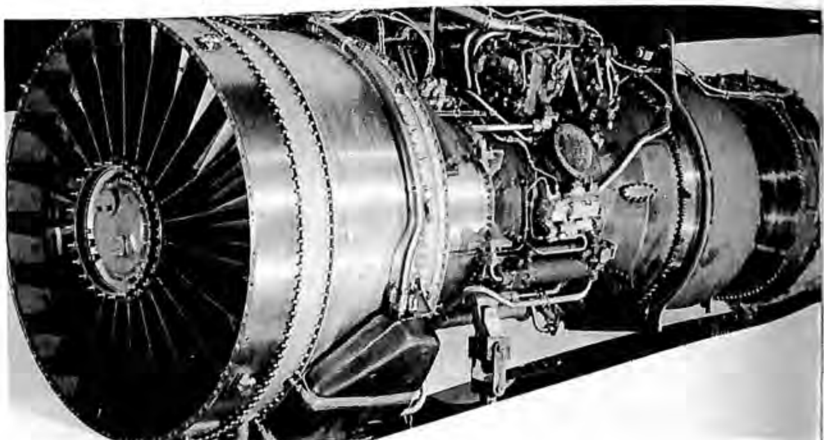
Configurations of the TF33-P-3 (JT3D-1 in the commercial version) power the Boeing B-52H missile platform bomber, the C-135B and KC-135B, as well as the Lockheed C-141A.

Specifications (TF33-P-3)

Length 136.3 inches; diameter 53 inches; weight 3,900 pounds; compression ratio 13:1; axial flow, dual rotor; compressor stages (including fan) 15; turbine stages 4.

Performance

Thrust 17,000 pounds.



S-140 GAS TURBINE

Prime Contractor: Solar, A Division of International Harvester Company

Remarks

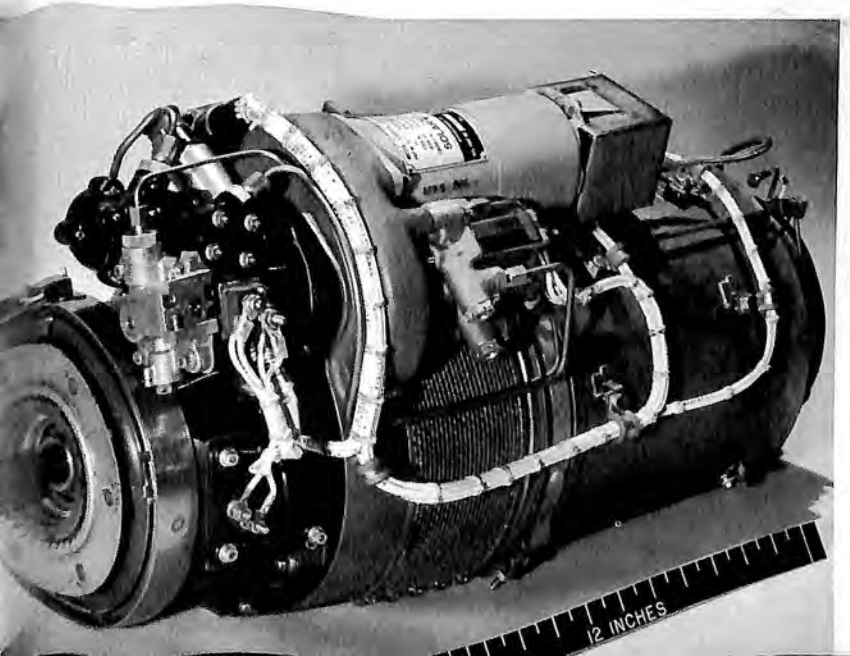
The Solar S-140 GTSS is a lightweight free-turbine type direct drive starter which mounts directly on aircraft main propulsion engines and operates on the same fuel as the aircraft. Developed by Solar under contract to the Navy Bureau of Weapons, it provides safe, reliable starts and eliminates the inherent inefficiencies of transferring starting to the main engines through pneumatic, hydraulic or electric means. Use of the GTSS will give the pilot complete cockpit control of main engine starting and eliminate the ground support equipment normally required for this purpose. The GTSS is capable of starting all major aircraft engines within 25 to 35 seconds.

Specifications

Length 21 inches; nominal diameter 9 inches; weight 75 pounds; 2 shaft; radial flow gas producer turbine and single stage axial flow power turbine; minimum overhaul life of 1,200 starts plus 1,000 hours of main engine overrunning.

Performance

Rating 140 horsepower.



T62T GAS TURBINE ENGINE

Prime Contractor: Solar, A Division of International Harvester Company

Remarks

Used as the auxiliary power unit in every major American military cargo helicopter program, the T62T Titan is an extremely rugged and compact gas turbine engine. The Titan turbine auxiliary power unit provides the power necessary to start main engines and operate all hydraulic and electrical systems, allowing aircraft operation completely independent of ground support equipment. Operating on a wide variety of liquid petroleum fuels, the engine starts quickly under extreme environmental conditions ranging from – 65 Fahrenheit to 130 Fahrenheit.

Specifications

Length 26 inches; diameter 12.5 inches; weight 70 pounds; radial flow; electric or hydraulic starting.

Performance

Rating 80 to 105 horsepower.

Nike-Tomahawk

SOUNDING ROCKETS

Listed under system contractor: manufacturer's nomenclature, type, stages and thrust, launch weight and overall length, performance, remarks and using organizations.

(Courtesy Missiles & Rockets magazine)

AEROLAB DEVELOPMENT COMPANY

ARGO A-2 (PERCHERON)

Boosted single-stage solid research rocket, Thiokol Castor TX-33 with two Thiokol Recruit TE-29's (122,000-lb. total thrust); weight 10,000 lbs.; length 21 ft.; 500-lb. payload to altutide of 200 n. mi.; first stage Shotput; NASA

ARGO A-3

Single-stage solid research rocket, Hercules M-6 Honest John (86,000-lb. thrust); weight 5,910 lbs.; length 21 ft.; 2,000-lb. payload to altitude of 10 n. mi.; used in Goodyear/USAF-ASD ballute tests; AF

ARGO B-1

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Thiokol Cajun TE-82 (9,600-lb. thrust); weight 1,540 lbs.; length, 23 ft.; 50-lb. payload to altitude of 100 n. mi.; NASA, AF

ARGO B-7

Two-stage solid research rocket, 1st—Hercules M-6 Honest John (86,000-lb. thrust); 2nd—Hercules M-5 Nike (48,700-lb. thrust); weight 5,900 lbs.; length 31 ft.; 400-lb. payload to altitude of 40 n. mi.; used in Goodyear/USAF-ASD ballute tests; AF

ARGO B-8

Two-stage solid research rocket, 1st and 2nd—Hercules M-5 Nike (48,700-lb. thrust each); weight 28,000 lbs.; length 27 ft.; 400-lb. payload to altitude of 30 n. mi.; used in Goodyear/USAF-ASD ballute tests; AF

ARGO B-9

Two-stage solid research rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Thiokol Yardbird TE-289 (17,100-lb. thrust); weight 1,800 lbs.; length 24 ft.; 100-lb. payload to altitude of 130 n. mi.; under development; AF

ARGO B-11

Boosted two-stage solid research rocket, 1st—Thiokol Castor TX-33 w/two Thiokol Recruit TE-29's (122,000-lb. total thrust), 2nd—Hercules X-259 (21,350-lb. thrust); weight 13,200 lbs.; length 34 ft.; 1,000-lb. payload to altitude of 450 n. mi; under development; NASA

ARGO B-13

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Thiokol Apache TE-307 (5,000-lb. thrust); weight 1,600 lbs.; length 27 ft.; 60-lb. payload to altitude of 135 n. mi.; operational; NASA

ARGO B-21

Boosted two-stage solid research rocket, 1st—Thiokol Castor TX-33 w/two Thiokol Recruit TE-29's (122,000-lb. total thrust), 2nd—Thiokol Subroc TX-261 (57,000-lb. thrust); weight 13,000 lbs.; length 42 ft.; 1,300-lb. payload to altitude of 250 n. mi.; under development (in-house)

ARGO B-23

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—United Tech. Ctr. FW-3 (6,000-lb. thrust); weight 2,160 lbs, length 22 ft.; 100-lb. payload to altitude of 360 n. mi.; under development; Navy

ARGO C-23

Three-stage solid sounding or research rocket, 1st—Thiokol TX-33 with two Thiokol TX-77's (147,000-lb. total thrust), 2nd—Thiokol TX-261 (57,000-lb. thrust), 3rd—Thiokol TX-306 (11KS-13430); weight 14,300 lbs.; length 41.3 ft.; 150-lb. payload to altitude of 2,000 n. mi., Mach 21; in development for AF

ARGO D-4 (JAVELIN)

Four-stage solid research rocket, 1st—Hercules M-6 Honest John (86,000-lb. thrust), 2nd & 3rd—Hercules M-5 Nike (48,700-lb. thrust each), 4th—Hercules X-248 (3,000-lb. thrust); weight 7,400 lbs.; length 48.7 ft.; 100-lb. payload to altitude of 550 n. mi.; NASA, AF

ARGO D-8 (JOURNEYMAN A)

Four-stage solid research rocket; 1st—Thiokol XM-20 w/two Thiokol 1.5KS-3500 Recruits (121,000-lb. total thrust), 2nd & 3rd—Lockheed Lance (47,000-lb. thrust each), 4th—Hercules X-248 (3,000-lb. thrust); weight 14,000 lbs.; length 62.0 ft.; 135-lb. payload to altitude of 1,260 n. mi.; Mach 24; holds record for highest altitude (1,269 n. mi.) for recovered payload; NASA

ARGO E-5 (JASON)

Five-stage solid sounding rocket, 1st—Hercules M-6 Honest John (86,000-lb. thrust), 2nd & 3rd—Hercules M-5 Nike (48,700-lb. thrust each), 4th—Thiokol TX-77 (46,000-lb. thrust), 5th—Thiokol T-55 (4,650-lb. thrust); weight 7,250 lbs.; length 56.5 ft.; 50-lb. payload to altitude of 500 n. mi.; Mach 12.5; AF

TRAILBLAZER I

Six-stage (incl. three downward-thrust packaged in reverse in 3rd stage) solid research rocket, 1st—Hercules M-6 Honest John (86,000-lb. thrust), 2nd—Hercules M-5 Nike (48,700-lb. thrust), 3rd—either Lockheed Lance (47,000-lb. thrust) or Thiokol TX-77 (46,000-lb. thrust), 4th—Thiokol T-40, 5th—Thiokol T-55 (4,650-lb. thrust), 6th—NASA/Langley 5-in. spherical motor; weight 7,500 lbs.; length 56 ft.; three stages up to altitude of 200 n. mi.; three stages down attain 24,000 fps (a "gun-fired" pellet fired downward has reached 35,000 fps); NASA

AMERICAN MACHINE AND FOUNDRY COMPANY

PURR KEE, ADVANCED

Two-stage sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Hercules X-200 (6,400-lb. thrust); length 6 ft.; in development for Navy

ATLANTIC RESEARCH CORP. (ARC)

ARCAS

Single-stage solid sounding rocket, ARC 29KS-336; weight 65 lbs.; length 6.6-9.1 ft.; 12-lb. payload to altitude of 40 mi.; all services and NASA

ARCAS, BOOSTED

Two-stage solid sounding rocket, 1st—ARC IKS-2200, 2nd—ARC Arcas 29KS-336; weight 100 lbs.; length 10.5 ft.; 12-lb. payload to altitude of 50 mi.; all services, NASA, Canada, Sweden

ARCHER

Single-stage solid sounding rocket, ARC 35KS-1375; weight 330 lbs, length 12.8 ft.; 40-lb. payload to altitude of 90 mi.; all services and NASA

ATHENA

Two, three, or four-stage research rocket, 1st—Thiokol Castor TX-33 w/ two Thiokol Recruit TE-29's (122,000 lb. total thrust), 2nd—either Hercules X-259 (19,000-lb. thrust) or Thiokol TX-261 (57,000-lb. thrust) depending on trajectory requirements, 3rd—Aerojet 30KS-8000, 4th—Hercules BE-3; weight 16,000 lbs.; length 50 ft.; 50 to 300-lb. payload to altitude of 200-500-mi.; four-stage version will employ two stages going up, fin stabilized, and two stages down, with guidance in 3rd stage; pre-selected angle-of-attack control 0 degrees ± 5 degrees; flight distance 417 n. mi.; re-entry velocities from 16,000 to 23,000 fps; for advanced reentry research and plasma-sheath studies; AF, ARPA

HONEST JOHN-NIKE-NIKE

Three-stage solid sounding rocket, 1st—Hercules M-6 Honest John (86,000-lb. thrust), 2nd and 3rd—Hercules M-5 Nike (48,700-lb. thrust); weight 6,500 lbs.; length 47 ft.; 250-lb. payload to altitude of 135 mi.; Army, AF, NASA

HYDRA-IRIS

Two-stage solid sounding rocket, 1st—three clustered Aero-jet Sparrow 1.8-KS-7800's (22,400-lb. total thrust), 2nd—ARC 52KS-4375; weight 1,350 lbs.; length 24 ft.; 100-lb. payload to altitude of 200 mi.; Navy

IRIS

Single-stage solid sounding rocket, ARC 52KS-4375; weight 1,350 lbs.; length 24 ft.; 100-lb. payload to altitude of 200 mi.; all services and NASA

METROC

Single-stage solid sounding rocket, ARC 16KS-140; weight 15 lbs.; length 4.6 ft.; 2-lb. payload to altitude of 20 mi.; all services and NASA

METROC, BOOSTED

Two-stage solid sounding rocket, 1st—ARC Metroc 16KS-140, 2nd—2.75 FFAR (Navy rocket, 720-lb. thrust); weight 26 lbs.; length 8.8 ft.; 2-lb. payload to altitude of 52 mi.; all services and NASA

NIKE-APACHE

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Thiokol Apache TE-307 (5,900-lb. thrust); weight 1,550 lbs.; length 23 ft.; 50-lb. payload to altitude of 130 mi.; all services and NASA

NIKE-ARCHER

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—ARC Archer 35KS-1375; weight 1,650 lbs.; length 25 ft.; 40-lb. payload to altitude of 230 mi.; all services and NASA

NIKE-CAJUN

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Thiokol Cajun TE-82 (9,600-lb. thrust); weight 1,550 lbs.; length 23 ft.; 50-lb. payload to altitude of 100 mi.; all services and NASA

SIDEWINDER-HV ARCAS

Two-stage solid sounding rocket, 1st—Naval Propellant Plant Sidewinder 1A, 2nd—ARC high-velocity Arcas 29KS-336; weight 168 lbs.; length 13.8 ft.; 12-lb. payload to altitude of 81 mi.; all services

SPARROW-HV ARCAS

Two-stage sounding rocket, 1st—Aerojet Sparrow 1, 2nd—ARC high-velocity Arcas 29KS-336; weight 206 lbs.; length 13 ft.; 12-lb. payload to altitude of 100 mi.; all services

SWIK

Two-stage solid research rocket, 1st—Thiokol Castor TX-33 (55,000-lb. thrust) 2nd—Hercules X-254 (14,100-lb. thrust); weight 13,200 lbs.; length 35 ft.; 300-lb. payload to altitude of 675 mi.; Army, AF

TRAILBLAZER II

Four-stage solid research rocket, 1st—Thiokol Castor TX-33 with two Thiokol Recruit TE-29's (122,000-lb. total thrust), 2nd—Lockheed Lance (47,000-lb. thrust), 3rd—Hercules Altair X-248 (3,000-lb. thrust), 4th—ARC/NASA 15-in. spherical (5,000-lb. thrust); weight 13,344 lbs.; length 50 ft.; two stages up, two stages downward to achieve re-entry velocity of 22,000 fps; NASA, Army, AF

HERCULES POWDER CO.

DEACON (POGO-HI)

Single-stage Hercules X-220 solid motor (6,100-lb. thrust); weight 155 lbs.; length 9.2 ft.; payload weight vs. altitude varies with each program; Army, Navy, NASA, ARPA

LANGLEY RESEARCH CENTER, NASA

METEOR SIMULATION VEHICLE (1)

(Modified Trailblazer II); Six-stage solid research rocket; 1st—Thiokol Castor TX-33 w/two Thiokol Recruit TE-29's (122,000-lb. total thrust), 2nd—Lockheed Lance (47,000-lb. thrust), 3rd—Hercules Altair X-248 (3,000-lb. thrust), 4th—NASA Cygnus-15 (3,200-lb.-thrust, 15-in.-dia. spherical), 5th—NASA Cygnus-5 (550-lb.-thrust, 5-in.-dia. spherical), 6th—Army Ballistics Research Lab. shaped-charge accelerator and re-entry pellet; ARC spin-stabilized velocity package contains last four stages; 13,500 lbs., 51.5 ft.; two stages up to 300 km altitude, remaining stages packaged in reverse to achieve 20 km-sec. re-entry velocity, 15 deg. off vertical at 75-km altitude; NASA

METEOR SIMULATION VEHICLE (2)

(Modified Nike-Cajun); Four-stage solid research rocket; 1st—Hercules Nike (53,000-lb.-thrust), 2nd—Thiokol Cajun TE-82 (8,600-lb.-thrust), 3rd—NASA Cygnus-5 (550-lb.-thrust, 5-in.-dia. spherical), 4th—Army Ballistics Lab. shaped-charge accelerator and re-entry pellet; Zimmey Corp. spin-stabilized velocity package which contains two sets of the 3rd and 4th stages mounted in reverse; 1,575-lbs., 27.5 ft.; two stages up to 120-km. altitude, two separate re-entries of different pellet materials each with 11 km/sec. re-entry velocity, 15 degrees off vertical at 75-km altitude; NASA

NAVY MISSILE CENTER, POINT MUGU, CALIF.

SPAROAIR

Air-launched two-stage research rocket for use on F3B or F6B jet aircraft; Mach 0.8 at 32,000 ft., 1st and 2nd—Aerojet Sparrow 111's; 35-lb. payload to altitude of 65 n. mi.; used in Projects Tee Pee, Jane, and Night Owl for plasma generation, infrared and ultraviolet research, respectively; Navy, Army, General Motors Corp.

NAVAL ORDNANCE TEST STATION (NOTS, CHINA LAKE, CALIF.)

HOVERING ROCKET SYSTEM

Two-stage research rocket, 1st—Thiokol Pershing TX-175 2nd stage, 2nd—NOTS to develop 19 x 3-ft.-dia. liquid engine (8,000-lb. thrust); weight, 700-lbs.; length, 27 ft.; recoverable payload to altitude of 65,000-50,000 ft.; 2nd stage carries command guidance, capable of stabilized 120-30 sec. hovering; two vehicles in development for upper-atmosphere research measurements and possibly surveillance use; Defense Atomic Support Agency

ROCKETDYNE DIV., NORTH AMERICAN AVIATION, INC.

AEOLUS 1-90

Single-stage solid sounding rocket (315-lb. thrust); weight, 41 lbs.; length, 4.25 ft.; 6-lb. payload to altitude of 90,000 ft.; launched from 5-in. gun or reinforced plastic shipping container; Navy

AEOLUS 1-200

Single-stage solid sounding rocket (500-lb. thrust); weight, 69.6 lbs.; length, 7.39 ft.; 6-8 lb. payload to altitude of 200,000 ft.; Navy

ROCKET POWER, INC. (RPI)

HOPI CHAFF DART

Single-stage RPI 3.0KS-4000 Hopi-II solid motor; weight, 93 lbs.; length, 11 ft.; 11.5-lb. payload to altitude of 300,000 ft.; NASA

JUDI BALLOON DART

Single-stage RPI 1.9KS-2100 Judi-I solid motor; weight, 33.7 lbs.; length, 9 ft.; 10-lb. payload (std. AF Mylar Robin Sphere) to 200,000 ft.; all services and foreign governments

JUDI CHAFF (OR PARACHUTE) DART

Single-stage RPI 1.9KS-2100 Judi-I solid motor; weight, 30.3 lbs.; length, 8.6 ft.; 10-lb. payload to altitude of 240,000 ft.; all services, NASA and foreign governments

JUDI INSTRUMENTED DART

Single-stage RPI 1.9KS-2100 Judi-I solid motor; weight, 33.7 lbs.; length, 9 ft.; 10-lb. payload to altitude of 220,000 ft.; all services and foreign governments

KISHA-JUDI

Two-stage solid sounding rocket; 1st—RPI 4.4KS-4800 Kisha-I, 2nd—RPI 1.9KS-2100 Judi-III; weight, 221 lbs.; length, 14 ft.; 16-lb. payload to altitude of 480,000 ft.; Sandia Corp.

ORIOLE

Single-stage RPI 5.5KS-6100 Kiva-I solid motor; weight 236 lbs.; length 13.6 ft.; 10-lb. payload to 473,000 ft. (Dart with 81.5 cu. in. payload volume); all services

PHOENIX-I

Two-stage solid sounding rocket; 1st—RPI 5.5KS-6100 Kiva-I, 2nd—RPI 3.0KS-4000 Hopi-II; weight 320 lbs.; length 18 ft.; 10-lb. payload to altitude of 225 mi.; all services

RAVEN

Single-stage RPI 8.5KS-1800 solid motor; weight 100 lbs.; length 10.8 ft.; 10-lb. payload to altitude of 250,000 ft.; 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 8.5KS-1800; weight 208 lbs.; length 17 ft.; 20-lb. payload to altitude of 400,000 ft.; all services

THUNDERBIRD

Single-stage RPI 15KS-4800 solid motor; weight 445 lbs.; length 16 ft.; 35-lb. payload to altitude of 620,000 ft.; under development for Navy

SANDIA CORP.

NITEHAWK 9

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Thiokol TE-416 Tomahawk (10,000-lb. thrust); 9-in.-dia. payload section; 40-60 lb. payload to 200 mi. altitude; Mach 8.5; Atomic Energy Commission

SPACE-GENERAL CORP.

AEROBEE 100

Boosted single-stage sounding rocket; sustainer—liquid IRFNA & JP-4 engine (2,600-lb. thrust for 40 sec.), booster—Aerojet 2.5-KS-18,000 solid motor; weight 1,470 lbs.; length 25.75 ft.; 70-lb. payload to altitude of 80 mi.; tower-launched; max. acceleration 15.2 g; NASA, AF

AEROBEE 150 & 150A

Boosted single-stage sounding rocket; sustainer—liquid IRFNA and aniline-furfuryl-alcohol mixture engine (4,100-lb. thrust for 51.8 sec.), booster—Aerojet 2.5KS-18,000 solid motor; weight (150), 1,943 lbs.; length (150), 29.67 ft.; weight (150A), 1,941 lbs.; length, (150A), 30 ft.; 150-lb. payload to altitude of 152 mi.; max. acceleration 10.3 g; tower-launched; 150 version has 3 fins, 150A has 4 fins; altitude 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 lbs.; length (300), 33.00 ft., (300A), 33.30 ft.; 35-lb. payload to altitude of 300 mi.; max. acceleration 63.8 g; 300A has 4 fins; NASA, AF

AEROBEE 350

Design goal 150-lb. payload to altitude of nearly 300 mi.; under development for NASA

ASTROBEE 200

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Aerojet 30KS-8000; weight 2,601 lbs.; length 26.42 ft.; 150-lb. payload to altitude of 170 mi.; max. acceleration 18.9 g; boom-launched; NASA, AF

ASTROBEE 250

Single-stage solid sounding rocket; Aerojet 28KS-57,000, optional auxiliaries—two Thiokol 1.5KS-35,000; weight 10,358 lbs.; length 34.17 ft.; 400-1,000-lb. payload to altitudes between 190-120 mi.; max acceleration 13 g; boom-launched; NASA, AF, Navy

ASTROBEE 1500

Two-stage solid sounding rocket, 1st—Aerojet 28KS-57,000 with two Thiokol 1.5KS-35,000, 2nd—Aerojet 30KS-8000; weight 11,493 lbs.; length 34.17 ft.; 130-lb. payload to altitude of 1,300 mi.; max. acceleration 37 g; boom-launched; under development for NASA, AF, Sandia (replacement for NASA Journeymen A)

THIOKOL CHEMICAL CORP.,

ASTRO-MET DIV.

ADVANCED TERRIER-TOMAHAWK

Two-stage solid sounding rocket, 1st—Hercules BT-3 Advanced Terrier (17,000-lb. thrust), 2nd—Thiokol TE-416 Tomahawk (10,000-lb. thrust); weight 2,820 lbs.; length 29.8 ft.; 200-lb. (12-in. dia.) payload to altitude of 185 mi. or 75-lb. (9-in. dia.) payload to altitude of 350 mi.; in development

NIKE-APACHE

Two-stage solid sounding rocket, 1st—Hercules, M-5 Nike (48,700-lb. thrust), 2nd—Thiokol Apache TE-307 (5,900-lb. thrust), weight 1,950 lbs.; length 23 ft.; 50-lb. payload to altitude of 130 mi.; all services and NASA

NIKE-TOMAHAWK

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Thiokol TE-416 Tomahawk (10,000-lb. thrust); weight 1,977 lbs.; length 29.7 ft.; 125-lb. payload to altitude of 200 mi.; all services and NASA

TOMAHAWK

Single-stage solid sounding rocket, Thiokol TE-416 Tomahawk (10,000-lb. thrust); weight 575 lbs.; length 16.25 ft.; 45-lb. payload to altitude of 100 mi.; fin stabilized; all services and NASA

TOMAHAWK DART

Single-stage solid sounding rocket; Thiokol TE-416 Tomahawk (10,000 lb. thrust); weight 677 lbs., length 19.25 ft.; 125-lb. payload to 60 mi. altitude; all services and NASA

How Solar gas turbines eliminate ground support equipment

Low cost main engine starting, auxiliary power and air conditioning on the ground are provided by Solar turbines for both military and commercial aircraft

The extremely rugged and compact *Titan*® gas turbine engine is used as the auxiliary power unit in every major U. S. military cargo helicopter program, including the CH-46A, CH-47A, CH-3C, CH-53A, and CH-54A. The *Titan* turbine APU provides the power necessary to start main engines and operate all hydraulic and electrical systems, thus allowing aircraft operation completely independent of ground support equipment. The *Titan* turbine operates on a wide variety of liquid petroleum fuels, and starts quickly under extreme environmental conditions ranging from —65F to 130F. The engine is certified by the Federal Aviation Agency for use as an essential power APU.

Commercial aircraft and business jets, including the F-27, FH-227, Falcon and Jet Star, are using a low cost integrated auxiliary power and air conditioning system composed of a Solar *Titan* gas turbine engine and a Stratos vapor cycle cooling system. The compact assembly produces D.C. or A.C. electrical power concurrently with cabin cooling or heating. The system is designed to pull down a heat-soaked environment to a comfort level within minutes under extreme ambient conditions. On the F-27 and FH-227, the unit also provides power for system checkout and main engine starting on the ground.

The Solar Gas Turbine Self-Contained Starter (GTSS) is a light weight, free-turbine type direct drive starter which mounts on aircraft main propulsion engines, and operates on the same fuel as the aircraft. It is conservatively estimated that the Solar GTSS will reduce aircraft turbine engine starting from one-half to one-eighth the cost of other systems now available. A complete gas turbine engine in itself, the starter provides safe, reliable starts and eliminates the inherent inefficiencies of transferring starting energy to the main engines through pneumatic, hydraulic or electric means. Use of the GTSS will give the pilot complete cockpit control of main engine starting, and eliminates the ground support equipment normally required for this purpose. The GTSS is capable of starting all major aircraft jet engines within 25 to 35 seconds, including the J-57, J-75, J-79, TF-30 and TF-33.

Solar Titan gas turbine now used in all major U.S. military helicopters

Solar GTSS cuts jet engine cost-per-start in half.

Solar gas turbine-driven electrical power generation systems now in production provide a wide range of continuous duty or standby electrical power from 20 kw to 750 kw. The family of gas turbine generator sets includes the *Saturn*® gas turbine 750 kw generator set, the T-350 gas turbine 200 kw generator set and the *Titan* gas turbine generator set with outputs of 20 kw or 30 kw. All Solar generator sets are compact and light weight, and are completely factory packaged. They are designed for low cost and ease of installation, maintenance and operation, and can be supplied as completely mobile units if desired.

For further information on Solar gas turbines and their many cost-saving applications in the aircraft field, write: Solar, Department O-391, San Diego, California 92112.

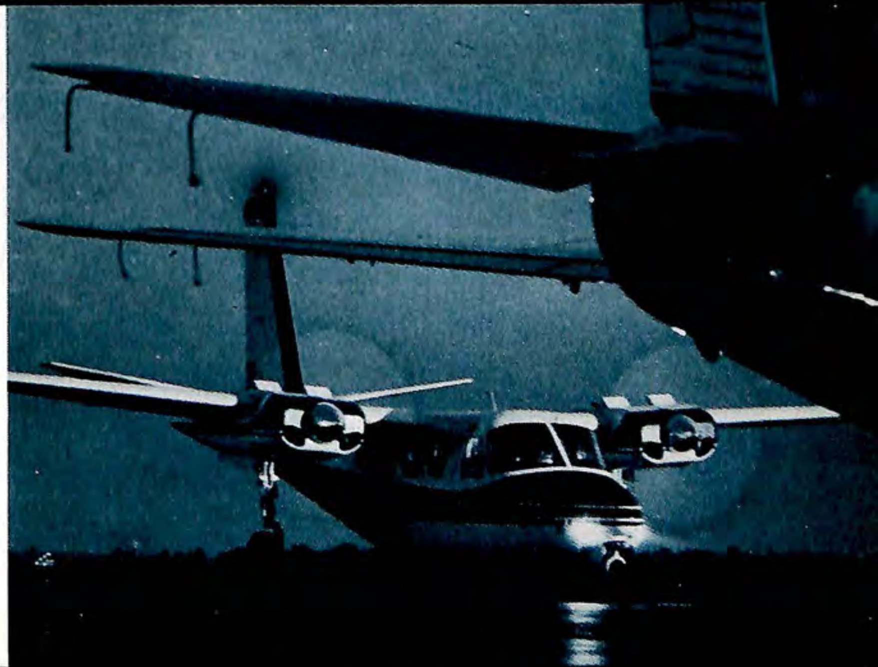
SOLAR

A Division of International Harvester Company

THE AERO COMMANDER 100

THE AERO COMMANDER 200

THE GRAND COMMANDER



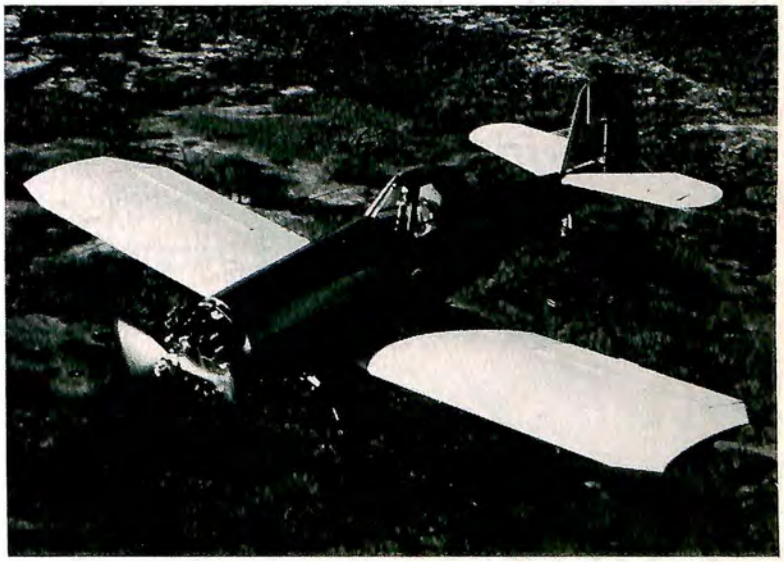
THE AERO COMMANDER 500U

JET COMMANDER, pure jet twin, 525 mph cruise, pressurized, air conditioned, 2 pilots, 4-7 passengers, 16,800 lbs. gross, $595,000 FAF Bethany • TURBO COMMANDER, prop-jet twin, 285 mph cruise, pressurized, air conditioned, 2 pilots, 4-8 passengers, 8,500 lbs. gross, $299,950 FAF Bethany • GRAND COMMANDER, twin 380 hp piston engines, 230 mph cruise, 5-11 places, 8,500 lbs. gross, $146,900 . . . with pressurization, air conditioning, $199,950 FAF Bethany • AERO COMMANDER 500U, twin 290 hp piston engines, 218 mph cruise, 4-7 places, 6,750 lbs. gross, $94,500 FAF Bethany • AERO COMMANDER 200, 285 hp, 210 mph cruise, 4 places, 3,000 lbs. gross, $29,500 FAF Albany • AERO COMMANDER 100, 150 hp, 128 mph cruise, 4 places, 2,250 lbs. gross, $8,500 FAF Albany • SNOW COMMANDER S-2D, 600 hp, working speeds 85-110 mph, 6,000 lbs. gross, $26,330 FAF Olney.

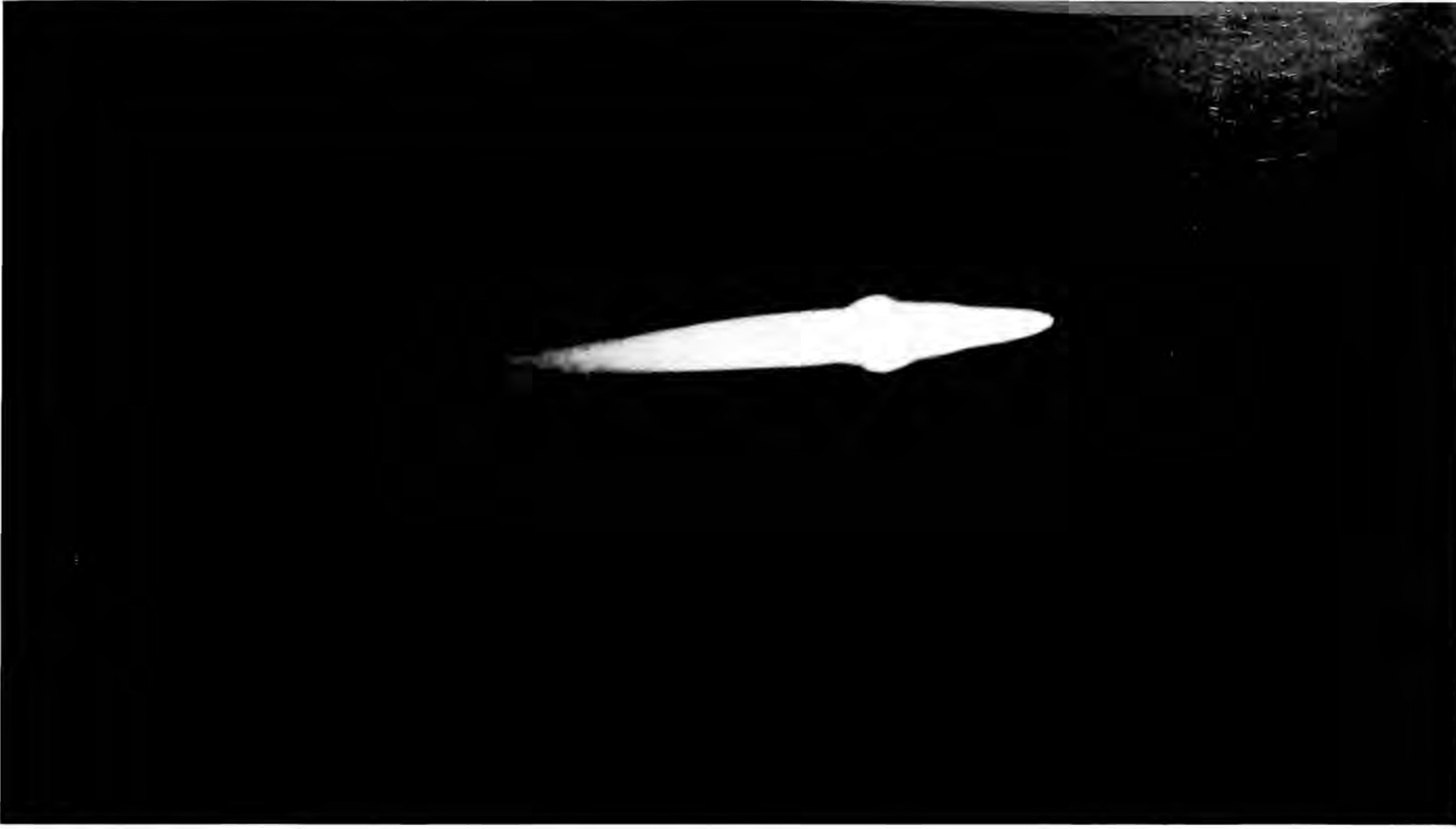
AERO COMMANDER

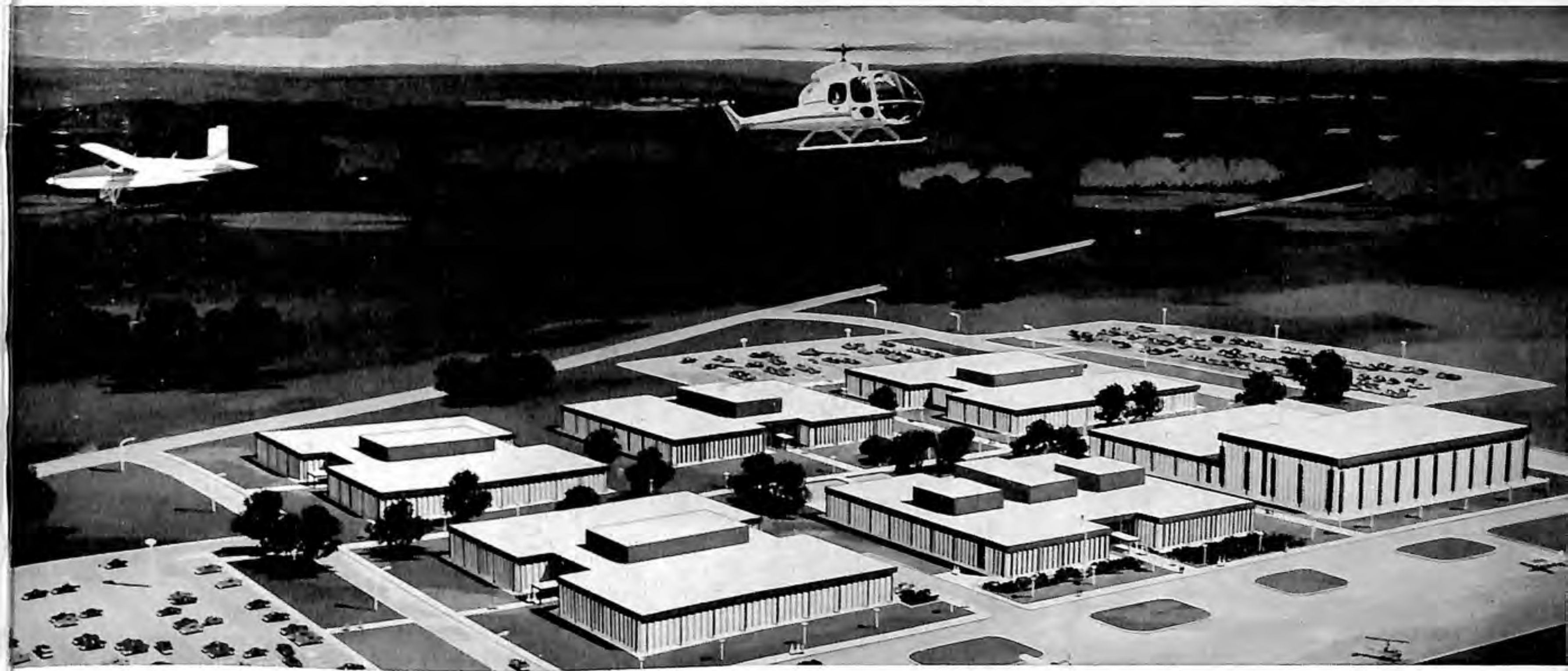
PRODUCTS OF ROCKWELL-STANDARD CORPORATION

AERO COMMANDER DIVISIONS, ROCKWELL-STANDARD CORP.
ALBANY, GEORGIA; BETHANY, OKLAHOMA; OLNEY, TEXAS



THE SNOW COMMANDER





THE PATTERN OF GROWTH AT FAIRCHILD HILLER

FH-227

Look to Fairchild Hiller and our seven divisions, where contributions to the national purpose are so diversified their only common denominator is technical excellence.

Today, we are sharply accelerating our planned program of growth. Focal point: the new Sherman Fairchild Technology Center (above), now taking shape in suburban Washington, D.C. at Germantown, Md.

At this complex of laboratory and administrative facilities, we will originate new concepts, new approaches, new applications of ingenuity for tomorrow's products and technologies.

FAIRCHILD HILLER
CORPORATION

AEROSPACE AIRCRAFT V/STOL SYSTEMS ELECTRONICS

CHRONOLOGIES of 1962–1964

Highlights of the years in which the Aerospace Year Book was not published are included here.

1962

JANUARY

•January 27
The 500 mile-per-hour, six-place executive aircraft, Jet Commander, built by Aero Commander, Inc., makes its first flight.

FEBRUARY

•February 8
Tiros IV meteorological satellite is launched.

•February 20
In the Mercury-Atlas 6 spacecraft, John H. Glenn, Jr., becomes the first American to orbit the earth, completing three orbits at an altitude of 100/163 miles.

MARCH

•March 7
NASA's 440-pound OSO (Orbiting Solar Observatory) is launched into a 344/370 mile orbit to study ultra-violet, gamma, and X-ray radiations from the sun.

APRIL

•April 26
Ranger IV lunar research vehicle impacts the moon after a 64-hour flight, but cameras and instrumentation failed to function.

MAY

•May 9
Sikorsky S-64 Skycrane helicopter, capable of lifting loads up to 10 tons, takes to the air for the first time.

•May 24
M. Scott Carpenter flies Mercury-Atlas 7 mission.

JUNE

•June 19
Tiros V meteorological satellite is launched.

JULY

•July 10
Telstar I, the world's first commercial communications satellite, is launched into orbit to carry out telephone and television experiments between the U. S. and Europe.

•July 18
Cessna executive twin Model 411 completes its first flight.

SEPTEMBER

•September 18
Tiros VI is launched for further meteorological exploration.

OCTOBER

•October 2
Explorer XIV scientific satellite is launched to study radiation, solar particles and solar winds, and magnetic winds.

•October 3
Walter M. Schirra, Jr., completes six-orbit flight in Mercury-Atlas 8.

•October 18
Ranger V is launched and later passes within 450 miles of the moon without a mid-course correction, although it fails to receive solar power and transmits no useful data.

•October 27
Explorer XV scientific satellite investigates the artificial radiation belt created by the July 9 high altitude nuclear explosion over the Pacific.

NOVEMBER

•November 27
Boeing 727, 70-to-114 passenger, 600 mile-per-hour jetliner is unveiled.

DECEMBER

•December 8
Bell Model 206 helicopter, prototype of the Army's OH-4A Light Observation Helicopter, begins ground and flight tests.

•December 14
Mariner II reports important scientific data on Venus as it passes within 21,000 miles of that planet on its 109-day space voyage.

1963

FEBRUARY

•February 9
Pratt & Whitney's JT-8D turbofan engine reaches flight status in the Boeing 727.

•February 14
Syncom I communications satellite is launched and achieves synchronous orbit, but loses communication.

APRIL

•April 2
Explorer 17 satellite, a 400-pound stainless steel flying laboratory equipped with eight primary detectors for direct measurement of the structure of the earth's upper atmosphere, begins its voyage.

•April 18
Northrop's X-21A laminar flow control demonstration aircraft, with air-inhaling wings to reduce drag and powered by General Electric J79 engines, begins series of flight tests.

MAY

•May 7
Telstar 2 active-repeater communications satellite is sent into orbit and successfully handles radio, TV, telephone and facsimile transmissions.

•May 15
L. Gordon Cooper, Jr., begins Mercury-Atlas 9 space flight, which is to last 34 hours and 20 minutes. Mission highly successful from the standpoint of landing and insertion into orbit.

JUNE

•June 10
The two-seat Republic F-105F, designed as a mission trainer as well as a combat fighter-bomber, takes to the air for the first time.

•June 19
Tiros 7 meteorological satellite is launched and is as highly successful as its predecessors in gathering cloud cover data for the U. S. Weather Bureau.

JULY

•July 20
United Technology Center successfully tests 120-inch-diameter, 1,000,000-pound thrust, strap-on solid rocket for the Titan III-C launch vehicle.

•July 26
Syncom II communications satellite is launched, achieves synchronous position over Brazil, and conducts a number of successful experiments.

AUGUST

•August 15
Northrop Norair's 1,000 mile-per-hour twin-jet F-5A, which can operate as an interceptor, fighter-bomber or reconnaissance plane, makes its first flight.

•August 22
North American-built NASA/USAF X-15 is flown to a record altitude for winged craft of 354,200 feet.

•August 28
Little Joe II, booster for the sub-orbital phase of the Apollo test program, makes its first test flight at White Sands Missile Range.

SEPTEMBER

•September 18
Nonorbiting test of ASSET re-entry vehicle is conducted from Cape Kennedy.

OCTOBER

•October 16
Air Force's B-58, built by Fort Worth Division of General Dynamics Corporation, sets world performance record by making the longest supersonic flight in history, from Tokyo to London in eight hours and 35 minutes at an average speed of 1,092 miles per hour.

•October 25
Titan II launch vehicle is formally accepted by NASA and scheduled to boost first unmanned Gemini capsule in 1964. Powered by hypergolic fuels—those which ignite on contact—it permits shorter count-down time than earlier launch vehicles.

•October 26
Rocketdyne Division of North American Aviation delivers the first production model of the 1,500,000-pound thrust F-1 engine, which is to power the first stage of the Saturn V booster.

•October 31
Army's Hiller OH-23G observation helicopter reaches speed of 123.77 miles-per-hour, a new rotorcraft record.

NOVEMBER

•November 7
Northrop Corporation's three-parachute landing system for the Apollo command capsule is tested successfully at White Sands.

•November 20
Lockheed XV-4A Hummingbird makes its first transition flight.

•November 27
Centaur two-stage booster test flight marks major step in development of large launch vehicles and first test flight use of liquid hydrogen as a rocket fuel.

•November 27
Explorer 18 satellite, compact physics laboratory designed to measure magnetic fields, cosmic rays, and solar winds in interplanetary space, is launched successfully.

DECEMBER

•December 5
Navy's Transit satellite, designed as a navigation aid for Polaris-carrying submarines, is sent into orbit for the sixth time.

•December 5
USAF Major Robert A. Rushworth tops Mach 6 for the first time flying NASA/USAFX-15.

•December 17
Initial test flight is conducted of C-141 StarLifter, a fan-jet powered cargo/personnel transport built by Lockheed-Georgia Company.

Pratt & Whitney's TF33 turbofan engine reaches flight status in the Lockheed C-141 StarLifter transport.

•December 19
Explorer 19 satellite is launched into orbit to perform experiments in air density measurement.

•December 21
Tiros 8 successfully launched on weather reporting mission.

1964

JANUARY

•January 11
Greb 5 piggyback radiation measuring satellite is launched into a 500/600 mile orbit.

•January 21
Relay 2 active repeater communications satellite is sent into its 1300/4600 mile orbit to conduct intercontinental microwave experiments between the U. S., United Kingdom, Brazil, France, Germany, and Japan.

•January 25
Echo 2, the balloon-type passive communications satellite, the first cooperative experiment of the U. S. and the Soviet Union, is launched into a 622/833 mile orbit.

•January 29
Saturn I super-booster, complete with a live upper stage, is successfully launched for the first time, lifting a weight of 37,700 pounds—the heaviest weight sent into orbit during the first seven years of manned space research.

APRIL

•April 8
First of two unmanned flights for the Gemini program, the GT-1 boilerplate Gemini is launched into a 99/204 mile orbit.

MAY

•May 25
General Electric-Ryan XV-5A Army VTOL makes its first conventional flight.

JULY

•July 1
Curtiss-Wright X-19 tri-service VTOL, which features four tilting, interconnected propellers on two short wings and is designed for a speed range from 0 to 400 miles per hour, completes its first test flight.

•July 17
TRS-6 (Tetrahedral Research Satellite), a 4 1/2-pound spacecraft designed to measure the intensity of charged particles in a large portion of the magnetosphere, is sent into a highly elliptical orbit of 120 to 65,000 miles after going aloft as a piggyback passenger on the Atlas-Agena D which launched the two NDS satellites.

•July 17
Two 20-sided, 500-pound Nuclear Detection Satellites (third and fourth of a series of 10), designed to aid in enforcing the atomic test ban by detecting atomic explosions in space, are launched into high altitude orbits (58,000 to 70,000 miles).

•July 28
Ranger 7 is launched from Cape Kennedy and sends back to earth the first close-up photos of the moon's surface before impacting the moon 68 hours and 35 minutes later.

AUGUST

•August 19
Syncom 3 synchronous comsat is launched and 10 days later is directed into orbit over the International Date Line, where it relays to the U. S. live television of the Olympic Games in Japan.

•August 28
Nimbus weather satellite is launched to photograph cloud cover on its near-polar circular orbit, where its cameras are to return about 1,000 photos daily.

SEPTEMBER

•September 1
First test launch of the Titan III-A is conducted.

•September 4
OGO (Orbiting Geophysical Observatory), an unmanned spacecraft weighing over half a ton and capable of carrying as many as 20 experiments covering such subjects as radio propagation, astronomy, magnetic fields, atmospheric measurement and energetic particles, is launched into its highly eccentric orbit with an apogee of 93,000 miles and a perigee of only 176 miles.

•September 29
The X-142, a tri-service V/STOL transport designed to carry 32 combat troops over an operational radius of 230 to 470 miles, makes its first flight as a result of a joint project of LTV, Hiller Aircraft, and Ryan Aeronautical Co.

OCTOBER

•October 14
The Sikorsky S-65A (CH-53A) helicopter, designed for heavy assault transport use by the Marine Corps, makes its first flight.

•October 28
Suborbital flight of re-entry vehicle for ASSET, a program designed to test various materials at high-speed re-entry into the atmosphere, is launched.

NOVEMBER

•November 17
General Electric-Ryan XV-5A Army VTOL makes its first complete transition from vertical to forward flight.

•November 28
Mariner 4 is sent into proper trajectory on a 350,000,000 mile flight, passing within 6,000 miles of Mars and sending back to earth 21 close-up photos of that planet.

DECEMBER

•December 11
Centaur 4 (consisting of an Atlas D lower stage with 360,000 pounds thrust and an upper stage composed of two liquid hydrogen engines producing 30,000 pounds thrust) is launched, achieves its test objectives, and is scheduled for operational use in 1965.

•December 12
In a 130-second static test, the Thiokol 156-inch solid rocket motor featuring a gimbaled nozzle generates almost 1,500,000 pounds thrust.

•December 31
The Turbo Commander, a turboprop aircraft built by Aero Commander, Inc., with cruising speed of 280 miles per hour, makes its first flight.

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