THE 1967 AEROSPACE YEAR BOOK

FORTY-FIFTH EDITION

AIA

Official Publication of the

AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.

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Published by
SPARTAN BOOKS *A Subsidiary of Publishers Company, Inc.*
1250 Connecticut Avenue, N. W., Washington, D. C. 20036

THE 1967 AEROSPACE

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YEAR BOOK

Aerospace Year Book
official publication of
Aerospace Industries
Association of America, Inc.
Published by
Spartan Books
A Subsidiary of
Publishers Company, Inc.
Washington, D. C.

Publisher
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Printed in the United States of America

Library of Congress Catalogue Card No. 19–13828

FOREWORD

by Karl G. Harr, Jr.

President, Aerospace Industries Association

1966 was a year of unprecedented overall advance in the aerospace industry.

This is so not because of the industry's sales, production and export statistics, although these include many new records, nor because of any single spectacular technical breakthrough, though there were more than a few of these. It is so because during 1966 on so many fronts involving government, industry and the general public, simultaneous and interrelated advances were made toward extending all of our aerospace frontiers.

In terms of overall accomplishment it was far and away the most impressive year in our national space effort. The fabulously successful Gemini program became a historical fact in 1966 as did many of the unmanned space probe programs, particularly Surveyor and Lunar Orbiter.

General aviation moved dramatically ahead with more than a 30 percent increase in aircraft shipments over 1965, itself a record year.

Transport aircraft showed a similar marked increase despite some delays occasioned by military needs.

Aerospace exports reached a postwar record of more than a billion and a half dollars, representing the ninth year since World War II that such exports have exceeded a billion dollars.

All of this occurred at a time of peak demand for aerospace equipment to support operations in Viet Nam.

More important than such statistical measurements, however, are their underlying causes. Among such we can regard 1966 as a year of unprecedented advance in public acceptance of and participation in both private flying and commercial air travel, the latter including both passenger and air cargo.

During 1966 there was also a much greater degree of reality to the effort to exploit industry's advanced capabilities for the solution of national needs other than space and defense. However far this evolution may still have to go before it becomes an accomplished fact, 1966 will stand as the year during which the proposition was firmly established, on all sides, that every effort must be made to try it.

In short, this was a year of notice to all that the problems that lie in the path of fullest exploitation of aerospace potential must be solved if the public interest is to be best served.

Historians may come to regard 1966 as being the point when the aerospace business completed its transition from a matter of only peripheral concern to the total public interest, to one squarely in the mainstream of American life.

It is a sobering thought. From the point of view of the industry it calls not only for sustained performance at the highest level we have promised, but also a recognition on our part of the responsibility we have incurred.

Such responsibility places many special obligations upon us because today decisions affecting us or made by us are no longer concerned with a fledgling industry of uncertain stability on the outskirts of American life but rather with a strong, established and dynamic industry whose capabilities, products and impact are central to the American economic and social fabric.

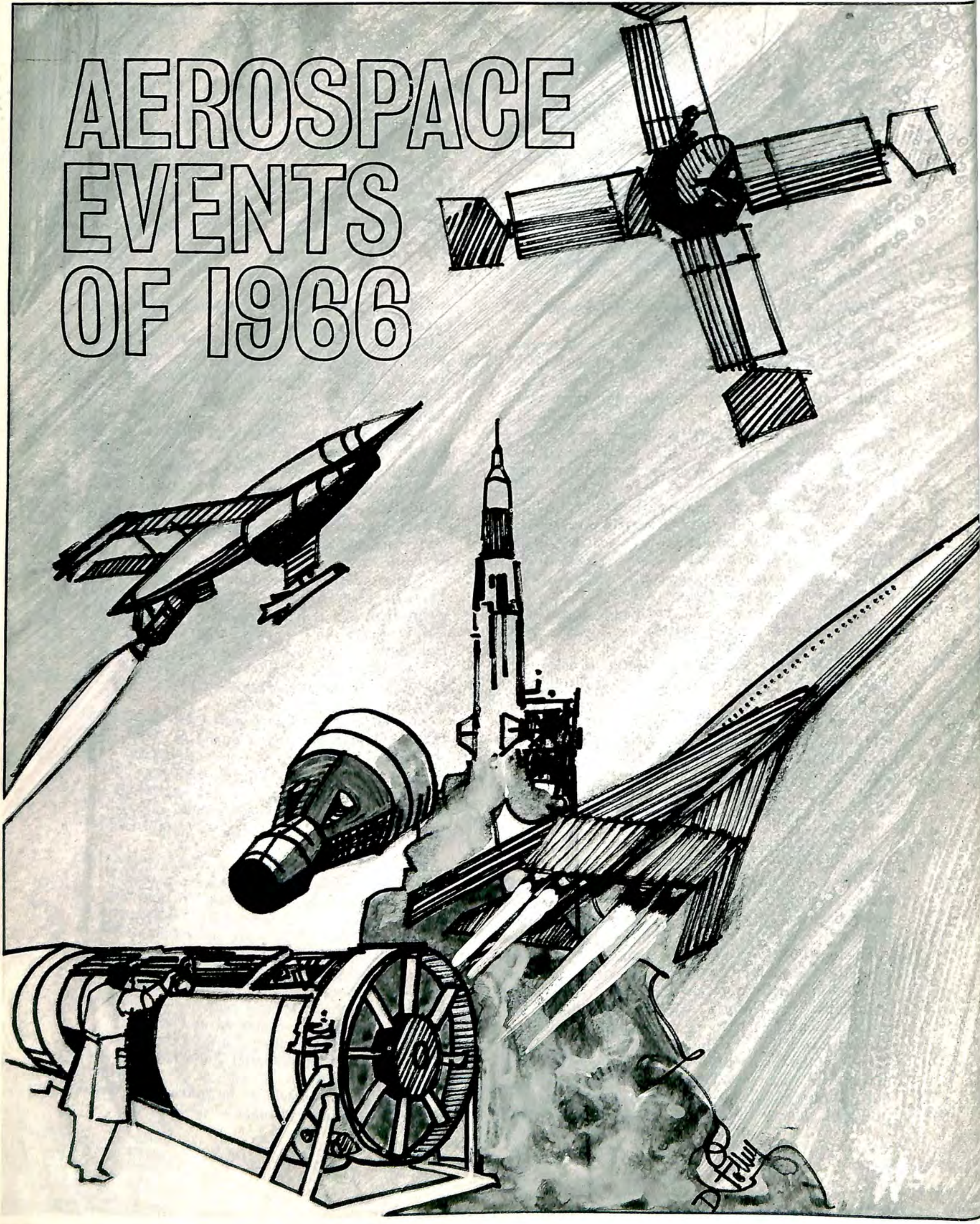
No aspect of our activities can be conducted without regard to the interrelationship of such activities with the total public well-being.

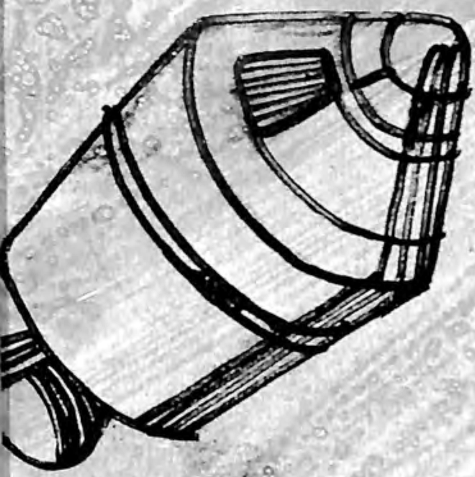
Also we in the industry now bear the responsibility to make the public aware of those things about which our particular vantage point gives us an advance view, including the potential benefits, problems and needs that lie ahead. One of the most important of these is to create public understanding of the nature and significance of lengthening lead times.

It will be a failure of the aerospace industry, perhaps more than of any other segment of our society, if the American people fail to grasp the significance *to them* of the change that has occurred in the time between decision making and result, as the accelerating technological revolution confronts us with projects of a scope, complexity and importance to the nation that we have never faced before.

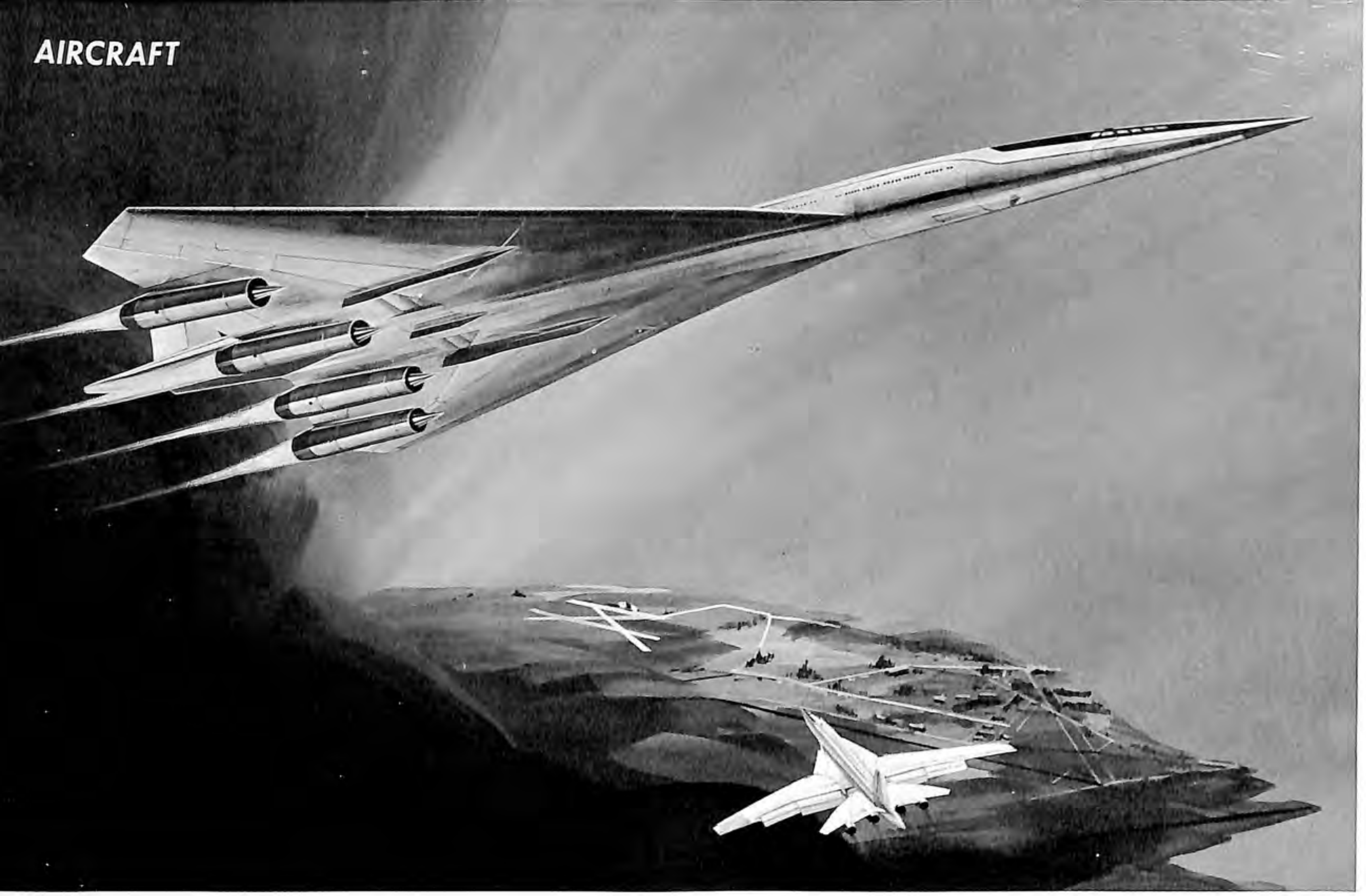
Finally, just as we have slipped into the mainstream of American economic and social life, so must we not shrink either from proclaiming what we know to be the potential contribution of technological advance to all aspects of our national well-being, or from taking the initiative to devise ways and means for its creative application.

AEROSPACE EVENTS OF 1966





The highlights of the aerospace year, including major developments involving aerospace people and equipment and the aircraft, missiles, launch vehicles, spacecraft, engines and systems which passed notable milestones in 1966.



SUPERSONIC TRANSPORT

A lengthy competition for the U.S. supersonic transport was resolved at year-end with the announcement by the Federal Aviation Agency that The Boeing Company and General Electric Company had been selected as the SST airframe/engine manufacturing team. The Boeing design features the variable sweep wing, permitting a delta-shaped wing for cruise at 1,800 miles per hour (top view in photo) and a relatively straight wing (lower view) for slow-speed performance exceeding that of current subsonic aircraft. The GE-4 engine, similar to the YJ93 which powers the XB-70 research airplane, is in the 60,000-pound thrust class. The 675,000-pound SST will be 306 feet long and will carry up to 350 passengers for more than 4,000 miles. The engine, 6 feet in diameter and 25 feet long, has 9 variable stator compressor stages and a 2-stage turbine. Major subcontractors associated with Boeing include Fairchild Hiller Corporation, Avco Corporation, LTV's Vought Aeronautics Division, Martin Company (Baltimore), Northrop Corporation and North American Aviation. By year-end 26 airlines had indicated plans to buy 114 of the planes at about $35,000,000 each. Tentative schedule called for prototype flights beginning in 1970, commercial service by 1974.

DOUGLAS DC-9 SERIES 30

In December, the Douglas DC-9 Series 30 received its FAA type certificate, clearing the way for 1967 commercial operations. Equipped with an advanced high-lift system, the Series 30 is 15 feet longer than the initial Series 10 and carries 115 passengers, compared with 90 in the earlier version.

DOUGLAS DC-8 SUPER 61

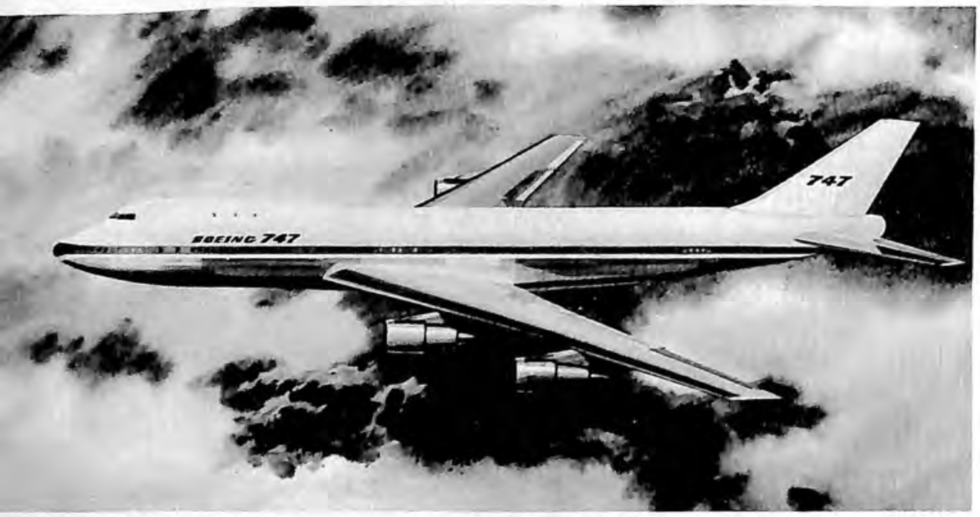
Douglas started deliveries of the DC-8 Super 61, the 187-foot long, 251-passenger advanced version. During its test program the plane made the first Southern California-Tokyo flight by a commercial jet, covering 5,630 miles (normal range is 3,500 miles). The Super 61 offers direct operating costs of less than 1 cent per seat-mile.

DOUGLAS DC-8 SUPER 62

The Douglas DC-8 Super 62, 7 feet longer than earlier DC-8 Series 50, began flight tests toward FAA certification, expected in 1967. Non-stop capability with a normal load of 189 passengers is nearly 6,000 miles. Douglas was also building a Super 63 which combines the high density of the Super 61 with the long range of the Super 62.

BOEING 737

Boeing started construction of its new entry in the short range jetliner category, the twin-engine 737. First flight tests were scheduled for 1967.



BOEING 747

Early in 1966 Boeing announced plans for a 680,000-pound "jumbo jet," the 747, which will be more than 228 feet long and span 196 feet. The company estimated production through 1972 at 200 units, the first to come off the line late in 1968.

FAIRCHILD FH-227

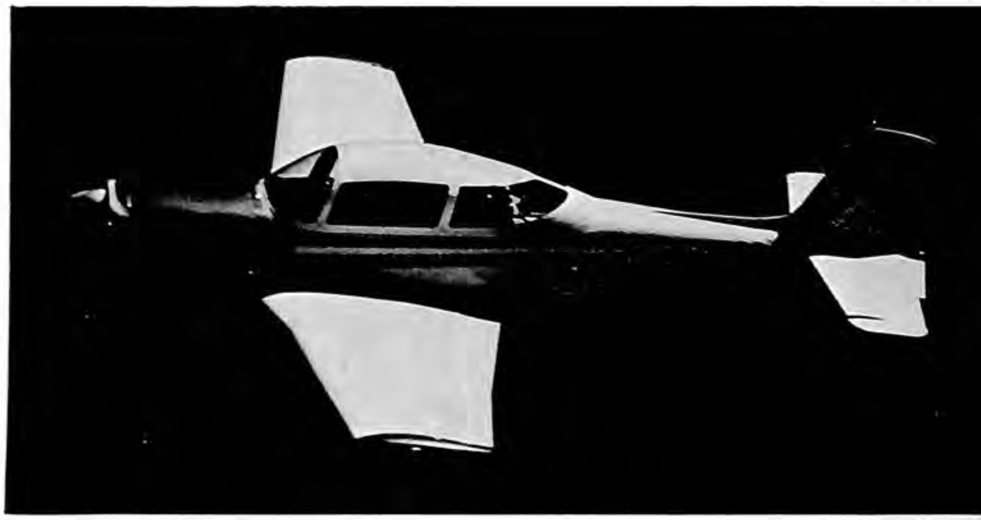
A newcomer to airline service was the Fairchild FH-227, an improved and enlarged version of the F-27 with a 6-foot longer fuselage offering additional passenger/cargo capacity.

LEAR JET MODEL 24

In March, Lear Jet receiver certification for its new Model 24, sister ship to the Model 23 with a number of improvements, including a 500-pound increase in gross weight.

AERO COMMANDER 200

Representative of the Aero Commander line was the 1966 Aero Commander 200, a 4-passenger low-wing craft. Also in production was the 100, a 4-place high-wing plane.



BEECHCRAFT DUKE, MODEL 99

Beech Aircraft Corporation announced production plans for 2 new aircraft, both in flight test status at year-end: the Duke (photo), a 260-mile-per-hour medium twin, and the Model 99, a 17-place turbine-powered high density airplane.

CESSNA 401/402

On November 1, Cessna introduced its Turbo-System Model 401 (photo), a 6- to 8-place executive aircraft, and the Turbo-System Model 402, a 9-seat air taxi commuter/air cargo plane. With other additions in 1967, Cessna planned to expand its twin line from 4 to 8 models.

PIPER NAVAJO

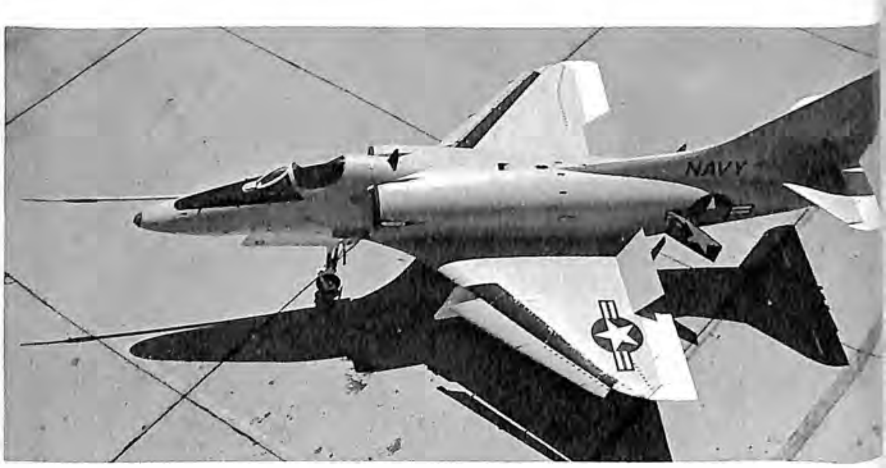
Piper introduced the 6- to 8-place twin-engine Navajo, designed for corporate, private or commuter airline use. The Navajo cruises at 210 miles per hour, 247 in a turbo-charged version.

LOCKHEED C-5A

Lockheed-Georgia started work on the world's largest airplane, the 350-ton C-5A Air Force heavy logistics transport expected to be operational in 1969. In photo foreground, adjacent to C-130 and C-141 production lines, are master models of fuselage sections.

GENERAL DYNAMICS F-111

The variable-sweep F-111, built by General Dynamics/Fort Worth, was undergoing an intensive flight test program at 5 U.S. sites. Tests involved 21 developmental models of both the Air Force F-111 and the Navy F-111B. More than 100 flights were made at speeds beyond Mach 2, some of them at Mach 2.5.



LTV A-7 CORSAIR II

The A-7 Corsair II, built by Vought Aeronautics Division of LTV Aerospace Corporation, was formally accepted by the Navy on October 14 at Cecil Field, Florida.

DOUGLAS A-4F SKYHAWK

The ageless Douglas A-4 Skyhawk marked its 12th year of production with introduction of a new model, the A-4F. The "F", which features a more powerful engine, a steerable nose wheel, wing-lift spoilers and an advanced escape system, made its first flight on August 31.

NORTH AMERICAN XB-70A

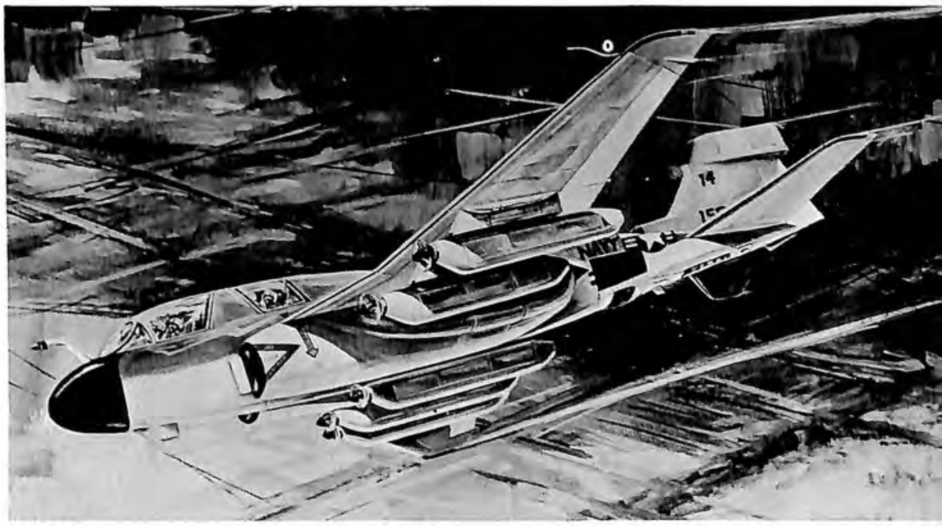
The USAF's XB-70A, built by North American's Los Angeles Division, became the first aircraft to achieve sustained Mach 3 flight. The milestone occurred on a May test flight.

BOEING/DOUGLAS A/RIA

Flight tests got under way on the A/RIA, Apollo Range Instrumented Aircraft, an airborne communications center for Apollo space missions. The plane is a Boeing EC-135N extensively modified by Douglas Aircraft Company's Modification Division. Douglas is converting 8 such aircraft.

GRUMMAN EA-6B

Under a Navy contract, Grumman initiated development of the EA-6B electronics warfare aircraft. The new plane is an advanced version of the EA-6A in Marine Corps service, 40 inches longer to accommodate an enlarged cockpit which will house 4 crewmen rather than 2.



GRUMMAN C-2A

The Navy's new COD (Carrier On-board Delivery) aircraft, the Grumman C-2A, became operational in 1966. The C-2A can carry 40 passengers or 15,000 pounds of cargo.

NORTH AMERICAN OV-10A

North American Aviation's Columbus Division started full production of the OV-10A limited warfare aircraft. A $60,000,000 contract awarded in October called for 185 planes for the USAF and Marine Corps.

BELL JETRANGER

Textron's Bell Helicopter Company received FAA certification for a new generation JetRanger 5-place turbirre-powered light helicopter. The new craft features operating costs 30 to 50 percent below previous models.

BELL HUEYCOBRA

In 1966, Bell was awarded substantial contracts by the Army for production of the 200-mile-per-hour HueyCobra assault helicopter. The craft carries the Army designation AH-1G.

FAIRCHILD HILLER FH-1100

Fairchild Hiller Corporation won FAA certification for the FH-1100 commercial turbine-powered light helicopter. The company started manufacture of the first 250 units.

LOCKHEED AH-56A

On March 23, the Army awarded Lockheed-California Company a contract for engineering development of the Advanced Aerial Fire Support System, the first helicopter designed exclusively as a weapons platform. It was designated AH-56A.

LOCKHEED MODEL 286

On July 25, Lockheed-California received FAA certification for the Model 286, the first rigid-rotor helicopter to be certified. The 5-place craft reached speeds of more than 200 miles per hour.

HUGHES OH-6A, 500

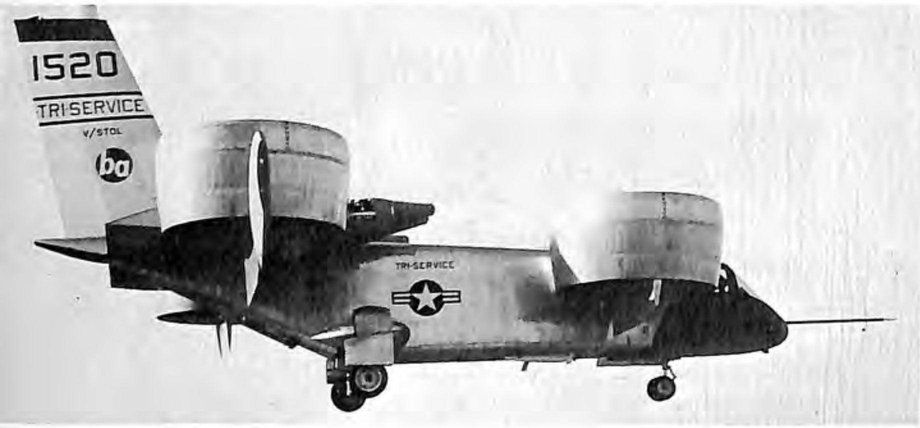
Hughes Tool Company started production on the Army's OH-6A light observation helicopter and announced plans to produce commercial versions of the craft: the luxury 5-seat "500" and a 7-seat utility model (photo), the "500U."

BOEING VERTOL CH-47B

A new model of the Army's Chinook helicopter, built by The Boeing Company's Vertol Division, made its first flight in October. The CH-47B was in production, with first deliveries scheduled for May 1967.

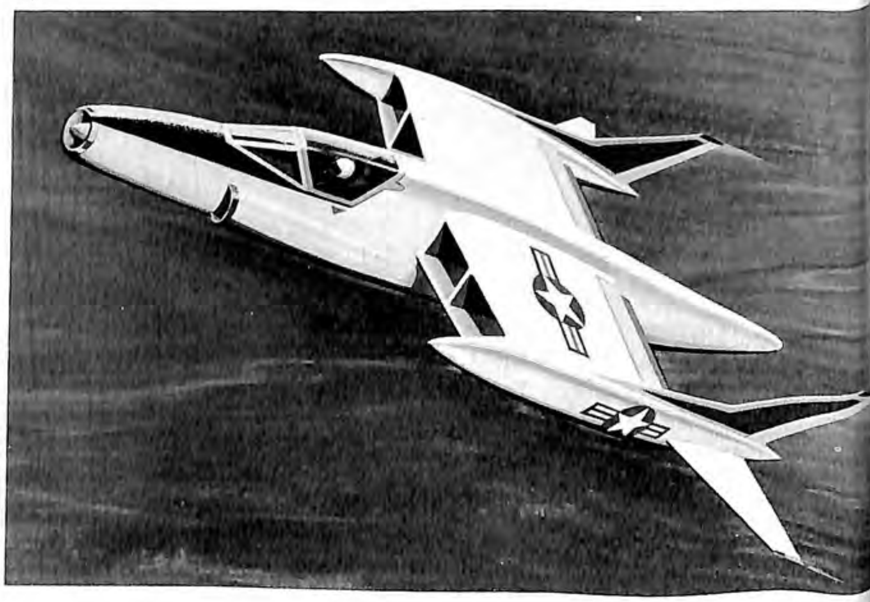
SIKORSKY STOWED ROTOR DESIGN

In September, Sikorsky Aircraft announced a new stowed rotor design, an aircraft which can hover like a helicopter and attain forward speeds of more than 500 miles per hour. Rotor blades hold and stow into the fuselage at speeds above 150 miles per hour.



BELL X-22A

Bell Aerosystems Company's tri-service V/STOL aircraft, the X-22A, started its flight test program. No. 2 craft continued the program after No. 1 was extensively damaged in a hard landing.



LTV XC-142A

The XC-142A tri-service V/STOL, developed by LTV Aerospace Corporation together with Hiller and Ryan, made a historic landing on the USS Bennington, first transport-type airplane to take off from and land on an aircraft carrier at sea.

LTV ADAM II

The Air Force and the Army jointly sponsored a 1966 research program on ADAM II, a V/STOL concept developed by LTV Aerospace Corporation which utilizes a high bypass ratio turbofan propulsion system for operational missions in a range from low to high speed forward flight. In photo, artist's concept of a fighter/attack aircraft.

POSEIDON

Under accelerated development during 1966 was Poseidon, offshoot of the Navy's Polaris family of fleet ballistic missiles. The Department of Defense announced its decision to start production of the Lockheed-built weapon and to deploy it aboard Polaris submarines over a period of years.

SRAM

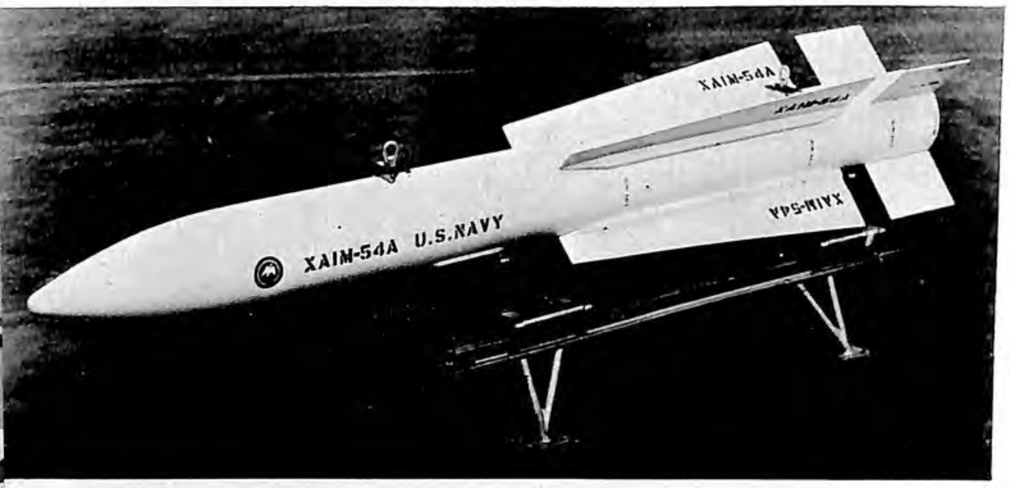
The Air Force initiated development of SRAM, a new short-range attack missile to be delivered by aircraft such as the FB-111. SRAM developmental contract was awarded to The Boeing Company.

MINUTEMAN III

In engineering development was the newest member of the Air Force's Minuteman family, Minuteman III. Being developed by Boeing, Minuteman III features an improved third stage, increasing its payload and permitting it to carry more penetration aids to counter antiballistic missile defenses. Decision was made to increase the number of Minuteman III's in the Minuteman II/III ICBM mix and to develop a new re-entry vehicle for Minuteman II.

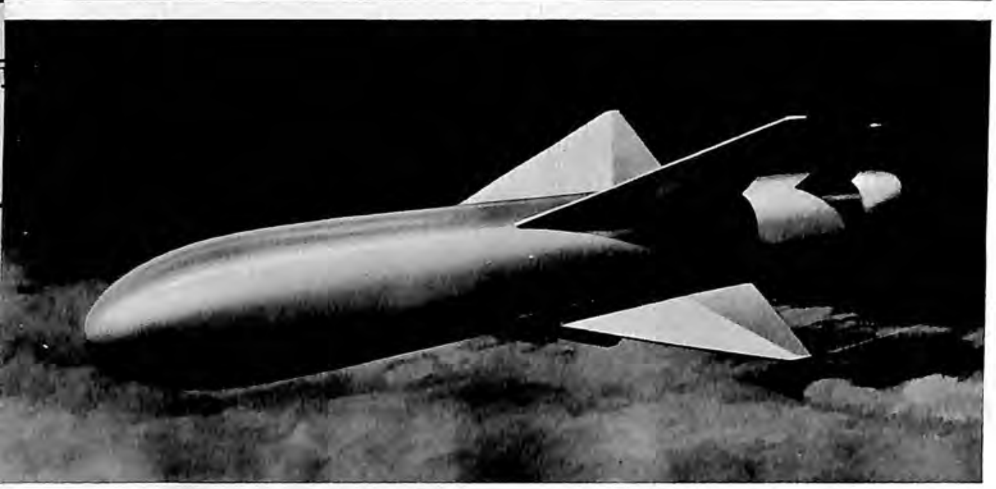
INTERIM ARM

In August, General Dynamics/Pomona was awarded a Navy contract for development of a missile called Interim ARM (Anti-Radiation Missile). An air-to-ground weapon capable of destroying enemy radar sites, the new system employs an adaptation of the Standard missile. Launch tests conducted in October were highly successful.



PHOENIX

First test firings of the Navy's Phoenix air-to-air missile, built by Hughes Aircraft Company, were made during the year. The AIM-54A Phoenix is designed for use with F-111B and A-6 aircraft.



CONDOR

The Navy initiated development of the Condor air-to-surface, TV-guided missile, designed to give carrier-based attack aircraft a standoff capability and increased bombing accuracy. In April, a developmental contract was awarded to North American Aviation's Columbus Division.

FIREBEE II

→

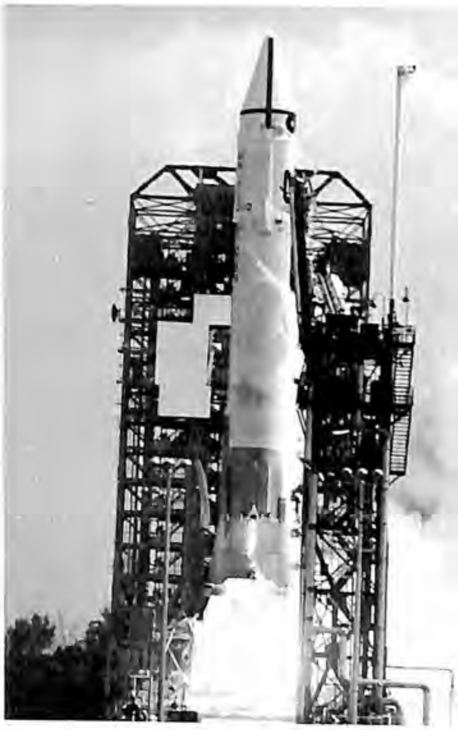
In the fabrication/assembly phase at Ryan Aeronautical Company was the Navy's supersonic drone, Firebee II. In photo, the drone is mounted atop an antenna range mast for radiation pattern tests. First flight tests were scheduled for 1967.

MAVERICK

The Department of Defense announced plans to initiate engineering development of a new television-guided tactical air-to-ground missile called Maverick. Contractor selection was to be made in 1967.

UPRATED SATURN I

The Uprated Saturn I, formerly Saturn IB, qualified for boosting manned Apollo flights with 3 successful unmanned launches in 1966. Chrysler and Douglas build the 2 stages of the vehicle; Rocketdyne supplies rocket power for both. The first (February 26) and third (August 25) flights were primarily checks of the Apollo heat shield; the second mission, shown at launch on July 5, involved a study of liquid hydrogen's behavior in orbit.

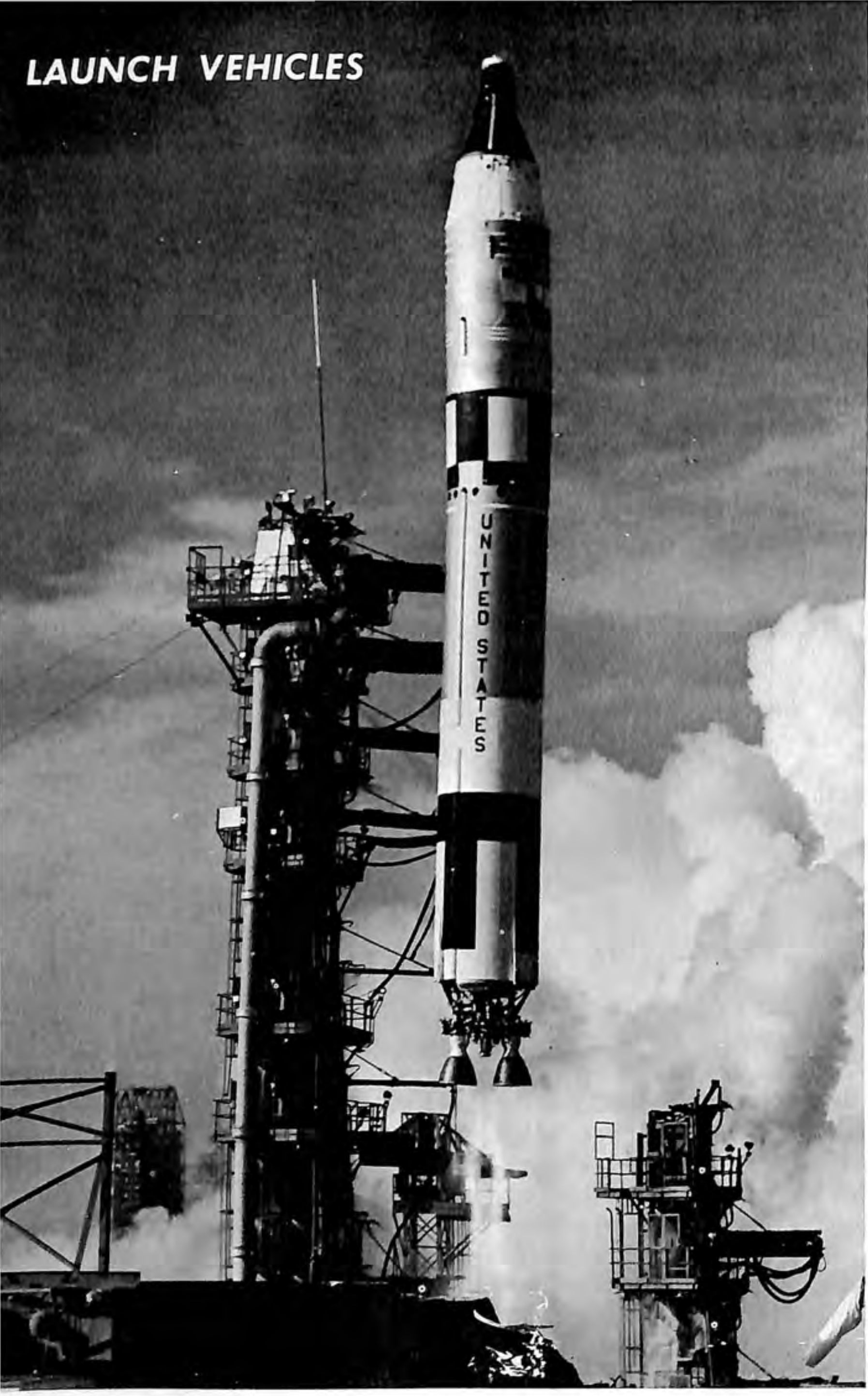


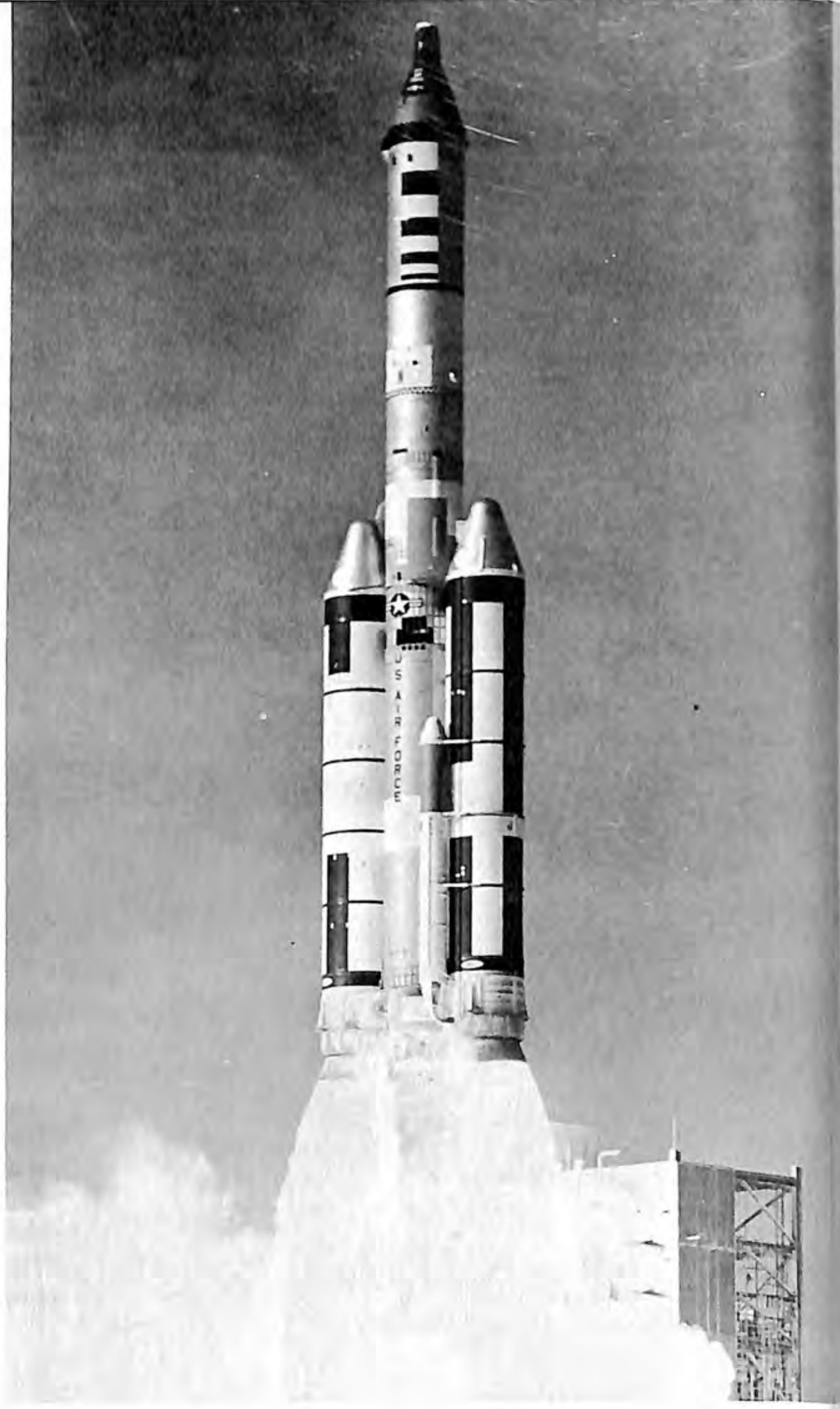
ATLAS-CENTAUR

Atlas-Centaur vehicles sent Surveyor spacecraft toward the moon on May 30 and September 20. On a third 1966 flight (October 26) Centaur achieved the first restart of liquid hydrogen engines in space. General Dynamics/Convair is prime contractor for the vehicle, Rocketdyne supplies Atlas rocket power, and Pratt & Whitney Aircraft builds the Centaur propulsion system.

ATLAS-AGENA

The Atlas-Agena combination which boosted several major military and NASA spacecraft—Discoverer, Ranger, Mariner, Samos and others—added new programs to its list. The vehicle, built by General Dynamics/Convair and Lockheed, successfully launched 2 Lunar Orbiters and 1 Applications Technology Satellite.



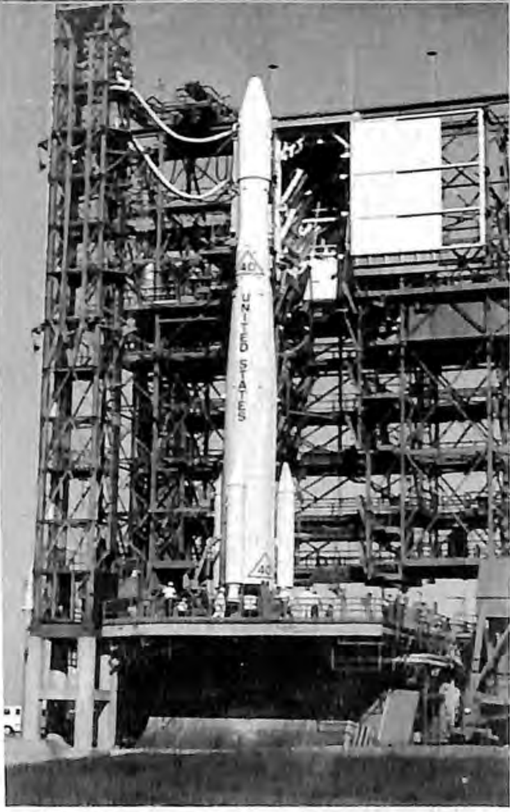


TITAN II

NASA's Titan II, built by Martin Company with propulsion systems supplied by Aerojet-General, scored 5 flawless launches of manned Gemni spacecraft during the year. In photo, the launch of Gemini 12, last mission in the program.

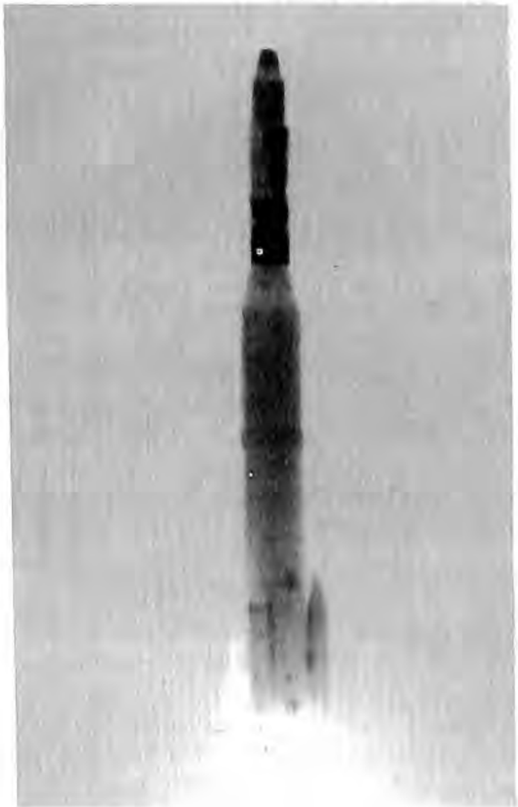
TITAN III

Titan III-C, the USAF's heavy booster, sent 8 IDCSP (Initial Defense Communications Satellite Program) spacecraft into orbit on June 16. The vehicle also performed perfectly on a November 3 boost of a Gemini capsule, primarily a test of the heat shield for the Manned Orbiting Laboratory. In development were a new version for unmanned flight, Titan III-B, which employs the first 2 stages of the core together with a variety of upper stages, and the MOL version, Titan III-M. Martin builds the vehicles, Aerojet-General the liquid fuel engines, United Technology the solid boosters. In photo, a special "long shape" version of Titan III-C employed on the November flight. The normal core is topped by a 38-foot Titan II propellant tank housing several scientific experiments.



THRUST AUGMENTED IMPROVED DELTA

The latest version of NASA's Douglas-built Delta booster, the Thrust Augmented Improved Delta, sent Pioneer VII into solar orbit on August 17.



LONG TANK THOR

The newest member of the Thor family, Long Tank Thor, successfully completed its initial flight in August from Vandenberg AFB. Long Tank Thor was scheduled for a number of assignments in Air Force space programs.

BURNER II

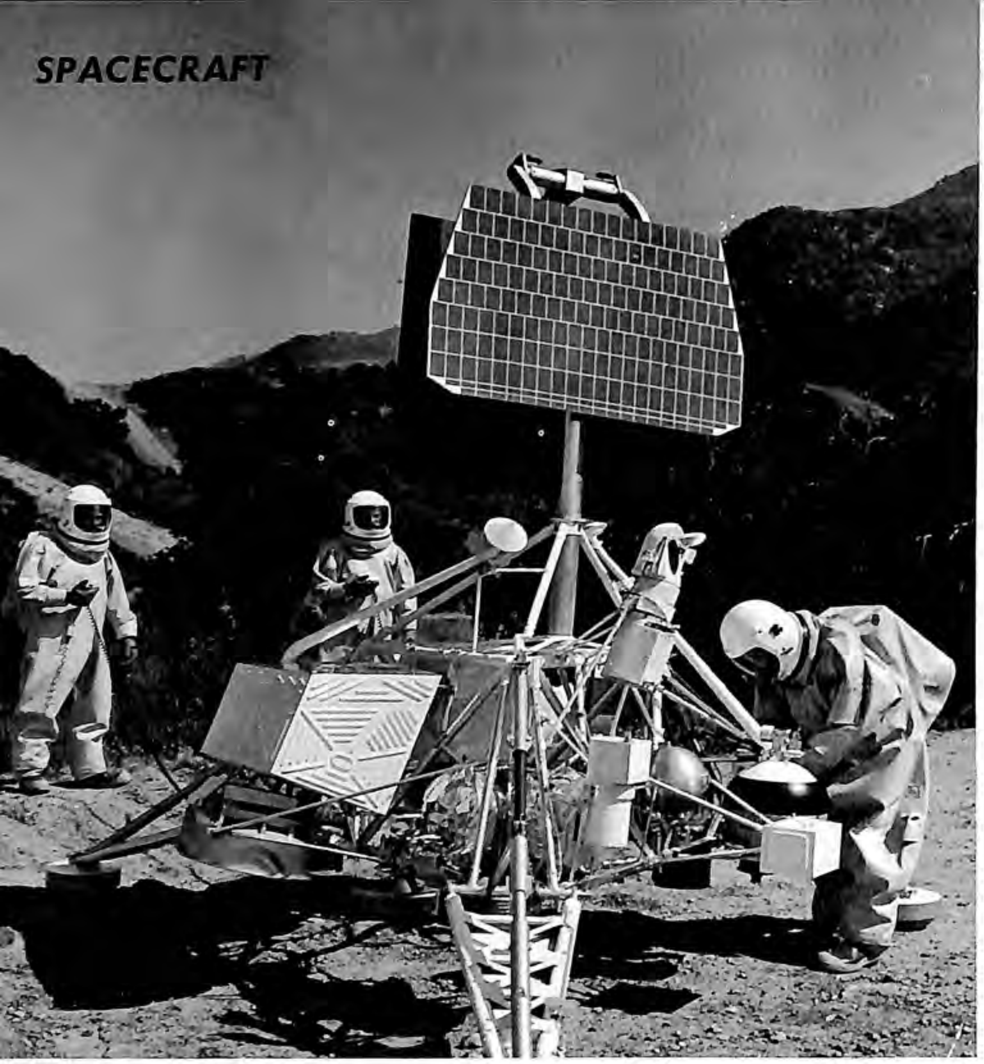
Boeing's Burner II, developed under Air Force contract as an upper stage space vehicle, made its first flight on September 15. It is the first upper stage designed for general space applications to employ a solid fuel rocket combined with full control and guidance capability.

GEMINI

The second phase of NASA's manned space flight program, Project Gemini, came to a highly successful conclusion on November 15 when Gemini 12 splashed down in the Atlantic within 3 miles of the recovery ship, the USS *Wasp* (in photo, astronauts Edwin Aldrin, left, and James Lovell, leave helicopter which flew them from impact point to the *Wasp*). There were 5 manned flights during the year, bringing the total to 12, 10 manned and 2 unmanned. (For details see Government Research and Development, NASA). The Gemini program saw the first manned maneuvers in space, the first rendezvous, first docking and the longest space mission up until the end of 1966, Gemini 7's 330 hours 35 minutes. It brought U.S. total manned spacecraft hours to 1,016 (compared with 433 for the USSR) and U.S. total man-hours in space to 1,994 (compared with 507). The final mission of the program set a record for extravehicular flight, when Aldrin remained outside his spacecraft for 5 hours 37 minutes. Major contractors participating in Gemini included McDonnell Company, prime; Rocketdyne, spacecraft propulsion; IBM, guidance system integration and computer; General Electric, fuel cells; Honeywell, guidance; Westinghouse, rendezvous radar; and AiResearch, environmental control system.

APOLLO

During 1966, NASA conducted 2 unmanned test flights of the Apollo Command and Service Modules (the third segment, the Lunar Module, was to be tested separately in 1967 prior to mating of all 3 modules on later flights). The formal start of the Apollo program came on February 23 with the launch of the first flight-rated spacecraft into a ballistic trajectory that ended with a splash in the Atlantic Ocean. Main purposes of this flight, successfully achieved, were systems checkouts and a test of the heat shield in one type of re-entry path. On the second flight, August 25, a different trajectory was followed; the spacecraft was sent into a suborbital path that took it three-quarters of the way around the world to a long, shallow re-entry. Photo shows how Apollo re-entered: first, at right, rockets fire to jettison the Service Module, then Command Module is pitched over and small roll engines position it for re-entry. The heat shield "ablates," or boils away, keeping the spacecraft interior cool by absorbing the energy of re-entry friction. Command and Service Modules are built by North American Aviation, Lunar Module by Grumman Aircraft Engineering Corporation.

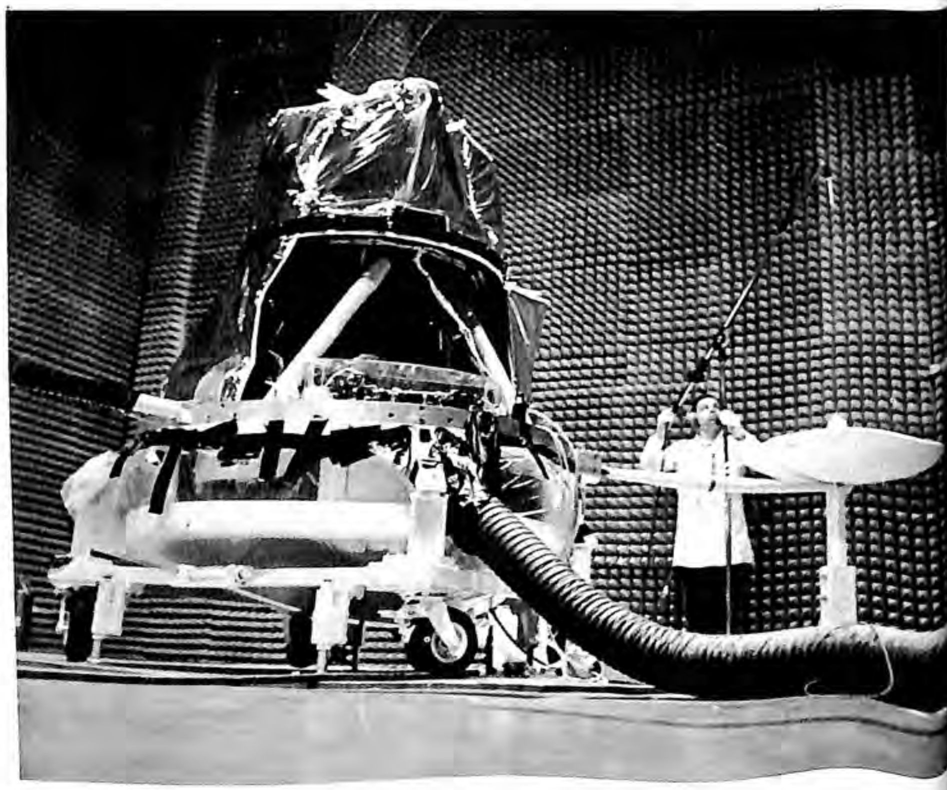


SURVEYOR

One of the most spectacular missions of the U.S. space program started with the May 30 launch of Surveyor 1, designed to study the surface of the moon. After a 63.6 hour flight, the craft successfully landed on the moon and sent back 11,150 photos up to July 13. Subsequent exposure to the cold lunar "nights" reduced Surveyor's transmitting capability, but usable signals were received as late as October. Program participants include Jet Propulsion Laboratory, management; Hughes Aircraft, spacecraft; Thiokol, rockets; and Ryan, radar altimeter and doppler velocity sensor system. In photo, Hughes technicians prepare to check out the vernier engine system.

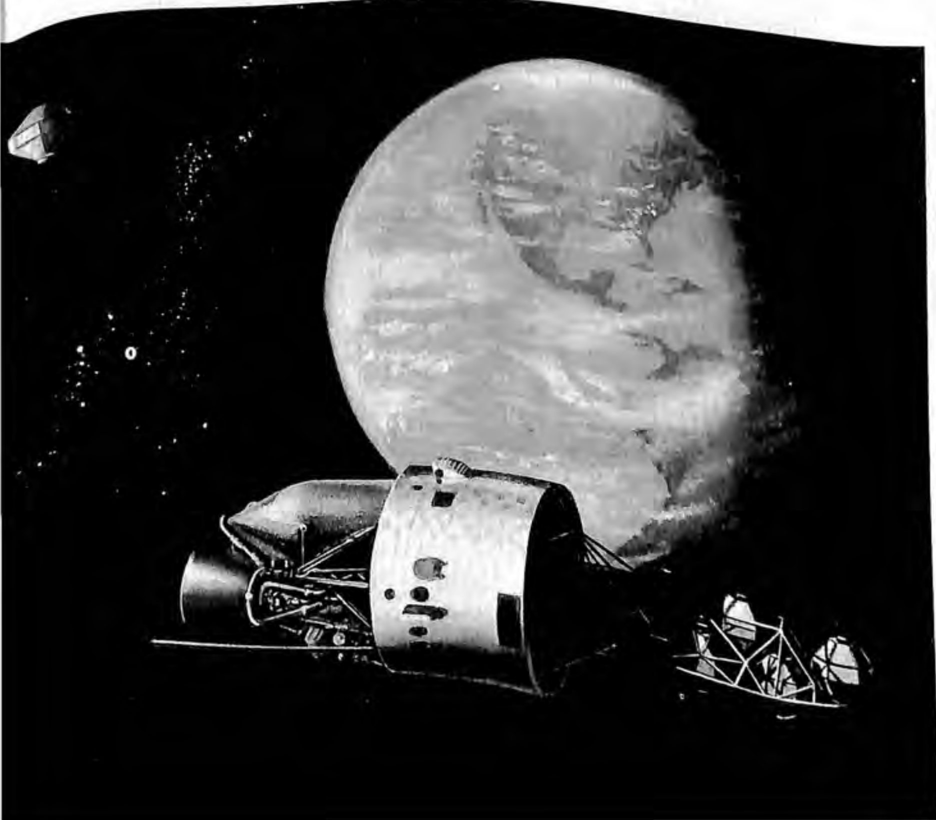
LUNAR ORBITER

Companion to Surveyor, Lunar Orbiter aids in selection of a site for the first manned lunar landing by taking complementary photos from lunar orbit. NASA flew 2 successful missions during the year; Lunar Orbiter 1 was launched August 10, Lunar Orbiter 2 on November 6. The 2 spacecraft combined sent more than 800 excellent photos of the moon, taken from altitudes of about 30 miles above the lunar surface. Boeing builds the spacecraft, RCA supplies power and communications, Eastman Kodak the cameras and Marquardt the maneuvering engine. In photo, Lunar Orbiter undergoes a simulated lunar transmission test at the Goldstone tracking station.



INTELSAT 2

An advanced commercial cosmat, designed also for use in support of the Apollo program, Intelsat 2 takes its name from the International Telecommunications Satellite Consortium, the 54 nation group for which the U.S. Communications Satellite Corporation serves as launch manager. Intelsat 2, bigger and more powerful than its predecessor, Early Bird, is designed to operate in synchronous orbit to provide satellite communications over the Atlantic and Pacific. The first Intelsat 2, unofficially called Lani Bird, was launched October 26; though it did not attain the exact orbit desired, it was able to handle transmissions between the Pacific areas and the continental U.S. Hughes Aircraft was building 3 additional Intelsat 2's.

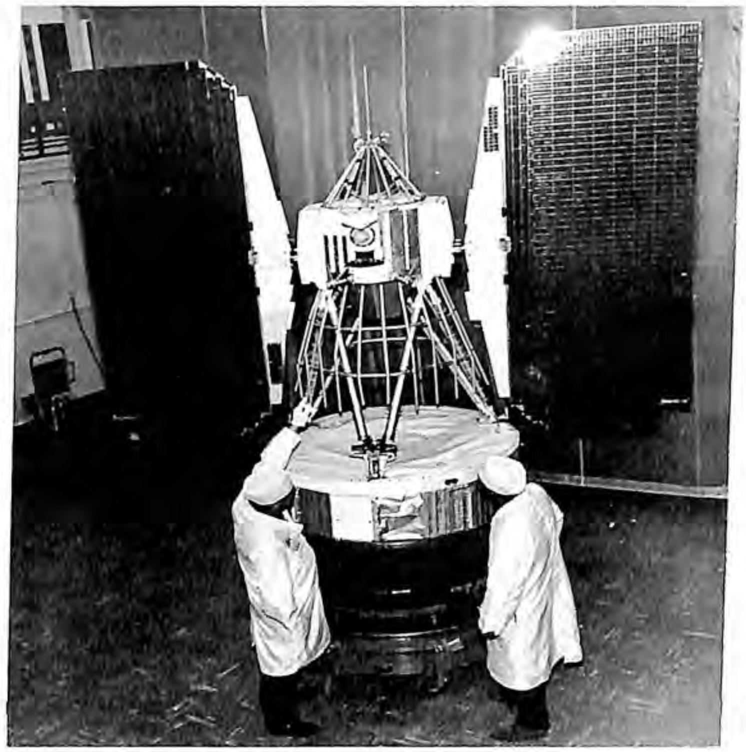


IDCSP

On June 16, a Titan III-C launched into obit the first increment of 7 spacecraft for the IDCSP (Initial Defense Communications Satellite Program). Launch of an additional 8 in 1967 was to round out the military comsat network, replacements to be sent up as required. The 100-pound, Philco-built satellites operate in circular equatorial orbit at 21,000 miles altitude. Photo shows how the Martin/Aerojet Transtage, upper stage of the launch vehicle which serves in this instance as a space delivery truck, ejects the comsats 1 at a time from a dispenser mechanism.

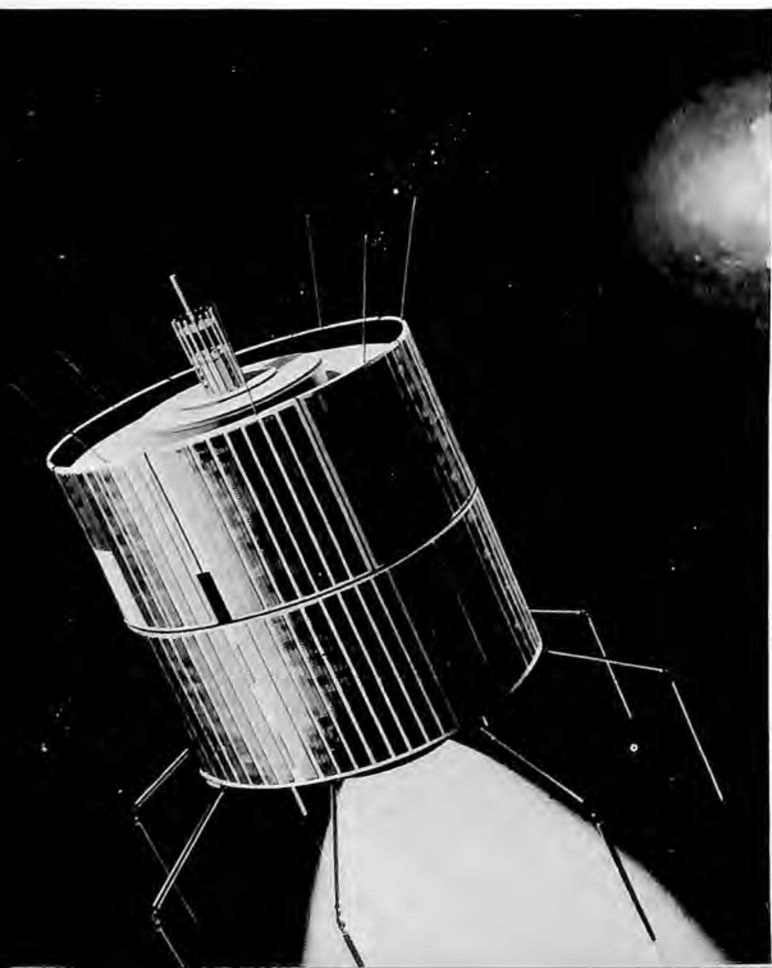
TIROS/ESSA

The Environmental Science Services Administration deployed a global operational weather observation system with launches of ESSA 1 on February 3, ESSA 2 on February 28 and ESSA 3, replacement for ESSA 1, on October 2. All functioned successfully. The spacecraft were advanced versions of the TIROS developed for NASA by Radio Corporation of America. In photo, ESSA 3.



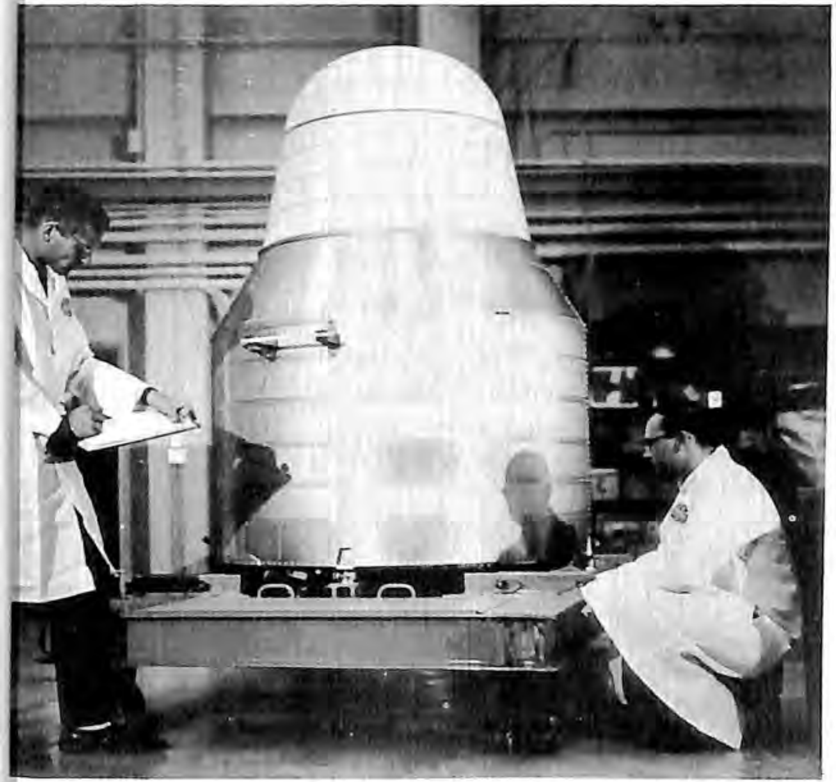
NIMBUS

The earth-oriented Nimbus 2, built by General Electric with RCA supplying the vidicon cameras, was launched May 15 into a near-polar circular orbit at 700 miles altitude. The advanced experimental weather satellite attained its objective of 60 days of trouble-free operation and continued to operate long afterward. In the original 60-day period, it returned more than 150,000 photos.



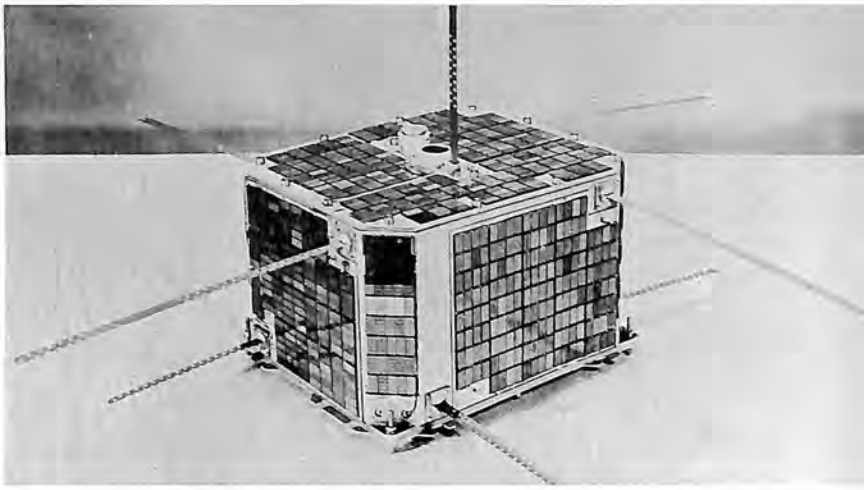
APPLICATIONS TECHNOLOGY SATELLITE

The first of 5 multipurpose spacecraft designed to handle a number of experiments in the applications field (Applied Technology Satellites), ATS 1 was launched December 6. Built by Hughes with General Electric responsible for stabilization, the 700-pound satellite transmitted color TV between North America, Asia and Australia, conducted communications tests with airborne jets and took a dramatic series of photographs of the earth from an altitude of 22,300 miles.



BIOSATELLITE

On December 14, NASA launched Biosatellite 1, first of a series of General Electric-built spacecraft designed for a large scale study of the effects of space on living organisms. The 940-pound spacecraft, which included a 4-foot re-entry vehicle, carried 13 biological experiments into a 170 mile circular orbit. Organisms included bacteria, bread mold, plant life, frog eggs and fruit flies.



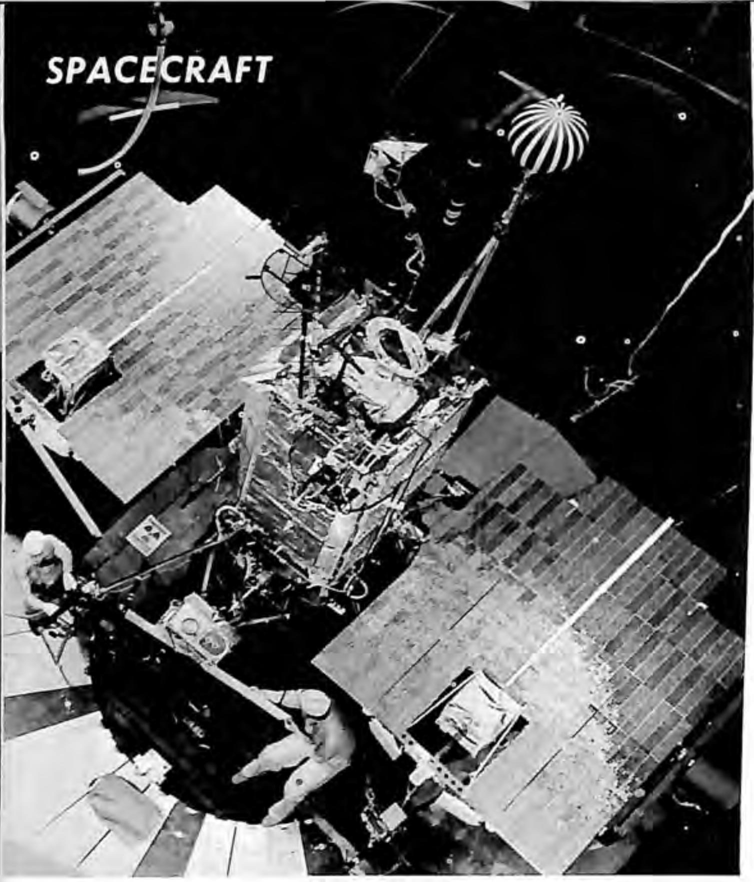
SECOR

The Army added 2 additional spacecraft to its network of SECOR geodetic/precision mapping satellites built by Cubic Corporation. SECOR 6 was launched June 9, SECOR 7 August 19. The latter was the first of a new series of active geodetic satellites.

PAGEOS

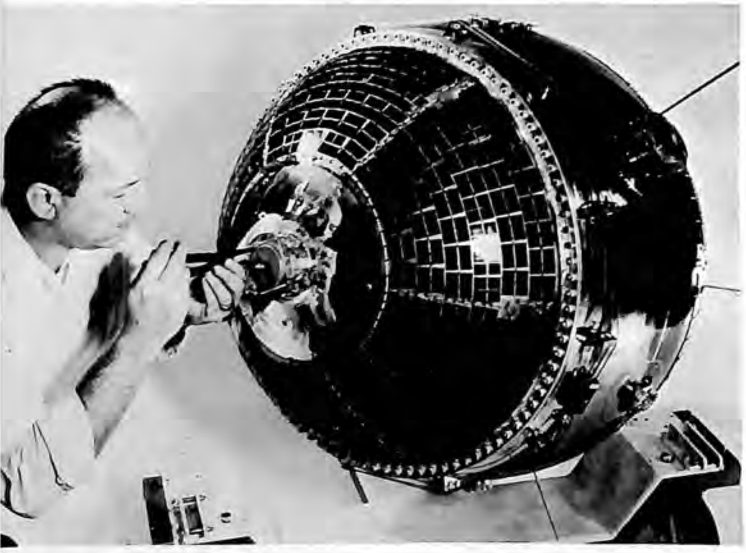
Launched June 23 was PAGEOS, a passive geodetic satellite used by the U.S. Coast and Geodetic Survey and the Army Map Service in connection with 41 ground stations around the world to develop a worldwide reference grid. PAGEOS, built by Goodyear Aerospace Corporation under NASA contract, is shown here in its launch canister; in space it inflates to 100 feet diameter and serves as a photographic target in space.

SPACECRAFT



ORBITING GEOPHYSICAL OBSERVATORY

The third of the Orbiting Geophysical Observatory family designed to investigate the relationship between the sun, earth and the space environment, was sent into a highly elliptical orbit reaching an apogee of more than 75,000 miles. The spin-stabilized OGO 3, launched June 7, continued to return data from 20 experiments after achievement of the 30 days in stabilized condition objective. TRW Systems is spacecraft prime contractor.

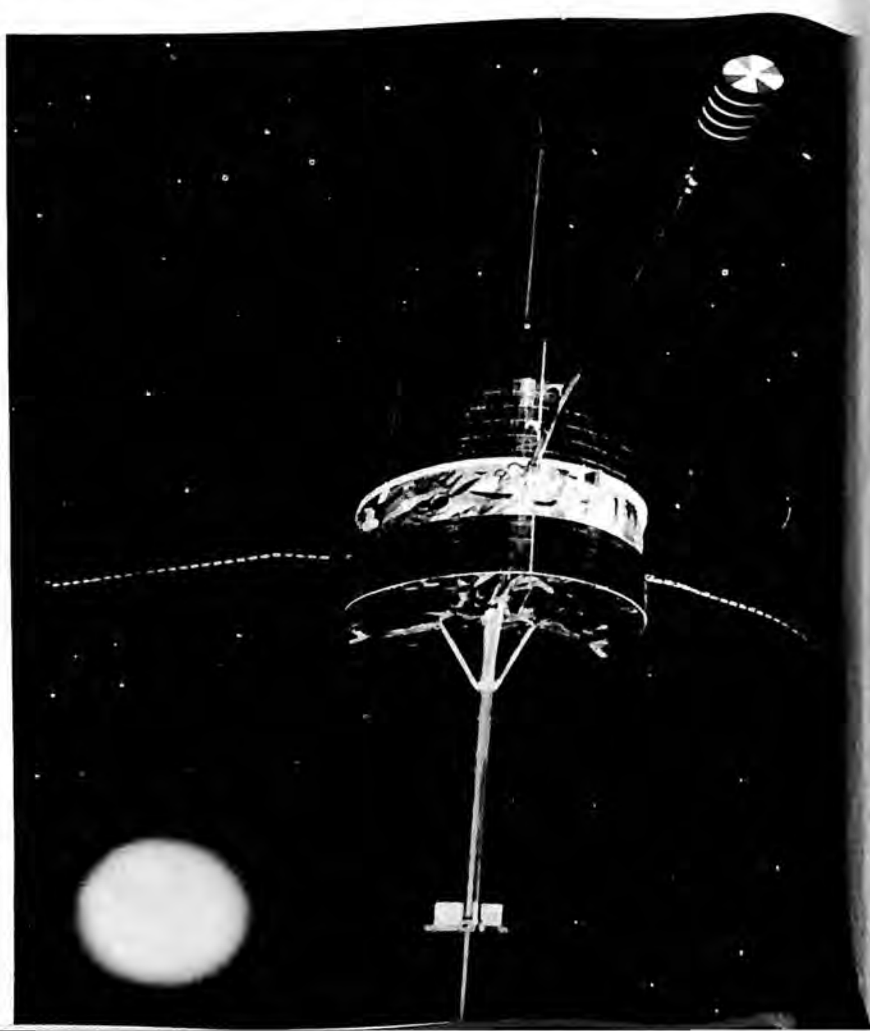


EXPLORER

Explorer is not a specific spacecraft but a code name given a series of scientific spacecraft of varying configurations, payloads and assignments. The 1966 members of the series were Explorers 32 (photo), sent into earth orbit on May 25 for aeronomy studies, and Explorer 33, an Interplanetary Monitoring Platform which failed to achieve its planned high-altitude orbit around the moon.

PIONEER

NASA continued its Pioneer series, solar-orbit spacecraft designed to investigate such areas as interplanetary magnetic fields, low energy charged particles, high energy particles, cosmic rays, electron density and micrometeoroids. Built by TRW Systems, Pioneer 7 was successfully launched on August 17.

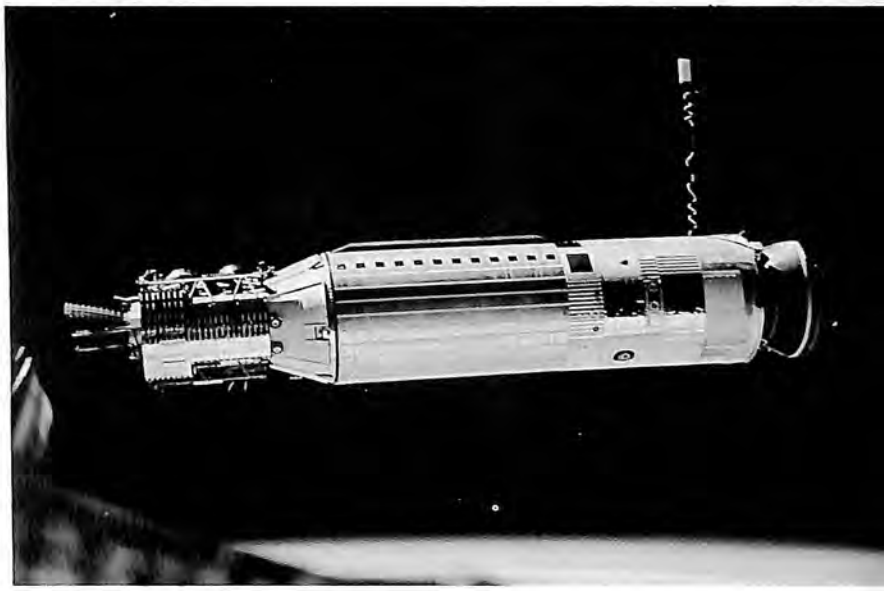


USAF ORBITING VEHICLES

During 1966, the Air Force launched 13 satellites called OV's (for Orbiting Vehicle) as part of its Aerospace Research Satellite Program, a project conducted by the Office of Aerospace Research to put low-cost experimental packages in space. Of varying design and purpose, the OV's are built by several companies, among them General Dynamics/Convair, Northrop, Space General Corporation, TRW Systems and Goodyear Aerospace. In photo, the Goodyear OV1-8, launched July 14 as a communications experiment.

AGENA

In addition to its service as a launch vehicle upper stage, the Lockheed-built Agena doubled in 1966 as a spacecraft, serving as the target vehicle on all Gemini missions involving rendezvous and docking. It participated in the world's first successful docking of 2 spacecraft with Gemini 8, in the first dual rendezvous (Gemini 10 with Agena 10 and Agena 8) and the first 1-orbit rendezvous, with Gemini 11.



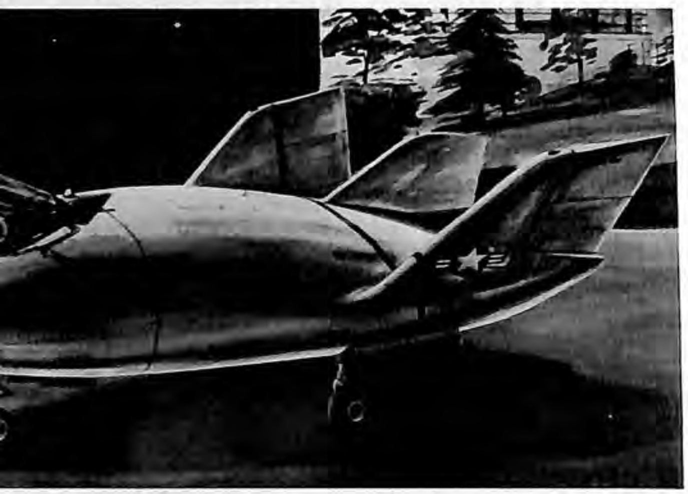
SCANNER

On August 16 and December 9, NASA conducted successful suborbital flights of Project Scanner vehicles. The Honeywell-built spacecraft are designed to explore horizon definition and measurement toward development of advanced stabilization and guidance equipment.

LIFTING BODIES

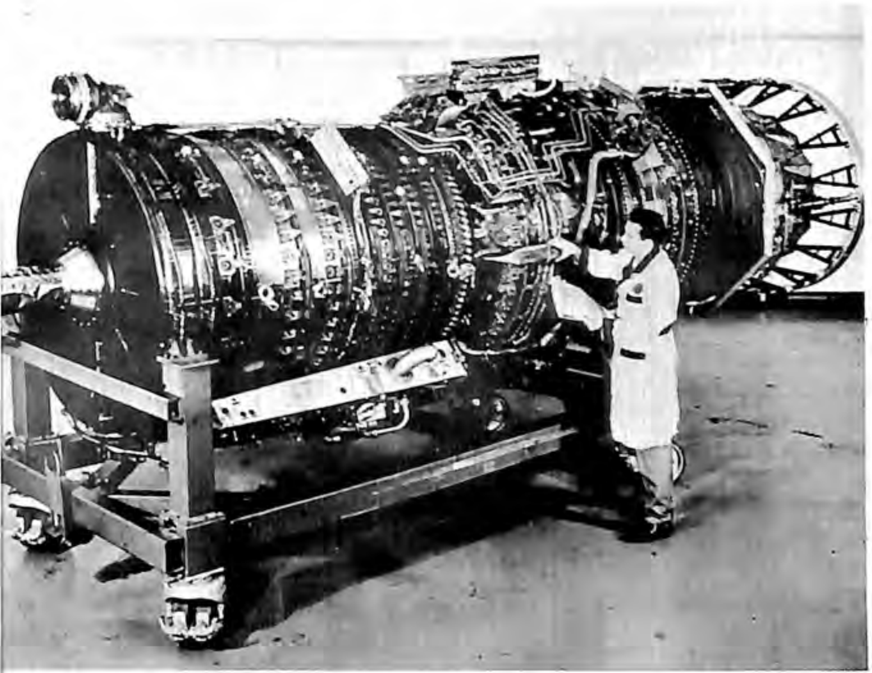
Neither aircraft nor spacecraft, strictly speaking, but containing characteristics of both are the "lifting bodies," tools of a new research program that reached flight status in 1966. A coordinated effort involving NASA and Air Force vehicles, lifting body research explores one aspect of an earth-to-orbit ferry craft that could be maneuvered during reentry and controlled to a landing at an ordinary airfield. With several types of manned and unmanned craft, researchers will investigate wingless vehicles that derive their lift from their bodies in speed ranges from about 15,000 miles per hour down to touchdown speed. The tool for the higher speed ranges, down to Mach 2, is the USAF's PRIME vehicle, the SV-5D (photo A). A small, unmanned, thumbnail-shaped craft, SV-5D is launched to orbital altitudes, directed into a reentry path and maneuvered by command during its descent. The first of 4 Martin-built SV-5D's made a flight on December 21. Behind it, for investigating the area from Mach 2 to landing speed, are 3 manned rocket-powered craft: the SV-5P (B), built by Martin for the USAF's PILOT project, and the Northrop-built M2 (C) and HL-10 (D), NASA vehicles. M2 made 14 glide flights during 1966 and HL-10 was being readied for flight at year-end; both were to start rocket-powered flights early in 1967. The SV-5P was under construction at year-end, slated to fly late in 1967.

A



B

C

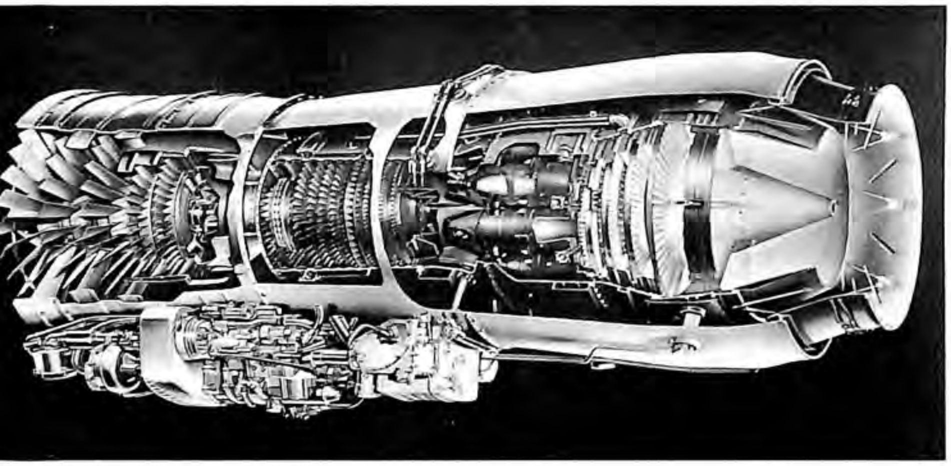


GENERAL ELECTRIC GE4

At year-end, the Federal Aviation Agency announced selection of the General Electric GE4 engine as power plant for the U.S. supersonic transport to be built by The Boeing Company. During FAA Phase II-C testing, a prototype model of the GE4 attained a thrust rating of 52,600 pounds in a test cell. Flight engines, however, will develop more than 60,000 pounds thrust. The engine is 6 feet in diameter and 25 feet long.

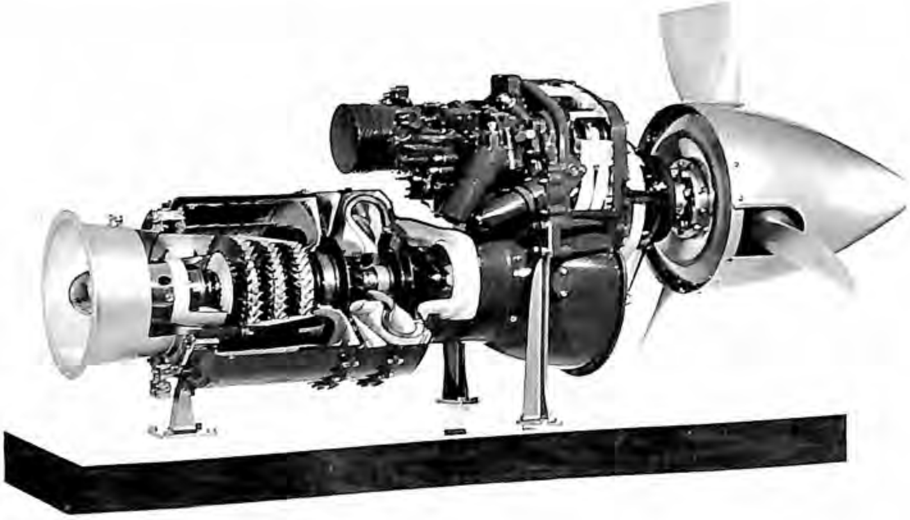
PRATT & WHITNEY AIRCRAFT JT9D-1

In photo, 2 workhorse Pratt & Whitney Aircraft commercial power plants are dwarfed by the company's new JT9D-1 turbofan engine (center) which will power the Boeing 747 jet. At left is the 3,000 pound thrust JT12 which powers the Lockheed JetStar and North American Sabreliner; at right the JT3D, the world's most widely used turbofan. The JT9D-1, actually 9 inches shorter than the JT3D, develops 41,000 pounds thrust, weighs 8,580 pounds, has a 5 to 1 bypass ratio and is 125 inches long.



ALLISON TF41

Allison Division of General Motors Corporation initiated development for the Air Force of the TF41, an advanced version of the Rolls-Royce RB-168-25 turbofan. The engine, to be used on USAF close support aircraft, develops 14,250 pounds thrust. It was scheduled to enter production in 1968.



AIRESEARCH TPE 331

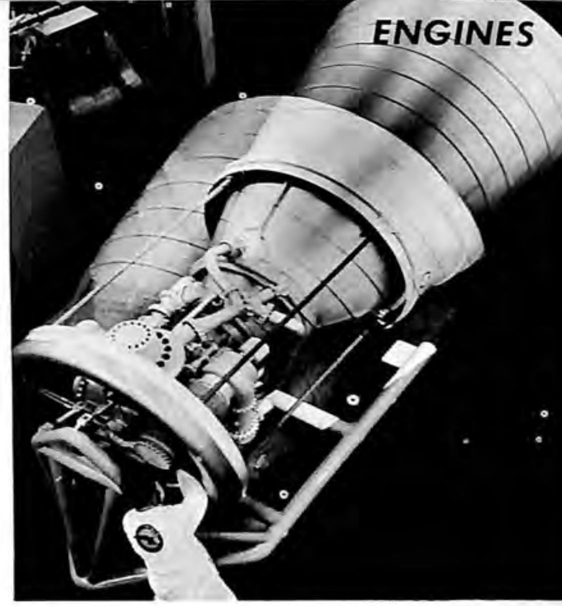
The Garrett Corporation's AiResearch Manufacturing Company announced development of a new version of its TPE 331, increasing its output from 605 to 700 equivalent shaft horsepower. The T76, military version of the engine, was selected to power the North American OV-10A.

AVCO LYCOMING T55

Avco Lycoming Division introduced to production a new model of its T55 engine. The T55-L-7C, rated at 2,850 shaft horsepower, made its flight debut in October in the Boeing Vertol CH-47B helicopter.

ROCKETDYNE AEROSPIKE

Rocketdyne developed a new rocket engine concept called Aerospike. The "toroidal" shaped engine can be arranged compactly to fit the geometrical shape of the vehicle it will propel. Applicable to either booster or upper stages, it employs a doughnut-shaped combustion chamber discharging its exhaust gases against a short center cone.



AEROJET 260-INCH SOLID

In February, Aerojet-General Corporation made a test firing of the world's most powerful solid rocket motor. The 260-inch diameter motor developed a thrust of 3,600,000 pounds. The motor was the second built and tested for NASA in a technology program that could lead to propulsion systems of 10,000,000 pounds thrust.

PRATT & WHITNEY AIRCRAFT 2-POSITION NOZZLE

Pratt & Whitney Aircraft developed a new concept for advanced rocket engines, the "2-position nozzle" for a shorter engine and higher specific impulse. The double image photo shows the position of the nozzle in both the extended and retracted position when adapted to the company's RL20 high pressure rocket engine.

UNITED TECHNOLOGY SOLID MOTORS

During 1966, United Technology Center's 120-inch diameter solid booster rockets performed flawlessly on 3 flights of the USAF's Titan III-C launch vehicle. UTC's smaller FW-4 upper stage solid motor also progressed in development and sales; new orders brought to more than 50 the number of FW-4's built or scheduled for production. In addition, UTC received 2 major USAF contracts for development of hybrid rocket propulsion systems.

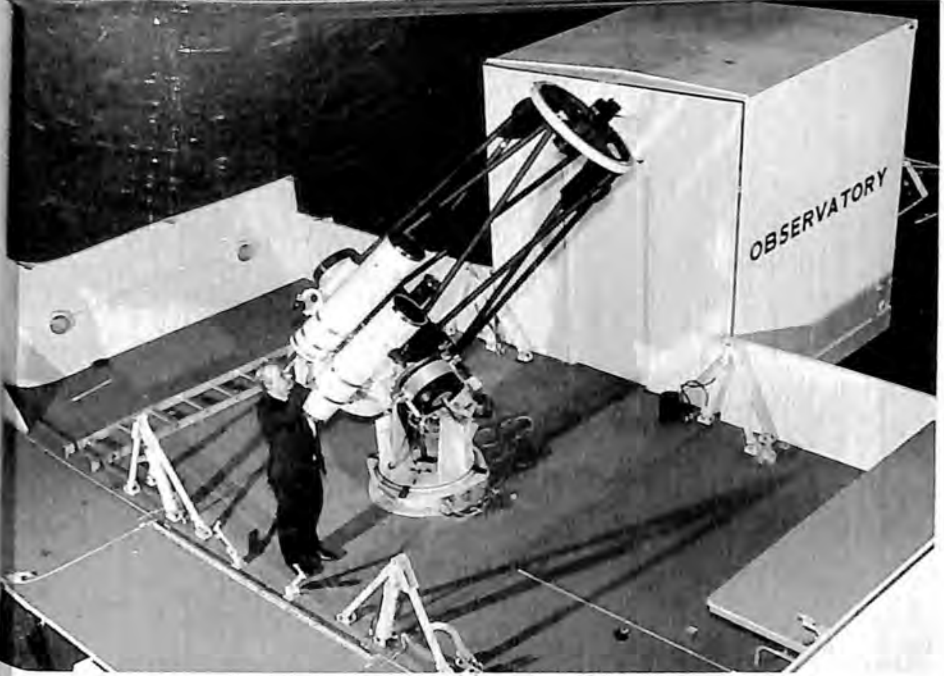
The term "systems" is used here to cover the equipment developed and built by the aerospace industry other than primary products, like aircraft, missiles and spacecraft. The systems shown are representative of the extremely broad industry product line.

HUGHES TERMINAL

Hughes Aircraft technicians are dwarfed by the giant antenna of the company's Mark 1B satellite communications ground link terminal being built for the Army. The terminal, which operates with the Initial Defense Communications Satellite Program, is air transportable and can be erected in 48 hours.

WESTINGHOUSE SPACE RADIO

Astronauts in space or on the moon, enclosed in a protective suit and in a vacuum, cannot talk to each other. To solve the problem, Westinghouse Defense and Space Center developed, under USAF contract, a radio communicator. The system consists of a transceiver for sending or receiving, located in the helmet, and a control unit mounted on the space suit (in development model shown, transceiver is packaged in box by engineer rather than in helmet).



GOODYEAR OBSERVATORY

Technician aims a 24-inch telescope, part of a completely mobile observatory for tracking and measuring satellites built by Goodyear Aerospace Corporation for NASA. Weighing 16 tons, the observatory can be moved into any terrain accessible by auto.

SPERRY ACCELEROMETER, GYROSCOPE

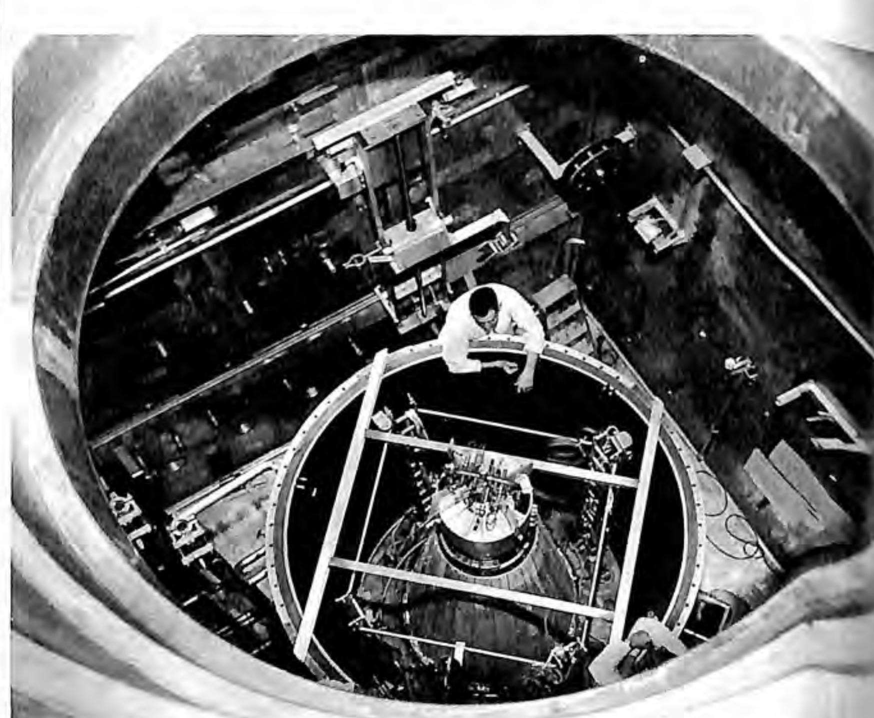
In photo, the small instrument at left is the Sperry 16 PIP (Pulse Integrating Pendulum) accelerometer used in the Apollo spacecraft. Three of these units, mounted on an inertial platform, provide continuous velocity and direction data. At right is the SYG-1000 floated integrated miniature gyroscope, which makes measurements of attitude during maneuvers of the Lunar Orbiter spacecraft. Both units were developed by Sperry Gyroscope Division of Sperry Rand Corporation.

RYAN ALTIMETER

Test engineer checks Ryan Aeronautical Company's new Model 602 radar altimeter. The system will be used by NASA's Apollo astronauts as they rehearse landing on the moon in the Lunar Landing Training Vehicle.

MARTIN SNAP-29

A half-scale model of SNAP-29, the space nuclear generator being developed for the Atomic Energy Commission by Martin Company/Baltimore, was unveiled in November. Fueled with polonium-210 and capable of developing 500 watts, SNAP-29 will be used on earth orbital or lunar surface missions to provide electrical power for up to 90 days.

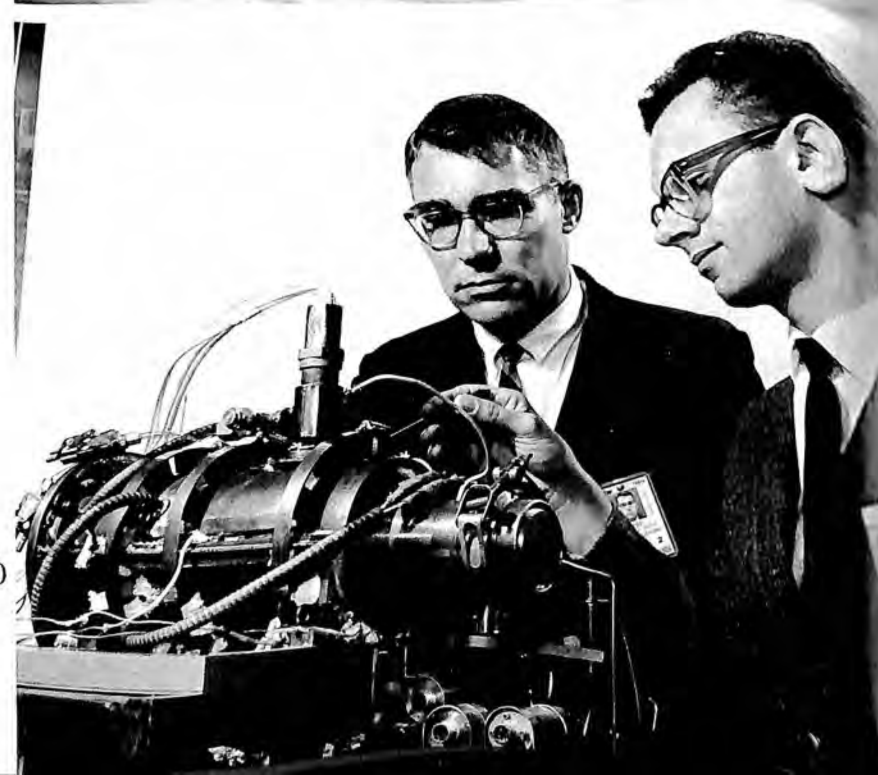


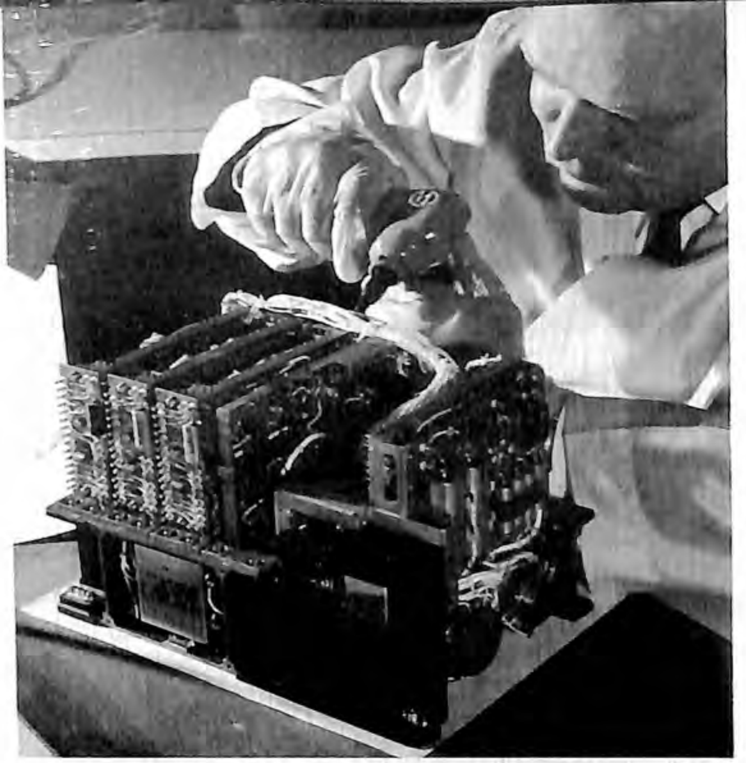
ATOMICS INTERNATIONAL SNAP-10A

A flight-qualified SNAP-10A nuclear reactor power system for space completed a full year of continuous electricity generation without adjustment by a human operator. The 500 watt system is being developed for the Atomic Energy Commission by Atomics International, a division of North American Aviation.

TRW TURBOALTERNATOR

The CRU V turboalternator assembly, designed to provide electric power for lengthy space missions, is inspected after a 4,700 hour test run. The system is being developed under subcontract to Atomics International by TRW Inc. as part of AEC's SNAP Mercury Rankine program to produce a 10,000 hour power conversion system.





SPERRY IRU

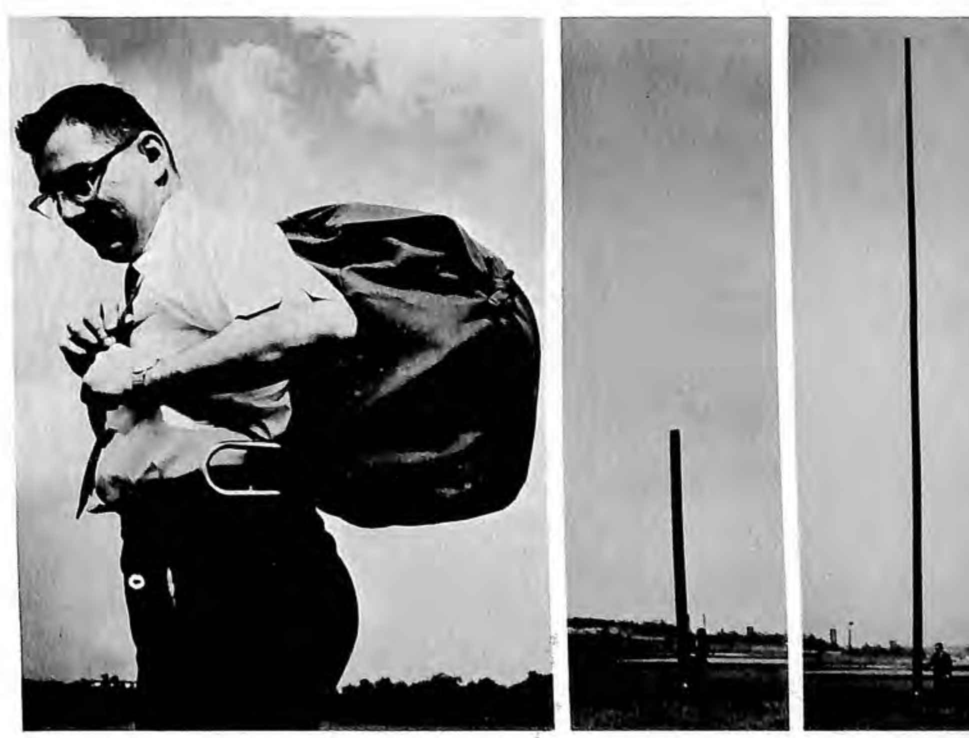
Sperry Gyroscope designed and built the Inertial Reference Unit (IRU) for the Lunar Orbiter spacecraft. IRU provides data critical to the attitude control system for pointing the spacecraft and its camera; it also supplies data for control of the rocket "burn" and for maintaining the proper attitude of the spacecraft while it is sending photos to earth.

RCA CAMERA

The most sensitive camera ever built for space operation was designed by Radio Corporation of America's Astro-Electronics Division for use aboard the Orbiting Astronomical Observatory. The RCA camera is the only TV eye of the spacecraft, which will study ultraviolet, X-rays and gamma rays.

GOODYEAR MAST

Goodyear Aerospace developed a 60-foot antenna mast that can be carried in a backpack. Photo sequence shows the backpack, the inflatable mast in process of deployment and, at right, the mast fully extended.



LTV ASTRONAUT MANEUVERING UNIT

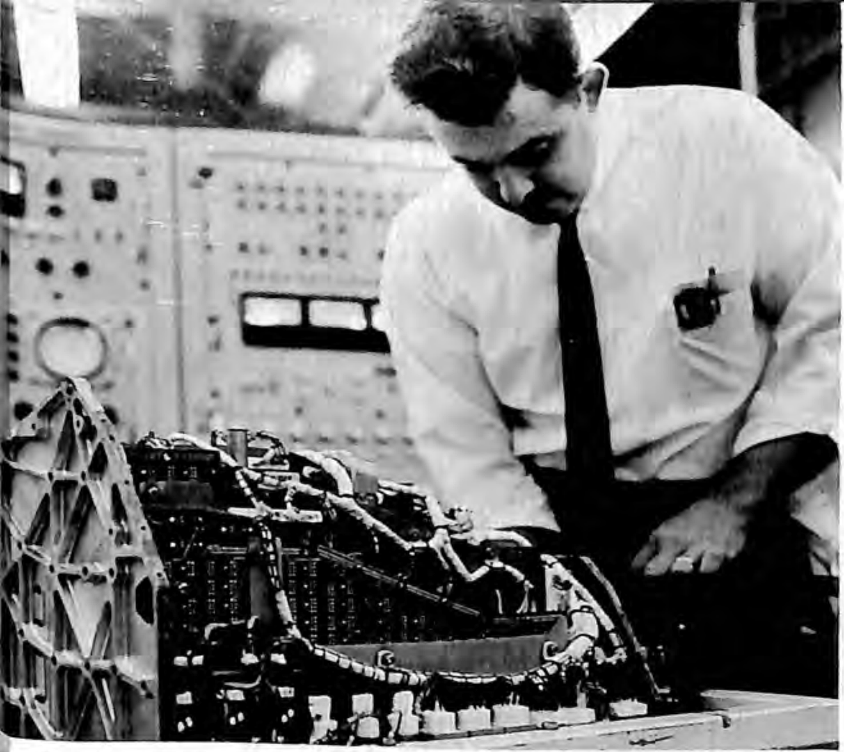
Under consideration for use in the Apollo program is the Astronaut Maneuvering Unit, developed for the Air Force by LTV Aerospace Corporation. It is designed to convert an astronaut in a pressure suit into a 1-man vehicle for performing space tasks outside his orbiting spacecraft.

BELL POGO STICK

Textron's Bell Aerosystems Company developed the Pogo Stick, a stand-up unit which permits its operator to step aboard a rocket propulsion system and fly. It is designed for a wide variety of missions both on earth and in the lunar environment.

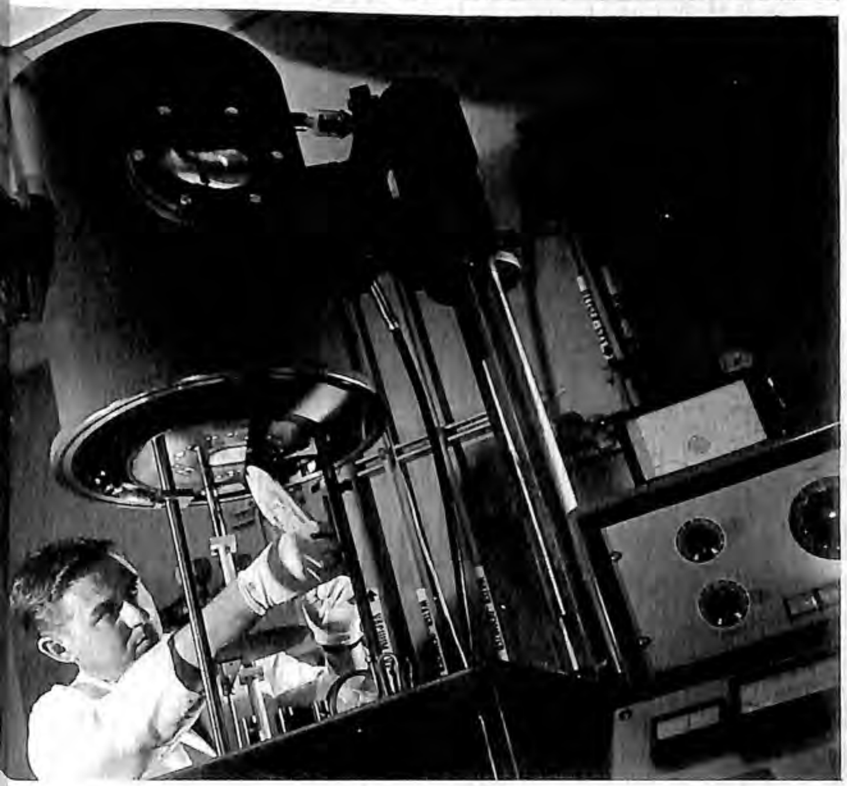
BELL FLYING CHAIR

Companion unit to the Pogo Stick is Bell Aerosystems' Flying Chair, shown here in a test flight at Niagara Falls International Airport. Rocket-powered, the system is designed for transporting men and equipment over earth terrain or over the surface of the moon.



IBM COMPUTER

At IBM's Electronic Systems Center, the GT-11 computer undergoes "debriefing," or post-flight inspection. The compact system guided Gemini astronauts on rendezvous and docking missions, including a first orbit rendezvous on Gemini 11.

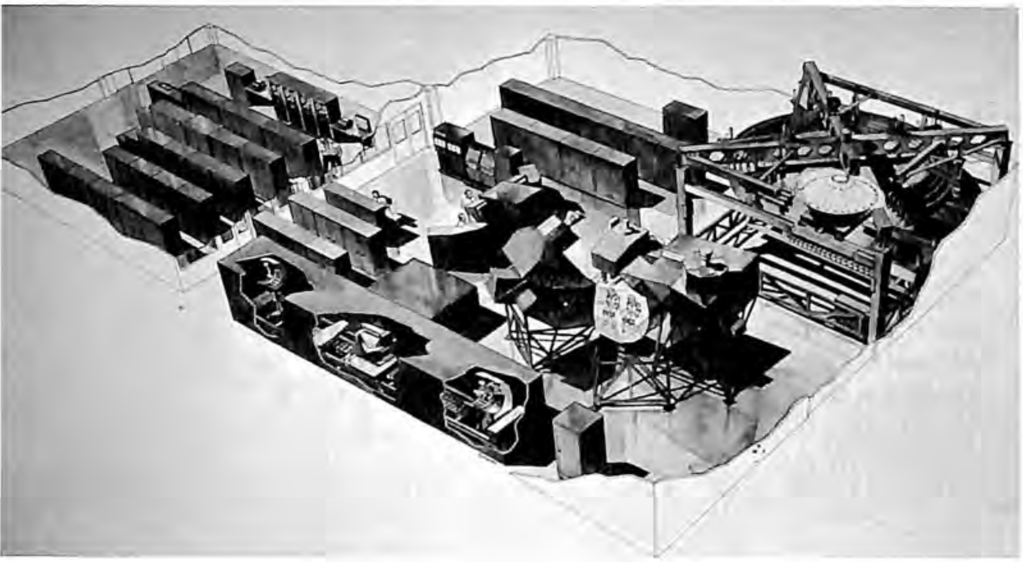


AUTONETICS AVIONICS

In photo, technician uses vacuum pressure technique to apply thin-film circuits to wafers for microelectronic computers employed in the F-111 avionics system. North American's Autonetics Division received contracts in June for 2 such systems, the Mark II for the F-111A tactical fighter and the Mark IIB for the FB-111 bomber.

GOODYEAR ARMOR

Contrasted with medieval armor is the 1966 version, which combines a ceramic facing and fiberglas backing. Worn by helicopter crewmen in battle action, the lightweight armor was designed by the Army's Natick Laboratories and built by Goodyear Aerospace.

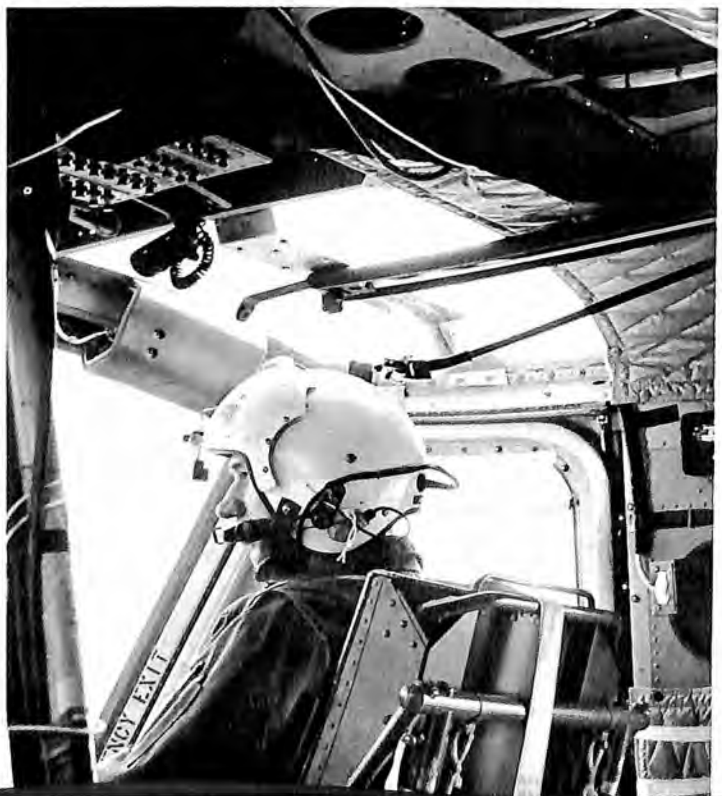


LINK SIMULATOR

For earth training of lunar mission astronauts, General Precision's Link Group developed the Lunar Module Mission Simulator, an exact replica of the internal Lunar Module environment. By means of an intricate combination of optics, mechanics and electronics, it accurately duplicates lunar mission operations such as separation of the modules, lunar approach, stay, launch and rendezvous for earth return.

RCA DIELECTRIC TAPE CAMERA

RCA engineer loads a dielectric tape camera with a unique electronic "film" prior to test of the new space-age imaging system. The camera system, which combines the functions of TV camera and tape recorder in a single unit, can be used for weather surveillance, lunar or planetary mapping or natural resources analysis.

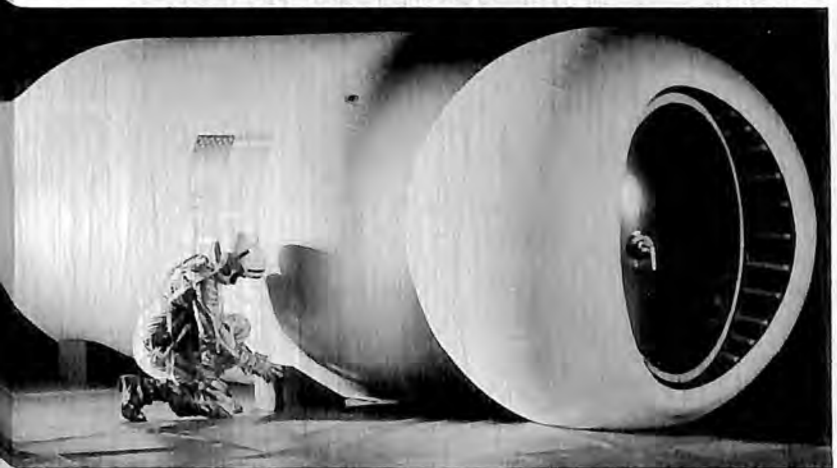


SPERRY VIPRE-FIRE

In photo is the helmet sight portion of Sperry Utah's VIPRE-FIRE (Visual Precision Fire Control) installed in a UH-1A helicopter. The sight reticle, mounted on the helmet, allows the pilot to train his guns on a target by turning his head and looking at it. An overhead linkage measures head movement and transmits an electrical signal to the guns.

GPL TALAR

A STOL airplane demonstrates the use of the TALAR landing approach system developed by GPL Division of General Precision, Inc. TALAR offers a low-cost solution to the problem of providing low-approach instrument landing capability for any aircraft or any airfield, particularly small private airfields now usable only during good weather. The system consists of a 25-pound portable transmitter on the ground and a 4-pound receiver in the airplane.



GOODYEAR SHELTER

Goodyear Aerospace developed this expandable Stay Time Extension Module for possible use on NASA moon missions. Measuring about 13 feet in length and 7 feet in diameter, STEM could house and support astronauts for periods on the lunar surface up to 2 weeks.

LIBRASCOPE WOVEN MEMORY

Librascope Group of General Precision, Inc., introduced a new electronic memory for computers, telemetry systems, control systems and other systems that is automatically woven on a loom. Called the Woven Plated Wire Memory, it has one of the fastest access speeds available in magnetic memories and offers savings in space, weight and power.

NORTH AMERICAN X-15

The NASA/USAF X-15 research aircraft continued its record-shattering ways in 1966. On November 18, USAF Major William Knight piloted the plane to a peak speed of 4,223 miles per hour during a 9-minute flight. This set an all-time record for any type aircraft and topped the X-15's own 1962 mark of 4,104 miles per hour.

WORLD RECORDS

The National Aeronautic Association, which represents the United States in the Federation Aeronautique Internationale, sanctions, certifies and registers all record attempts within the U.S. in order that they may be officially recognized by other nations. NAA's Contest Board compiled this list of records completed in the U.S. during 1966.

CLASS	DATE	AIRCRAFT	PILOT	RECORD DESCRIPTION	RECORD
WORLD RECORDS (Absolute)					
MANNED SPACECRAFT					
---	9/13–15/66	Gemini 11	Cdr Charles Conrad, USN LCdr Richard P. Gordon, Jr., USN	Greatest altitude in earth orbit	850.65 miles
WORLD CLASS RECORDS MANNED SPACECRAFT					
K	7/1/66	Gemini 10	Cdr John Young, USN	Precision of landing	3.85 miles
K	11/11–15/66	Gemini 7/12	Cdr James A. Lovell, Jr., USN	Total time in space	425 hrs. 20 mins.
JET AIRCRAFT (Unrestricted Weight)					
				Speed over recognized courses:	
C–1	8/15–16/66	Douglas DC-8-61	A. G. Heimerdinger	Los Angeles/Tokyo	487.8 mph
C–1	8/18/66	Douglas DC-8-61	A. G. Heimerdinger	Tokyo/Winnipeg	510.12 mph
BUSINESS JET AIRCRAFT Class C-1.f (13,227–17,636 lbs.)					
C–1.f	5/23–26/66	Lear Jet Model 24	Henry G. Beaird	Speed around the world	350.11 mph
				Speed over recognized courses:	
C–1.f	5/26/66	Lear Jet Model 24	Henry G. Beaird	Anchorage/Seattle	468.25 mph
C–1.f	5/24/66	Lear Jet Model 24	Henry G. Beaird	Barcelona/Istanbul	455.07 mph
C–1.f	5/25/66	Lear Jet Model 24	Henry G. Beaird	Colombo/Singapore	417.88 mph
C–1.f	5/24/66	Lear Jet Model 24	Henry G. Beaird	Istanbul/Teheran	442.69 mph
C–1.f	5/24–25/66	Lear Jet Model 24	Henry G. Beaird	Karachi/Columbo	423.03 mph
C–1.f	5/26/66	Lear Jet Model 24	Henry G. Beaird	Los Angeles/Wichita	520.09 mph
C–1.f	5/25/66	Lear Jet Model 24	Henry G. Beaird	Manila/Osaka	543.49 mph
C–1.f	5/25/66	Lear Jet Model 24	Henry G. Beaird	Osaka/Sapporo	411.73 mph
C–1.f	5/24/66	Lear Jet Model 24	Henry G. Beaird	St. Johns/Santa Maria	458.49 mph
C–1.f	5/24/66	Lear Jet Model 24	Henry G. Beaird	Santa Maria/Barcelona	449.02 mph
C–1.f	5/26/66	Lear Jet Model 24	Henry G. Beaird	Seattle/Los Angeles	471.31 mph
C–1.f	5/25/66	Lear Jet Model 24	Henry G. Beaird	Singapore/Manila	376.20 mph
C–1.f	5/24/66	Lear Jet Model 24	Henry G. Beaird	Teheran/Karachi	453.45 mph
C-1.g (17,636–26,455 lbs.)					
C–1.g	6/4–7/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Speed around the world	267.33 mph
				Speed over recognized courses:	
C–1.g	6/7/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Anchorage/Seattle	460.09 mph
C–1.g	6/5/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Athens/Teheran	395.64 mph
C–1.g	6/6/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Bombay/Colombo	484.09 mph
C–1.g	6/6/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Colombo/Manila	263.84 mph
C–1.g	6/7/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Los Angeles/New York	357.48 mph
C–1.g	6/7/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Los Angeles/Oklahoma City	461.52 mph
C–1.g	6/5/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Madrid/Athens	436.68 mph
C–1.g	6/6/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Manila/Taipei	416.16 mph
C–1.g	6/6/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Manila/Tokyo	294.84 mph
C–1.g	6/4–5/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	New York/Madrid	325.62 mph
C–1.g	6/4/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	New York/St. Johns	462.24 mph

CLASS	DATE	AIRCRAFT	PILOT	RECORD DESCRIPTION	RECORD
				Speed over recognized courses:	
C—1.g	6/7/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Oklahoma City/New York	455.43 mph
C—1.g	6/4/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	St. Johns/Santa Maria	385.16 mph
C—1.g	6/4/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Santa Maria/Madrid	390.96 mph
C—1.g	6/7/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Sapporo/Anchorage	325.44 mph
C—1.g	6/7/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Seattle/Los Angeles	455.25 mph
C—1.g	6/6/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Taipei/Tokyo	477.57 mph
C—1.g	6/5/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Teheran/Bombay	266.87 mph
C—1.g	6/7/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Tokyo/Anchorage	294.44 mph
C—1.g	6/7/66	Jet Commander	Arthur Godfrey, Richard Merrill, Fred Austin, Karl Keller	Tokyo/Sapporo	389.12 mph
C—1.g	9/25/66	Jet Falcon	M. B. Burton	Boston/Gander	639.75 mph
C—1.g	9/26/66	Jet Falcon	George Eremea	Lajes/Lisbon	515.62 mph
C—1.g	9/27/66	Jet Falcon	George Eremea	Lisbon/Paris	534.06 mph
C—1.g	9/25/66	Jet Falcon	H. B. Burton	New York/Boston	550.62 mph
C—1.g	9/25/66	Jet Falcon	H. B. Burton	New York/Gander	622.44 mph
C—1.g	9/26/66	Jet Falcon	George Eremea	St. Johns/Lajes	514.15 mph
C—1.g	9/26/66	Jet Falcon	George Eremea	St. Johns/Lisbon	484.81 mph
C—1.g	9/16/66	Jet Falcon	George Eremea	Seattle/Los Angeles	539.28 mph

HELICOPTERS

E-1 (Unrestricted Weight)

E—1	4/6—7/66	Hughes YOH-6A	Robert G. Ferry	Distance in a straight line	2,213.04 miles
E—1	3/26/66	Hughes YOH-6A	Jack Schweibold	Distance in a closed circuit	1,739.96 miles
E—1	3/27/66	Hughes YOH-6A	Jack L. Zimmerman	Altitude in horizontal flight	26,448 feet
E—1	3/20/66	Hughes YOH-6A	CWO Richard D. Szczepanski, USA	Speed in a 2000 km closed circuit	141.523 mph

E-1.b (1102–2204 lbs.)

E—1.b	3/21/66	Hughes YOH-6A	Jack L. Zimmerman	Distance in closed circuit	1,056.408 miles
E—1.b	3/27/66	Hughes YOH-6A	Jack L. Zimmerman	Altitude in horizontal flight	26,448 feet
E—1.b	3/24/66	Hughes YOH-6A	LtCol Richard T. Heard, USA	Speed over a 3 km course	170.70 mph
E—1.b	3/24/66	Hughes YOH-6A	LtCol Richard T. Heard, USA	Speed over a 15/25 km course	171.85 mph
E—1.b	3/13/66	Hughes YOH-6A	Maj A. L. Darling, USA	Speed in a 100 km closed circuit	161.22 mph
E—1.b	3/13/66	Hughes YOH-6A	Maj A. L. Darling, USA	Speed in a 500 km closed circuit	155.19 mph
E—1.b	3/13/66	Hughes YOH-6A	Maj A. L. Darling, USA	Speed in a 1000 km closed circuit	158.19 mph
E—1.b	3/27/66	Hughes YOH-6A	Jack L. Zimmerman	Time to climb to 3000 meters	4 mins. 1.5 secs.
E—1.b	3/27/66	Hughes YOH-6A	Jack L. Zimmerman	Time to climb to 6000 meters	7 mins. 12 secs.

E-1.c (2204–3858 lbs.)

E—1.c	4/6—7/66	Hughes YOH-6A	Robert G. Ferry	Distance in a straight line	2,213.04 miles
E—1.c	3/26/66	Hughes YOH-6A	Jack Schweibold	Distance in a closed circuit	1,739.96 miles
E—1.c	3/27/66	Hughes YOH-6A	Jack L. Zimmerman	Altitude in horizontal flight	18,055 feet
E—1.c	3/23/66	Hughes YOH-6A	Col Joseph L. Gude, USA	Speed over a 3 km course	172.41 mph
E—1.c	3/12/66	Hughes YOH-6A	Col David M. Kyle, USA	Speed in a 100 km closed circuit	156.28 mph
E—1.c	3/12/66	Hughes YOH-6A	Col David M. Kyle, USA	Speed in a 500 km closed circuit	155.24 mph
E—1.c	3/12/66	Hughes YOH-6A	Col David M. Kyle, USA	Speed in a 1000 km closed circuit	153.09 mph
E—1.c	3/20/66	Hughes YOH-6A	CWO Richard D. Szczpanski, USA	Speed in a 2000 km closed circuit	141.523 mph
E—1.c	3/27/66	Hughes YOH-6A	Jack L. Zimmerman	Time to climb to 3000 meters	5 mins. 36.2 secs.

Turboprop Aircraft

C-1.f (13,227–17,636 lbs.)

C—1.f	7/17/66	Grumman OV-1 Mohawk	LCol J. J. Collins, USA	Distance in a straight line	2,385.12 miles

CLASS	DATE	AIRCRAFT	PILOT	RECORD DESCRIPTION	RECORD
C–1.f	6/17/66	Grumman OV-1 Mohawk	LCol E. L. Nielsen, USA	Speed in a 100 km closed circuit	293.41 mph
C–1.f	6/16/66	Grumman OV-1 Mohawk	James F. Peters	Time to climb to 3000 meters	3 mins. 45.6 secs.
C–1.f	6/16/66	Grumman OV-1 Mohawk	James F. Peters	Time to climb to 6000 meters	9 mins. 9.4 secs.
C–1.f	6/16/66	Grumman OV-1 Mohawk	James F. Peters	Altitude in horizontal flight	32,000 feet

Piston Engine Aircraft

C-1 (Unrestricted Weight)

C–1	6/1–7/66	Beech Baron C55	Robert Wallick	Speed around the world	186.53 mph

C-1.b (1102–2204 lbs.)

C–1.b	7/3/66	Aero Commander 200	William Brodbeck	Speed over a 3 km course	227.488 mph

C-1.c (2204–3858 lbs.)

C–1.c	1/11/66	Cessna 210	Walter D. Cable	Altitude	39,334 feet
C–1.c	7/13/66	Aero Commander 200	Donald E. Washburn	Speed over a 3 km course	239.44 mph

C-1.d (3858–6614 lbs.)

C–1.d	7/1–2/66	Cessna P-206	Geraldine L. Mock	Distance in a closed circuit	3,778 miles
C–1.d	7/16/66	Piper PA-250	Frances Bera	Altitude	40,154 feet
C–1.d	6/1–7/66	Beech Baron C55	Robert Wallick	Speed around the world	186.53 mph

Hot Air Balloons

AX-4 (600–900 Cubic Meters)

AX–4	10/11/66	Piccard Balloon	Deke Sonnichsen	Duration	1 hr. 17 min. 50 secs.
AX–4	10/11/66	Piccard Balloon	Deke Sonnichsen	Distance	21.0 miles
AX–4	10/11/66	Piccard Balloon	Deke Sonnichsen	Altitude	21,250 feet

AX-7 (1600–2200 Cubic Meters)

AX–7	7/10/66	Raven S-50 Balloon	William R. Berry	Altitude	18,980 feet

AX-8 (2200–3000 Cubic Meters)

AX–8	8/25/66	Barnes Balloon	Tracy L. Barnes	Altitude	28,585 feet

AX-9 (3000–4000 Cubic Meters)

AX–9	8/25/66	Barnes Balloon	Tracy L. Barnes	Altitude	28,585 feet

AX-10 (Over 4000 Cubic Meters)

AX–10	8/25/66	Barnes Balloon	Tracy L. Barnes	Altitude	28,585 feet

FEMININE RECORDS

Piston Engine Aircraft

C–1	4/10/66	Cessna P-206	Geraldine L. Mock	Distance in a straight line	4,515.93 miles
C–1	7/1–2/66	Cessna P-206	Geraldine L. Mock	Distance in a closed circuit	3,778 miles

U.S. NATIONAL RECORDS

Commercial Airlines

–––	1/11/66	Lockheed Electra	Capt William B. Moody American Airlines	Albany/Boston	325.00 mph
–––	1/16/66	Lockheed Electra	Capt William B. Moody American Airlines	Boston/Albany	330.37 mph
–––	1/1/66	Boeing 727	Capt William F. Butela American Airlines	Buffalo/New York	374.94 mph
–––	1/11/66	Lockheed Electra	Capt William B. Moody American Airlines	Detroit/Buffalo	378.18 mph
–––	1/1/66	Boeing 707	Capt W. H. Sumrall American Airlines	Phoenix/Chicago	653.12 mph
–––	10/5/66	Boeing 727	Capt Harold Sevigny American Airlines	Washington, D.C./Boston	564.37 mph

AIA LEADERSHIP

In November, Karl G. Harr, Jr., (top) was re-elected president of Aerospace Industries Association. Courtlandt S. Gross, (lower left) chairman of the board of Lockheed Aircraft Corporation, was named chairman of the AIA board for 1967. He succeeded J. S. Parker, vice president and group executive of General Electric Company (lower right).

WRIGHT BROTHERS MEMORIAL TROPHY

The Wright Brothers Memorial Trophy, administered by the National Aeronautic Association, was presented to Juan T. Trippe, founder, chairman and chief executive officer of Pan American World Airways. The trophy, awarded annually for "significant public service of enduring value to aviation in the United States," was presented at the Wright Memorial Dinner in Washington, D.C., on December 15. Trippe was cited for his efforts toward accelerating U.S. air transportation progress. In photo, Trippe receives trophy from Secretary of Transportation Alan S. Boyd.

COLLIER TROPHY

The 1966 Robert J. Collier Trophy was awarded to James E. Webb and the late Dr. Hugh L. Dryden, Administrator and Deputy Administrator of the National Aeronautics and Space Administration, "representing all of the Gemini program teams." The award was presented in the National Air and Space Museum by Vice President Hubert H. Humphrey. In photo, Webb, left, and Mrs. Dryden.

BREWER TROPHY

The Frank G. Brewer Trophy was awarded to Mrs. Jane Marshall, editor of the National Aerospace Education Council, in recognition of "her contributions to enlarged aerospace horizons for those who teach our nation's youth." Joseph T. Geuting, Jr., vice president of the National Aeronautics Association, presented the trophy at a banquet climaxing the 1966 National Conference on Aerospace Education.

HARMON INTERNATIONAL AVIATORS TROPHY

The 1966 Harmon International Aviators Trophy went jointly to the crews of Gemini 6 and 7 who accomplished the first space rendezvous on December 15, 1965. Presentation was made December 15 by Vice President Humphrey in the Executive Office Building. Photo, left to right, Captain Walter M. Schirra, Jr., USN; Lieutenant Colonel Thomas P. Stafford, USAF; the Vice President; Colonel Frank Borman, USAF; and Captain James A. Lovell, Jr., USN.

A

B

AMERICAN HELICOPTER SOCIETY AWARDS

C

The American Helicopter Society's Frederick L. Feinberg Award went to Delford M. Smith, president, Evergreen Helicopters, for risking his life in a helicopter rescue (Photo A, Smith, at right, receiving award from John L. Buehler, AHS board chairman). The Igor I. Sikorsky International Trophy for advancement of the helicopter art was presented to Sikorsky Aircraft Division, designer and builder of the Navy SH-3A which set a world distance record (Photo B, Buehler presents trophy to Commander J. R. Williford, USN, and Lee S. Johnson, president, Sikorsky). LTV Aerospace Corporation, prime contractor for the XC-142A, won the Paul E. Haueter Award for successful development of a V/STOL aircraft (Photo C, LTV's W. Paul Thayer accepts award). Other AHS awards: the Dr. Alexander Klemin Award, to Irven H. Culver, Lockheed-California Company; the Captain William J. Kossler Award to Major General Harry W. O. Kinnard for the officers and men of the First Cavalry Division (Airmobile), U.S. Army; the Grover E. Bell Award, to Paul J. Carpenter, Army Aviation Material Laboratories; Honorary AHS Fellowships, to John P. Reeder, NASA, and Robert G. Loewy, USAF chief scientist.

A

B

C

ARMY AVIATION ASSOCIATION AWARDS

Captain James A. Scott, III, USA, was named Army Aviator of the Year by the Army Aviation Association of America (Photo A, Scott accepts award from Assistant Secretary of the Army Robert A. Brooks at the AAAA Honors Luncheon in Washington, D.C., October 14). AAAA's James H. McClellan Aviation Safety Award went to Gerard M. Bruggink of the Army Board for Aviation Accident Research (Photo B, Bruggink, left, with Howard E. Haugerud, president of the James H. McClellan Foundation). The Outstanding Army Aviation Unit Award was presented to the Army's First Cavalry Division (Airmobile). In Photo C, the division's commander, Major General Harry W. O. Kinnard, and Sergeant Major Kenneth W. Cooper pose with the trophy. Also presented was the Aviation Soldier of the Year Award, to Sergeant First Class Donald A. MacNevin, a 3-tour Viet Nam veteran.

Tough birds take care of themselves.

Take the Jet Commander up there. It's built with fail-safe structural design, airliner-type back-up systems, and a straight wing for greater stability at any speed. This tough bird carries the same high safety rating as jet airliners, *plus* FAA approval to operate under minimum weather conditions. It can land where the fields are small, or the weather is too rough for other business jets.

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In the meantime, think about that statement at the top of the page.

Aero Commander

The tough birds from Rockwell-Standard

Ryan Firebee:

World's most shot at aerial target!

First in Mobility. In the midst of swampland and heavily wooded hills, the U.S. Army recently tested its new Redeye shoulder-fired guided missile against Ryan target-drone Firebees. Launched from a mobile launcher, the high performance Firebees provided perfect combat simulation for the heat-seeking Redeye missiles. The terrain was rugged and air spaces were confined, but the Redeye exercise was a complete success. The Ryan Firebees had performed to exacting requirements—again.

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First in Versatility. The Ryan Fire is the first and only remote contro aerial target to provide realistic si lation for the evaluation of nearly e major surface-to-air and air-to-air sile weapons system. Further, this hi reliable and truly versatile aerial veh can execute missions for combat veillance and target acquisition. carries more than 1,000 pounds of ternal stores, such as pods, rockets other heavy payloads. Versatility—p And then some!

Being firs is a Ryan tradition!

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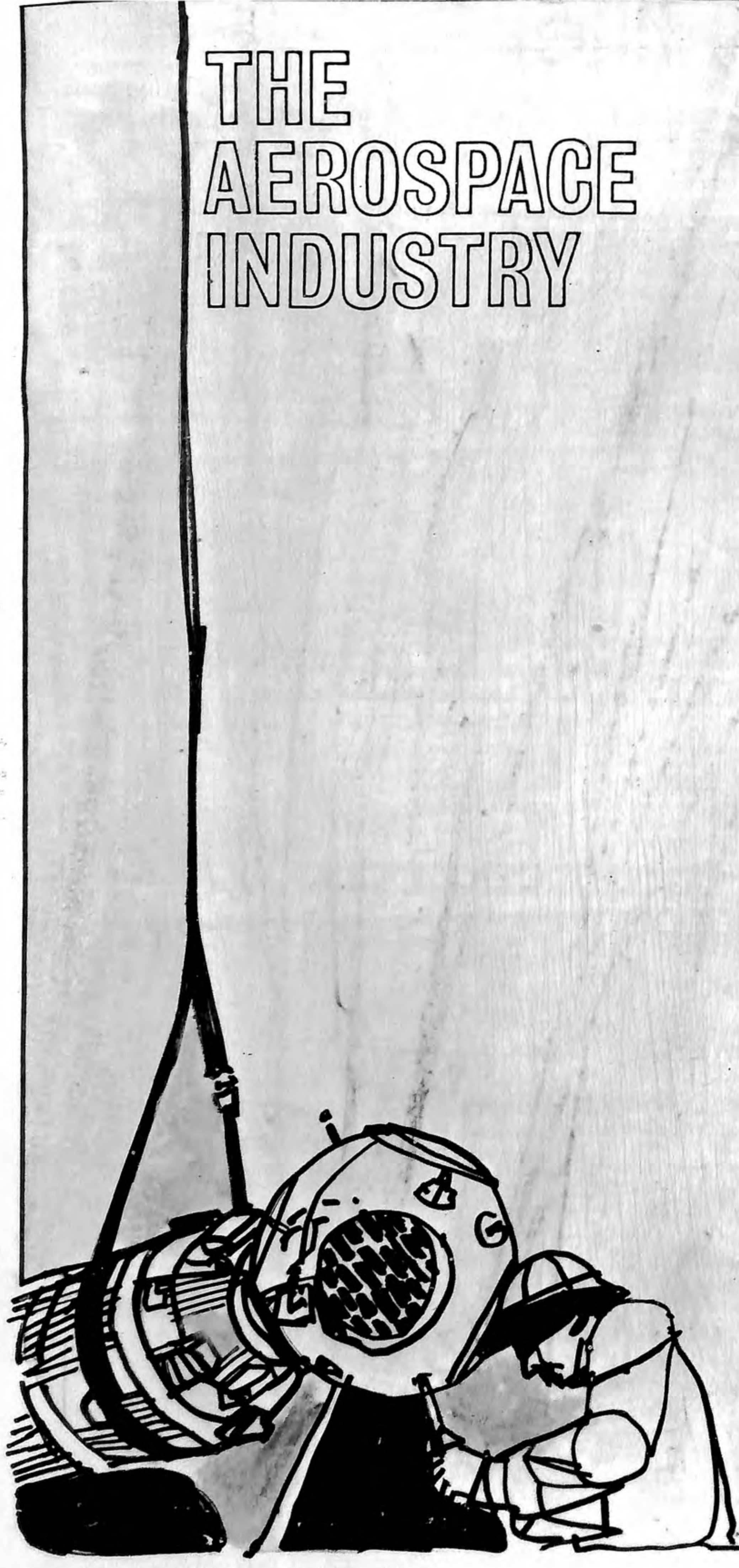
THE AEROSPACE INDUSTRY



In 1966, the aerospace industry achieved new records in such categories as sales, backlog, deliveries and capital expenditures while continuing to make broad technological gains in defense, space, civil aviation and non-aerospace fields. Total sales amounted to more than $23.8 billion, up over 15 percent from 1965's $20.7 billion, with the demand for commercial aircraft one of the primary contributors to the sales growth.

Among other key economic indicators of the vitality of the industry during 1966 were these:

Earnings, as a percentage of sales, were 3.0 percent, one of the highest in recent years.

Backlog of orders by the end of the third quarter of the year reached $27.1 billion, up from over $18.7 billion for the same quarter of 1965.

Exports reached a postwar record of $1.512 billion, an increase of nearly 3 percent above the $1.474 billion in aerospace products exported in 1965. This was the ninth year since World War II that aerospace exports exceeded $1 billion.

Employment was expected to reach 1,349,000 by the end of 1966, an increase of almost 11 percent above that at the end of 1965. Scientists, engineers and technicians accounted for a substantial part of the gain.

Capital expenditures increased sharply to $730,000,000 in 1966 compared to $410,000,000 in the previous year.

Aircraft sales—commercial and military—increased to nearly $11.8 billion, up from $9.7 billion in 1965.

Total civil aircraft shipments approximated $2.4 billion in 1966 compared to $1.7 billion in 1965. Shipments of general aviation aircraft during 1966 reached 15,700 compared with about 12,000 in 1965. The dollar value of these aircraft rose $318,000,000 in 1965 to more than $410,000,000 in 1966.

Sales of space exploration equipment during the year approximated $5.8 billion, an increase over the $5.3 billion sold in 1965.

Missile sales gained from $3.6 billion to more than $3.8 billion in 1966. Gaps left by the phasing out of some missile projects were filled by increased activity on more advanced types.

Sales of non-aerospace products and services by aerospace companies increased to about $2.5 billion in 1966 from $2.0 billion in 1965. This is a rapidly growing area of aerospace industry activity which includes commercial and military electronics, submarine construction, water purification, oceanographic activities and various other applications of aerospace technology to non-aerospace problems.

Despite record sales in 1966, however, profits in the industry remained at a relatively low level in comparison with those of all manufacturing industry. The 3.0 percent of profit to sales was considerably lower than the 5.6 percent average for all manufacturing in the United States.

The postwar record in exports recorded in 1966 largely resulted from the demand for commercial air transporters. Expanded foreign sales programs by U. S. manufacturers stimulated buyers abroad as well as improved export financing programs by U. S. banking and government agencies, which provided necessary credit arrangements for foreign nations in the purchase of aerospace products.

Payrolls in 1966 increased by 18 percent above 1965 to $10.7 billion. This reflected not only the rising level of employment but the increased wage scales for aerospace employees.

The number of scientists and engineers within the industry rose from 203,000 in December 1965, to an estimated 230,000 in December 1966. Much of this increase was reported by aircraft manufacturers. At year-end, scientists and engineers constituted 17 percent of the total aerospace work force and made up nearly ⅓ of all scientists and engineers engaged in U. S. industrial research and development.

Looking toward 1967, Karl G. Harr, Jr., president of Aerospace Industries Association, predicted a further rise in sales to approximately $25.3 billion, an increase of more than 6 percent. He anticipated that sales of aircraft would increase to nearly $13.4 billion and that non-aerospace sales would climb to about $2.7 billion. Missile sales were expected to remain fairly stable while sales of spacecraft and space equipment were expected to decline to $5.4 billion.

ABEX (FORMERLY AMERICAN BRAKE SHOE CO.)

In 1966 the Aerospace Division of Abex Corporation was heavily engaged in the manufacture of hydraulic pumps, motors, servovalves and components for a wide variety of military aircraft operating in Southeast Asia. The increasing demands of military agencies for these products resulted in an expansion of the facilities of the Oxnard, California, plant. Abex hydraulic components were being used on helicopters, fighter bombers and interceptors assigned to the Air Force, the Marine Corps, the Navy and the Army.

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

The West German subsidiary of Aerospace Division, Aerohydraul Gmbh, was making shipments to European aircraft customers of the hydraulic pumps and servovalves that were designed in the main plant in California. These products were being used by SAAB in Sweden for military aircraft and by West Germany for the Lockheed F-104G fighter. In addition, Abex equipment was being shipped to Fokker in the Netherlands and to Agusta-Bell, the Italian licensee of Bell Helicopter Company. A licensee of the Aerospace Division, H. M. Hobson, Ltd., of Wolverhampton, England, commenced production of Abex hydraulic pumps for use on the British F4K airplane that will be used by various military agencies in the United Kingdom.

The Denison Division of Abex continued to support the space program by furnishing hydraulic components and systems for test equipment, ground support equipment, handling devices and fuel pumping equipment. The 5,500,000 pound crawler transporter at John F. Kennedy Space Center is steered and maintained level with Denison hydraulics. Denison pumps also supply power to operate service arms and work enclosures on the mobile launcher and service structures, to actuate erectors raising rockets into firing position, and to actuate engine gimbaling systems and engine valves before launch.

Large Denison piston pumps supply fuel under pressure to vehicles at launch until the on-board system reaches 90 percent thrust. These pumps also supply fuel for static firing and quality-control checkout, as well as powering ground support stands for jet aircraft checkout.

At the Abex Research Center, initial physical metallurgy and basic foundry evaluation phases were completed on the Air Force sponsored superalloy casting program. The actual production of large test castings (about 100#) was started, with testing scheduled for 1967.

The Air Force sponsored program on heat-resistant, glass-reinforced laminates was completed during 1966, the major accomplishment being development of a soluble pre-preg resin system without loss of the thermal and oxidative stability improvement achieved during the first phase. At year-end, this improved system was being tested for specific applications by several Aerospace companies.

AERODEX, INC.

Among the highlights of Aerodex' year were receipt of the company's first pure jet overhaul contract, a new series of military contracts and a substantial addition to its facilities at Miami International Airport.

The jet contract, awarded by the Air Force in August, was for the overhaul of Pratt & Whitney Aircraft J57 engines used in B-52's, F-100's, F-101's and F-102's. It was the initial increment of a potential $16,600,000 award.

In July, the USAF gave Aerodex a contract of $8,400,000, first installment on a $28,000,000 pact, for work on Pratt & Whitney Aircraft R-4360 reciprocating engines. The following day, Aerodex received another USAF order for $1,800,000, part of a possible $5,100,000 deal, for the overhaul of Wright R-3350 piston engines. These were renewals of work on the 2 engines that has been in progress since 1959.

In addition, Aerodex won a USAF $1,000,000 contract in March, supplemented by a $4,000,000 fiscal 1967 addition, for overhaul of Allison T56 turboprops. At year-end, Aerodex' backlog for Air Force work alone exceeded $50,000,000.

Expanding rapidly with these and other contracts, Aerodex added another 225,000 square feet of work space with the sub-lease of a building from Pan American World Airways. The structure is similar to another leased from Pan Am 11 months earlier; it brought Aerodex' total area to more than 1,000,000 square feet.

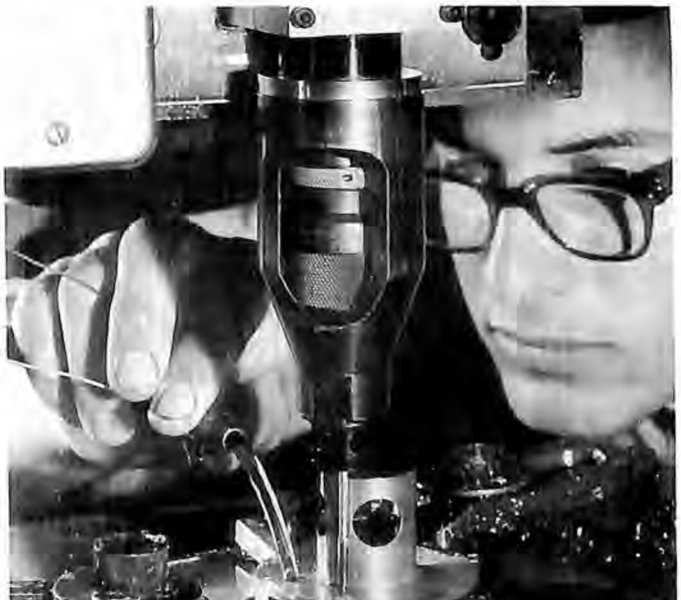
In addition to the major Air Force work, Aerodex has overhauled R-985, R-1300, R-1820, R-1830, R-2000, R-2600 and R-2800 engines. Besides the Air Force, Aerodex' U. S. customer list included Zantop Air Transport, Capitol Airways, International Aerodyne, California Airmotive Corporation, Airlift International,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

At year-end, Aerodex was overhauling an average of 270 engines a month. Work force totaled about 3,300, but the growing list of contracts indicated a 1967 expansion to about 4,300.

AEROJET-GENERAL CORPORATION

Successful completion of NASA's Gemini program was a major milepost in 1966 for Aerojet-General Corporation. All of the 2 unmanned and 10 manned missions were powered by first and second stage Aerojet-built Gemini/Titan propulsion systems. The 24 engines operated flawlessly over a total of 64 minutes, giving precision performances within 1 percent of preflight predictions.

August marked the 25th anniversary of the first American manned rocket flight in 1941. The flights were made to test jet-assisted take-off (JATO)



Example of precision is this special machine used by Aerojet-General's Downey plant to make a part for the Apollo propulsion system. In 1½ hours, the machine drills 2,300 precisely-spaced holes .030 inches in diameter.

rockets developed by Dr. Theodore von Karman, eminent scientist who soon thereafter founded Aerojet to produce JATOs for World War II use. Success of the JATO helped revive American interest in rocketry and paved the way to today's manned programs.

A number of significant events occurred at Aerojet during the year, among them:

Successful test firing of a second 260-inch solid rocket motor built for NASA and beginning of work on a third, more powerful advanced motor for testing in 1967;

Two successful flights of the Air Force Titan III-C, in which Aerojet's Transtage engine cut off and started repeatedly, changing payload altitude and orbit like a "space switch engine";

Flawless operation of the propulsion system for the Apollo service module during 2 unmanned suborbital Apollo/Saturn test flights. The engines started 3 times as scheduled on 1 flight, 4 times on the second;

Announcement by the Air Force of Aerojet's selection to develop and produce a third stage for the advanced Minuteman III;

Completion of a successful test series in which NERVA (Nuclear Engine for Rocket Vehicle Application) was test fired as a complete system with reactor and engine components. Advancements were made on the nozzle for the larger Phoebus system;

Successful completion of a series of tests demonstrating technology advances in pumps and thrust chamber of a high energy liquid hydrogen/liquid oxygen propulsion system of 1,500,000 pounds thrust;

Achievements in improved control techniques for both solid and liquid fuel rockets; and

Continued development and production in other major rocket programs, including ARES, Polaris, Titan, Delta, Apollo, Sparrow and many others.

While remaining a leader in rocket propulsion, the company recorded many notable achievements in other areas during the year as well.

First system operation of the SNAP-8 nuclear electric power generating system for use in space was achieved in 1966. The system under development converts nuclear power into electrical energy through a Rankine cycle. It is designed to produce 35,000 watts of electrical power, which could be used by a lunar base or satellite.

Aerojet joined Allied Chemical Corporation in forming the jointly owned Idaho Nuclear Corporation, which has responsibility for managing a major segment of operations at the AEC's National Reactor Testing Station, Idaho Falls, Idaho.

Production increased on 2 models of the Navy's sophisticated Mark 46 antisubmarine torpedo, which has the capability of diving deeper and traveling faster than any other Navy device of its kind. High volume deliveries began in 1966.

Excellent progress was made on development of systems to store cryogenic fluids for long duration space missions. Tests in the company-sponsored program have involved use of almost 2 billion pounds of cryogenic fluids since 1945.

New research programs were undertaken for the Air Force on plasma arc welding and explosive spot welding techniques for titanium, maraging steel and other refractory metals.

Among Aerojet's titanium products in production were propellant tanks for the Apollo Lunar Module ascent propulsion system, solid rocket motor cases for Athena and Minuteman, helium and nitrogen storage vessels for the Improved Delta space booster, and the gimballing system for the Apollo Service Propulsion System.

Ordnance production increased 200 percent over a year ago, as a new subsidiary, Batesville (Arkansas) Manufacturing Company, completed its first full year of operation and another subsidiary, Camden (Arkansas) Manufacturing Company, was established.

Announcement of still another subsidiary brought favorable reaction from throughout the nation as the company opened the Watts Manufacturing Company near the area hit by riots in South Los Angeles a year ago. Personnel will be trained on the job, with initial work on construction of general purpose tents for the Department of Defense.

Aerojet's architect-engineering-construction division was active in a variety of areas ranging from control of chemical pollutants to ship automation. Installation began on an electronic control system for a 43-mile automated water control section for the State of California, and work was concluded as a member of the team building the $114,000,000 Stanford Linear Accelerator.

The Industrial Systems Division, providing automated warehousing and materials handling equipment, has expanded considerably, with sales increased by 400 percent in recent years. Contracts during 1966 included post office systems in Canada, New York and Oakland, and for air terminals in Amsterdam and Dallas. Work progressed on the automated drum handling warehouse for Union Carbide in South Charleston, West Virginia.

System integration began on a computer controlled, life-like medical manikin for use in training anesthesiologists. Simulating a patient on the operating table, the dummy will respond realistically to treatment, with changes in color, heartbeat and pulse.

Lightweight armor for helicopter pilots was supplied in quantity, following successful use of initial orders.

Ten new test and measuring instruments were added to the product line of Aerojet's Aerometrics Division, which designs and produces highly accurate devices for aerospace and commercial markets. The new products: 5 electronic counters, 2 phase meters, pulse generator, pulse sampler and multimeter for measuring voltage current and resistance. All employ micrologic and are compact, lightweight and portable. Aerometrics was also marketing quartz lamp brazing apparatus, ultrasonic cleaners, laboratory apparatus for plastic and high temperature refractory metals research, aircraft instruments and pressure, temperature, and flow transducers.

Aerojet-General Nucleonics developed an Underwater Radioisotope Power Supply (URIPS) for undersea applications. First unit was sold to the Navy in 1966. It will furnish 1 watt of power over a period of 5 years. URIPS is suitable for use by the scientific community, government agencies and the oil, ocean mining, and undersea instrumentation industries.

AGN also was operating a 250-watt thermal research reactor available for activation analysis, reactor training and other commercial and research activities.

Climaxing 5 years of thin film circuitry development, a Microelectronics Division was formed to work on volume production techniques for military, aerospace and commercial applications.

A major second step was taken in the application of aerospace systems analysis/engineering methods in solving socioeconomic problems. Aerojet was a pioneer in this field with preliminary studies on waste management and crime prevention for California a year earlier. In 1966, the state chose the company to investigate, plan, and design a regional solid waste management system for Fresno County.

First commercial application of Aerojet's Reverse Osmosis water purification system occurred in the California oil fields, to soften and desalt water at the site for steam flooding wells, drinking and general usage.

An Aerojet system for the Air Force called TRAP (Terminal Radiation Program) became operational in the Pacific. The equipment is used to track and take optical pictures of ICBMs to gain information for use in anti-missile systems.

To extend its capabilities in industrial hygiene, health physics, micrometeorology and air sampling control devices, Aerojet acquired a small scientific specialty firm, Weather Measure Corporation, which markets meteorological equipment and provides meteorological and consultant services to government agencies and business interests.

A new Aerojet underwater acoustics test facility for oceanic research went into operation during the year. Its principal uses will be for development of underwater weapons, sonars and acoustic locating devices.

Aerojet began a program to make the outboard wing sections for military aircraft, using the most advanced methods of glass filament winding. Designed to match existing metal wing specifications, the glass wing was expected to offer improved efficiency and reliability at reduced cost.

AERONCA MANUFACTURING CORPORATION

Aeronca, during 1966, continued to expand its coverage of the aerospace structures field. Its new welded honeycomb core manufacturing unit went into full production and core sales for industry were started. Stainless steel, titanium, hasteloy and other types of welded honeycomb core were being produced in support of Aeronca's expanding structures capability.

Production of the brazed stainless steel Apollo Command Module for North American was sustained. This was matched by additional production of ceramic filled, double core Saturn heat shield brazements. These two projects give Aeronca product coverage at both ends of the Apollo moon vehicle.

Production was expanded on the brazed stabilator of McDonnell's F-4 fighter. Speed brakes, which are special high temperature brazements, were reordered for use on Grumman's A-6B. Another interesting brazing contract, with NASA, covers successful development of a high strength, fluxless aluminum brazement.

Closely associated were advances in structural bonding. Production was expanding in panels and assemblies using titanium, fiberglas and aluminum skinned honeycomb core panels. A wide variety of these were being made for helicopter use.

Parallelling production of these two joining techniques was Aeronca's own research and development investigation into several other areas. For example, high temperature, polyaromatic adhesives were in prototype use. Brazing of #718 nickel steels permits use in high temperature areas over 1000° Fahrenheit.

Another enlarged field of effort was Aeronca's fiberglas work. During the past 10 years, Aeronca has produced fiberglas assemblies for antenna housings, radomes and even warheads. This and the latest know-how has been put to use in manufacturing the Mark 57 Minecase. Heavy fiberglas sections, heretofore hand made, were being machine manufactured to exacting production requirements. Other 1966 production included bonded fiberglas honeycomb panels and miscellany of fiberglas parts.

Aircraft structures, in wide variety, continued to be the backbone of Aeronca's production. Continuing orders from Boeing for 707 wing sections and chords, 727/737 assemblies; 50 gallon wing tip external fuel tanks and 150 gallon underwing external fuel tanks for Northrop's F-5; and multipurpose pylons for McDonnell's F-4 helped build Aeronca's backlog to a new high. Structures of many configurations were being made. Three large 60-foot diameter tracking antennas were about complete. These antennas have tracking capabilities far in excess of any other antennas of this size. Included are bonded honeycomb reflectors, the ground support structure, the drive and mount mechanisms, and all controls with their recording equipment. In addition, Aeronca was making mobile communications antennas in volume. These included a series of trailer-mounted, quick-erectable reflectors in the 28-30 inch class. Other new ground equipment contracts included Level Wind assemblies and Cargo Pallets.

Aeronca was participating in the preliminary requirements on new planes such as the Boeing 747, Lockheed C-5A and the Supersonic Transport.

With dynamically expanding production capability, Aeronca officials felt that the already record-breaking sales and backlog would climb to even greater heights.

AEROSPACE CORPORATION

During 1966, Aerospace Corporation continued in its mission of supplying general systems engineering/technical direction, planning, and research on a wide range of missile-space programs and projects for the U.S. government, principally the Air Force. The corporation was organized in 1960 as a nonprofit organization and was formed with the support of the Air Force to provide these services.

In the area of manned space flight, Aerospace Corporation was providing general systems engineering for the Air Force Manned Orbiting Laboratory and also providing technical direction to industry efforts on the MOL during the year. In the Gemini program, the corporation worked with industry to assure the man-rating of the USAF Titan II booster and provided technical assistance to the Air Force in supplying and launching for NASA the Atlas-Agena combination used in conjunction with Gemini rendezvous missions.

In addition to providing general systems engineering and technical direction for the USAF Titan III-C, Aerospace engineers worked on the planning and development of other versions of the Titan III standard launch vehicle. Tital III-B combines the Agena with the two basic Titan III liquid stages. The Titan III-M, an uprated version of the Titan III-C, will launch the MOL. A proposed Titan III-D is in the planning stage. Corporate engineers continued to work with the Air Force and contractors to maintain the high reliability of the SLV-2 Thor and the SLV-3 Atlas.

The Initial Defense Communications Satellite was one of the military satellite programs for which the company supplied general systems engineering and technical direction. The first set of 7 comsats was successfully launched by a Titan III-C on June 16, 1966. Aerospace also studied both an advanced follow-on to the initial communications system and a tactical communications satellite. During the year, the company continued its systems engineering and technical direction work to increase the effectiveness and efficiency of the world-wide Air Force Satellite Control Facility.

During the year, Aerospace system planners studied many survivable missile system concepts. Methods considered for providing survivability included land mobility, super-hard fixed basing, and active system defense. The company provided general systems engineering and technical direction for the Air Force on study contracts leading to a preliminary design for an advanced ICBM, designated 120 A. Additionally, the company was working to increase the operational effectiveness of the Minuteman and Titan II ICBM systems. Aerospace performed extensive work in the reentry systems area and was providing general systems engineering and technical direction for the Mark 12 and Mark 17 reentry systems. The company was also working with the Air Force in providing technical direction for programs to increase the reentry capabilities for the Minuteman, Titan, Polaris, and Poseidon missile systems.

The corporation's engineering and planning work was solidly backed by research and experimentation in the company's laboratories. Research was being conducted in plasmas, electronics, aerodynamics and propulsion, materials, and space physics.

During the year special study areas included an investigation of the technologies which will provide savings in the cost of space operations, efficient and effective methods of assuring astronaut safety, and advanced launch vehicles, including recoverable and reusable vehicles.

In 1966 Aerospace Corporation employment averaged slightly more than 4,000; of these, nearly 1,900 were scientists and engineers. The company's General Offices, El Segundo Technical Operations, MOL Systems Engineering Office, and Laboratory Operations are located in El Segundo, California, near Los Angeles International Airport. Another major installation is the San Bernardino(California) Operations, located in that city. Field offices are maintained at the 3 national test ranges and in Washington, D. C.

ALLISON DIVISION
GENERAL MOTORS CORPORATION

Addition of a turbofan engine to its gas turbine development program marked one of the most significant milestones of 1966 for the Allison Division of General Motors.

Allison late in the year was awarded a multi-million-dollar contract by the Air Force Systems Command for the development and production of the TF41, a new turbofan engine for a USAF close-support aircraft.

The new engine, an advanced version of the Rolls-Royce RB-168-25 engine, will be developed jointly by Allison at its Indianapolis plants and by Rolls-Royce Ltd. in Derby, England.

The TF41, scheduled to enter production in 1968, will have 14,250 pounds thrust and is being developed specifically to meet the requirements of the USAF's A-7 aircraft which will be used to provide air support to ground combat troops.

The subsonic swept-wing aircraft will carry a variety of external weapons including bombs and missiles, and will play a significant role in limited scale warfare. With this new engine plus other gas turbines earlier in production or development, Allison will have complete coverage of the gas turbine market—turbofan, turboprop, turboshaft and turbojet.

Substantial gains were reported in sales of the larger military and commercial gas turbine aircraft and stationary engines. Significant advances also were reported in the development of large new turboprop and turboshaft engines, and lightweight lift engines.

In line with the division's growth, Allison began a major building program to expand production facilities. The division also acquired from the General Services Administration 2 government-owned properties which Allison had operated for production of aircraft engines and various types of bearings.

Allison was selected in April as the United States contractor in a joint program with Great Britain to develop a new turbojet lift engine for vertical take-off and landing (VTOL) aircraft. Allison, 1 of 4 U.S. bidders, will work with Rolls-Royce in developing the ultra-lightweight gas turbine. The engine, which will produce an exceptionally high amount of thrust for each pound of engine weight, will be utilized initially for fighter-type aircraft. Allison currently is testing compressors, combustors and turbines of flight weight and is running an advanced lift engine configuration.

A major growth pattern began to evolve in 1966 for the lightweight 317-horsepower T63 turboshaft engine. This is the powerplant for the Army's OH-6A Light Observation Helicopter which early in the year set 23 records for rotary wing aircraft. At year-end, OH-6A claimed more records than any other helicopter. New records claimed by the Army—12 for speed, 5 for distance and 3 each for climbing and sustained altitude—were established in 3 different helicopter classes by 5 Army and 2 civilian pilots.

A commercial version of the engine, the Model 250, will power helicopters already sold by Bell, Hiller and Hughes in 18 major areas of the world for deliveries starting in 1967. Five foreign sales and service distributors were selected during 1966 to handle the engines in their respective areas. Engine production got underway in November 1965, and more than 400 engines had been delivered by the end of 1966.

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

New, more powerful T56 Series turboprops that incorporate aircooled blades and vanes were in full-scale production for the USAF Lockheed C-130 Hercules transport and the Navy's P3B anti-submarine warfare plane. T56's also power the carrier-based Grumman E2A radar picket plane and a cargo-carrying adaptation, the C2A.

Sales of 501-D13 turboprop engines for the Convair 580 conversion program, and industrial gas turbines for stationary installations also showed an appreciable increase in 1966.

Two additional local service carriers—Lake Central Airlines and North Central Airlines—announced plans to convert their Convair 340/440 aircraft from piston engines to Allison gas turbines. This brought to 5 the airlines ordering conversions. North Central's order was for an initial 20 with an option for 11 more, and Lake Central's initial order was for 8 with 8 on option. By year-end, 97 Convair 580's were in service or on order by 5 airlines. A total of 133 was on order, including 14 corporate operators, the U. S. Air Force, Federal Aviation Agency and the Royal Canadian Air Force. At the end of 1966 Convair 580's had accumulated more than 250,000 aircraft hours. Overall, Allison military and commercial turboprops had logged more than 22,000,000 hours in the air.

Extending further the horsepower growth of current T56 Series engines was the T56-A-18 being developed with Navy funds and logging time on an Allison test stand. Equipped with air-cooled blades and vanes in its first 2 turbine stages, the A-18 at a rating of 5,325 equivalent shaft horsepower will be approximately 350 pounds lighter and 30 inches shorter than the T56-A-1 rated at 3750 equivalent shaft horsepower.

Aerospace pressure vessels continued in production for the Apollo and Titan III-C programs.

The year also marked the production of Allison's first end-product in its 51-year history—military tracklaying vehicles. These are the M551 General Sheridan, an air-droppable amphibious armored assault reconnaissance vehicle, and the M109 self-propelled 155 millimeter howitzer. First of these vehicles began coming off production lines in June at the Cleveland Army Tank-Automotive Plant, for which Allison formally assumed responsibility on January 1, 1966. Both vehicles are equipped with Allison transmissions and the M551 also incorporates a unique Allison-developed gun-launcher breech mechanism.

Allison's Military Vehicles Organization at Warren, Michigan, was developing jointly with the Federal Republic of Germany a new Main Battle Tank. This assignment involves a unique program for General Motors in international cooperation between 2 nations developing a military product which can be built by both countries for joint use.

To speed all phases of design and development as well as production and to reduce costs wherever possible throughout the division, Allison continued to revise and expand its Zero Defects program built around the concept of doing every job right the first time.

Divisional employment was up more than 18 percent by year-end, with approximately 18,000 on the payroll at Indianapolis, Cleveland and Warren.

ALUMINUM COMPANY OF AMERICA

Aluminum Company of America in 1966 announced: start-up of a new fourth potline at its Warrick Operations raising the plant's annual rated capacity to 175,000 tons of primary aluminum; a new facility capable of producing 48 million pounds of atomized aluminum annually to be built at its Rockdale (Texas) Works; NASA's giant Vehicle Assembly Building contains more than 4,000,000 pounds of specially designed V-beam aluminum siding, sheet, and extrusions; commercial production of close-tolerance coiled sheet at its $90-million Warrick Operations sheet mill; production of giant hemispheres which are among the largest structural forgings ever made; plans to build a second 50,000-ton potline at its Badin (North Carolina) smelter; a new alloy that endows massive aerospace forgings with high strength and good resistance to stress corrosion cracking; supplying aluminum for hangars built by Climatrol Corporation designed to be airlifted to U. S. fighting forces in Vietnam; a new fastener material that produces the highest strength aluminum rivets and threaded fasteners now available; first publication of data on allowable stresses for a number of widely used aluminum alloys; production of high strength forgings for NASA's Uprated Saturn I space vehicle; wide use of alloy 7075 in the A-7A Corsair II, the Navy's newest fighting plane; receipt of a $15,000,000 Navy contract to produce rocket motor tubes for an air-to-ground weapon; use of a new Alcoa alloy for an experimental part of a NASA program investigating novel design for rocket fuel tanks; a new sales division to assume all functions of the former jobbing and impact sales division; supplying aluminum parts for the highly successful Surveyor spacecraft that soft-landed on the moon; design and construction of a rugged, portable, floating aluminum airfield that converts marshes and rice paddies into hardened operating areas; and plans to install an additional hydraulic forging press at its Vernon (California) Works.

A new fourth potline came on stream in 1966 at Alcoa's Warrick Operations, raising the plant's annual rated capacity to 175,000 tons of primary aluminum. The addition is necessary to meet the metal requirements of the Warrick Operation's adjacent new fabricating complex, including 2 hot mills and 2 high-speed cold-finishing mills, and to augment Alcoa and customer needs for basic aluminum at other locations. Start-up of the new line raised Alcoa's total rated primary aluminum ingot capacity to 1,050,000 tons annually.

A new facility capable of turning out 48,000,000 pounds of atomized aluminum annually will be built at the company's Rockdale (Texas) Works. Most of the immediate output will be produced to Defense Department specification to meet increasing demands created by the war in Vietnam. Atomized aluminum's many uses include fuel for solid propellant rockets and missiles, and as an ingredient in explosive charges. Aluminum for the operation will come from potlines at the Rockdale smelter.

The giant Vehicle Assembly Building at the Kennedy Space Center contains more than 4,000,000 pounds of Alcoa's specially designed V-beam aluminum siding, sheet, extrusions, and other aluminum products. Aluminum was selected for the VAB exterior because of its rigid strength, resistance to salt air corrosion, and availability of pleasing gray and white enameled finishes.

At its sprawling $90,000,000 Warrick Operations near Evansville, Indiana, Alcoa is producing annually more than 240,000,000 pounds of close-tolerance coiled sheet. The most advanced combination of computerized hot breakdown and high-speed finishing mills, and interrelated supporting facilities ever planned to make one product was installed at Warrick in the space of 3 years. The precision-rolled, light gauge product is tailored specifically for such mass markets as rigid containers, building products, and heat exchanger equipment. The production cycle at Warrick begins with alloying molten high purity aluminum from the potlines and casting the metal into rolling ingots. The ingots are processed through the balance of the computerized complex which includes a 66-inch wide hot reversing mill capable of rolling 22-inch thick ingots down to 1-inch slabs; the industry's first and only 6-stand continuous hot mill which reduces slabs to coils of sheet one-eighth inch thick; 2 mile-a-minute 5-stand tandem cold mills, one 60 inches and the other 44 inches wide, producing coils of finished sheet 48 inches and 36 inches wide.

Huge hemispheres which are among the largest structural forgings ever made were produced at Alcoa's Cleveland (Ohio) Works during 1966. The giant bowls were designed for a variety of operations at extreme ocean depths. They will be machined to desired dimensions and used either singly as structural components in underwater vehicles, or in pairs joined together to form spheres that can support heavy equipment or house delicate electronic equipment. Each part is 8 feet in diameter and weighs 12,000 pounds. The hemispheres are expected to broaden vastly aluminum's capability for undersea applications. Such uses with spheres up to 3½ feet in diameter already involve defense, communications, exploratory and salvage functions.

A second 50,000-ton potline scheduled to be built at Alcoa's Badin Works was scheduled to come on stream in mid-1967. The $10,000,000 facility is part of a modernization program instituted in 1964 at the Badin smelter.

A new aluminum alloy that endows massive aerospace forgings with both high strength and good resistance to stress corrosion cracking was unveiled by Alcoa. The outstanding characteristic of new alloy X7080 is its ability to develop high mechanical properties with a boiling water quench. Although water at 212 degrees Fahrenheit is cool to a forging in the 800 degree range, the low rate of quench—compared to room temperature water (70 degrees)—generally is not associated with good mechanical properties among high strength aluminum alloys. The new alloy imparts to bulky hand forgings—3 inches thick and over—typical tensile strengths ranging from 67,500 to 70,000 pounds per square inch. Large die forgings display typical tensile strengths in the range of 70,000 to 71,500 pounds per square inch. The high properties coupled with low residual stresses resulting from the boiling water quench, are ideal for numerous aerospace applications, including large airframe parts and aircraft landing gear forgings. The low residual stresses will make unnecessary the cold working operation in special dies now required for many aircraft bulkhead and spar forgings to relieve residual stresses. Considerable savings in tooling costs will be realized by eliminating this requirement.

Uniquely designed hangars built by Climatrol Corporation using Alcoa aluminum can be assembled by 6 men in 72 hours without special equipment. Airlifted to Vietnam, the hangars are employed as aircraft maintenance shelters. Each weighs less than 10,000 pounds, can be assembled on cleared ground without a foundation, and will withstand 70-mile per hour winds.

Data on allowable stresses for a number of widely used aluminum alloys were presented for the first time in "Alcoa Handbook of Design Stresses for Aluminum," a hard-cover handbook. The book was prepared especially for engineers and architects concerned with design of aluminum strength members.

High strength Alcoa forgings form key structural members in NASA's new uprated Saturn I space vehicle. The parts are produced on a 35,000-ton Air Force press for Hayes International and serve as the main links between the uprated Saturn I

Alcoa's Cleveland Works produced high-strength forgings for the Uprated Saturn I launch vehicle.

thrust structure and 8 huge fins which help stabilize the 1,300,000 pound vehicle in flight. Alcoa also supplies sheet, plate, and castings for the S-IB first stage and S-IVB second stage.

One of the Navy's newest fighting planes is a hard-hitting attack aircraft built largely of Alcoa aluminum, and designed for close, low-level troop support missions. Designated the A-7A Corsair II, the plane was developed and fabricated by LTV Aerospace Corporation's Vought Aeronautics Division, Dallas, Texas. Approximately 18,000 pounds of aluminum are required for the Corsair II, which is sufficiently rugged for either land or carrier-based operations. Sheet and plate for fuselage and wing skin, and extruded and forged structural members are supplied by Aluminum Company of America in high-strength alloy 7075. Each wing rack, or pylon, is an Alcoa forging with a built-in hoist to facilitate ordnance loading.

Alcoa received a $15,000,000 contract to produce 2.75-inch rocket tubes for an air-to-ground weapon which has become an armament mainstay in the Vietnam conflict. The aluminum tubes are produced at the company's revitalized New Kensington Pennsylvania Works.

An experimental part employing an aluminum-zinc-magnesium type alloy was built for NASA by Boeing's Wichita Division. Two half circles were welded together to complete a ring 16 feet in diameter. Following machining, the 2-ton band was used in the fabrication of a rocket fuel tank of novel design. The work was part of a NASA research program investigating the performance of launch vehicle tankage constructed in other than the customary cylindrical configuration. In heat-treated tempers, the Alcoa alloy displays high weld strength for room temperature and cryogenic applications without post-weld processing.

A new sales division was formed by Alcoa to market aluminum impacts and fabricated products manufactured at the New Kensington Works. The new organization—Alcoa's Manufactured Product Sales Division— assumed all functions of the former jobbing and impact sales divisions whose products include such diverse items as storage tanks, atomic reactor elements, fuel tanks, and a variety of complex, high strength parts for military and commercial markets.

Aluminum's role in the success scored by Surveyor I was commended by Hughes Aircraft Company, developer of the soft-landing moon vehicle. The main structural framework and 3 foldable legs which support Surveyor's maze of electronic and mechanical assemblies were made of high strength, thin-wall aluminium tubing. Aluminum was selected for the critical application because of its light weight, strength, and ability to provide a highly polished finish to help protect sensitive equipment in the extreme temperature range encountered on the moon surface.

Alcoa developed for the Navy a rugged, portable, floating aluminum airfield that converts marshes and rice paddies into hardened operating areas. A 13,000 pound UH-34D helicopter executed a series of landing and taxi tests on the aluminum helipads installed on both water and marshy surfaces. The aluminum panels performed to expectations, withstanding 13-ton landing impacts, and resisting bending and shearing forces set up as the helicopter taxied to within two feet of the airfield edge. The new landing mat—designated AM-3 by the Bureau of Naval Weapons—was designed by Alcoa and produced under a Naval Air Engineering Laboratory contract. The mat is an assembly of aluminum panels bolted together to form a high strength, rigid structure. Fabricated of sheet and extrusions, each panel is approximately 8 feet long, 3 feet wide, and 6 inches thick. All elements are joined by adhesive bonding except the rectangular framing which is welded. The interior of each panel contains more than 750 diamond-shaped cells of aluminum sheet filled with blocks of polyurethane. Operational requirements include lightweight construction, ability to replace damaged panels easily, and a two-year life expectancy.

Plans to install an additional hydraulic forging press at its Vernon (California) Works were announced by Alcoa. The new press was scheduled to begin production by mid-1967 and was to have a rated capacity of 3,000 tons. It will increase Alcoa's overall capacity to meet growing demands for forgings on the West Coast. The press will be housed in an extension to an existing building and will require a total investment in excess of $1,000,000.

AVCO CORPORATION

AVCO LYCOMING DIVISION

Avco Lycoming Division continued its extensive production of T53 and T55 gas turbine engines during 1966, with both programs reaching new highs in rates of production. The schedule, already accelerated, were increased several times again, and the manufacturing operation was extended to a 3-shift, 6-day program.

To help meet the ever expanding demand for Avco Lycoming engines, the company in late March broke ground for a new 400,000 square foot plant on a 150 acre site in Charlestown, South Carolina. The requirement for construction of the new facility called for the building to be completed in 60 days, an almost impossible task, but one which was accomplished 6 days ahead of schedule.

While outfitting of the plant continued, machine tools began to arrive and in September, the first production components for T53 engines rolled off the lines. At the close of the fiscal year the Charleston payroll exceeded 700 persons with the buildup toward the projected 2,000 man level. Several component lines were completely established and other work, such as the production of particle separators, which are filtering devices for T53 engines, and the manufacture of ground support equipment, were transferred to that facility.

The T53, which is the Army's prime helicopter power plant, is used in the Bell UH-1 "Huey" series of helicopters as well as in the Grumman OV-1 "Mohawk" observation aircraft. Both saw extensive 1966 combat duty in Viet Nam, as did the Boeing CH-47A "Chinook," powered by twin Avco Lycoming T55 engines.

Also performing yeoman service in the Southeast Asia theater was the T53 powered Kaman HH-43 "Huskie" rescue helicopter which accounted for the saving of the lives of several hundred American pilots and crewmen, and the Bell UH-1E, being used by the U.S. Marine Corps in the northern sections of Viet Nam.

The T53-L-11, a 1,100 shaft horsepower model, was the principal 1966 production item, but early in the year the Division began phasing its advanced T53-L-13 into the production cycle with first deliveries of the new model completed in August. This advanced unit, with an increase of 300 horsepower, was scheduled to power the Bell UH-1 series as well as the Army's new armed battle helicopter, the AH-1G "HueyCobra" which was to begin rolling off the assembly lines early in 1967.

A turboprop version, designated the T53-L-15, was being readied for production at Stratford; it was to power advanced versions of the Mohawk aircraft.

The T55 production model, rated at 2,650 shaft horsepower, was replaced late in the year by the T55-L-7C, rated at 2,850 shaft horsepower. This power plant made its flight debut in mid-October, powering the twin engines advanced CH-47B "Chinook." The more powerful Avco Lycoming engines provide the advanced "Chinook" with a 42 percent increased payload of 14,500 pounds and an increase in speed to 155 knots.

Other production programs, including the manufacture of constant speed drives, also increased in tempo. The LD-6 series of drives, rated at approximately 25 horsepower, were being produced in quantity for the Douglas A-4E, A-4F and TA-4E aircraft for the Navy, as well as for the A-4G and A-4H aircraft for military assistance programs.

Re-entry vehicle production during fiscal 1966 continued at about the same level as in the preceding year, with manufacturing centered on the Mark 11A vehicle for use on the Minuteman II weapon system. Preliminary production activities also commenced for the advanced Mark 17 re-entry vehicle and for the Mark 1 penetration aids program.

On the research and development side, Avco Lycoming expanded its activities even further.

Prime emphasis was placed on the development of the AGT-1500, the new gas turbine engine being developed under Army sponsorship for tanks and other vehicular applications. The new unit, awarded to Avco Lycoming in October, 1965, after intensive competition, calls for the development of a light weight unit that will weigh about one-half the most modern diesel engine, but which will equal or exceed the efficiencies, including specific fuel consumption. The contract called for delivery of a number of prototype units within 36 months, including 2 scheduled for installation in modified tank chassis for test purposes in January, 1967. A major milestone on this program was reached in

October when the first gas producing unit was successfully operated on the test stand.

In its aircraft line, Avco Lycoming continued advanced development of both its T53 and T55 families of engines with the T53 slated to be uprated to a level of 1,800 shaft horsepower and the T55 to a level of 3,800 shaft horsepower. New turbine technology was being applied, some of which was gained through the use of the Division's unique "Hot Turbine" test facility, one of the most advanced of its type currently in use.

In the marine engine field, Avco Lycoming introduced its new CODAG system for high performance marine craft including commercial crew and utility boats. The new concept, which stands for Combined Diesel and Gas Turbine, is built around an Avco Lycoming TF-20 marine engine which is then mated, through a combining gear box, to any diesel engine in the 150 to 500 horsepower category. The advantage of such a system is that it provides economical diesel power for long endurance, low speed phases of a mission along with the high power, high speed capability of the turbine when required.

Although development efforts were continuing, the Division recorded its first sale of a CODAG system late in the year with delivery for test and evaluation scheduled for 1967.

Another promising area of development involved a mechanical actuator system for use on control systems for supersonic-type aircraft. Prototype units were under test and evaluation by North American Aviation at year-end.

Avco Lycoming Division, Williamsport, Pennsylvania in 1966 experienced a record volume of sales of reciprocating engines. The advent of the lightweight turbocharger which maintains horsepower at altitude and also allows bleed-off for cabin pressurization created new horizons for the reciprocating engine in the field of general aviation. In 1966, Avco Lycoming reciprocating engines powered more types of executive and utility aircraft than engines of any other manufacturer.

Wide acceptance of third level commuter type airlines, air taxi, private and corporate aircraft as well as the continued expansion of the rotary wing field indicated continued expansion in 1967, and Avco Lycoming recips were slated to provide many of the power requirements for general aviation aircraft. To meet the requirement for increased performance of new aircraft designs, Avco Lycoming introduced new engine models in 1966 and planned additional models in 1967. In fiscal 1966, Avco Lycoming Division, Williamsport, entered the aircraft landing gear field, and continued expansion in the manufacture of landing gears was anticipated in 1967.

AVCO AEROSTRUCTURES DIVISION

Avco Aerostructures Division, in Nashville, Tennessee, is a major manufacturer of large airframe assemblies and various aerospace components. Increased demand by both military and civilian customers for the Division's products in 1966 required plant expansion and a doubling of the employment from 2,000 to 4,000 persons.

During the year the Division received a contract to produce center, inner and outer wing panels for Lockheed Aircraft's C-5A, the world's largest military jet transport. Both Boeing and Lockheed selected the Division to make important parts for their competing supersonic jet transport designs. The Division continued to build tail assemblies for the Lockheed C-130 Hercules and wings for the Lockheed C-141 Starlifter, another military transport. Requirements of U.S. forces in Viet Nam resulted in increased production of components for the Bell Helicopter "Huey" series.

In the commercial field, the Division was producing wings for the Grumman Gulfstream II, a long range business jet aircraft.

Division engineers developed a unique fluxless brazing process for the construction of rocket booster and manned spacecraft thermal conditioning panels. The brazed units permit the sensitive instruments which they carry to remain at optimum temperatures for the duration of a mission.

AVCO EVERETT RESEARCH LABORATORY

Avco Everett Research Laboratory, located in Everett and Haverhill, Massachusetts, was involved in a wide variety of aerospace projects.

Reentry physics remained one of its major interests. The Division continued the studies it began 11 years ago for the Air Force-Army's Nike-X antimissile defense system. Airborne Laboratory teams gathered data for this program by monitoring incoming missiles in the Pacific.

Long a leader in magnetohydrodynamics and related fields, the Laboratory during 1966 completed and tested what is probably the world's largest superconducting magnet. This device brought nearer the building of a large-scale commercial magnetohydrodynamic power generator, a project being studied by Avco and 10 major power companies represented by the American Electric Power Company.

For NASA the Division was developing a superconducting magnet system for an Apache sounding rocket. It also received orders from the Navy and the Army to study superconducting applications for marine and aircraft electric motors.

In 1966, Avco Everett designed and installed a 20-megawatt MHD pilot-accelerator for the Air Force Arnold Engineering Development Center.

Everett scientists developed a laser which will have an exceptionally high output, and they were also conducting laser studies for the Air Force.

The Laboratory continued its work in medical technology. The National Institutes of Health asked it to furnish 50 Kantrowitz-Avco auxiliary left ventricles for evaluation by the medical community. This device—developed by the Laboratory and Maimonides Hospital of Brooklyn—was designed as a permanent aid to persons with chronic heart disease. It was implanted in two terminally ill patients in 1966. The Laboratory also continued its studies for the Navy and Air Force in the fluid dynamics of blood.

AVCO ORDNANCE DIVISION

The demands of the Viet Nam war caused a massive influx of orders for Avco Ordnance Division, an important supplier of military ammunition. Employment doubled and production reached record levels.

The Richmond, Indiana, facility received major orders for 40 millimeter and mortar ammunition, bomb and rocket fuzes, bomb parts, and conventional weapons.

It developed a new rocket-boosted ammunition called Avroc, to be used in the M-79 grenade launcher and the M-75 helicopter grenade launcher.

The Division was also producing air-launched munitions, miniaturized proximity fuzes, 30-millimeter ammunition for a new helicopter weapon system and target markers. It was arming and fuzing strategic missiles, including the Navy's Polaris and the Air Force's Minuteman.

AVCO MISSILES, SPACE AND ELECTRONICS GROUP

Early in 1966, Avco formed a Missiles, Space and Electronics Group, headquartered in Wilmington, Massachusetts, to centralize direction of these important aerospace functions. The Research and Advanced Development Division was divided into the Missile Systems Division, which stayed in Wilmington, and the Space Systems Division, which took over RAD's facilities in Lowell, Massachusetts. The company's Electronics division in Evendale, Ohio, was included in the group. Avco Instrument Division in Tulsa, Oklahoma, was absorbed into the Electronics Division.

AVCO ELECTRONICS DIVISION

Avco Electronics Division manufactures tactical communications equipment, space electronics and infrared systems, commercial products, and instrumentation.

In 1966 the Division made important advances in the development of communications equipment. Late in the year, the Division won an order to develop and produce the AT-440 receiver-transmitter for the Lockheed C-5A aircraft. This radio represents a major step forward in high frequency airborne communication, setting new standards in reliability, performance and compactness. It incorporates the principal of binary tuning, a development unique to Avco. The Division also began producing the AN/ARC-123 radio for the Air Force F-111. Two lightweight manpack radio sets were developed and went on field test, and the Division's AM-4306 amplifier, which will be used with Army radio equipment, went into production. The Division was also developing UHF communications equipment that will require no maintenance.

In space communications, the Division continued to develop its telemetry equipment and command-radio receivers and decoders for space vehicles, missiles and rocket boosters.

Production of infrared countermeasures receivers for the F-111 went into its third year, with output being stepped up as more F-111's were produced. The Division continued its work on advanced infrared airborne equipment.

The Division began to develop radar equipment, which will be used by the North American Air Defense Command, designed to spot and track enemy missiles launched off-shore by submarines.

It was also making shock machines, mass spectrometers, vacuum chambers, and specialized testing instruments.

In the commercial field, it began manufacturing intercom systems under sub-contract.

Division teams install, operate and maintain electronics equipment for the military services, NASA and non-government organizations. These field engineering activities expanded.

During the year the Division opened its new facilities in Huntsville, Alabama, where it employed 120 persons. The work at this facility involved the development and production of space communications equipment, the most important of which was for the Saturn rocket booster.

AVCO MISSILE SYSTEM DIVISION

Some of Avco Missile System's most important work is its development of reentry vehicles for intercontinental ballistic missiles and antimissile systems. Most of these vehicles, which are produced at Avco Lycoming's Stratford, Connecticut, plant, have been for the Air Force Minuteman program. In 1966, the Division received a contract to develop and flight test the Mark 17, a new highly sophisticated vehicle. This will be integrated into the Minuteman II ICBM, the country's most advanced missile.

The Division also received Air Force contracts to continue its development of penetration aids. It was working on sub-systems for short range air-to-surface missiles, as well as surface-to-surface and surface-to-air weaponry.

AVCO SPACE SYSTEMS DIVISION

Heat shields built by Avco Systems Division for the Apollo spacecraft were proved during the year, in 2 suborbital flights. The Division was building heat shields for 13 spacecraft for missions near the moon, and 2 of these were to test the heat shields during lunar flights.

The Division, in a related project for NASA, constructed 2 small flight models of spacecraft covered with Apollo ablative material.

Owing to its work in the Apollo program, the Division obtained 2 contracts connected with NASA's manned spacecraft program. One was for production of full-scale mock-ups of the Apollo Service Module with the Lunar Module. The other was for a variety of spacecraft models for wind tunnel and ballistic range testing.

The Division culminated 3 years of research with the delivery of the Resistojet, a low-thrust electrically propelled rocket. Used successfully in the launching of a scientific satellite, it is one of the smallest flight-qualified spacecraft engines.

The Division also received contracts from the Kitt-Peak National Observatory and Harvard University to build small scientific satellites.

Several programs involved with interplanetary exploration were carried out for NASA. These included the design of 2 unmanned probes, one to take atmospheric readings of Mars, and a larger vehicle to do this as well as take photographs of the planet's terrain and send them to earth. Also under way were studies of 2 possible manned explorations of Mars, spacecraft sterilization, and deep space communication.

In the important field of composite materials, Avco engineers developed a process for strengthening composites by weaving their fibers in 3 perpendicular planes. The Division also continued its manufacture of boron filament for the Air Force.

BEECH AIRCRAFT CORPORATION

A highlight of the year for Beech Aircraft Corporation was the award of a $9,800,000 Army contract for production of 48 utility aircraft of twin-engine, turbine-power design and the training of pilots and mechanics.

The contract called for delivery by June, 1967. It also contained an option for an additional 40 utility aircraft to be delivered at the rate of 10 a month after June 1967. If the option is exercised, the total contract, including spares, was expected to exceed $20,000,000. Follow-on orders, in addition to deliveries under option, were expected to extend production of the Army utility aircraft for several years.

The Army utility Beechcraft described in the contract—modifications of the Beech NU-8F series developed in 1963—will be powered by twin Pratt & Whitney Aircraft PT6A-20 engines identical to the pressurized King Air corporate transport powerplants.

Beechcraft also will train 20 instructor pilots and 20 instructor mechanics on operation and service of the aircraft. This training will be scheduled at the Beechcraft facilities in Wichita, Kansas, where weekly instruction is scheduled on operational techniques in the transition from piston-engine aircraft to the Beechcraft turboprop King Air.

Classes include ground school instruction in maintenance and operation of the utility aircraft as well as transition flight checks for pilots—similar to the civilian program operated for corporate users of Beechcraft throughout the year.

In accordance with Army requirements for mission support, the Army utility aircraft described in the contract will be capable of accommodating up to 10 combat troops, or from 6 to 8 persons in varied interior configurations plus a crew of 2 in a 300 nautical-mile radius of action. The utility aircraft also can be converted to an air-evacuation ambulance with the installation of 3 litters, which still leaves room for 3 ambulatory patients.

Modifications will include a cargo door forward of the regular airstair cabin door to provide overall cargo accommodations of 53½ by 51½ inches. All-weather operation will be permitted by a full complement of avionics and navigation equipment. Performance of the Army Beechcraft utility airplane was estimated to exceed military specifications for maximum cruise speed, maximum endurance, rate of climb on one engine, service ceiling and ferry range. With a maximum gross weight of 9,500 pounds, the utility aircraft will be capable of carrying 2,000 pounds of useful load cruising at speeds of more than 200 miles per hour. It will have a range of nearly 1,250 miles including a 30-minute fuel reserve or maximum flight endurance of about 8½ hours. The aircraft will have an estimated service ceiling of 26,400 feet and single-engine service ceiling of 11,400 feet. At maximum weight, the craft in military service can operate from fields as short as 1,000 feet in length. The airplane is 35 feet 3 inches long, 14 feet 8 inches high and has a wing span of 45 feet 10½ inches. Awarding of the utility aircraft contract marked the third decade of association between Beechcraft and the U. S. Army.

During 1966, Beech was offering a product line of 17 business and utility aircraft, ranging in size from the 2-place single-engine Musketeer to the pressurized, turbine-powered King Air A90. New to the line were the Turbo Baron 56TC, a 300 mile-per-hour light twin; the Queen Air A65; and a 6-place version of the Musketeer Super III.

Beech also announced production plans for two new aircraft: a pressurized 260 mile-per-hour medium twin designated the Duke, and the Model 99, a 17-place turbine-powered high-density airplane. The latter was in flight test status during 1966 and the Duke was scheduled to fly at year-end.

Major military programs included a $16,900,000 add-on contract with McDonnell Company for F-4 Phantom II assemblies; a $5,700,000 add-on with Bell for Iroquois UH-1 assemblies; a $2,500,000 contract extension from the Army for the Model 1025 Cardinal target missile; a $17,000,000 extension for assemblies for the USAF Lockheed C-141; a Navy contract extension of $4,000,000 for the AQM-37A target missile. Beech completed deliveries to the Army under a $2,500,000 contract for T-42A twin-engine instrument trainers and made deliveries of the VC-6A, military version of the King Air, to the USAF's Special Air Mission fleet.

In the missile field, Beech, along with RCA, was selected as 1 of 3 contractor teams to conduct a program detailing final proposals for development of the Surface-to-Air Missile Defense system (SAM-D).

Beech's Boulder (Colorado) Division, a pioneer in cryogenics since 1954, was engaged in design, development and production of highly sophisticated ground support and on-board systems for national space programs. Beech provided the cryogenic

Beechcraft Boulder Division worker assembles cryogenic storage vessel for Apollo Lunar Module.

loading and transfer systems for the Gemini project and was building, under contract to Grumman, supercritical helium conditioning units and liquid helium storage and transfer units for the Lunar Module.

In April 1966, Beech opened a new division at Salina, Kansas, and by year-end the division had 2 major production lines in operation: the 1025 Cardinal target missile and wing assemblies for all Beechcraft airplanes with the exception of the Musketeer.

The company estimated fiscal 1967 sales in the area of $175,000,000-$180,000,000.

BELL AEROSYSTEMS COMPANY

A TEXTRON COMPANY

For Bell Aerosystems Company the year 1966 was one of expansion in the fields of aviation, avionics, space, transportation and in company facilities and personnel.

Bell, one of the diversified manufacturing operations of Textron Inc., is headed by President William G. Gisel, an executive with more than 25 years of service in aerospace industry. Company headquarters and main plant are located adjacent to Niagara Falls International Airport, New York. The company also maintains an avionics instrument laboratory in Cleveland, Ohio, and electronic research facilities in Tucson and Fort Huachuca, Arizona.

Employment at year's end exceeded 6,000, an increase of more than 1,700, and Bell expected to hire additional employees to match its rise in new business. Office facilities for new employees were being provided in a 100,000-square-foot building constructed at the company's main plant.

Bell was playing an important role in the United States space effort to get man to the moon with programs involving propulsion systems, positive expulsion tanks for propellants and other liquids, and training of astronauts.

Under contract to Grumman Aircraft Engineering Corporation and for the National Aeronautics and Space Administration, Bell was developing the ascent rocket engine which will power the Lunar Module from the moon's surface to rendezvous with the orbiting Apollo Command and Service modules. This 3,500-pound thrust engine underwent extensive testing at the Bell Test Center and NASA's White Sands facility and production models were being produced.

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 provided during the year 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 Modules. Other programs were the Lunar Orbiter, the Centaur launch vehicle, the Agena target vehicle for Project Gemini and an Air Force satellite program.

The company substantially enlarged its "clean room" facilities to support its positive expulsion tank programs. The rooms were also being used for fabricating and assembling the LM ascent engine.

In preparation for landing a man on the moon, Bell's 2 Lunar Landing Research Vehicles (LLRV) were being used in a NASA program to investigate lunar landing techniques and problems. These vehicles were being modified for use by astronauts at the Manned Spacecraft Center (MSC) in training for landings on the moon. Bell expected to build additional vehicles, called Lunar Landing Training Vehicles, similar to the LLRV's.

Bell played a major role during 1966 in the Gemini program by providing the primary and secondary propulsion systems for the Gemini Agena target vehicle. The 16,000-pound thrust, multi-start Agena engine helped set new space records and accomplishments including the highest altitude achieved by man. The standard, reliable Agena engine also had a workout during the year by placing many payloads in space among which were several NASA programs including OGO, Lunar Orbiter, OAO, Pageos and Nimbus, plus a number of Air Force programs.

To prepare for their Gemini missions astronauts received part of their training in a Bell simulator located at Cape Kennedy called an Earth Orbital Scene Generator which enabled them to practice rendezvous and docking in space.

Bell made 2 major innovations to its world-famous Rocket Belt in 1966. The company developed a Flying Chair and Pogo Stick using the basic Rocket Belt concept in new configurations. In addition, the company announced it was working on an advanced 1-man propulsion system which will use a turbojet engine as its power plant. This will enable flight durations and greater control capability than is available in the Rocket Belt.

In other rocket propulsion activity, the company continued development and testing of small rocket motors and associated propellant tankage and controls for the Minuteman program.

During 1966 Bell continued its work on advanced space vehicles such as a rocket-propelled Manned Flying System (MFS) which may be used to carry astronauts over the moon's surface.

Other devices Bell was designing and studying for future space travel include a Remote Maneuvering Unit (RMU) and a Dual Maneuvering Unit (DMU), which incorporates the best features of the RMU and an Astronaut Maneuvering Unit. All of these devices were being studied in a new versatile space simulator Bell completed in 1966. This simulator is the first to employ 3-D projection.

While Bell was active in the nation's space program, several major developments took place during 1966 in other company activity.

Bell, a leader in air cushion vehicles, began tooling up for quantity production of these speedy amphibious craft which ride on a cushion of air over most surfaces. The company started production of 20 vehicles consisting of 7-ton, 10-ton and 25-ton craft.

The 7-ton craft, known as the SK-5, began its first U. S. military role in Viet Nam where it successfully underwent a Navy evaluation program. The Navy was operating 3 SK-5's in Patrol Air Cushion Vehicle (PACV) Division 107.

Bell ACV's were also active in demonstration programs in the United States. A year-long demonstration project, featuring the nation's first scheduled ACV passenger service, was successfully concluded at Oakland, California, in August. During

Bell Aerosystems announced plans to produce this 25-ton, 90-passenger Air Cushion Vehicle.

this period two craft carried 13,600 passengers and logged 179,000 passenger miles across San Francisco Bay. Bell also conducted demonstrations with its ACVs in Alaska, Puget Sound and Canada. In addition, Bell established Bell Aerosystems Canada, a division of Textron Canada Limited, to develop full utilization of ACV's in Canada.

In the field of vertical/short takeoff and landing (V/STOL) aircraft, Bell's X-22A airplane started its flight test program as part of a Tri-Service V/STOL research program. Two aircraft were built by Bell with one continuing the research program following a hard landing and extensive damage to first aircraft.

In avionics, Bell's SPN-10 All-weather Carrier Landing System (ACLS) played an important role in Viet Nam through use of the system in landing aircraft under adverse weather conditions. Bell received contracts from the Navy to replace the SPN-10 analog equipment with SPN-42 digital systems to improve reliability and maintainability.

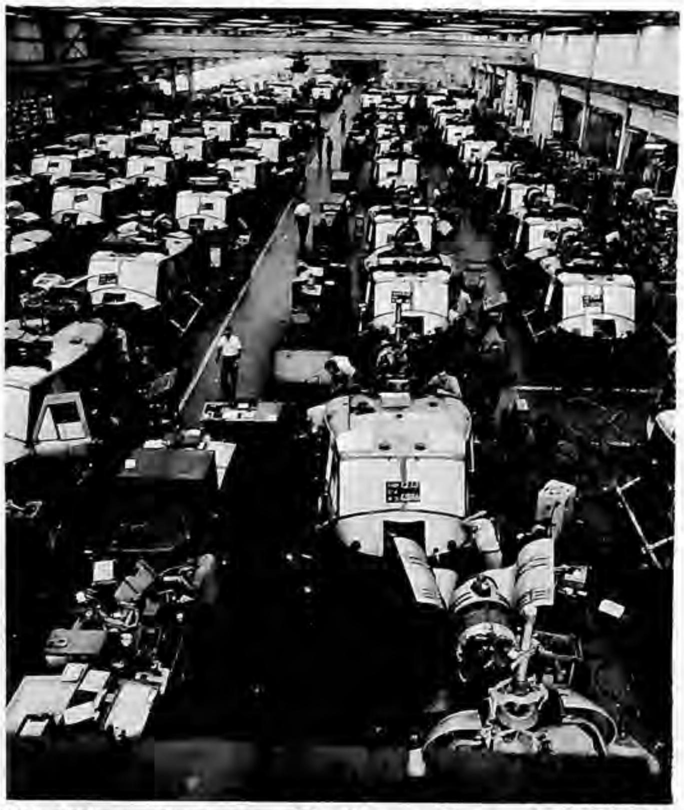
Under another Navy program, Bell developed and successfully demonstrated a Shipboard Gravity Meter which enables precise measuring of gravity forces under the ocean. This new device, based on an original Bell concept utilizing an accelerometer, provides versatility and accuracy heretofore unobtainable.

BELL HELICOPTER COMPANY

Production, sales and employment figures at Textron's Bell Helicopter Company reached record highs in 1966. Widespread acceptance of the commercial JetRanger and Army contracts for substantial numbers of the new HueyCobra presaged another banner year for the company in 1967.

Employment at the Fort Worth, Texas, facilities passed the 10,000 mark, an increase of 30 per cent during the 12-month period. One new production facility was opened.

Bell continued to produce a heavy volume of UH-1B and UH-1D Iroquois models for the Army as well as Marine Corps UH-1E and Air Force UH-1F versions in quantity. All but the UH-1F were operational in Viet Nam, as was the Army OH-13S, a 3-place light observation ship. Also built for the Army was the 2-place TH-13T instrument trainer.



UH-1D's on final assembly line at Textron's Bell Helicopter Company.

The company's 1966 commercial production included, in addition to the JetRanger, 2 other new models. The 3-place 47G-4A is a utility craft and the 47G-5 is available as a 2-place aerial application model or as a 3-place utility ship.

Other commercial models produced in 1966 were the turbine-powered, 10-place 204B, the 4-place 47J-2A and the 3-place 47G-3B-1.

The 5-place, turbine-powered JetRanger, introducing a new era of flight mobility, was an instant hit. Rolled out in January, it began a 14,000-mile, coast-to-coast demonstration tour of the United States and Canada in April. Completing the 4-month junket, it was then taken to England for appearances in September.

The JetRanger received FAA certification in October and production in quantity began immediately after.

March 8, 1966, marked the 20th anniversary of the awarding of the first commercial helicopter license—to a Bell Model 47. It was with this licensing that the federal government initially approved the helicopter as a carrier of passengers "for hire or reward."

Three days after that anniversary, the Army announced that it would order the HueyCobra, a high-speed aerial weapons platform with greater ordnance-carrying capability and more staying power than any currently-operational ship in its classification. A development contract for design, production and qualification testing of 2 prototype models was awarded April 7. Six days later the Army included 110 HueyCobras in an order.

The largest contract ever awarded by the Army Aviation Materiel Command, also the largest ever received by Bell Helicopter, was announced June 28. It was the definitization and upward revision of a letter contract, bringing the new total to $249,457,443. The contract covered production and delivery of 2,115 UH-1 Iroquois models.

Bell also was extremely active in research and development programs during 1966.

The company fulfilled a contract with the Army for a new VTOL composite research aircraft. Bell's design, under competitive evaluation, is the tilt-rotor Model D266. Supporting the tilt-rotor concept is the company's 15-year background of development and actual flight tests.

A joint Army-Bell-Continental Motors Corporation program to provide a twin engine for the UH-1 series was successfully completed and preliminary evaluations were made by the Army, Navy and Air Force. The project demonstrated the compatability of the T-67 twin powerplant with the UH-1 to provide the combat-proven Huey with still greater mission potential.

A spacecraft recovery rotor system, which would enable space pilots to maneuver their capsules to earth at low, safe speeds, was successfully tested in the wind tunnel at Ames Research Center, Moffett Field, California. The 25-foot-diameter, 3-bladed rotor system was designed and built by Bell under contract with NASA.

An "instant" helipad was designed and tested by company engineers, using "off-the-shelf" materials that can be sprayed on mud, soft or dusty terrain. The 50 x 50-foot landing area withstood weights of landing helicopters ranging from a 9,500-pound UH-1D to a 33,000-pound Army CH-37.

Perhaps more significant than any of the records and accomplishments listed was the milestone reached in October—10 years of on-schedule deliveries of aircraft to the U. S. government.

THE BENDIX CORPORATION

ECLIPSE-PIONEER DIVISION

In 1966, The Bendix Corporation's Eclipse-Pioneer Division continued to play a major role in the aerospace industry with record sales and orders, an expanding research and development effort, and a wide range of products associated with practically every major domestic aviation, missile and space program as well as foreign projects.

In February 1966, a contract was awarded to the Division for equipment that would provide an all-weather landing capability for USAF's giant C-141 fanjets. The systems, slated for all C-141's in government inventory, included completely monitored microelectronic, redundant flare computers, fail-operative yaw dampers and vertical navigation equipment. The Division was also producing the Lockheed-built C-141's automatic flight control system, central air data computer and vertical scale indicators.

During the year, the precision approach and landing system, which last year won Federal Aviation Agency (FAA) approval for use in commercial service, was ordered by Boeing and 19 airlines for installation on Boeing 707's and 720's. Most of the more than 500 systems ordered were for Category II systems; but, as a prelude to future fully automatic operations, more than 60 of the systems ordered will additionally equip the airliners to remain on automatic control all the way to touchdown.

Under a contract for the company's Microvision all-weather landing aid, runway beacons were installed at the FAA testing center at Atlantic City, N. J., and Microvision airborne equipment was installed in an FAA DC-7. At year-end, the Microvision system, which permits a pilot to "see" the runway through obscure weather and visually monitor his approach, was undergoing FAA tests and evaluations under actual operational conditions.

Work on the Anglo-French Concorde supersonic transport (SST) accelerated during the year with continued engineering development of the automatic flight control systems (AFCS), including all-weather landing equipment, and receipt of new research and development contracts for air data computers and vertical velocity indicators. The Concorde's AFCS, as with the USAF C-141 equipment, called for completely monitored microelectronic, redundant flare computers and fail-operative yaw dampers. Eclipse-Pioneer application of the latest techniques of microelectronic technology to such systems has been pacing the industry.

The Bendix PB-60 automatic flight control system, previously certified for such diversified aircraft as the Japanese YS-11 turboprop, Italian Piaggio-Douglas PD 808 twinjet, and the American Jet Commander, was approved for use on the Pan Am Falcon, manufactured by France's Generale Aeronautique Marcel Dassault, and North American T39 Sabreliner executive jets, Beechcraft Queen Air executive transport, and DeHavilland CV-2 Caribou military transport.

Both the USAF and Navy ordered additional automatic dead reckoning navigation systems. The Air Force ordered the system for its RF-4D and F-4D aircraft while the Navy designated these systems for use on F-4J fighter aircraft, A-6B and A-4D attack aircraft. The British also ordered the system for the F-4J's which they bought from the U.S. These self-contained systems continuously compute, transmit and display essential information needed by the pilot in the navigation of his aircraft.

Both research/development and production contracts were received for redundant yaw damper systems for the B-58 Hustler bomber. Eclipse-Pioneer was also providing the B-58 with flight control systems, air data systems, and support equipment.

The year also saw 58 pairs of vertical scale instrumentation ordered for USAF's Lockheed-built mammoth new C-5 jet transport.

In the area of automatic checkout equipment, the AN/GSM-133 general purpose programmer comparator was, at year-end, being weighed by the military for a wide range of programs. Among those being considered for the "133" were the F-111 A&E shop, the C-141 all-weather landing system and the RF-4C and F-4C IRAN (Inspect and Repair as Necessary) programs. The "133," successor to the highly successful AN/GJQ-9 which has been used in some 14 different aircraft, missile and space programs, provides all necessary present and future growth capabilities to handle automatic checkout implementation through the coming decade.

In the space field, Eclipse-Pioneer teamed with the Martin Company and was awarded a NASA contract on Apollo Applications to study scientific and engineering considerations for Apollo missions. The AA program called for such studies as mission analysis, equipment integration, tracking and support requirements.

Production continued on the highly successful guidance platforms for NASA's Saturn program. The moon rocket's platform is designed to generate velocity and acceleration information which determines the accuracy of pitch programming and final insertion of the payload into orbit.

For the ninth consecutive year, inertial guidance systems were produced for the Army's Pershing missile program. As the total Pershing firings passed the 100 mark, the guidance system continued to maintain its perfect record.

Eclipse-Pioneer continued to provide liquid-floated Pendulous Integrating Gyro Accelerometers (PIGA) for USAF's Minuteman II missile program. 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.

The Division won a research and development order for PIGA accelerometers to be used on the Self-Aligning Boost and Re-Entry (SABRE) guidance platform for a maneuvering re-entry type missile. A study contract on the SABRE guidance system was also received.

Also for Minuteman, the Division continued to provide 2 security devices which are links in the missile's electronic launch system that prevent unauthorized firings. The devices are known as the Launch Enable Execute Decoder (LEED) and the Digital Safety Control Switch (DSCS).

Orders also were received for reaction wheels for use on the control system of the Nuclear Detection Satellite, a space vehicle frequently referred to by its code name, Vela.

Work continued on the production of 2 units for NASA's Lunar Module. One, a range indicator, will provide the LM astronauts with altitude and rate of altitude change information during descent from the Apollo command and service module to the lunar surface. On the return to the mother ship, the indicator will show separation distance and rate of closure between the two vehicles. The second LM device is an electro-mechanical actuator that will provide precise positioning of the LM ascent-descent engine throttle as the vehicle descends to the moon.

For the Army, the Division continued to produce radar antenna pedestals for Hawk missile systems and radar simulator stations for Nike-Hercules missile installations. The radar simulator stations supply simulated targets and an electronic countermeasure environment for training Army personnel.

Reflecting the increased activity, Eclipse-Pioneer employment peaked at 11,000 during the year.

BENDIX AEROSPACE SYSTEMS DIVISION

Bendix Aerospace Systems Division, as the Corporate focal point for the development of extraterrestrial exploration systems, was finalizing the detailed design of a roving vehicle for use on the lunar surface. Under contract to NASA's Marshall Space Flight Center, this lunar vehicle, called the Local Scientific Survey Module (LSSM), is being designed for use on the Apollo Applications Program (AAP). The program is the immediate follow-on to the Apollo program and will provide our astronauts with the means to travel on the lunar surface and the instruments to obtain scientific and engineering data on the nature of the moon and its environment. The first lunar surface launch is scheduled in 1970.

The one-man vehicle will carry an astronaut, in his spacesuit with backpack and a 700-pound scientific equipment payload over 125 miles (200 kilometers) of lunar terrain. Life support for a vehicle sortie is provided by three Portable Life Support Systems, one on the astronaut's back and two stored on the vehicle. The vehicle is driven by a mobility controller in the driver's station which provides power through a sealed traction drive mechanism in the hub of each of the four vehicle wheels.

In 1966, Systems Division completed the study of the specific scientific missions for NASA 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.

In early 1966, Systems Division completed the fabrication, assembly, and acceptance testing of the Mobility Test Article (MTA). This 25-foot-long, 1,750-pound vehicle is a full dimension, 1/6 mass scale vehicle to evaluate the mobility concept and performance of proposed lunar vehicles for post-Apollo exploration. The LSSM mobility concept is a direct out-growth of this MTA system design.

A field test program with this vehicle, conducted under the direction of NASA's Marshall Space Flight System, is in progress at Aberdeen Proving Ground and at Yuma, Arizona. Field tests with the vehicle will determine soft soil performance, slope climbing, obstacle and crevice crossing and turning characteristics, and energy consumption.

BENDIX PRODUCTS AEROSPACE DIVISION

One of the major new developments during 1966 for The Bendix Corporation's Products Aerospace Division, South Bend, Indiana, was the division's selection as the subcontractor for designing and manufacturing the main and nose landing gears for the Lockheed C-5A program.

The contract covers the manufacturing of hardware to support the first 58 production aircraft. Major additions to engineering and manufacturing facilities were under way to accommodate the extreme size of not only the C-5A gears but those of the other new generation of large aircraft now being developed.

In general, the division's aircraft landing gear product line was maintained at high volume to support the McDonnell F-4 and other continuing programs.

Bendix Products Aerospace also was selected during 1966 as the supplier of wheels and brakes for the Boeing 727-200 series and the Douglas DC-8-63 series aircraft. The year also saw increased production of wheels and brakes to support the high manufacturing and use rates of the many operating commercial jet aircraft models equipped by Bendix. The trend was expected to continue as the Boeing 737 and Douglas DC-8-61 and -62 series programs entered into volume production.

Active research and development continued throughout the year in the field of aircraft wheels and brakes, with emphasis placed on improved frictional and heat sink materials. Laboratory techniques previously developed by Bendix were extensively used in this work. For example, an entire landing gear system, including shock strut and primary wing fittings, can be tested in the division's laboratories. This procedure assures that performance advancements of friction materials obtained are not at the expense of frictional stability and attendant roughness. Significant advances in brake weight and envelope volume have been made through the use of more refractory type friction materials. Further weight reductions proved technically feasible through the use of beryllium and other exotic materials in heat sink components. Work was continuing to advance the potential use of titanium alloys in aircraft wheel and brake structure. A 1966 phase, conducted under USAR sponsorship, was concerned with improved techniques in the forging and machining stages.

The year 1966 at Bendix Products Aerospace also meant increased production of large gas turbine controls for such outstanding new programs as the Pratt & Whitney Aircraft engines used on the F-111 and A-7A aircraft.

Fuel systems were being fabricated for use on development Lycoming AGT-1500 engines being provided for the Army Tank Automotive Center. The durability, optimum performance and competitive price of this control system makes it suitable for the commercial market as well as for the military.

Study and development programs were being carried out on fuel control systems being considered for use on such important new engine programs as the Pratt & Whitney Aircraft SST engine, advanced Allison T56 turboprop engine and the Wright Aeronautical lift cruise WTF60 engine.

Additional expansion occurred in the manufacture of the DP simplified lightweight control system for small gas turbine powered aircraft. Aircraft programs included the Beech "King Air," de Havilland Beaver and Twin Otter, the LOH helicopter, Bell JetRanger and Fairchild Hiller FH-1100 commercial helicopters.

Further expansion took place on fuel injection systems for general aviation reciprocating engines. Aircraft with Bendix RS injection included Hughes, Piper, Beech, Riley, Aero Commander and Mooney.

Studies were being carried out jointly by Bendix Eclipse-Pioneer Division and Bendix Products Aerospace Division in the application of microelectronic technology to the design of gas turbine engine control components.

Research and development continued in the field of fluid state components for gas turbine engine controls. Vortex amplifiers and jet-on-jet units were successfully demonstrated in such areas as temperature sensors, closed loop speed control, frequency difference detection, and up/down counters.

Demand continued high during the year for the division's capabilities and facilities in landing systems techniques which have been dedicated to the nation's space programs. Landing gear and vehicle landing dynamics studies were completed under contract from various NASA facilities, JPL, and Bell Aerosystems Company in 1966. Work in this field was still expanding.

Production volume of the unique Tension-Torsion Rotor Link, recently developed by Bendix for the helicopter industry, showed further gains in 1966. While major volume currently remains with the Bell UH-1 series, these steel wire filament links were chosen to retain the main and tail rotor blades on the Lockheed AAFSS program and for the Bell Model 206.

In high temperature materials, development and evaluation continued on chromium composite materials for gas turbine engine parts, leading edges and other applications in oxidizing temperature environments from 2,000 degrees to 3,000 degrees Fahrenheit. Emphasis was 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 2,500 degrees Fahrenheit or 500 degrees above production materials.

PIONEER-CENTRAL DIVISION

The year 1966 was one of expansion and growth for the Bendix Corporation, Pioneer-Central Division in every way. One of the new developments was a Radio Frequency Mass Gaging unit for fluid measurement. This equipment should prove especially useful for measurement of propellants under the zero "G" conditions of space.

Plant facilities were expanded by the construction of a new Administration and Engineering building which was occupied in October 1966. A new cryogenic test cell primarily designed for liquid hydrogen testing was also completed. This test facility was remotely located from the main plant as a precaution due to the critical nature of liquid hydrogen and other cryogenic fluids.

As the physical facilities at Pioneer-Central grew so also did the working force. Additions were made in various sections of the Engineering Department, Sales and Service Departments, and in production areas. This build-up in manpower was in full swing as the year ended.

RED BANK DIVISION

In 1966, Red Bank continued to add to its line of environmental-free brushless AC generating systems and at year-end had a complete family of systems rated from 15 KVA to 60 KVA.

One of these systems, rated at 30 KVA, was being produced for F4 Phantoms. Rugged and compact for its size, the unit supplies the F4 with clean, reliable electric power to operate its many instruments and other accessories. The unit also supplies the type of dependable operating life and low maintenance required in combat zones.

With the trend to lighter power systems, Red Bank initiated several "material-development" programs and was looking to reduce the weight of these AC systems even more.

The highly successful oil-cooled, brushless AC generators prompted the development of similar DC generators and during 1966 Red Bank produced several of these DC units and put them through preliminary tests. Initial engine tests were extremely successful and more severe road tests were scheduled. The new type generators would be immune to tough field environments encountered by ordnance vehicles and would find many applications.

Work continued on developing low-cost electric power systems for use in executive aircraft. Small brushless DC generator prototypes were built and tested during the year and scheduled for flight-tests.

These new brushless DC generators do not depend on the aircraft battery to start generation. Completely independent of an external power supply, the generators require only a drive or power takeoff to start generation.

In the executive field 3 new electric power systems were put into production during the year and all 3 systems were scheduled for use in Grumman's Gulfstream II aircraft. Capable of producing more than 70,000 watts of both AC and DC electric power, the systems include the latest state-of-the-art design techniques and construction materials.

New type transformer-rectifiers were developed during 1966. Prototypes of a 200-ampere unit were tested and checked in actual applications with good results. A complete line of these static conversion devices was planned.

Red Bank's static inverter continued to win acclaim for its outstanding performance in the Gemini space program. One of 54 critical parts in the program, the static inverter converts DC power to highly-precise AC power to operate the guidance equipment installed in the Titan booster.

YORK DIVISION

During 1966, 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.

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, and transformers. The Division is also working toward further development of lighter weight, smaller volume and higher reliability electronic systems for missile and space applications.

THE BOEING COMPANY

During 1966, The Boeing Company expanded rapidly, introducing new airplane models, launching its first space vehicles and piling up record orders and commercial backlog. Increased tempo in production of current airplanes and helicopters was matched by rush-schedule construction of facilities to be used in present programs and in building of the giant 747 subsonic transport. Simultaneously, the company exerted major effort in preparing its proposal for an American supersonic transport and in building a full-scale, $2,000,000 mock-up of its proposed variable geometry SST.

In the space field, Boeing delivered its first Lunar Orbiter vehicles, which successfully photographed the moon from minimum altitudes and the earth from near the moon. Burner II, an upper stage space vehicle built by Boeing, was successfully launched from atop a Thor booster, and work progressed on Advanced Minuteman intercontinental missiles. Boeing-built first stages for Saturn V rockets underwent successful tests at Huntsville, Alabama, and were emplaced at Cape Kennedy launching sites.

For the Navy, Boeing began construction of a hydrofoil gunboat using water-jet propulsion; and in the international field the company was a competitor both in the United States and Germany (through a partially-owned subsidiary) in a program to produce a short takeoff and landing fighter plane for U. S. and German forces.

Meanwhile, production of helicopters for United States armed forces increased steadily. A new model, the UH/CH-46D Sea Knight medium helicopter, joined the Marines' aerial fleet, and a prototype for a new, large helicopter, the Army CH-47B Chinook, made its first flight. The "B" is an advanced model of the Chinooks operating successfully in Viet Nam.

Boeing employment exceeded 130,000 persons by mid-October.

Most dramatic development of 1966 for Boeing was the announcement early in the year of the company's plan to build the model 747 jet transport, largest airplane ever designed for commercial service. Original announcement was accompanied by Pan American World Airways' revelation that it had ordered 25 of the huge planes, each weighing 680,000 pounds, measuring 228 feet 6 inches long and with a wingspread of 195 feet 9 inches.

This plan to build the 490-passenger 747's was confirmed in July. Prior to that time, excavation and ground clearing had begun at Everett, Washington, and construction began immediately on a facilities complex to include the world's largest-volume building, a final assembly structure containing 158,000,000 cubic feet of space. By mid-October, Lufthansa, BOAC, Trans-World Airlines, Japan Air Lines, Air France, and Continental Airlines had joined the list of 747 customers. Orders by October 15 totaled 56 airplanes. Boeing was prepared to build 200 by December 1972, and 400 by December 1975.

The 747, while accommodating more passengers than any existing or definitely announced commercial airliner, is so designed—a single-deck cabin 20 feet wide, with 4 wide doors for ordinary passenger use and 6 others available if needed, plus double aisles, space-breaking partial partitions, lounges and private cabins—as to afford unmatched comfort and spaciousness. It will be able to operate from any airport suitable for current intercontinental jetliners. The first 747 was scheduled for completion late in 1968.

Meanwhile, at the other end of the family of Boeing commercial jets, the first 2-engined model 737 short-to-medium range jetliners were under construction, with flights scheduled for early 1967. By October 27, orders for the smallest Boeing plane totaled 124. This figure compared to 656 total for the familiar 707-720 models and 541 for the popular 727 three-engined jet. Deliveries, as of October 15, totaled 840 for all models. Deliveries late in 1966 were slowed by delays in receipt of airplane engines.

Boeing's major effort in the American supersonic transport competition reached a climax on September 6, when the company's refined proposal for a 350-passenger, 306-foot-long airplane, featuring a variable geometry wing, was submitted for government and airline advisory committee study. The Boeing proposal, including more revenue seats than any other SST currently being built or proposed, was in direct competition with a double delta airplane proposed by Lockheed Aircraft Corporation for government approval of a 2-prototype program. Boeing's design, in which a wing adjusted to a sweep-back of approximately 42 degrees allows practical subsonic efficiency by integrating the variable geometry wing—swept back to 72 degrees—with large horizontal stabilizers to give a single lifting surface for the contemplated 1,800-mile-per-hour cruising speed. A movable nose will be lowered to provide pilots with exceptional visibility during takeoffs and landings, which can be made at existing airports suitable for intercontinental subsonic jetliners. (*Editor's Note:* President Johnson announced on January 1, 1967, that Boeing had been named winner of the competition. See Aerospace Events.)

During 1966, interest in air freight capabilities grew steadily and affected virtually all models of Boeing planes and most of the 57 customers who had signed for them by October 15. A quick-change (QC) concept developed by Boeing allowed complete conversion of a model 727 from passenger to freight configuration, or back again, in 30 minutes, and proved popular from its inception. A similar system was offered for model 737's, and many of the larger planes ordered during the year also were convertible or designed especially for freight.

First launch of a Lunar Orbiter photographic space vehicle was made on August 10, only 28½ months after a contract was signed with NASA's Langley Research Center. Thus, it became the first U. S. spacecraft to achieve orbit of a planetary body other than earth, the first spacecraft to change lunar orbit, the first to provide U. S. photos of the moon's far side and first to photograph Earth from deep space. The second Lunar Orbiter was launched November 6, and it successfully achieved photographic orbit and returned pictures of even higher quality than had Lunar Orbiter 1.

A modernization program for Minuteman intercontinental missiles was begun at Whiteman Air Force Base, Missouri. Ultimately, this program will replace 800 existing Minuteman missiles with the larger, more powerful Minuteman II. Each launch site at 5 Minuteman wings must be enlarged to accept the new system. Meanwhile, a total of 200 other Minuteman II missiles were being emplaced in new installations at Grand Forks, North Dakota, and Malmstrom AFB, Montana.

On September 15, a Burner II upper stage space vehicle, built by Boeing and using a Thor booster, was launched successfully from Vandenberg AFB. This was part of a program managed by the Air Force Space Systems Division. First flight came only 15 months after Boeing signed the first $6,500,000 contract for 2 ground test and 3 flight vehicles. In July 1966, a $2,200,000 follow-on contract for 5 additional flight vehicles also was awarded to Boeing.

The HiBex (High-G Boost Experiment) program was concluded during the year with an above-ground launch at the White Sands Missile Range in New Mexico. All test objectives were met on the program, for which Boeing was prime contractor.

In July, Boeing was awarded a one-year $2,100,000 contract to continue study of an airborne warning and control system (AWACS). Three firms were in competition for the advanced study contract, and Boeing and Douglas were chosen to continue. The Boeing-proposed system would employ 707-320 jetliners equipped with advanced radar, communications and data equipment.

A highlight of the year for Boeing was the company's selection as developer/producer of a new Air Force weapon, the Short Range Attack Missile (SRAM). SRAM is a nuclear-tipped missile designed to penetrate enemy defenses at low altitude and to permit the launching aircraft to "stand-off" beyond the range of enemy defensive weapons. SRAM will be used by the FB-111 bomber and is also adaptable to the B-52 or the USAF's Advanced Manned Strategic Aircraft.

The selection brought a $235,800,000 contract on a fixed price incentive contract. The funds included $142,300,000 for development of the missile, which carries the designation AGM-69A, together with $93,500,000 for an initial production quantity.

Production of Vertol helicopters, by government direction, was rapidly increased during the year to meet current needs of the Army, Navy and Marines in Viet Nam. Employment at the Vertol Division in Pennsylvania climbed above 12,000 persons, and the world's largest helicopter production facility, a one-time steel forging plant converted to modern usage, added 1,000,000 square feet to the division's available space. With the new Sea Knight already in operation and the advanced Chinook in test flights, the division was expected to provide approximately 12 percent of Boeing's total business for 1966.

Production of helicopters under Boeing license for the Japanese self-defense forces and civilian purchasers in Asia continued at the Kawasaki company factories in Japan.

Early in 1966, Boeing's advanced marine systems organization received a Navy contract for construction of a hydrofoil gunboat (PGH-2) powered by a gas-turbine-driven water-jet propulsion system for foilborne operations. For displacement operations, a Diesel engine will provide the water-jet propulsion.

Subcontracting on the 71-foot, 60-ton gunboat began in mid-year and final assembly was scheduled to start early in 1967, with delivery promised for late in 1967.

CESSNA AIRCRAFT COMPANY

Cessna Aircraft Company advanced through its best and one of the most significant years in the company's 39-year history. New company records were set in aircraft deliveries, sales and earnings and employment.

Cessna expected to cap its record-setting year with 8,000 commercial aircraft, representing a substantial increase over the 5,629 aircraft delivered during the 1965 calendar year.

The most significant contributor to this increased unit volume was the 1966 Model 150. The 2-place aircraft marked a major milestone for Cessna when the 3,000th 1966 Model 150 rolled off the assembly line in July, nearly quadrupling Cessna's 1965 production run of 760 units. Success of the Model 150 program was attributed to a combination of design, volume production, quality, price, marketing programs and Cessna's expanding world-wide team of dealers and wholesalers.

The 3,000th Model 150 rolled off Cessna's line in July, nearly quadrupling total 1965 production of 760 units.

Closely linked to the record production of the popular trainer was Cessna's learn-to-fly and $5 introductory flight coupon program. The learn-to-fly program had been initiated 2 years earlier to increase the number of student pilots throughout the entire aviation industry and broaden the base of the private aircraft market. To support the learn-to-fly and $5 coupon program, Cessna created the largest single advertising campaign in its history.

The program was acclaimed a success and the outlook for continued success is good. Surveys by Cessna showed the program well on-target towards achieving an industry goal of 193,000 student pilot starts in the industry by 1968. More than 50,000 introductory flight lesson coupons were redeemed at Cessna dealers during the program's first 14 months and Cessna estimated the program already has generated $26,000,000 in revenue for the company's field sales organizations, more than was initially envisioned when the learn-to-fly campaign was launched.

Student pilot license issuances grew from 61,000 in 1962 to an estimated 125,000 or more at the end of 1966, and this rate of increase—30,000 more each year in the industry—was expected to continue. Of these students, Cessna figures the majority will be trained by Cessna dealers in the Model 150, and subsequently will be prime prospects for new Cessna aircraft. To meet this demand, the 1967 Model 150, which started production in August, also was expected to exceed 3,000 units.

Consolidated sales in Cessna's 1966 fiscal year, ending September 30, totaled $202 million, a 35 percent increase over 1965's previous record total of $148,419,000. Preliminary figures indicated earnings of $4.13 per share, compared with $3.30 per share the previous year.

Commercial aircraft sales totaled $140,185,000, up 51 percent over the preceeding year. All of Cessna's other operations—Industrial Product Division, Aircraft Radio Corporation, National Aero Finance Corporation and the McCauley Division—also showed substantial sales increases during the year, except defense business which was about equal to 1965. Military backlog, however, increased 75 percent over 1965 which was expected to result in significantly higher military sales in 1967.

Cessna's commercial aircraft deliveries during the 1966 fiscal year gained 57 percent over fiscal 1965. In the fiscal year, Cessna delivered 7,922 aircraft, an increase of 2,884 airplanes over fiscal year 1965. This was by far the biggest year in the company's history and represented a doubling of Cessna's unit business during the past three years. The company set 12 consecutive monthly delivery records during its fiscal year, capped off by a September delivery of 812 units to set a new company single month delivery record.

The 1966 fiscal year also marked the eleventh straight year Cessna has been the industry leader in unit production and the ninth consecutive year the company has been in the number one position of dollar volume leadership. The 7,922 aircraft in the fiscal year gave Cessna over 50 percent of the industry's total unit deliveries during the 12-month period. The largest gain came from the 2-place Model 150, the Model 172 and its companion model, the Skyhawk. Another large increase came in multi-engine aircraft sales where all 4 twins showed substantial sales gains, jumping from 567 units in fiscal 1965 to 817 units in 1966, a gain of 44 percent. Late in the year, Cessna's 200-mile-per-hour tandem twin Super Skymaster was acclaimed "Plane of the Year" for 1966 by editors of a national general aviation magazine.

Cessna was awarded a $4,000,000 contract in 1966 from the Army Aviation Materiel Command for 255 T-41B trainer aircraft, an off-the-shelf version of the commercial Model 172. The new Army primary trainer features a constant speed prop, a top speed of 153 miles per hour and a cruising speed of 148 miles per hour. The U. S. Air Force and 2 overseas Air Forces had previously adopted the T-41A series for primary flight training purposes.

In April, Cessna introduced its first aircraft designed specifically for the aerial application market—the Agwagon, which is available with either a 230 or 300 horsepower engine. The all-metal, low wing Agwagons are designed to fly faster and operate more economically than any other competitively priced aerial application airplane on today's market. More than 150 Agwagons had been delivered by the end of October.

In September, Cessna revealed plans to double its twin-engine line from 4 to 8 models for 1967 in a concentrated move to serve a broader segment of the booming multi-engine market. The company indicated that the new additions would place Cessna in market areas the company previously has not served.

On November 1, Cessna introduced its new six to eight place Turbo-System Model 401 executive twin and the new Turbo-System Model 402 9-seat air taxi commuter and air cargo twin. Both aircraft are in the low-cost medium twin field and open a new twin-engine market area for Cessna. The Model 401 represents a price break-through for customers advancing from the light to medium twin executive class. The Model 402, designed to meet the needs of the expanding air taxi and air cargo business, features a large roomy cabin specifically designed to provide an economical 9-seat commuter which can be quickly changed in minutes to a light cargo transport.

The company also announced plans to introduce its new 6-place pressurized Turbo-System Model 421 during the last half of 1967, well ahead of the original schedule. Cessna predicted that the 421 corporate twin would be the lowest priced, new pressurized twin-engine aircraft on the executive market and would be entering a price category previously served only by unpressurized aircraft. The 421 is priced at $159,950. Cessna announced that the fourth new twin addition would be in the lower cost area and was expected to debut in 1967. The 4 new twins, added to Cessna's earlier 4 twins, will give the company the largest line-up of multi-engine aircraft offered by any general aviation manufacturer.

Cessna hit another milestone in November 1966, when the company delivered its 70,000th airplane.

In addition to the big sales increase in Cessna's commercial aircraft, a significant development in the expansion of Cessna's military product line was established by the receipt in August of an initial Air Force order for 39 AT-37D twin-jet strike aircraft for counter-insurgency (COIN) warfare. At the end of the 1966 fiscal year, prospects were excellent for follow-on production orders of the new attack aircraft, which has more than twice the engine thrust and almost twice the gross weight of the standard T-37 trainer. The AT-37D's excellent maneuverability, small silhouette, low engine noise and high speed across the target, self-sealing fuel cells, twin-engine safety and armor plating gives the aircraft excellent survivability as well as being relatively easy to support at remote sites. Meanwhile, production of the T-37B and T-37C jet trainers continued under existing contracts. Other military contracts contributing to Cessna's overall sales success included modification of Cessna O-1 "Bird Dogs" for the Army and Air Force, continued production of military aircraft ordnance dispensers and containers, and several subcontracts on the McDonnell F-4B and F-4C.

To keep pace with production requirements, Cessna added 229,000 square feet of manufacturing, assembly and warehouse floor space at its Wichita facilities during 1966 and had another 285,000 square feet under construction. Employment at all Cessna operations, both in the U. S. and overseas, passed the 11,000 mark, up from 8,400 at the end of 1965.

CHANDLER EVANS CONTROL SYSTEMS DIVISION OF COLT INDUSTRIES INC

The Chandler Evans Control Systems Division of Colt Industries in 1966 continued volume production of TA 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 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 35,000 Chandler Evans main fuel controls have been produced, logging close to 3,000,000 service hours in Army helicopter operations—over half of them under jungle combat conditions.

Also, 1966 was Chandler Evans Control Systems Division's tenth 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 35 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 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.

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

In the regenerative engine field the division also developed and produced the IC-14 fuel control for a Ford gas turbine truck engine. Like other Chandler Evans fuel controls, it integrates fuel pumping, metering, filtering, pressure regulation and turbine speed governing in a unitized package.

Production of the Chandler Evans EHSV electrohydraulic servo valve for machine tool and similar control functions continued during 1966.

In still a different aerospace control area the Chandler Evans Control Systems Division in 1966 was actively working on stored gas actuation systems for several different missile programs, some of which were in production and others of which were 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.

CONTINENTAL MOTORS CORPORATION

Total sales and net income of Continental Motors Corporation and subsidiaries for the fiscal year ended October 31, 1966, rose to the highest level in recent years. Consolidated net earnings of Continental Motors Corporation for the 1966 fiscal year were $5,544,590 on total sales of $232,442,113.

Substantial progress was also made during fiscal 1966 in the modernization and expansion of the company's facilities. Of major importance was completion of a computerized communication system linking Continental Motors' manufacturing facility in Muskegon, Michigan, with the company's network of branch plants. This new system reduces substantially the time previously required to process and ship service parts orders, thereby expediting service to distributors, dealers and users of Continental products.

Shortly after the close of the 1966 fiscal year, plans were finalized for establishment of a new branch near Harrisburg, Pennsylvania. With the addition of the Harrisburg facility, scheduled to become fully operational in 1967, Continental Motors has 5 branch plants. Others are located in Chicago, Atlanta, Dallas and Salt Lake City. In addition, the company's wholly-owned subsidiary, Continental Motors of Canada Limited in St. Thomas, Ontario, has capabilities similar to the firm's branch plants in the United States.

During the 1966 fiscal year Continental Motors established an engine remanufacture and overhaul facility in Mobile, Alabama. Specific programs in work or scheduled for transfer to the new Mobile operation included overhaul of military tank engines, remanufacture of commercial aircraft engines, and other engine rebuilding programs.

Sales of Continental aircraft engines and spare parts during the 1966 fiscal year were approximately 25 percent greater than those recorded in 1965, reflecting the growing demand by corporations and private citizens for general aviation aircraft. Increased public interest in personal flying, stimulated to a great extent by the popular "Learn To Fly" promotion programs initiated by the general aviation aircraft industry in 1965, was particularly noteworthy.

Continental Motors produced over 55 percent of all engines installed in business and personal type aircraft during 1966. With such aircraft becoming safer, faster, more utilitarian, and easier to fly and own, record production schedules for 1967 were being predicted by light aircraft manufacturers.

Continental's major customers in the business and personal aircraft market continued to be Cessna Aircraft Company and Beech Aircraft Corporation, both of which reported record sales for 1966. In addition, Continental Motors was also supplying engines for certain models of aircraft built by Aero Commander, Alon, Inc., Bellanca, Maule Aircraft Corporation, and others. Cessna introduced its new Model 401 and Model 402 twin-engine airplanes during 1966, both powered by Continental's new 300-horsepower TSIO-520-E engine.

Continental increased its aircraft engine horsepower range in 1966 with the 375-horsepower GTSIO-520-D geared turbocharged engine. This new engine powers Cessna's new Model 421 pressurized twin engine business aircraft. The GTSIO-520-D is an uprated version of Continental's 340-horsepower GTSIO-520-C, utilized in the twin engine Cessna 411 and introduced in 1965.

During the year Beech Aircraft Corporation announced first deliveries of a new single-engine Beechcraft Bonanza—the V35TC, powered by a Continental TSIO-520-D turbocharged engine. This latest in a line of familiar V-tailed business aircraft that stretches back over 20 years will provide greater performance and increased utility among single-engine 4- to 5-place aircraft.

Continental's "Zero-Time" remanufactured engine program was receiving wider implementation through the company's branch plant network. Under this program owners of Continental-powered aircraft can exchange their original engine for a like model factory-remanufactured powerplant that has been restored to new-engine standards. Each zero-time remanufactured engine is automatically covered by the original Federal Aviation Agency type certificate, and by the same comprehensive engine warranty that protects all new Continental aircraft engines. When this program is fully implemented at all branch plants, most zero-time engine exchanges can be completed within 48 hours, as compared to a considerably longer period required for major overhaul.

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

Many new advanced engine design concepts which should prove of substantial interest to light airplane manufacturers in 1967 were included in Continental's continuous engineering development program. Progress also continued to be made on the company's program to provide the business and personal aircraft industry with a total power package—a concept in which such items as exhaust manifold systems, turbochargers, and controls will be included with each aircraft engine.

Continental-powered Cessna and Beech aircraft of the business and personal type continued to serve American armed forces in Viet Nam and other trouble spots throughout the world, and in military pilot training programs. Cessna primary trainers ordered by the military services this past year will be powered by Continental's IO-360-D 210-horsepower engines. This same basic engine is also used in the Cessna 337 Super Skymaster, selected as a forward control airplane for use in Viet Nam.

Other Continental-powered Cessna and Beech aircraft were being utilized by military services to make pinpoint aerial supply drops, for photo reconnaissance, and for light cargo and administrative purposes. Such use of these aircraft by the armed forces extends to the defense establishment numerous economic advantages since they are all military adaptations of existing, off-the-shelf business and personal aircraft that have already been thoroughly tested and proved in civilian applications.

Continental Motors Corporation, together with its subsidiaries, continued to be the world's foremost independent engine producer, manufacturing, in addition to commercial aircraft powerplants, engines in many different horsepower classes for a wide variety of material handling, automotive, industrial, agricultural and marine equipment—as well as piston and turbine engines for military land and air vehicles. The firms and its subsidiaries have manufacturing, engineering and development facilities in Detroit and Muskegon, Michigan; Mobile, Alabama; Toledo, Ohio; Milwaukee, Wisconsin; and Waterboro, South Carolina, in addition to a network of strategic branch plant locations.

COOK ELECTRIC COMPANY

A host of new developments in the space and missile fields were evidenced at Cook Electric during 1966.

One of the most prominent sources of recognition came with the delivery of the first prototype ultraviolet spectrograph developed for Northwestern University. The spectrograph will be used by astronauts in protographing the star fields and steller emissions from aboard Apollo spacecrafts. This joint industry/university undertaking for the National Aeronautics and Space Administration was expected to yield important scientific data that cannot be discerned from the earth's surface.

In another NASA project, Cook Electric, working in conjunction with the University of Wisconsin Astronomy Department, delivered a second experimental package for use in the Orbiting Astronomical Observatory (OAO). This package, which serves as the eyes of the OAO satellite, has an accuracy so remarkable that it can locate and track an object the size of a golf ball at 20 miles.

Once again research and development played an important role in company growth, exemplified by a major contract award from Sperry Gyroscope Company for the design, development, and production of a Wave Period Processing unit. An outgrowth of Cook's previous research and development efforts, the Wave Period Processor will be used in the Navy's PAIR (Performance and Integration Retrofit) program.

The basis for the PAIR program is to retrofit the Navy's primary fleet sonar equipment: the AN/SQS-23 used in anti-submarine warfare. The first in a series of 5 prototype wave processors was scheduled for delivery to Sperry in early 1967.

Engineers at Cook Electric were completing work on an FM version of a unique miniature magnetic recorder proposed for use on the Apollo Space Flight program and in new industrial applications. The FM advance is a variation of the biomedical recorder originally developed by Cook Electric for use by NASA on the Gemini program. The FM recorders receive and record 7 channels of data; 6 channels record physiological data, the 7th a channel of time. The FM variation will facilitate higher accuracy data and easier transcription on standard data processing equipment, and better serve industrial applications.

In another highlight of 1966, Cook developed and manufactured a new and advanced Direction Finding System for the Air Force. These new systems are to be installed on selected HC-130 aircraft by the Air Force's Special Test Squadron at Hickam AFB, Hawaii. The systems will be used to locate, track, and mark re-entering space vehicles, and participate in "air-snatch" recovery operations of space satellites.

Significant advances were also made in the field of audio communications, with the development of new Multi-Channel Key Panel Equipment.

This equipment was developed to provide increased reliability and versatility in operations communications for both commercial and military applications. The Key Panel, available in 5, 10, and 15 channel configurations and 2 or 4 wire cable schemes, is compatible with standard telephone cable distribution systems.

In a related advance, Cook engineers have developed an Applique Unit which provides audio and visual signaling supervision for point to point circuits along with operation between key panels and telephone instruments.

In still another development the Data-stor Division was selected as a major subcontractor to The Boeing Company. The Division, which manufactures computer peripheral equipment, designed and built photoelectric tape readers to be used in the Air Launch Control Center for the Minuteman ICBM.

After an extensive series of environmental tests ranging from extremes of temperature (212 to minus 70 degrees Fahrenheit), humidity, shock and vibration, and to prolonged subjection to intensive nuclear radiation, the reader proved itself extremely rugged and reliable. The tests were carried out at the company's Inland Testing Laboratories, an independent testing and environmental simulation facility located at the Morton Grove, Illinois, headquarters complex. The readers on order were to be delivered in early 1967.

The Company's Data-stor Division was engaged in a major production program for Model 55 Photoelectric Tape Readers, used by the General Electric Company and Control Data Corporation in the Posiedon and Polaris missile programs.

The year also featured continued development in the fields of parachute technology, camera capsules, biomedical recorders used on Gemini and Apollo spaceflights, and radar and guided missile electronic countermeasures.

CURTISS-WRIGHT CORPORATION

Operating divisions of the Curtiss-Wright Corporation made substantial progress in 1966 on programs aimed at expanding technological areas of interest.

At Wright Aeronautical Division, development of a lift-cruise engine, in connection with an Air Force competition, continued along with work on energy conversion systems, and a number of projects related to basic engine and component technology, such as turbine blades and discs, compressors, and liquid metal regeneration.

Further progress also was made on the various configurations of the Rotating Combustion engine. Milestones reached during the year included the successful completion of a 1,500-hour endurance test; initiation of several other test programs for military evaluation, including a 500-hour dynamometer test and a 10,000-mile endurance run; and field testing by both the Army and the Air Force of a portable electric generator system built by Westinghouse, which incorporates an RC engine as its basic power plant.

Westinghouse, in conjunction with its marketing effort of the 60 kilowatt/400 cycle system, placed an order for 12 RC engines for delivery in 1967.

Early in the year, Curtiss-Wright concluded an agreement with Outboard Marine Corporation (OMC), whereby OMC obtained licenses under patents to develop, manufacture and market Wankel-type Rotating Combustion engines.

OMC also concluded agreements with NSU Motorenwerke A. G. and Wankel GmbH, which, combined with the Curtiss-Wright agreement, granted to OMC nonexclusive licenses to manufacture and sell Rotating Combustion engines as power plants in OMC marine products throughout the world.

Increased demands for a variety of traditionally-produced aerospace components led the company to devote considerable resources to the manufacture of these items, with a necessary curtailment of some research and development. Major efforts of the various divisions, in this category of activity, included:

Wright Aero, all components of the forward, aft, combining and engine transmissions for the CH-47A "Chinook" helicopter, being produced by Boeing's Vertol Division, and engine components and space parts for Curtiss-Wright reciprocating and jet engines; Curtiss Division, rotor fold actuators for the CH-46 "Sea Knight" helicopters, also produced by Boeing/Vertol, and propellers and blades for various Air Force cargo aircraft; Metals Processing Division, Buffalo, jet engine components, produced for various prime engine contractors; Marquette, windshield wiper assemblies and other accessories for aircraft.

Curtiss Division continued production of actuation systems for a variety of aircraft, for the General Dynamics F-111 and the Boeing 737 jet liner, for example, while winning a competition to supply servo actuators for the guidance system of the Navy's Condor missile, being developed by North American Aviation.

The Division also continued one of its earlier specialties, fiber glass propeller blades, with additional orders to provide them for the Canadair CL-84 V/STOL aircraft, along with gear boxes and other components of the transmission system.

Eastern and National Air Lines became the first commercial carriers to order the diagnostic engine analyzers, based on sonics technology, developed by Curtiss Division. The Army joined earlier Navy interest in the program with contracts to Curtiss for the development of analyzers for the T-53 engine and transmission of the UH-1 helicopter.

The Electronics Division continued production of instrumentation and rod control systems for principal manufacturers of nuclear power plants, and won the competition to build a new C-141 flight simulator and to modify seven existing C-141 simulators. Radar maintenance trainers and other simulators also were marketed by the division during the year.

At Metals Processing Division, an effort was undertaken to develop a practical method of extruding 30-foot-long wing panels, with integral stiffeners, from titanium, a feat never before accomplished in the metalworking industry. At year-end, several extrusions had been made with what the Air Force called "very promising results."

Progress also was reported at MPD on development of new "super" alloys through the pre-alloy metal powder process.

DOUGLAS AIRCRAFT COMPANY, INC.

Expansion along its two major production fronts, commercial and government, highlighted Douglas Aircraft Company activity during 1966.

By year-end, sales were almost 30 percent over 1965, with total company employment rising by almost the same figure to support the increased production. The company's business backlog continued its rise to a total of $3,000,000, representing an increase for the year of almost $1,000,000.

Orders for commercial jetliners accounted for 80 percent of the backlog, with the remainder arising from the United States space program and military purchases of missiles and aircraft.

AIRCRAFT GROUP

The Aircraft Group had orders for more than 500 of its 4-engined DC-8 and twin-engined DC-9 jetliners from more than 50 domestic and overseas airlines as of October 31, 1966.

Scheduled for first delivery to an airline by the end of the year was the DC-8 Super 61, first of 3 new advanced models in the company's highly-successful DC-8 family. The big commercial jet—world's largest—flew for the first time March 14, 1966.

The Super Sixty Series, which also includes the Super 62 and Super 63, offers specific capabilities never before enjoyed by commercial carriers. The Super 61 seats 251 passengers in all-tourist configuration, 62 more than any previous DC-8. It has a 187-foot-long fuselage, 37 feet longer than previous DC-8's.

The Super 62, which took to the air for the first time August 29, 1966, is the world's longest-range commercial jet. The Super 63 will combine the seating capacity of the Super 61 and the long-range capabilities of the Super 62, to provide an earning potential nearly twice that of any current passenger or cargo jet.

First deliveries of the DC-8 Super 62 were expected early in 1967, closely following the DC-8 Super 61's debut in commercial service. First flight of the Super 63 was scheduled for the first part of 1967.

Both the Super 62 and Super 63 incorporate longer wings and new aerodynamically-improved engine nacelles and pylons that increase either range or payload capacity.

The Super 62's major distinction is range. With a fuselage extension of seven feet, it will carry a full load of 189 passengers from Southern California to northern Europe, a distance of nearly 6,000 miles without refueling. It will be utilized most heavily on polar and transoceanic routes.

Normal range of the Super 61 is 3,500 miles. But one of the big transports vastly exceeded this limit on August 16, 1966, when it spanned the Pacific Ocean in the first nonstop flight by a commercial jet between Los Angeles and Tokyo. The 5,630-mile hop was made during a demonstration tour.

Deliveries of the new DC-9 twinjets began in November 1965, and since then airlines in the U. S. and overseas have inaugurated commercial service with them. Orders for the versatile, short-to-medium-range airliner continued to roll in, with the total at 400 on October 31, 1966. Three versions of the DC-9 were in production: the Series 10 version,

In July, the first DC-9 Series 30, 15 feet longer than earlier model, rolled off Douglas' line at Long Beach, California.

with seating for 90 passengers; the Series 30 capable of carrying up to 115 passengers and the Series 40 which will have a maximum capacity of 125.

The first Series 30 made its maiden flight on August 1, 1966, to start a test program leading toward certification and deliveries early in 1967.

Among military programs, the Navy's rugged A-4 Skyhawk entered its 12th year of production with additional orders following the development of each succeeding model. The latest version, the A-4F, made its first flight on August 31, 1966. The TA-4F trainer version had already completed flight testing and was being delivered to operational squadrons.

Among a number of smaller production projects was the Apollo Range Instrumented Aircraft (A/R-IA) program underway at the Douglas Modification Division in Tulsa, Oklahoma. A/RIA production will be complete with the conversion by late 1967 of 8 Air Force jet transports into flying communications stations for use during manned Apollo flights and Air Force space missions.

MISSILE AND SPACE SYSTEMS GROUP

The year saw wide-scale use of Douglas products in space—hugh Saturn S-IVB moon rocket stages launched from Cape Kennedy, the reliable Delta rockets sent aloft on near-and-deep space missions and numerous classified firings by the Air Force of the Thor missile.

During the year Douglas continued the design and development of the Air Force Manned Orbiting Laboratory (MOL), for which the company is vehicle contractor.

Production at MSSD's sprawling Space Systems Center in Huntington Beach, however, continued to be dominated by the Apollo program. Douglas has responsibility for design and production of the S-IVB, second stage of the Uprated Saturn I rocket and third and final stage of the Saturn V vehicle that will send U. S. astronauts to the moon by 1970.

On a moon-bound flight, the S-IVB will be called upon to send the Apollo spacecraft into earth orbit, and, after a coasting period, re-start to propel the manned payload toward the moon.

A crucial phase of Saturn development was passed successfully on June 26, 1966, with the second firing of an Uprated Saturn I. Purpose of this launch was to determine whether hydrogen fuel in the S-IVB tank could be controlled under conditions of weightlessness, a requirement for the all-important re-start of the rocket engine. Television cameras peering into the orbiting S-IVB's tank proved that gentle acceleration by small rockets controlled the fuel satisfactorily. Contracts with the National Aeronautics and Space Administration called for Douglas to build 27 S-IVB stages.

Delta continued to hold its position as the most frequently used NASA rocket. During the year, it launched the weather-watching satellites ESSA I, II and III; Pioneer VII, a radiation probe sailing around the sun; Explorer 32, a test of temperature, density and pressure of the upper earth atmosphere, and Explorer 33 (Imp 4), another radiation experiment on a wide-swinging orbit of the earth.

The ESSA III launch on October 3, 1966, marked the first Delta launch from the Western Test Range at Vandenberg Air Force Base, California. Delta is a 3-stage vehicle using the Air Force Thor, another longtime Douglas product, as its first stage booster.

Both Delta and Thor reflect the Douglas "building block" approach to rocket development, having undergone succeeding engineering advancements in power and payload capabilities. Also, both have records of more than 90 percent in launch success. Most recent development in the Thor program is a long-tank version, increasing the first stage burn time and resulting in 500 pounds greater payload capacity for earth orbit.

A broad spectrum of research and study programs paralleled the Missile & Space Systems Division's production activities. These included the study of a Manned Orbital Research Laboratory (MORL) for NASA, continued investigation of biotechnological problems in space and the feasibility of future interplanetary flights.

Research and development of the Army's Zeus as part of the Nike X antimissile missile system turned to an advanced and longer-range version. Douglas is subcontractor to Western Electric and Bell Telephone Laboratories on the Zeus airframe.

The high-velocity Genie air-to-air missile entered its 10th year of production for the Air Force.

Plans for moving the corporate headquarters into new offices near Century City in West Los Angeles were announced. Douglas will occupy the top seven floors of a 20-story building scheduled to be completed in 1968.

At the Space Systems Center, engineering groups moved into two new 180,000-square-foot additions on January 7 and August 15, 1966. Two towering rocket assembly structures also went into operation, along with a 60,000-square-foot addition to the manufacturing facilities.

The Advanced Research Laboratory, an extension of corporate activity, was officially opened on April 5. The ultramodern scientific establishment provides basic research support of the company's missile, space and aircraft programs. Located adjacent to the Space Systems Center, it offers facilities for 100 scientists and technicians conducting research in mathematical sciences, biophysics, life sciences and material sciences.

Further expanding Douglas capabilities in research will be the Donald W. Douglas Laboratories at Richland, Washington, scheduled to be completed and occupied near the end of 1966. The laboratories will be operated in conjunction with Douglas activities at the Atomic Energy Commission's Hanford plant, where Douglas United Nuclear, a joint subsidiary of Douglas and United Nuclear Corporation jointly operates reactor and nuclear fuel fabrication facilities under AEC contract.

FAIRCHILD HILLER CORPORATION

The year 1966 was one of records and innovations at Fairchild Hiller Corporation. Sales and earnings established new marks, many new products rolled off assembly lines, and the company dedicated a new focal point for its research and development activity, the Sherman Fairchild Technology Center, in suburban Washington, D. C., at Germantown, Maryland.

Located within the Center's campus setting are the corporate offices and the Space and Information Systems Group, composed of the Electronics and Information Systems Division and the Space Systems Division. The Center was planned and developed as a primary facility for advanced work in spacecraft systems, structures, space electronics and communications sciences.

The Technology Center is serviced by a unique 600-foot, on-site airstrip for rapid liaison between customers and other Fairchild Hiller facilities, provided by the company's Heli-Porter STOL aircraft and helicopters.

Other divisions of the company include: Aircraft Division, Hagerstown, Maryland; Aircraft Service Division, St. Augustine, St. Petersburg and Crestview, Florida; Republic Aviation Division, Farmingdale; Long Island, New York; the Stratos Group, composed of Stratos/Bay Shore, Bay Shore, Long Island, New York, Industrial Products Division, Winston-Salem, North Carolina, and Stratos-Western, Manhattan Beach, California, and the manufacturing facilities of the Electronics and Information Systems Division at Winston-Salem.

AIRCRAFT DIVISION

Aircraft Division is the name of the 1966 combined Aircraft-Missiles and Hiller Aircraft Divisions. The consolidation of the divisions brought together 2 organizations with complementary objectives to utilize better the capabilities of the engineering and manufacturing facilities. Responsibilities of the division include development, manufacture and marketing of the company's transport aircraft and implementation of light aircraft programs associated historically with the Hiller name.

In 1966, production increased on the new FH-227 and F-27J turboprop transport aircraft. Order backlog at year-end for these aircraft stood at 80, highest in the history of the program. The FH-227 is a 300-mile-per-hour, high-wing aircraft backed by more than 1,000,000 miles of operations. The aircraft, longer than its F-27 counterpart, can carry up to 52 passengers and is readily convertible to all-cargo configuration. FH-227's and F-27J's are in production for carriers including Mohawk, Northeast, Ozark and Piedmont.

An initial quantity of 100 Heli-Porters, Fairchild Hiller's unique eight-piece turbine-powered light aircraft with STOL performance was also in production at the Hagerstown facility.

The division was also manufacturing the first 250 FH-1100's, commercial turbine-powered light helicopters, as well as SL4, L4 and 12E standard helicopters. The FH-1100 received formal FAA certification during the year.

First of the newly-modified C-123K assault transports were test-flown. The C-123K's, an improved version of the original Fairchild-built twin engine transport, have 2 auxiliary GE-J85 jet engines added for increased short takeoff and landing performance. About 120 C-123's are to be modified.

In September, the division introduced a new FH-227B propjet transport for the corporate and executive aircraft market.

AIRCRAFT SERVICE DIVISION

Florida-based Aircraft Service Division presently encompasses a rapidly expanding three-plant operation at St. Augustine, St. Petersburg and Crestview. At these facilities hundreds of aircraft were reconditioned including modification, overhaul, and inspection and repair. Among the major tasks performed were electronics repair, corrosion control, fuel cell reconditioning, dope and fabrication work, and precision spare parts manufacturing.

Among major 1966 programs at the St. Augustine headquarters facility were C-119 twin engine cargo aircraft overhaul and P5M flying boat overhaul.

The St. Petersburg facility was performing modification and overhaul on the C-130 Hercules transport aircraft for the Air Force and Coast Guard and C-135 jet cargo aircraft for the Air Force.

The Crestview facility modified and overhauled Republic F-105 fighter-bombers, T-33 jet trainers, C-123 assault transports, and HU-16 air-sea rescue amphibians.

ELECTRONICS AND INFORMATION SYSTEMS DIVISION

Fairchild Hiller's Electronic and Information Systems Division moved into new facilities in the Sherman Fairchild Technology Center at Germantown, Maryland, and also completed construction of a new 45,000-square-foot manufacturing facility at Winston-Salem.

The division was engaged in expanding technologies in meteorological systems, advanced communication systems, satellite power systems, missile guidance systems, electronic reconnaissance, data acquisition and annotation, special purpose computers, and surveillance and counter-measure equipment.

Production continued on the division's Auxiliary Data Annotation Systems (ADAS) for the RF4 and RF101 supersonic reconnaissance aircraft. ADAS provides frame-by-frame film annotation essential to interpretation of aerial reconnaissance photographs.

The division also began production of a new Stores Management System (SMS), an airborne miniaturized computer system which continually informs the aircraft pilot of on-board weapons status. The SMS will be utilized in the F-111 variable-wing fighters.

First 4 buildings of Fairchild Hiller's Sherman Fairchild Technology Center were completed in October.

As part of its space effort, the division continued work on its Automatic Picture Transmission Systems (APTS), which permit meteorological satellites to instantaneously transmit photographs to ground stations throughout the world.

In manufacturing was an airborne central data tape recorder, a magnetic recorder designed to accept and store reconnaissance data as encoded by the ADAS. The recorder stores and reproduces the information in a format compatible with ground-based magnetic tape readers.

The division was also developing equipment to provide ground photo interpretation units with extremely rapid access to flight data information, and manufacturing meteorological stations, in portable vans and shelters, for the Army.

REPUBLIC AVIATION DIVISION

Manufacture of major sub-assemblies for the F4 Phantom supersonic jet fighters continued throughout 1966. Sub-assemblies included aft fuselage with fins, rudders and tail cones, and stabilator assemblies and engine access doors.

The division completed Phase I of a contract for a study of the feasibility of developing a "safety car." Awarded by New York State to Republic, the study involved 2 auto designs and recommendations pertaining to the performance tests and safety levels. The project was continuing under Phase II.

The division, in competition with 3 other U. S. aircraft builders in the joint United States/Federal Republic of Germany vertical-short takeoff and landing tactical fighter aircraft program, submitted its study proposal. By year-end, one U. S. firm and one German firm were to be awarded a contract for joint development of the advanced fighter aircraft.

The division along with Aircraft Division, was selected during 1966 as one of 6 major subcontractors on the giant Boeing 747 jet transport. Fairchild Hiller will engineer and manufacture all movable wing surfaces.

The division continued production of the Bikini surveillance system for the Marine Corps. The system is composed of 2 drones, a launcher, radio control equipment, and a photographic film processor which fit into a jeep-drawn trailor. Two men can have the system operational in less than 10 minutes and have developed reconnaissance film available less than 15 minutes after drone recovery.

SPACE SYSTEMS DIVISION

Space Systems Division proceeded with advanced research, development and design activity on deployable mechanisms and extremely long extendible structures for future space programs. These structures, to be stored in compact form during spacecraft launch, can be deployed in orbit to hundreds of feet to perform tasks as solar arrays, gravity gradient booms, and antennas.

SSD produced an advanced solar array for Nimbus meteorological satellites which contains 19,500 solar cells. Work was also performed on NASA's radio astronomy experiment (RAE) satellite including the main housing, exterior solar paddles, and tubular extendible element antennas.

The year marked first anniversaries of the 3 Pegasus meteoriod detection satellites. The Fairchild Hiller-built spacecraft, largest structured satellites ever sent into earth orbit, continued to function satisfactorily, transmitting to earth information on micometeoroid hazards in space.

Major support services under contract to NASA's Marshall and Goddard Space Flight Centers continued.

STRATOS GROUP

Stratos/Bay Shore

Stratos/Bay Shore Division specializes in the development and manufacture of aerospace industrial compressors, heat exchangers, high-speed turbo machinery and high temperature pneumatic valves and controls. The equipment serves on many aircraft and missiles.

In 1966, the division was manufacturing a family of 11 low silhouette air conditioners for use in Army mechanized equipment. Among other products: vapor cycle cooling systems for the Navy's E-2A early warning systems, air conditioning units to cool electronics and other aircraft components on the Navy 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 FH-227 and F-27J propjet transports, and air turbine drives for the C-103 Hercules cargo transports.

The division also held contracts to supply cooling for F-111 variable wing fighter aircraft for the Navy and Air Force, and 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 was producing a series of unique flare launching devices which it designed for military aircraft. The launchers utilize a quick ejection system.

Other programs at Stratos/Western included: design, development and manufacture of intricate valves and regulators required for space vehicles; production of 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 ballistic missiles.

The division was also building 4 major components for the Air Force's Titan III space vehicles, and was the major producer of sonobuoy launch systems and underwater sound source dispensers for the Navy's anti-submarine warfare aircraft.

Industrial Products Division

Stratos Group's Industrial Products Branch was manufacturing nationally known products for over 2,000 industrial companies.

Included among them were specialized components for speed control transmissions and differential gearing for printing presses, rubber processing equipment, glass making machinery, and radio telescopes; and air regulators, relays and volume boosters for paper making machinery.

Governnaire Pneumatic Controls, Specon Multi-Speed Transmission and Kendall Pressure Regulators were in manufacture for companies in many industries including: mining, tobacco, textile, paper, printing, chemicals, petroleum, rubber, steel, transportation equipment and metal working machinery.

THE GARRETT CORPORATION

The year 1966, 30th anniversary year for The Garrett Corporation, proved to be the best year in the company's history.

Each of Garrett's 7 divisions and 2 subsidiaries established new marks for employment, sales, shipments and production backlog. The outlook for 1967 appeared equally bright.

Corporate-wide employment by year-end was up 20 percent over 1965 to a new high of 12,800. The highest employment level previously recorded was in 1957, with 11,000.

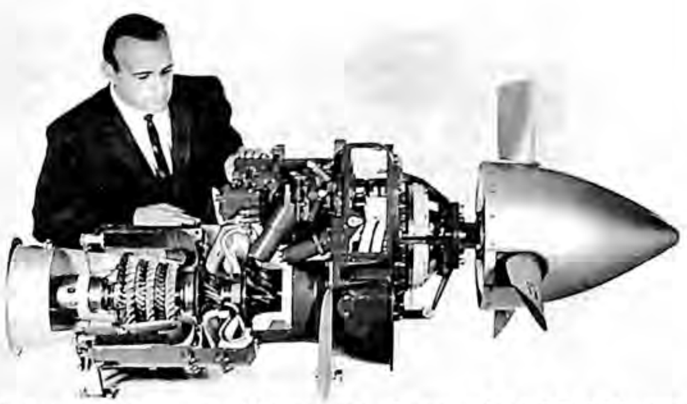
Garrett's activities and product areas continued to be widely diversified, and, while several new non-aerospace programs were being pursued, the company's primary role continued in developing and producing sophisticated systems for the military and commercial aerospace industry. Garrett's 1966 work ratio was approximately 60 percent commercial and 40 percent military.

GARRETT-AiRESEARCH PHOENIX

The second largest division of The Garrett Corporation, AiResearch Manufacturing Company of Arizona, contributed significantly to the company's overall success in 1966. The division's traditional major product line, small gas turbine engines, was enhanced by substantial development and production contracts received during the year. Orders for the TPE-331 turboprop engine continue at a high rate.

Aero Commander ordered the rugged, lightweight engine for its twin-engine Turbo Commander executive aircraft. Mooney Aircraft, which selected the AiResearch powerplant for the twin-engine MU-2 designed by Mitsubishi Heavy Industries, ordered an additional 120 engines late in 1966.

Volpar Aviation placed an order for an additional 50 engines for conversion of Beech 18 aircraft to turboprops. Fairchild Hiller also ordered a substantial quantity of TPE-331's for its Heli Porter utility aircraft.



Orders for Garrett-AiResearch Phoenix's TPE-331 continued at a high rate.

A significant milestone in the AiResearch turboprop program was achieved in midyear when it was announced that Garrett was developing an uprated version of the TPE-331. The higher powered engine will be rated at 700 equivalent shaft horsepower, up from the current commercial rating of 605. Time between overhaul (TBO) of 1,000 hours for the TPE-331 was approved by the Federal Aviation Agency to further indicate the engine's design simplicity and mechanical ruggedness.

A military version of the AiResearch turboprop engine, designated the T76, was previously selected by the Navy to power the North American OV-10A tri-service aircraft. Seven prototype aircraft were undergoing extensive evaluation flight testing during the year. In December, the Department of Defense placed an $11,600,000 contract with Garrett for engine production. Delivery of these 715 shaft horsepower engines was to begin early in 1967.

Evaluation and refinement of the revolutionary new, inflatable MUST hospital developed by AiResearch Phoenix continued during the year. As part of this evaluation program by the Army Medical Service, a complete 100 bed hospital was deployed in South Viet Nam, where it was undergoing field testing. In its first few hours under combat conditions 4 major surgical operations were performed using its advanced electrical and environmental facilities.

Other new inflatable components of the hospital complex, including a prototype clinical laboratory, were being evaluated by the Army. A dental unit and oral surgery unit were in the prototype stage.

In the field of airborne gas turbine auxiliary power units (APU) AiResearch Phoenix maintained its leadership in 1966. Multimillion dollar contracts for APU's were received for the 2 new air transport industry giants—the Boeing 747 and the Lockheed C-5A. Other APU programs included the Douglas DC-9, Boeing 727 and 737, Grumman Gulfstream II, Hawker Siddeley DH 125 and the BAC One-Eleven.

Research and development continued in AiResearch's space power programs in 1966. Major milestones were achieved with successful stable operation of potassium bearings for 500 and 2,000 hours and a 500-hour performance test of a space boiler. These programs and their ultimate power conversion systems will eventually provide electrical power in space for periods of 1 to 5 years for the next generation of space missions.

GARRETT-AIRESEARCH LOS ANGELES

During the year AiResearch Manufacturing Division, Los Angeles, Garrett's largest division, achieved notable success in the space environmental control field. By year-end, with the conclusion of the Gemini program, AiResearch life support systems had logged more than 1,000 hours of manned space flight.

In addition to the spacecraft's primary environmental system, an AiResearch Extravehicular Life Support System (ELSS) provided the astronauts with life supporting atmosphere during excursions outside their spacecraft on the final four Gemini missions. This unit played an important role in establishing man's capability to perform useful work in the hard vacuum of space under weightless conditions.

The Gemini program also established the company as a leader in the storage of cryogenic fluids. The reactants—liquid oxygen and hydrogen—for the Gemini fuel cells regulated and stored in systems produced by AiResearch Los Angeles. During the year the division was developing a similar cryogenic storage vessel to store liquid helium aboard the Apollo Lunar Module. This vehicle will separate from the Apollo spacecraft and land 2 astronauts on the moon's surface.

At year-end AiResearch was preparing for the first manned launch of the Apollo spacecraft. As in the Mercury and Gemini programs an AiResearch environmental control system was selected to keep the Apollo astronauts alive and comfortable during earth orbital and lunar missions.

In its traditional field of environmental systems for aircraft, AiResearch Los Angeles continued to maintain its leadership. At midyear, Lockheed selected AiResearch to develop and manufacture an advanced environmental system for the huge C-5A military transport, as did Boeing and Douglas for stretched versions of the 727 and DC-9.

AiResearch Los Angeles also entered the main propulsion field in 1966. Competing with the nation's foremost ramjet builders, the division was selected by NASA to design and build hypersonic ramjet engines capable of speeds up to 3,500 miles per hour. These engines will be flight tested on the X-15 research vehicle.

In more down-to-earth propulsion projects, AiResearch Los Angeles and Phoenix divisions teamed up with the Budd Company to enter the railcar transportation field. The Turboliner, first gas turbine powered railcar, was unveiled in September and began 8 months of intensive track tests on the Long Island Railroad. The Turboliner is powered by twin AiResearch Phoenix industrial gas turbine engines with aircraft-type air conditioning supplied by AiResearch Los Angeles.

Military and commercial airframe builders continued to be the major customers for AiResearch. Virtually every aircraft in production relies on AiResearch systems and components. The entire Boeing transport series, Douglas DC-8 and DC-9, Lockheed C-41, C-5A, P-3V, and F-104, McDonnell F-4 series, Northrop F-5, General Dynamics F-111, Grumman Gulfstream I and II, and numerous other aircraft built in the U. S. and allied countries incorporate AiResearch systems. At year-end, AiResearch was heavily engaged in developing systems for future aircraft, including the supersonic transport.

Product lines which contributed substantially to AiResearch's overall success included heat transfer systems, missile systems, flight and electronics and electromechanical systems. An airborne turbojet engine analyzing system, which continually monitors and records vital engine performance during flight, underwent critical evaluation by the Air Force during the year. Under Air Force contract, AiResearch was equipping 40 F-4's and F-105's with the system for continued evaluation. A similar program was in progress for C-141 transports.

A commercial version of this system, called Aircraft Integrated Data Systems (AIDS), which monitors other critical aircraft systems in addition to engine performance, was selected by American Airlines for its 400 Astrojet fleet of BAC One Elevens.

AiResearch Los Angeles was also named to build a central air data computing system for the Integrated Light Attack Avionics System (ILAAS) being developed for the Navy by Sperry Gyroscope.

The new computer represents a departure from conventional airborne units in that it is a digital computer supplying digital information to the ILAAS Computer Central.

AIR CRUISERS DIVISION

During 1966, Garrett's Air Cruisers Division experienced substantial growth both in physical size and unmber of employees. Working area approximately doubled with the addition of 60,000 square feet of manufacturing floor space at its location near Belmar, New Jersey. An active recruiting program increased the number of personnel by 35 per cent to meet heavy customer commitments.

Sales and backlog for Air Cruisers, which is primarily engaged in designing and manufacturing inflatables for the air transport industry, surpassed all previous years, even with competition at its keenest. Forecast for 1967 included planning for an additional 30 percent growth.

Of prime importance to the division in 1966 was the MUST field hospital program. Air Cruisers manufactured and shipped MUST inflatable shelters which, before year end, were being evaluated under combat conditions in Southeast Asia. The success of this program formed a basis for a sizable potential for additional inflatable shelter production in coming months.

The advent of new model aircraft, such as the stretched Douglas DC-8, the SST, the Boeing 747, and 737, and the Lockheed C-5A initiated extensive development programs for Air Cruisers in 1966. Prototypes of inflatable survival equipment, such as rafts and escape slides, were designed and fabricated for these aircraft and were being evaluated by the airframe manufacturers.

AiRESEARCH AVIATION DIVISION

The year was one of expansion for AiResearch Aviation Division of The Garrett Corporation. To meet the overall demands of the growing aviation industry, AiResearch Aviation launched a national expansion program including the opening of a complete modification and maintenance facility at MacArthur Airport, Long Island, New York, and the construction of a new customer service, business aircraft terminal and office building located at Los Angeles International Airport.

Engaged in aircraft modification, maintenance and sales, the division is distributor for the Grumman Gulfstream I and II and the Hawker Siddley DH-125.

Because of anticipated Grumman Gulfstream II sales in the eastern market, AiResearch expanded its operation with a Long Island facility to better serve a majority of this market, located in the New York area. The Long Island facility was opened on August 1, 1966, and it found enthusiastic acceptance from the east coast business aircraft operators.

The Los Angeles customer facility will provide business aircraft operators with one of the finest executive terminals available to them in the U.S., including features such as a visiting executive office, transient pilot lounge, flight planning facilities, sleeping quarters for transient pilots, and a passenger reception area which will accommodate the flow of executive traffic in an attractive atmosphere.

GARRETT MANUFACTURING LIMITED

Garrett's Canadian subsidiary, Garrett Manufacturing Limited in Rexdale, Ontario, experienced an excellent growth period in 1966. Sales and backlog moved steadily upward for the 500-man facility.

By year-end, an expansion program aimed at doubling the present 45,000-square-foot area was well underway. GML was primarily engaged in development and production of airborne electronics, aircraft temperature control systems, pneumatic signal generators, static inverters, radio emergency beacons and turbomachinery overhaul.

In an announcement just before year-end, the Canadian Department of Defence selected Garrett Manufacturing Limited as systems manager for the production of gas turbine-powered main electrical generating systems for a new class of Canadian destroyers, designated the DDH 280 class.

AiRESEARCH INDUSTRIAL DIVISION

AiResearch Industrial Division, leading producer of exhaust-driven superchargers for diesel and gas engines continued to maintain its position in the face of stiff competition.

In 1966, sales and production moved sharply upward as a host of light aircraft manufacturers announced new aircraft with engines turbocharged by AiResearch. Beech, Piper, Cessna, and Mooney introduced new models incorporating the performance boosting unit. On some models the turbochargers also provide cabin pressurization.

As a result of increased business, the division added a complete new test facility and a 35,000 square foot addition to its manufacturing plant.

GARRETT SUPPLY DIVISION

Garrett's oldest division, Garrett Supply, moved into a new 50,000-square-foot facility in mid-1966, and by year-end had initiated another expansion program to nearly double warehouse space.

New industrial customers and a rapidly expanding market for the division in Southern California and Arizona contributed to rapidly growing sales. The firm was stocking more than 100 famous brands of industrial tools and supplies, including more than 70,000 industrial items from grinding wheels to power transmission equipment and office furniture. An equally bright picture for the firm was forecast for 1967.

GARRETT INTERNATIONAL S. A.

Garrett International S. A., wholly-owned subsidiary of The Garrett Corporation, played an important role in the company's worldwide sales, service and product support programs in 1966.

Headquartered in Geneva, Switzerland, Garrett International maintains offices in major European cities, South America, and Japan. A major repair and overhaul facility is operated in Raunheim, Germany.

Of singular note during the year was the construction and launching of the first Grumman Dolphin hydrofoil for which Garrett is worldwide distributor and sales agent. Sea trials on the 82 passenger "Corsario Negro" were completed by year-end and the hydrofoil was scheduled to enter commercial passenger service in the summer of 1967 in the Canary Islands. The craft was built in Germany for Maritima Antares, a Spanish shipping firm.

In addition to marketing traditional Garrett product lines in Europe and the Far East, Garrett International has been instrumental in the introduction of Garrett turboprop-powered aircraft to the European market. During 1966, the Pilatus Turbo Porter, the Aero Commander Turbocommander and Mitsubishi MU-2, which incorporate the AiResearch TPE-331 engine, were introduced in Europe.

AIRSUPPLY COMPANY

Airsupply Division of The Garrett Corporation, nationwide sales and engineering representative for suppliers of aerospace and industrial products, continued to expand its market areas in 1966.

The division broadened its sales participation into programs relating to rapid transit systems ships and submarines. From its new headquarters building in Santa Monica, California, Airsupply maintained branch offices in 20 cities throughout the United States.

GENERAL DYNAMICS CORPORATION

General Dynamics continued its growth pattern of the past several years in 1966, both in supplying governmental needs (U. S. and foreign) and in supplying important segments of the civilian economy with a wide variety of major systems and individual products.

In the aerospace area, the company's older, proven aircraft continued frontline service with the U. S. armed forces (F-102, F-106, B-58) and with commercial carriers (880, 990, 240/340/440 transports, new 600/640 turboprop conversions), while a major new multi-purpose military aircraft, the variable-sweep-wing F-111, was readied for service with the U. S. Air Force and U. S. Navy as well as for several foreign air forces.

In space, its established launch vehicle, Atlas, went on to new successes in 1966, and the Centaur hydrogen-fueled space vehicle proved itself ready for future missions.

General Dynamics was the top exporter of United States weapons in the 1962-65 period according to the Department of Defense, the bulk of its sales overseas made up of advance orders for F-111 aircraft and for Terrier and Tartar tactical missiles.

In 1966 and the years that will follow, these programs and others, notably the Redeye antiaircraft missile were expected to make the diversified aerospace contractor a leader in the export field for major military systems as well as for such other products as communications equipment, electronic products, commercial aircraft, nuclear research reactors and marine systems.

In light of the aerospace industry's new interest in oceanography, the success of the corporation in the marine and oceanographic fields, which continued growing in 1966, was encouraging to many. An acknowledged leader in military submarine construction since 1900, especially of the nuclear-powered variety since 1955, General Dynamics also established a strong capability in the peaceful or commercial use of the submarine. In 1966 it launched two vessels of its own for research and development work (*Star II and Star III*), gained a government contract for two other advanced submersibles (*Autec and Alvin II*), and commenced design and construction of the world's first nuclear-powered research submarine, *NR-1*, for the Navy.

Toward the year-end, announcement was made of another possible nuclear research submersible for the U. S. government for possible contract assignment in 1967, based on a General Dynamics feasibility study of the use of such a vessel for fisheries research.

In the surface ship field, General Dynamics not only delivered the 3 Apollo Instrumentation Ships it was readying for NASA in 1966, but by year-end held contracts for construction of 13 other major ships for the Navy at the company's Quincy division. It also became active in the hydrofoil field and continued research in several air cushion vehicle programs.

FORT WORTH DIVISION

Flight demonstration of the F-111 variable-sweep-wing airplane throughout its exceptionally large performance envelope was under way at five Air Force contractor test sites around the country with 21 developmental aircraft as 1966 drew to a close.

Focal point of this accelerating flight-test activity was the Fort Worth division. The Texas plant also was readying the first production F-111A fighter-

Production-type F-111 fighters take shape on the assembly line at the Fort Worth Division of General Dynamics.

bomber for its initial flight before the end of the year. Delivery of this first production article to the Air Force was scheduled in January 1967.

Scores of performance milestones were passed in 1966 as the effort to develop the world's first practical sweep-wing airplane gained momentum.

Wing-sweep operations were numbered in the thousands. With wings extended virtually straight out, F-111's were airborne after using only 2,060 feet of runway; many landings were made with less than 2,000 feet of ground roll. Supporting this short landing performance were approach speeds of about 113 knots and touchdown speeds as low as 105 knots.

With their wings swept aft, F-111's recorded hundreds of supersonic flights. More than a hundred flights were made at twice the speed of sound, including evaluations at Mach 2.5 at altitude.

At low level, F-111's demonstrated unsurpassed supersonic penetration capability. The versatile aircraft, now delta-shaped, raced across the Gulf of Mexico at Mach 1.2. Using terrain-following radar, other F-111's skimmed over mountaintops and dashed across the desert floor at near-supersonic speeds on test missions from Edwards Air Force Base, California.

Even as flight testing of Air Force developmental F-111A fighter-bombers and Navy F-111B developmental air superiority fighters accelerated, the Fort Worth plant was gearing its assembly lines for volume production of the sweep-wing airplanes. Employment passed 18,500 as the machining, fabrication, and assembly departments expanded in order to achieve production quantities and schedules.

Engineering effort increased steadily during the year on the FB-111 strategic bomber and the RF-111A reconnaissance fighter. Both these airplanes had been ordered into development by the Department of Defense in December 1965.

Work began on the F-111K—the Royal Air Force version ordered early in the year by the United Kingdom—and continued on the F-111 fighter-bomber version ordered previously by Australia for the Royal Australian Air Force. Both countries assigned technical teams to the Fort Worth plant to determine spares and ground support requirements for their airplanes.

Development of the Mark II and Mark IIB avionic systems for advanced versions of the F-111 was announced by the Air Force in June. The Fort Worth division is prime contractor for both avionic systems.

The General Dynamics division also continued research efforts on more than 100 study contracts encompassing a variety of aerospace activities, and dozens of U. S. Air Force B-58 supersonic bombers returned to their home plant for inspection-and-repair-as-necessary.

CONVAIR DIVISION

Continued successes in space, aircraft component subcontracts and modification of existing aircraft, and continued progress in development of the "monster" buoy highlighted the year's activities at the Convair division.

The Convair-produced Centaur high-energy upper stage was highly successful during the year. Centaur successfully launched 2 Surveyor spacecraft toward the moon on 2 occasions. The first Surveyor successfully landed on the moon and sent back pictures of the surface. The second Surveyor did not complete its assigned mission.

Centaur completed its research and development program when it achieved a restart of its hydrogen engines in space. An Atlas launched a Centaur vehicle, which ignited its engines at first time, placing itself into a parking orbit. Following a coast period, the Centaur engines were started again in the weightlessness of space, sending the Surveyor mass model payload on a lunar transfer trajectory. The model did not impact the moon. The National Aeronautics and Space Administration announced that Centaur had achieved full operational status following this, the 10th flight of an Atlas/Centaur.

In addition to boosting Centaur upper stages, Atlas space launch vehicles continued to boost other payloads with a high degree of reliability. In combination with Agena upper stages, Atlas vehicles continued to boost payloads with a high degree of reliability. In combination with Agena upper stages, Atlas vehicles successfully boosted OAO (Orbiting Astronomical Observatory) and OGO (Orbiting Geophysical Observatory) spacecraft into earth orbit, and sent 2 Lunar Orbiter spacecraft into an orbit around the moon for transmission of pictures back to earth.

Atlas vehicles successfully launched target stages into orbit for rendezvous. Atlas vehicles also successfully launched upper stages into orbit for use as rendezvous targets by the Gemini astronauts rehearsing for flights to the moon.

An Atlas vehicle without upper stages successfully launched two OV1 satellites into different earth orbits in the continuing Office of Aerospace Research scientific experiment program.

A significant production milestone was passed for the Atlas during 1966. The Convair division delivered the 500th Atlas to be produced to the Air Force during ceremonies at the Convair plant at San Diego. The 500th vehicle was later used to launch the target vehicle for rendezvous during the final Gemini flight of 1966.

A major aircraft subcontract was awarded to Convair during the year by the Lockheed-Georgia Company. The contract, valued in excess of $40,-000,000, called for production of the C-5A fanjet transport empennages. Lockheed is developing the 700,000-pound airlifter for 1969 delivery to the Military Airlift Command. The total C-5A empennage program, as currently planned, is expected to amount to more than $60,000,000.

While preliminary work began on the C-5A empennage, production of C-141 Starlifter empennages continued under existing contracts from Lockheed. Go-ahead was given just before the start of 1966 for production of additional C-141 empennages bringing the total dollar value of contracts for tail sections to approximately $70,000,000.

Several Air Force contracts were awarded Convair for modification of F-102 and F-106 aircraft produced originally by the division. External fuel tanks, refueling equipment, cooling of infrared systems for the F-102 and F-106 were among the tasks started under contracts awarded by the Air Force San Antonio Air Materiel Area (SAAMA).

Conversion of series 240, 340, and 440 Convair-Liners to Rolls-Royce turboprop power continued for airline, charter and executive operators in the United States and overseas. The converted 240 series aircraft is called the Convair 600, while the converted 340/440 is renamed the Convair 640. Deliveries of converted aircraft were completed to Caribbean-Atlantic Airlines (Caribair), and the last delivery to Hawaiian Airlines was made in November. Deliveries of conversion kits to Trans-Texas Airways were to continue into 1967.

Martins Air Charter, Amsterdam, the Netherlands, put one converted 440 into service with conversion of a second scheduled to start in November.

Pacific Western Airlines, Vancouver, B.C., Canada, announced the purchase of 4 converted 440 aircraft for delivery in 1967 and 1968.

The Air Force Ballistic Systems Division awarded Convair a contract to refurbish Atlas ICBM's retired from active service with the Strategic Air Command. The series E and F Atlases are scheduled for use with upper stage vehicles for the ABRES (Advanced Ballistic Re-Entry Systems), Nike target, and Office of Aerospace Research scientific satellite programs. Refurbishment includes updating of the telemetry, range safety, electrical, autopilot, and engines systems.

The Coast Guard awarded a contract to build a large navigation buoy to replace a lightship off the East Coast. Except for superstructure changes, the Coast Guard Buoy will be similar to the Oceanographic Data Buoy developed by Convair for the Office of Naval Research.

The first ONR buoy, Bravo, is anchored off Bermuda for tests to optimize mooring line length for extreme water depths. A second ONR buoy, Alpha, was nearing completion at San Diego, California, and was to be moored off the coast of Southern California in early 1967. RF Transmission tests are planned at buoy-to-shore station distances up to 3,000 miles to confirm preliminary system tests made previously between stations in San Diego and Hawaii.

POMONA DIVISION

Contracts for 2 new and varied programs – Interim ARM and ASWICS – were awarded General Dynamics' tactical missile division at Pomona, California, during 1966. Meanwhile, production of the shoulder-fired Redeye guided missile for the Army and Marine Corps, and Terrier and Tartar guided missiles for the Navy continued at Pomona. In addition, development work on the Standard Missile system showed outstanding progress during the year. The initial development and pilot line production contract was awarded in 1965.

A $7,500,000 interim ARM (Antiradiation Missile) contract to develop an air-to-ground missile capable of destroying enemy radar sites was issued in August by the Navy Air Systems Command. The new system employs an adaptation of the Standard Missile, which is fired from attack and fighter-bomber aircraft at antiaircraft radar units. Launch tests conducted in October were very successful.

The ASWICS (Antisubmarine Warfare Integrated Combat System) study contract was awarded in late October. Work will feature the preliminary design of an integrated combat system for future U. S. Navy use.

The 29-pound Redeye system successfully passed Arctic environmental tests and demonstrated an amazingly high degree of accuracy in live-round firings conducted at Fort Bliss, Texas, by U. S. Army trainees and at Twenty-Nine Palms, California, by Marine Corps trainees. Australia and Sweden indicated definite plans for use of Redeye.

The Redeye system was successfully converted from discrete component circuitry to linear integrated circuitry—a major milestone in analog control systems. Separate components were almost completely replaced by microcircuits.

Five new Terrier/Tartar ships were commissioned during 1966 by the Navy, making a total of 62 armed by the 2 missiles produced at the Pomona division. Included were the *USS Standley, USS Fox, USS Wainwright* and *USS Jouett,* all Terrier ships, and the Tartar-armed *USS Brooke.* In this same area, hardware and technical assistance was provided to establish Tartar repair facilities in Australia and Japan.

Other new work at Pomona included a reentry vehicle impact investigation for the Air Force and a short-range decoy system developed by Pomona division engineers to provide added defense for Navy surface ships.

The Engineering Standards Laboratory at the division completed the latest and most accurate secondary time and frequency standard available to the industry. The installation provides the high accuracy frequency and time standards required for missile development, missile checkout, instrument calibration and telemetry. It consists of an ultra stable crystal controlled oscillator, a phase comparator, a frequency multiplication bank and clock and a very low frequency radio receiver.

ELECTRONICS DIVISION

The year 1966 marked the start of major production of key tactical radio equipment by the Electronics division of General Dynamics and preparation for production of equipments both for AUTODIN and Aerospace Ground Equipment (AGE) for the F-111 program.

The division set up a new microcircuitry department and expanded laboratory facilities for work in hydroacoustics. It also established 2 new operations, 1 in Orlando, Florida, and the other in Newark, New York. The Florida facility, now called the Dynatronics Operations, resulted from the acquisition of Dynatronics, Inc., and the Newark facility, called the Newark Operations, was set up to meet increased production needs. Dynatronics has an excellent reputation in the field of telemetry and its acquisition extends the division's communications capabilities.

The division's regular product and service areas include tactical radio communications; data processing equipment and systems; antisubmarine warfare gear including electroacoustic and hydroacoustic devices, markers, sonobuoys, receivers and sensors; aerospace tracking and navigation systems; AGE equipment; reconnaissance and electronic countermeasures hardware and systems, and telemetry systems, subsystems, antennas, and RF components.

The Apollo Instrumentation Ships program, for which the Electronics division is prime contractor for General Dynamics, was on schedule with all 3 ships, *USNS Vanguard, USNS Mercury* and *USNS Redstone,* delivered to the Government and with *Vanguard* now assigned to the Eastern Test Range for Category III tests.

These new ships are floating electronic platforms equal in communications and control capabilities to the Houston Space Center and will be used to assist in the tracking of the Astronauts when the space flights to the moon are made. The 3 sea-going electronic platforms are needed since three-quarters of the world is sea and land-based tracking stations cannot track the total space flight because of the Earth's curvature.

In addition to being prime contractor, the division also furnished 8 of the 12 major electronic systems aboard each ship. General Dynamics' Quincy division did the ships' engineering and shipyard work; the Electric Boat division provided the ships' position and attitude-measuring system; the Convair division built the 30-foot telemetry antennas; the Pomona division furnished Category II test personnel; and the Stromberg-Carlson subsidiary provided shipboard communications. The Electronics division provided training in operation and maintenance for 22 subsystems.

The division responded to newly defined requirements for additional AUTODIN work for the digital subscriber terminal equipment it was building for this system. AUTODIN is a worldwide digital communications system operated under the administration of the Defense Communications Agency. Training of both Army and Navy personnel who will use the equipment got under way.

A major development, the ANDEFT/SC-320, which is a variable-rate, ultra-highspeed data modulator-demodulator (MODEM) specifically designed for rapid and error-free digital communications over long-range, high-frequency radio circuits, was demonstrated in 1966. It has a data capability of 9,600 bits a second and provides new techniques for operational versatility and accuracy.

Hughes Aircraft Company awarded the division a contract for Tactical Air Navigation (TACAN) equipment which will be a microelectronic unit for use in the F-106 aircraft. The contract award was based on the division's work in this area and the development of the first all-solid-state airborne TACAN unit, the AN/ARN-52 (XN-1). The division was also in production of a terrain-following radar (TFR) unit for a foreign country.

Production began rolling in 1966 on the AN/MRC-107 communications central in a jeep-mounted configuration for the Tactical Air Command. These will be deployed throughout the world and are to be used by forward air controllers. In addition, the division was delivering AN/GRC-106, a single side-band, high frequency radio to the military and to NATO countries.

In 1966, AGE equipment for the F-111 was delivered to the Air Force. A major new concept in AGE systems called CENPAC for central data-processor and controller has been accepted by the Air Force. The new systems obsolete the use of programmer-comparators. CENPAC uses digital computers for conducting programmed electronic tests.

The microcircuitry department was working on developments using hybrid thin-film, hybrid thick-film and multichip-interconnection techniques. These programs follow through from basic research through development, circuit layout, prototype fabrication and production, to the packaging of modules that meet military specifications.

Film circuits are produced by subtractive etching of resistor-conductor films and attachment of thin-film capacitors or by evaporation through masks. Thick-film circuits are made by screening and firing conductors, resistors, and capacitors arranged in dielectric layers on a ceramic substrate to which active components are attached before the circuit is encapsulated. Multichip integrated circuits are produced by interconnecting resistor, capacitor, diode, and transistor chips in a microcircuit package.

Laboratory facilities include a 1,600-square-foot clean room equipped with evaporators, vacuum systems, fabrication areas, a coordinatograph, cameras, etching machines, and coating and spraying equipment. A chemical section deals with problems of materials and special techniques, with organic or inorganic quantitative analyses, and with the synthesis, preparation, and purification of materials. Optical equipment is available for measuring absorption, reflection and emission spectra from the ultraviolet to the infrared region and for interferometric and metallographic measurements.

The Logistics and Field Operations department began the training of Peace Corps volunteers at Julian, California. The volunteers were being trained as food-production advisors to serve in rural India as part of the Indian government's program in this area.

CANADAIR LIMITED

Canadair's policy of diversification continued to show progress with new contracts being obtained in such fields as aviation, military vehicles, architectural products and electronics.

One 1966 contract called for 20 CL-41G tactical-trainer aircraft for the Royal Malaysian Air Force. This aircraft is a multirole jet based on the side-by-side training aircraft that is the standard jet trainer of the Royal Canadian Air Force. The Malaysian version can carry up to 3,500 pounds of standard ordnance stores, including bombs, rockets, air-to-surface missiles and extra fuel tanks.

Twenty Canadair CL-215's, in its water bomber configuration, were sold to the Forestry Department of the Province of Quebec, while an unannounced number were sold to the French Government as a protection against the ravages of forest fires. Several other configurations of the amphibious aircraft were developed, enabling it to serve as an air sea rescue or maritime patrol aircraft, as a transport or cargo carrier, for crop dusting or spraying, forest fertilizing or general agricultural work.

The company also received orders in excess of $18,000,000 for the manufacture of components for Lockheed's C-5A transport. These orders included 58 ship sets of main landing gear fairings and doors, ailerons and aft cargo doors. Canadair became the first firm to receive 3 major subcontracts for this aircraft, which will extend work to 1970 and, at its peak, will provide approximately 800 additional jobs at the Montreal plant.

Progress was made in the development of the company's CL-84 tilt-wing V/STOL aircraft, which by mid-October had achieved a notable series of flight test achievements, with total operational time of almost 300 hours, including more than 70 hours of flight time.

The CL-84 hoisted a live subject in simulated rescue mission from both hard surface and from a life raft in open water, was evaluated by NASA pilots and checked out military pilots. It has been demonstrated before hundreds of service personnel from a large number of countries.

Production was scheduled to start on approximately 125 CF-5 (Northrop F-5's) fighter aircraft for the Canadian Defence Force, plus the necessary spares and equipment. The company was also completing the "stretched" program of CL-44 turboprop airliners for Icelandic Airlines, the new version, known as the Canadair 400, being 15 feet longer and capable of carrying 189 passengers transatlantic.

Subcontract work on components for the F-111 continued as did a subcontract for F-5 boat tails.

The Federal Republic of Germany became a full partner with Canada and Great Britain in the development of the CL-89 short-range reconnaissance drone system, known officially as the AN/USD-501, which was undergoing a series of test flights at the Army's Yuma (Arizona) Proving Ground.

The CL-89 is a rocket-takeoff, jet-powered surveillance vehicle that travels near the speed of sound. The 8-foot, 200-pound missile-shaped drone has twin 70 millimeter cameras mounted in its belly that can photograph critical detail on the ground, even at night by use of flares. On completion of the preset flight behind enemy lines, the CL-89 returns to a preselected point and lands by parachute. If desired, the drone has the capability of automatically processing its own film in flight.

The company completed the order for 33 prefabricated airport traffic control tower cabs to be used by the U. S. Federal Aviation Agency. Considerable interest was being shown in the Canadair-designed and manufactured transportable control tower, which can be used as a permanent traffic control center at secondary airfields or as a temporary center at temporary airfields, or wherever required when required by an emergency.

In non-aviation fields, diversification programs brought in such contracts as an Army award for advanced production engineering on the XM-571 (CL-91) Dynatrac, an all-purpose, all-terrain, articulated tracked vehicle; design and fabrication of new custom-designed curtain walls for 2 high-rise buildings; and for the subassembly of harnesses for electronic communication systems with manufacture of components and modules to follow.

Work was also proceeding on the fabrication of ball valves for U. S. nuclear and non-nuclear submarines.

Canadair's research and development facility was working on a variety of projects, such as escape systems for flight vehicles, operations research survivability and vulnerability studies and medical research on a venous blood pressure recording system.

GENERAL ELECTRIC COMPANY

DEFENSE ELECTRONICS DIVISION

The General Electric Company's Defense Electronics Division continued in 1966 to be 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, guidance and fire control for the Polaris and Poseidon fleet ballistic missiles, flight controls for the F-4 and the F-11 aircraft, advanced radar and sonar detection equipment, the new Chaparral ground-to-air missile and a wide variety of advanced computers.

With headquarters in Utica, New York, the division includes the Heavy Military Electronics Department and Special Information Products Department in Syracuse, New York; the Light Military Electronics Department in Utica and Johnson City, New York; the 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 in 1966.

SPECIAL INFORMATION PRODUCTS DEPARTMENT

The Special Information Products Department (SIPD) 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 were used in all the major U.S. space programs, including Gemini, Mercury, Ranger and Mariner. SIPD, in cooperation with the Air Force and NASA, continued working on newer and more precise radio tracking techniques which will considerably enhance the state-of-the-art in guidance and instrumentation technology for missiles and space use.

SIPD's Comupter and Data Systems Operation was producing a family of military computers for mobile, airborne, shipborne and similar environments. These computers, compatible with the commercial G.E. 600 series are well-suited for command and control, message-switching and other high performance real-time data processing applications.

SIPD designed, produced and was installing a precise range, range-rate and angle-tracking system for NASA's satellite network.

ELECTRONICS LABORATORY

The Electronics Laboratory continued in 1966 to engage in applied research, advanced development, and support activities in electronics and related fields for the defense Electronics Division. Work was also undertaken for other components and customers of the company.

Investigations underway at the Laboratory included developments of advanced, high-speed circuits and memories, control and instrumentation, data recording and display, and signal detection. Other areas included optoelectronic and microwave devices, solid-state materials, guidance techniques, chemical and biological detection and information processing.

The Laboratory continued to advance the state-of-the-art in computed displays. These displays accept speed, attitude and altitude information from an aircraft simulator and convert them to a video display of the earth as it would appear through the windshield of an aircraft. The video display is updated 30 times per second.

In 1966, a computed display was delivered to the Joint Army-Navy Aircraft Instrumentation Research

Committee for use in a pilot information study program. The laboratory was working to add an object-generating capability to a computed display already in place at NASA in Houston, Texas. NASA uses its display to simulate moon landings and to evaluate new spacecraft guidance techniques.

Also developed was an airborne, real-time recorder display that utilizes the thermoplastic recording technique. The unit records and displays infrared, radar, and electro-optical data from aircraft sensors.

The Laboratory was also concerned with techniques for detecting chemical and biological agents. Of particular significance in 1966 was the development of a method that permits bacteria to be detected and identified by their metabolic products. Through a liquid-gas chromatographic process, 32 strains of bacteria were "fingerprinted." Research on the technique was continuing to determine its usefulness in identifying mixed strains.

Adaptive processing techniques developed in the laboratory were demonstrated by the jet engine analyzer. This machine, built as an elementary demonstration model, can detect and identify several malfunctions in a jet engine by simply listening to the sound of the engine. Similar adaptive techniques are being applied to the classification of radar and sonar signals to permit accurate and automatic target identification.

HEAVY MILITARY ELECTRONICS DEPARTMENT

The Heavy Military Electronics Department, which developed the giant BMEWS surveillance radar subsystem 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 AN/SQS-26 bow-mounted shipboard sonar, the largest in the Navy; the AN/SQQ-14 mine detecting-classifying sonar; radar beam-forming and steering equipment for the Nike X Missile Defense Systems multi-function array radar (MAR); operation and maintenance of Air Force Spacetract satellite tracking radars; and a mobile hi-power acquisition radar (HIPAR) for the improved Nike-Hercules system.

Additional work was done on a microelectronic radar indicator for ground equipment (MIRAGE), which has broad air, sea and land applications. A lightweight phased array radar technique for a compact tactical array radar (COMTAR) system concept was successfully demonstrated and a contract to study high frequency radio propagation was announced. Official designation of the latter program is IDA, for "Ionospheric Dispersion Analysis." Data were being collected over a path between a transmitter site at Coco Solo in the Panama Canal Zone and a receiver sight near Stockbridge, New York. The new contract called for construction of transmitter equipment on Pingorssuit Mountain near Thule, Greenland, and at another site to be chosen.

ORDNANCE DEPARTMENT

The major 1966 program underway at the General Electric Ordnance Department was inertial guidance and fire control systems and support equipment for the fleet ballistic missiles—Polaris and Poseidon.

In 1966 the department received an award for Phase II work on the Poseidon, the Navy's newest deterrent weapon. The department was giving industrial support to Massachusetts Institute of Technology in developing the new Mark 3 guidance system for the Poseidon missile.

The department was also designing the new fire control system, Mark 88, for Poseidon. It will be a sophisticated system stemming from Polaris fire control techniques. The fire control system keeps track of constant changes of the FBM submarine, continuously updating the missile target instructions until the moment of firing.

In addition, the department was engaged in work on equipment in the following areas: stabilization and position control, using servo systems and power drives; weapon control systems for aiming, presetting and controlling guns and missiles; advanced inertial guidance and attitude reference systems; underwater ordnance; chemical and biological detection, and handling and manipulating equipment.

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, weapon control, guidance, computing and data processing.

The department received new 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 the Air Force's F-111A, the Navy's F-111B, and the United Kingdom's F-111K. The attack radar and optical sight were evaluated in aircraft and were being installed on the F-111A. 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-1 Phantom II, F-3H Demon, F-105 Thunderchief, F-104 Starfighter and F-101 Voodoo.

The attack radar system, designated the AN/APQ 113, was the latest in a long line of radars developed and manufactured by G.E. The attack radar allows the crew of the 2-man aircraft to fire at a target without actually seeing it. In addition, it updates the information utilized in the navigation subsystem.

Extensive use was 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.

The Army's Advanced Aerial Fire Support System (AAFSS) will carry a swiveling gunner's station being supplied by LMED.

The department was contributing to both the gun and missile portions of the Army's new Vulcan/Chaparral Air Defense System. LMED is producing the Chaparral missile (a modified Sidewinder Missile, formerly manufactured by General Electric) for the missile ground-to-air, air defense role. The 20 millimeter Vulcan Air Defense System—a gun system being produced by G.E. in Burlington, Vermont—incorporates a LMED gyro lead-computing gun sight.

FLIGHT PROPULSION DIVISION

During 1966, General Electric's Flight Propulsion Division continued development of air-breathing turbine propulsion systems for the next generation of fighter, transport, VSTOL and commercial aircraft, while increasing production of engine models to meet growing commercial and military demands.

Research and development progress included new metals and composite materials for use in production engines and for future propulsion systems.

The Division was re-aligned in March to consolidate business activities into three major Division-wide functions—Engineering, Operations, and Military Production Engine Programs. Dissolved in the move were the former Small Aircraft Engines Department, Large Jet Engine Department and the Advanced Engine Technology Department. The former Commercial Engine Department was renamed Aviation Products and Services Department, and several Division-wide support operations were created to serve the entire Division.

In Hooksett, New Hampshire, an engine component plant was established, the sixth plant in the Division. Others are in Lynn and Everett, Massachusetts; Evendale, Ohio; Rutland and Ludlow, Vermont.

As part of the Federal Aviation Agency's Phase II-C competition for the supersonic transport, 3 prototype GE4 turbojet engines in the 50,000 pound thrust class were built. In May, the company announced that the GE4 in production would be in the 60,000 pound thrust class, and would continue to retain much of the proven design approaches of the Mach 2-plus J79 turbojet and the Mach 3 J93 turbojet that powers the USAF North American XB-70.

The prototype GE4 went into the test cell for its first running at idle speed on July 18. Two days later, the engine attained 100 percent speed with perfect operation. Full unaugmented power was reached on August 23, with more than 40,000 pounds of thrust, thus exceeding the performance requirement.

As testing continued, the GE4 became the world's most powerful turbojet engine when it produced 52,600 pounds of thrust, with augmentor, on October 28, exceeding the guaranteed thrust by 4 percent and substantially bettering the guaranteed specific fuel consumption. The engines on test for the Federal Aviation Agency easily accumulated the required 100 hours of test running. (*Editor's Note:* G.E. was announced as winner of the SST powerplant competition on December 31,1966. See Aerospace Events.)

The feasibility of business jet aircraft for international commerce was proved twice in 1966, both times with G.E. engines. An historic round the world flight by a Lear Jet in May, and a subsequent round the world flight by a Jet Commander in June, both powered by twin G.E. CJ610 turbojet engines, proved the concept. The German-built Hansa Jet also is powered by CJ610 engines.

Pan American Airways and Dassault continued successful worldwide sales of the Fan Jet Falcon business jet powered by twin CF700 turbofan engines by G.E.

In September, the Falcon established a class speed record on a flight from Newfoundland to Lisbon.

A 3 percent thrust growth for the CJ610 engine was revealed in June. Two models, the CJ610-5 and -6, being delivered in 1966, offer takeoff thrust of 2,950 pounds.

To meet the growing demands of the business jet aircraft operators, a world-wide support system for inspection, overhaul, engine exchange, engine lease, and field service for CJ610 and CF700 engines was established. G.E.'s pioneering engine exchange program, started in 1965, was augmented by an engine component exchange program in 1966 to allow aircraft operators more useful operating time.

Major facility expansions were made at Strother Field, Kansas, for the complete overhauls of CJ610 and CF700 engines.

Deliveries of the CT58 commercial helicopter engine continued in 1966 to Sikorsky for its S-61 and S-62 aircraft, and to Boeing/Vertol for its V-107 helicopters.

G.E.'s commercial airliner engines, the CJ805 series, accumulated more than 5,000,000 flight hours through the end of 1966 in service with 14 U.S. and international airlines operating Convair 880 and 990 airliners.

With a bypass ratio of more than 8 to 1, the mammoth TF39 turbofan for the USAF/Lockheed C-5A heavy logistics transport went on test in early 1966, producing more than 41,000 pounds of thrust. By cost, some 60 percent of the TF39 engine was to be supplied to G.E. by other companies. The engine design incorporates such advanced concepts as high bypass ratio and air cooled turbine blades. Some TF39 parts have a design life as high as 30,000 hours.

Production continued for G.E.'s small military turbojet, the J85, in 1966, as Northrop T-38 trainers for the Tactical Air Command and F-5 Freedom Fighters for the U.S., Canada and Military Assistance Program countries were shipped to many new areas.

Contracts were received for non-afterburning J85 engines as boost power units for C-123K and AT-37B aircraft.

In mid-1966, the 4,000th J85 engine was shipped from the Lynn, Massachusetts, plant, and its 2,000,000th hour of flight was logged.

At Evendale, Ohio, the 3,000th J79-15 turbojet for the McDonnell Phantom II was built and shipped in October. The 17,000 pound thrust engine for Air Force Phantoms was due to be replaced by the J79-17, rated at 17,900 pounds of thrust. The final J79-8 for the Navy Phantom II was shipped in June, followed immediately by the first J79-10, at 17,900 pounds of thrust, which underwent operational testing in an advanced F-4J.

Progress in all forms of V/STOL propulsion were in evidence in 1966, including turboshaft, turboprop, lift cruise, direct thrust and deflected thrust engines, as well as lift fan systems.

The versatile and highly efficient GE1 family of engines accounted for much advanced work. The GE1/9 deflected thrust engine, for example, was being developed under U.S. Air Force contract for the U.S./Federal Republic of Germany advanced V/STOL fighter competition.

Testing of large lift fans was conducted as a follow-on to the test flight program of the G.E. J85/lift fan system in the Ryan XV-5A.

The T58 turboshaft engine, powerplant for 11 U.S. military helicopters and 3 commercial versions, passed the 1,500,000 flight hour mark in 1966. In addition to Navy, Air Force, Marine Corps and Coast Guard applications, the T58 was powering helicopters used by 6 commercial airline operators. The second step growth engines, the -5 and -10 models, were installed in antisubmarine assault and rescue helicopters being delivered to both U.S. and foreign users. During 1966 1 T58-powered aircraft, a Coast Guard search and rescue helicopter, set an endurance record of 12 hours on continuous flight. Other T58 aircraft saw considerable active service in South East Asia. Under funded programs, third step growth engines were under test in the factory with qualification set for 1968.

In the T64 area, the 4-engine XC-142 tilt-wing V/STOL continued its highly successful flight evaluation and test program, while the T64-powered Sikorsky CH-53 heavy assault helicopters entered Marine Corps service and an HH-53 for the USAF was announced.

In August, the Italian Air Force selected the T64 turboprop to power the Fiat G222 STOL transport. In Japan, 2 T64's powered the Kawasaki GK210 patrol plane on its first flight, as the 4-engine Shin Meiwa Flying Boat was being readied for its first flight in 1967. Development of the T64-16, an advanced model of the production T64-6 model, continued. The T64-16 turboshaft will power the Army/Lockheed Advanced Aerial Fire Support System rigid-rotor helicopter, the AH-56.

G.E. jet engines modified for land and sea uses included LM100 gas turbines (T58 engines) used as powerplants for hydrofoils, air cushion vehicles, and ore-handling off-highway trucks. The HS VICTORIA, world's first ocean-going commercial hydrofoil, successfully completed its test trials in 1966 and was to enter service in 1967 with a 75-passenger capacity.

The LM1500 gas turbine (J79 engine) also powered marine craft such as the high-speed Asheville-class patrol gunboats (PGM) and was used to drive an aircraft catapult system for the military.

APOLLO SUPPORT DEPARTMENT

The Apollo Support Department, headquartered at Daytona Beach, Florida, met or exceeded its contract commitments on 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 approximately 2,300 employees at Daytona Beach and another 1,000 were working in Huntsville. There were additionally about 1,100 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 business interests include electrical and electronic support equipment to provide: Operational control, determination of system condition, assurance of system operation, restoration of system readiness. This electrical and electronic support equipment is combined in sophisticated systems comprising computers, peripheral equipment, and displays. The equipment may be applied to factory test, pre-flight launch verification and checkout, post-launch analysis, off-line maintenance and control functions, and data collection, processing, recording, and display.

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 major system elements with each other and with the system objectives. This is basically a problem of communications, in the broadest sense. In turn, General Electric was assisting in the development of documentation.

In the area of checkout, in addition to engineering studies, ASD was actually developing and producing the hardware used to check out, or determine the operational readiness of, the Apollo system. This is the kind of equipment which is seen in the blockhouses and control centers at Cape Kennedy. For the Command, Service and Lunar Modules, this equipment is known 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 called Launch Support Equipment—or specifically by the function of the facility with which it is used, such as Propellant Tanking Control Equipment, Measurements Calibration System, Telemetry Ground Support Equipment, or Radio Frequency Test Equipment.

MISSILE AND ARMAMENT DEPARTMENT

The Missile and Armament Department at Burlington, Vermont, continued in 1966 as the company's development and manufacturing facilities for aircraft and ground vehicle armament.

In addition, the Department was conducting research and development and design activities on materials and equipment for re-entry vehicle programs.

Production of the world's fastest firing guns, the 20 millimeter Vulcan cannon and the 7.62 millimeter Minigun—a 6-barrel system capable of firing up to 6,000 rounds a minute—increased in 1966 with the award of several new Air Force and Army contracts. Pods containing these weapon systems for attachment to Air Force combat aircraft also were produced.

Contracts were received for the new Vulcan Air Defense System 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 helicopter armament.

MISSISSIPPI TEST SUPPORT DEPARTMENT

Personnel strength at the Mississippi Test Support Department grew to 1,500 in 1966. A company operation since 1963, MTSD 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 2 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 7-mile man-made canal system was begun in 1966. 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 cryogenic 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 custo-dial. 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 achieved readiness in April, 1966 for initial static tests 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) SI-C booster stages for the Saturn V was scheduled to begin late in 1966 upon completion of the dual-position S-IC test stand, which will tower nearly 40 stories high.

RE-ENTRY SYSTEMS DEPARTMENT

The Re-entry Systems Department is headquartered at Philadelphia and employs nearly 6,000 people, of which about 2,500 are engineers, scientists or technicians.

Primary areas of activity for RSD include the development and production of re-entry bodies, dynamic nuclear power conversion systems, electric propulsion systems, deep submergence oceanics, and development and application of new technologies necessary for departmental product lines.

The Mark 12 re-entry system for the Air Force Minuteman III ICBM tops the list of current programs at Re-entry Systems Department. Other projects include the Biosatellite, the Air Force Maneuvering Ballistic Re-entry Vehicle and a family of research and test vehicles from such programs as Re-entry Measurement Vehicles, Re-entry Vehicle Technology, Observables Program and reentry effort on small systems.

The Department is also studying application of defense and space systems analysis methods and systems management techniques to major social and economic problems. These include the areas of transportation, municipal water, sewer and medicine.

The Re-entry Systems Department is headquartered at the Re-entry Systems Center adjacent to the campus of the University of Pennsylvania at Philadelphia. Other facilities are located at Philadelphia, and Valley Forge, Pennsylvania and Evendale, Ohio. Total floor space of all facilities has grown to 1,250,000 square feet and includes unique manufacturing and testing equipment and research laboratories.

Special chambers and test devices are capable of subjecting re-entry vehicles to virtually every condition found in space and on earth. Data gathered in this testing is then analyzed in a flight test data processing facility.

SPACECRAFT DEPARTMENT

The Spacecraft Department continued its work on unmanned satellites with several successful performances of its systems or subsystems in space.

Nimbus II, the meteorological observatory satellite, was launched in 1966, attaining its design goal of six months of successful operation in orbit. Nimbus B, scheduled for launch in late 1967, passed through the design, manufacturing, and assembly stages at the Space Technology Center during 1966.

The first Orbiting Astronomical Observatory (OAO) was launched in April 1966. The flight was terminated after 2 days because of a power failure; however, the G.E.-supplied stabilization and control system successfully achieved the required pointing accuracy under star-tracker control. The third OAO flight stabilization and control system was delivered to the OAO prime contractor in October 1966. It meets the increased pointing accuracy requirements of the Princeton experiment, 1/10 second of arc.

On June 16, 1966, the Air Force's Gravity Gradient Test Satellite (GGTS), designed and fabricated at the Spacecraft Department, was launched into a near-synchronous orbit as part of a multiple payload on board a Titan III-C launch vehicle.

The GGTS proved the feasibility of gravity gradient stabilization at synchronous and near-synchronous altitudes. Its pointing accuracy, however, was off 15 degrees in a cross plane, apparently due to magnetic particle viscous dampers to lock. G.E. was developing a new version of the magnetically anchored rate damper that is not subject to this failure mode.

The Spacecraft Department continued its development of gravity gradient attitude control and stabilization systems for several of NASA's Applications Technology Satellites. Initial hardware deliveries for ATS-1 were made to the prime contractor in 1966.

GENERAL LABORATORY ASSOCIATES, INC.

The facilities of General Laboratory Associates, Inc., Norwich, New York, were being augmented by a new 45,000-square-foot modern building on which construction started in July. This structure will house expanded production activities, needed to accommodate the planned company growth.

The successful lunar landing by Surveyor I early in June hinged on the key role played by the liquid hydrogen Centaur rocket engine in the second stage, designed and built by Pratt & Whitney Aircraft. The GLA ignition system fired this engine at the precise 100th of a second scheduled to bring the spacecraft to required orbiting velocity.

When the Apollo/Saturn 203 launch took place on July 5th at Cape Kennedy, GLA ignition equipment fired the Rocketdyne J-2 engine in the booster, and numerous EBW units designed and developed at GLA were used to activate various functions of the Saturn.

The successful sub-orbital flight of the Apollo spacecraft on August 25 was marked by the performance of the PC3A-2 Powercel, built by Pratt & Whitney Aircraft, which supplied on-board electrical power at programmed levels during the mission. These fuel cells were equipped with power, accessory and instrumentation harnesses by GLA.

Production activity continued throughout the year on ignition systems for installation in commercial aircraft, notably several Boeing and Douglas models. The stretched version of the Douglas DC-8, besides GLA ignition, carries a newly designed compact power supply unit of GLA design.

GENERAL PRECISION, INC.

General Precision, Inc., through a planned program of selective diversification and selective new-product development, continued during 1966 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; Link Group, Binghamton, New York; and Tele-Signal Corporation, Hicksville, New York. General Precision employed at year-end more than 15,000 people in plant space of about 2,700,000 square feet.

In line with its selective diversification program, changes in defense procurements were met by General Precision 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.

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 and Italy.

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.

A notable highlight of this program occurred during the year when the company announced that it received participation awards and was the first corporate headquarters to receive the "Zero Defects Achievement Award."

AEROSPACE GROUP

The development of a series of low-cost, high-performance inertial navigation systems made 1966 a very exciting year for the Aerospace Group. Early in the year a prototype low-cost inertial system was extensively flight tested at Holloman Air Force Base, New Mexico, and these tests demonstrated that production systems would outperform the goals set by the Air Force for such a system.

The award-winning GRYOFLEX gyro, a unique development of the Gyrodynamics Branch of Kearfott Systems Division, made the low-cost breakthrough possible. This led to the KT-70 series of Low Cost Inertial Navigation Systems for which several contracts were received. A number of AN/ASN-57 and AN/ASN-58 Gyrocompass Attitude Reference sets were built and delivered to the Navy for the evaluation flight testing. Low cost inertial systems were designed and were being built for use in the P3C antisubmarine patrol bomber, the F-105 Thunderstick II fighter bomber, and SRAM air-to-surface missile. Use of General Precision low-cost inertial navigators was under active consideration by a major commercial airliner.

The Doppler radar developments of GPL Division complement the low-cost inertial accomplishments of the Kearfott Systems Division. Elements of the GPL lightweight HELIPATH Doppler set were combined with the HEREFLEX and VEREFLEX heading and vertical reference sub-systems to provide the Doppler Heading Attitude Reference

System (DHARS) for the AAFSS (Advanced Aerial Fire Support System) advanced helicopter. GPL Division was also producing a modified version of the HELIPATH Doppler radar for use in the huge C-5A transport, and a modified version of the APN-153 Doppler radar for use in the FB-111 variable geometry fighter bomber.

Kearfott Systems Division and GPL Division were cooperating in a number of studies to produce improved combined systems. One such combined system is a Doppler-inertial navigator for AMSA (Advanced Manned Strategic Aircraft). Another is a Doppler-Inertial-Loran combination (DIL).

All of these efforts were supported by the development and production of navigation computers, analog-to-digital and digital-to-analog interface devices, servo components, indicators and control/display panels by Kearfott Products Division.

Two very promising digital computers—the GPK-10 and GPK-20 (Digital MINAC)—were produced during the year. The GPK-10 low-cost, compact general-purpose digital computer, is an improved miniaturized version of the AN/ASN-24(V) computer employed in C-141 StarLifter aircraft. The GPK-20 Digital-MINAC computer is a digital, solid-state, programmable version of Kearfott's much used MINAC-5 tactical aircraft computer.

Under contract to the Autonetics Division of North American Aviation, Kearfott Products Division designed and was producing control/display panels for the Mark II avionics system used in F-111 and FB-111 aircraft. Unique electroluminescent displays were produced for the Lunar Module of the Apollo spacecraft.

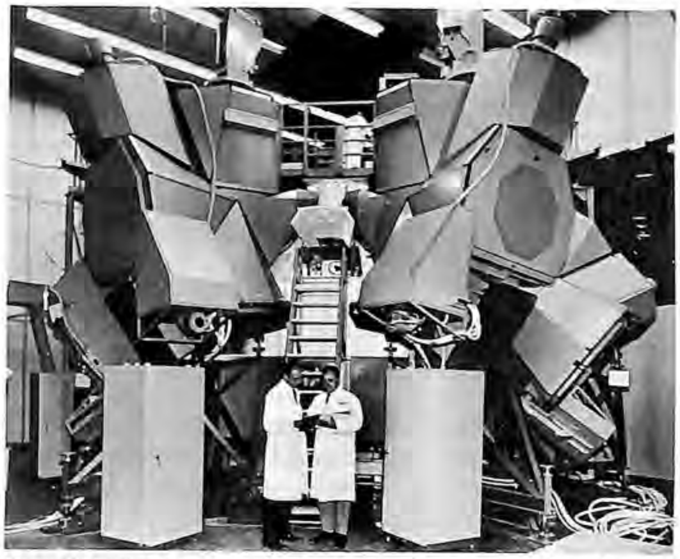
Another Kearfott Products Division accomplishment for the year was the development of miniature, compact-when-packed and low-silhouette radio communications antennas. Under Army and Marine Corps contracts they developed an extremely efficient, tunnel-diode, ferrite-rod antenna for manpack radio use and a variety of inflatable antennas for use in a jungle environment.

On the Lunar Orbiter of 1966, 2 Kearfott thrust-vector-engine control actuators helped provide precision control of the spacecraft, and Kearfott products participated in the successful Surveyor I mission from launch to lunar landing. Three floated rate integrating gyros helped stabilize the Atlas booster, a digital computer performed the guidance calculations on the Centaur second stage and a strapdown triad of floated rate integrating provided precise attitude reference on the Surveyor craft.

LINK GROUP

At the Link Group the 1966 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 System 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 Lunar Module missions, and for the new high-speed military and commercial jet aircraft.



Completed at General Precision/Link was the Apollo Mission Simulator, a primary training system for Apollo astronauts.

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 LM 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 a 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 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 9 spacecraft plunged toward the lunar surface.

A television ground data-handling system built by the company was used to produce the television picture and photographs of the moon's surface that were received as electronic signals from the Surveyor spacecraft. These pictures disproved the "15-

feet-of-lunar-dust" theory which had been claimed as a deterrent to a manned lunar landing.

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 is not equipped with the company's controls to provide power, speed and accuracy for the steel-making process. Controls are also supplied to the nonmetallic material manufacturers including producers of packaging and printing materials, paper, plastic fiber and textiles.

During the year, Link formed a School Trainer Division to sell and service the new Link Allstate automobile Good Driver trainer and other educational products.

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.

TELE-SIGNAL CORPORATION

Tele-Signal Corporation is an engineering oriented, highly skilled manufacturer of electronics equipment and systems for long-distance telegraph, telephone and data communications.

A relatively young company, Tele-Signal has shown remarkable progress in building both domestic and international markets for its product lines. These products include: telephone transmission equipment that provides for many simultaneous conversations over a single transmission path; systems which permit simultaneous telephone and multiple teletype and/or data signals over a single transmission circuit without interference; speech-privacy systems; encoding and decoding systems used for remote selection, monitoring, alarm reporting, control and metering of products in gas, petroleum and water pipelines, for water, power and sewage utilities operations; for remote control of radio transmitters and receivers. These remote functions can be effected over great distances.

During its 9 years of operations, Tele-Signal has combined many units of tone equipment with other complex solid-state devices of its own design to provide highly reliable communications systems. These systems are used by all branches of the military in their communication networks throughout the world. Other government agencies, such as NASA, the Federal Communications Commission, Federal Aviation Agency, Weather Bureau, Corps of Engineers, and the Department of the Interior employ these systems in their installations in the U.S. and abroad, and for communications in outer space.

Private communications carriers depend on these systems in their daily world-wide operations, and utilities and pipelines companies use Tele-Signal tone systems for remote supervisory control and metering.

A number of numerous and unusual products were developed and placed in production and, as a necessary adjunct to these complex precision systems, special testing and maintenance equipment was developed for production and field servicing.

B. F. GOODRICH COMPANY

During 1966, the B. F. Goodrich Company's Aerospace and Defense Products Division received the tire, wheel and brake contract for the Lockheed C-5A and the advanced aerial fire support system (AAFSS). The C-5A contract amounted to more than $13,000,000.

The recently developed liquid-cooled brake satisfactorily completed certification tests on a Boeing 727 as required by the Federal Aviation Agency. Flight testing was to continue into 1967, after which the brake was scheduled to go into regular passenger service.

The liquid-cooled brake system employs a new principle to prevent heat build-up on the braking surfaces. Circulating fluid absorbs heat and carries it away from the brake, wheel, and tire assembly. The heat exchanger is manufactured by Harrison Radiator Division, General Motors Corporation, Lockport, New York.

The revolutionary liquid-cooled brake will help to increase aircraft safety. It operates up to 1500 degrees cooler on the linging surfaces than conventional brakes on jetliners, thereby preventing the build-up of heat in the brakes, wheels and tires.

The cooler operating brake system results in improved life of the brakes, wheels and tires and the company expected it to find wide use on jet aircraft of all types.

A major expansion of the Wheel and Brake Plant at Troy, Ohio, was completed during the year to further increase production capacity at this B. F. Goodrich facility.

The space-saving foldable aircraft tire developed in 1965 received further testing on combat-type military vehicles to demonstrate the "run-flat" capability of this tire when damaged or completely deflated. The tire takes up only one-half to three-fourths as much space as a conventional tire in the wheel well of a plane with landing gear retracted, but it inflates to standard size for takeoffs and landings.

A family of rigid PVC foam sandwich panels was developed for structural use in aerospace applications. Various "skins" can be bonded to the core material which can be supplied in a variety of densities and thicknesses.

GOODYEAR AEROSPACE CORPORATION

An expanding role in rapidly advancing space and missile technologies, major diversification and important contributions to the nation's military effort marked the activities of Goodyear Aerospace Corporation during its 27th year.

The year also was one of significant expansion. Boosting its role as a major supplier of plastic parts, the company opened a plant—its third—at Jackson, Ohio, achieving a major technological advance by introducing Spraypreg, a highly automated process for producing reinforced plastics.

The giant Goodyear Aerospace 175,000 cubic foot Vee-Balloon swings 2 huge logs over Willamette National Forest. The "Skyhook," in service with an Oregon lumber firm, can carry up to 10 tons for ½ mile.

A subsidiary of The Goodyear Tire & Rubber Company, Goodyear Aerospace maintained peak production levels at its headquarters plant in Akron, Ohio, and at its manufacturing and development facility in Litchfield Park, Arizona.

Employment during the year averaged about 9,000 persons, approximately ⅓ of them engineering, scientific and technical personnel.

During 1966, there were these notable achievements:

AKRON

The Subroc antisubmarine missile, for which Goodyear Aerospace is prime contractor, was accepted for fleet use by the Navy and continued as a major production item. Subroc, the revolutionary underwater-to-air-to-underwater weapon, has a range far beyond that of any antisubmarine weapon except aircraft.

In Viet Nam, combat helicopter crews were protected by nonmetallic body armor developed by Goodyear Aerospace. Lighter but more effective than steel, the ceramic and fiberglass armor was protecting crews and instruments aboard a wide range of military aircraft operating in combat zones and was used on shallow-draft patrol boats.

The company also remained the major source of lightweight, high-strength cargo pallets made for the Air Force 463L system, which has standardized the air transport function. Constructed of aluminum and balsa, each pallet weighs less than 300 pounds, but handles loads up to 5 tons.

Goodyear continued to supply canopies and windshields for the McDonnell F-4C Phantom and also to develop and manufacture a variety of advanced weapon and flight simulators to train military pilots.

For the Air Force, the company designed and built a flexible, reinforced plastic-cloth fabric radio antenna mast that can be inflated to a height of 60 feet for use in dense terrain during combat. Deflated, the mast can be carried as a package measuring 1 cubic foot. It has an effective range of approximately 25 miles.

Goodyear Aerospace continued as a major supplier of transmitting and receiving microwave antennas. Built for the Western Electric Company, the horns were being used across the nation in television and microwave networks.

In space-oriented activities, Goodyear built the ball-shaped canister assembly used to orbit the 100-foot-diameter Pageos balloon for NASA.

And to track the Echo I-type satellite, the company designed and built the country's first "go-anywhere" observatory, a compact, 16-ton mobile unit which follows Pageos' orbital course and measures its light intensity.

Goodyear Aerospace built an inflatable wire grid passive communications satellite which was placed in orbit 600 miles above the earth in July.

Built for the Air Force, the "wire ball in the sky" acts as a reflector for radio waves.

At year-end, a Goodyear Aerospace Ballute (balloon parachute) had made possible more than 12 successful recoveries of the ALARR rocket, a high-altitude Air Force system for sampling radioactive debris. In the recovery system, the Ballute reduces payload speed from supersonic to less than 420 miles per hour, at which time a nylon parachute is deployed. A Ballute was also incorporated into the recovery system for the hypersonic PRIME SV-5D lifting body built by the Martin Company for the Air Force Systems Command's Space Systems Division.

Goodyear Aerospace also designed and built a full-scale prototype of a structure that could permit extended exploration of the moon—an expandable lunar shelter for NASA's Langley Research Center.

ARIZONA DIVISION

The Arizona Division was chosen to fabricate two major subassemblies for the Boeing Company's 490-passenger 747 airliner. The plant was assigned production of the central wing section of the aircraft in its metalcraft facilities, and doors for main and nose landing gear in its reinforced plastics facilities. Earlier, the company had announced that it would assume production responsibility for wing sections for the Boeing 707 and 720 series jets.

The Litchfield Park facility also was engaged in production of canopies and windshields for the Northrop F-5A and the LTV A-7A aircraft.

The company's "super skyhook," a 162-foot-long V-shaped balloon that can lift up to 10 tons, was used for the first time in harvesting timber from previously inaccessible areas of the Pacific Northwest. Built at Litchfield Park, the Vee-Balloon is held aloft by 175,000 cubic feet of helium.

In March, Karl L. Fickes retired as manager of the Arizona Division. He was succeeded in Litchfield Park by Morris B. Jobe, formerly sales manager at company headquarters in Akron.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION

For the first time in the 37-year history of Grumman, gross sales in 1966 hit $1 billion. Also notable was a continuing and substantial expansion of programs, personnel, and physical space.

From a personnel level of 14,500 in 1962, Grumman at year-end employed 33,500 people, 4,200 of them placed on the payroll during 1966. The company also added more than 400,000 square feet of workspace during the year.

The corporation was producing a variety of military and civilian aircraft as well as moving into outer space and inner space work. In 1966, 149 military planes were produced. Five model types were in production and were being used in Viet Nam.

The A-6A has proved to be one of the most respected aircraft in Viet Nam, largely because of its all-weather capabilities and strike potential. More than 200 of these planes had been manufactured through 1966.

The company's EA-6A was delievered to the Navy in 1966 and the first detachment was sent to Viet Nam in November for use by the Marines. This electronic countermeasures aircraft is the only one of its type in existence.

Another plane, the E-2A Hawkeye, also proved its effectiveness in Viet Nam. The next generation aircraft, designated E-2B, was expected to be developed by 1970.

The Grumman Mohawk was scheduled to continue production into 1968. Modification of the plane was begun in 1966, and by the end of 1967 the number of Mohawks in the air over Viet Nam was expected to double.

The S-2E Tracker, an antisubmarine warfare aircraft, has been in production since 1962 and has undergone 4 modifications. A total of 1,500 Trackers have been fabricated, including 48 in 1966. The company expects that 38 more will be produced in 1967.

Although there are 3 model types that are no longer in production (the HU-16 Albatross, the E-1B Tracer, and the C-1A Tracer), the company still had more different types of aircraft (8) operating in 1966 in the South China Seas than any other U. S. airframe manufacturer.

In addition, the new C-2A Greyhounds began supporting the Navy logistically in mid-1966. They were to be used in Viet Nam in 1967.

By the end of 1966, the F-111 program had shown 1,300 accident-free flights. Indications were that production would go through 1969, with a total of more than 490 aircraft, including 24 for Australia and 50 for the United Kingdom, involved.

Grumman was selected to produce an A-6A trainer version of its Gulfstream I. This should increase the training rate of A-6A pilots and bombardier-navigators.

Twelve Gulfstream I's were delievered during 1966, bringing to 176 the total delivered since the late fifties.

A new version of this executive aircraft, the jet Gulfstream II, made its first flight in 1966. Certification was expected in the spring of 1967.

Grumman's durable Ag-Cat continued to be a high seller in the agricultural crop-dusting field. Four hundred forty have been produced since 1958, 62 in 1966. A new Super Ag-Cat, which develops 450 horsepower and adds an additional payload that approximates the empty weight of the Ag-Cat, was certified during the year.

In 1966, 6 flight test models of the Lunar Module (LM) were in production. The basic configuration of the LM is virtually set. The first manned LM mission was expected to be LM 2.

The company's Orbiting Astronomical Observatory (OAO) was launched in April 1966, and completed 20 orbits. Systems operation and design proved sound. It was expected that a new OAO would be delivered to the Goddard Space Flight Center soon for ground operations. Two more OAO's will follow.

A military hydrofoil (the PGH) was scheduled to be launched in the last half of 1967. This follows

Grumman was awarded a $3,600,000 Navy contract for design, construction and test of a hydrofoil patrol gunboat designated PG(H).

the 1966 launching of a commercial hydrofoil (the Dolphin). It is a 65-foot, 88-passenger craft that has been purchased by a Spanish firm to take passengers between Las Palmas and Tenerife in the Canary Islands.

Of further note was the development, with Dr. Jacques Piccard, of a mesoscaph (PX-15) that is capable of going down 2,000 feet into the sea. One of its tasks will be a 4- to 6-week submerged drift mission that will cover 1,500 miles from Miami to Nova Scotia. The drift will be provided by the waters of the Gulf Stream.

GYRODYNE COMPANY OF AMERICA, INC.

Gyrodyne's 20th year, 1966, was also its most satisfactory year in terms of production, gross sales and net income. Gross sales for the fiscal year which ended on April 30 were up 28 percent and earnings increased 159 percent to $2.89 per share.

The company's main production continued to be the QH-50 series of drone helicopters and other components of the antisubmarine DASH Weapon System. In January, deliveries of the advanced model QH-50D began to phase into the fleet inventory. The D model has a lighter, more powerful engine, with improved performance, payload and endurance than the C model which completed its production run in December 1965. Also phased into production in 1966, after approximately 2½ years of research and development, were new, all-weather fiberglass rotor blades, standard equipment on all QH-50D drone helicopters. These were the first all fiberglass molded rotor blades to conform to Navy specifications and to be approved for production.

During the year, advances were made in furthering the development and capabilities of drone helicopter systems. A successful flight test program was completed wherein a QH-50C drone equipped with a television camera was used to demonstrate the feasibility of obtaining real-time reconnaissance and surveillance data for a ground station with permanent recording on video tape for later study and analysis.

The Pacific Missile Range Aircraft Target Test Program at Point Mugu, California, was successfully completed in February. Three QH-50A drone helicopters were utilized as targets for over 100 firing presentations during a 4-month period. The complete operation which included flight control of the drones, maintenance of the drones and the ground station was accomplished by 2 Gyrodyne technicians without incident.

In a newly developed technique, drone helicopters had control transferred to a piloted aircraft and back to the ground station on several occasions, demonstrating an expanded capability for a variety of drone helicopter missions.

In a cooperative experimental development with the U. S. Naval Oceanographic Office a significant test was conducted at the U. S. Naval Air Test Center, Patuxent River, Maryland, in the collection and remote transmittal of oceanographic data. The test utilized a QH-50D drone helicopter which was specially equipped with dispensers capable of dropping SSQ-36 air-expendable Bathythermographs and S-Band telemetry modified to retransmit BT signals to a remote command and monitor post. This experiment may have wide application to rapid large area collection of a variety of oceanographic data with significant cost effectiveness.

In early 1966 Gyrodyne received its first foreign order, from the Japanese Defense Agency. At year-end, accommulated orders for drone helicopters, training equipment and spares amounted to approximately $1,670,000.

Gyrodyne was moving ahead in other important areas. The program of investing corporate funds in oil and gas exploration and development continued. Gyrodyne Petroleum, Inc., a wholly-owned subsidiary was formed November 9, 1965, to consolidate the company's activities and investments in this area of diversification. Likewise, another wholly-owned subsidiary, Flowerfield Properties, Inc., was formed June 14, 1966, for the purpose of holding certain of the company's property, investments and its limited partnership interest in the development of an extensive citrus grove in Florida.

HARVEY ALUMINUM

The year 1966 was a significant period for Harvey Aluminum. Primary aluminum facilities operated at record levels, new plants and equipment went into operation, and advancements were made in the fabrication of mill products in aluminum, titanium, zirconium, and steel alloys for aerospace applications.

The new aluminum rolling mill at Lewisport, Kentucky, went into production, enabling the company to supply heat treatable aluminum plate up to 12 feet wide. The mill was also producing a full range of aluminum sheet.

In other areas of the company's expansion program, a new alumina plant in St. Croix, U. S. Virgin Islands, was being readied to go into production; bauxite mining facilities were being developed in the Republic of Guinea in Africa; and an aluminum smelting and fabrication complex was under construction on the island of Karmoy in Norway.

During the year, a second 8,000 ton hydraulic forging press was put into operation at the company's Torrance, California, plant.

Harvey continued to supply extrusions, forgings, impacts, tubing, sheet, and other wrought aluminum mill products for airframe, space vehicles, missiles, and ground support equipment. Production remained strong on the AM-2 landing mat, which was designed and developed by the company.

Shipments of titanium and steel alloy mill products were substantial to meet advanced performance requirements. Harvey was extruding titanium and steel alloy sections to a 9-inch circle size. Extensive work was underway to supply titanium components for the supersonic transport program.

Important progress was accomplished in composite materials, with the company's research and development division producing high strength plate with an aluminum alloy matrix reinforced with steel whiskers or fibers. This Harvey development fulfills the need for materials with higher physical properties in proportion to their weight.

Materials produced by Harvey Aluminum during the year went to such aerospace programs as the C-141, C-5A, F-4, F-5A, UH-1, CH-53A, S-64, 707, 727, 737, 747, COIN, DC-8, DC-9, Gemini, Polaris A3, and Saturn.

HERCULES INCORPORATED

Hercules Incorporated continued work on well-established projects and also moved into new areas during 1966. Long a leader in the field of double base solid propellant, Hercules announced during the year the establishment of capability in the composite propellant field. Named Hercopel, the new propellant was 6 years in development, and it will be produced for small- and medium-size rocket motors at a new facility constructed at the company-operated Allegany Ballistics Laboratory.

Hercules expanded its filament winding know-how during 1966 to include boron, with applications for such items as re-entry vehicles and rotor blades for helicopters.

Sophisticated new techniques for the control of thrust and solid propellant rockets were successfully demonstrated during 1966. Continuing their work on propellant additives during the year, Hercules scientists achieved the highest specific impulse demonstrated in the free world.

During 1966 the major solid propellant projects were Poseidon, Sprint, Minuteman Stage 3, A3 Polaris Stage 2, and Hibex. All of these programs use high energy double base propellant and glass filament wound cases.

Poseidon work continued on contracts awarded last year for both propulsion stages. Hercules was working alone on the second stage and with Thiokol Chemical Corporation in a joint venture on first stage. Hercules is manager of the joint venture. Production of research and development motors was underway, and the first static test firing was set for 1967.

During 1966, all development work on Sprint continued to be successful. The performance requirements of the Sprint system made the development of suitable motors one of the most difficult assignments ever undertaken by Hercules scientists. Sprint continued to be an active part of the Nike-X system.

On the Hibex (High-G Boost Experiment), all objectives of the program were achieved. Problem areas handled in the propulsion effort covered propellant structural strength and vehicle control, effects of high-g and attendant high heating rates on the motor and control system design. The Hibex development program marked one of the most successful efforts in rocket history. Studies were underway to determine if production or additional development work will be undertaken on Hibex.

During the year Hercules 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 Nuclear Detection Satellites and communication satellites into orbit.

Work also continued on magnetohydrodynamic (MHD) generation of electrical power created from solid rocket exhaust.

HONEYWELL INC.

Through the 3 divisions making up its newly redesignated Aerospace and Defense Group, Honeywell broadened and deepened its contributions to national aerospace programs in 1966. The group's space, aircraft and defense sales increased about 25 percent over the previous year, employment rose nearly 20 percent to 16,800 persons, and plant space grew by nearly 240,000 square feet.

Honeywell's broad-based competence to meet technological challenges in all 4 environments—space, air, surface and undersea—was demonstrated in numerous ways during the year. Some of the important ones, described by division, follow:

SYSTEMS AND RESEARCH DIVISION

This division, center of systems management for advanced space, weapons, reconnaissance and avionics programs and of applied research to solve future defense and space requirements, demonstrated its ability as a large-scale systems manager with the successful flight of a NASA Project Scanner spacecraft in August.

The 3-stage rocket carried a 550-pound research package some 380 miles over the Atlantic Ocean on a 13-minute suborbital flight to gather data on the infrared content of the earth's horizon. The data from this and future flights is expected to help NASA scientists improve present spacecraft guidance technology. Honeywell was responsible for vehicle structure, attitude control, propulsion integration, instrumentation, communications, power supplies and launch support.

As an extension of the suborbital program, Honeywell scientists were funded by Langley Research Center early in the year to study flight characteristics of an orbiting Scanner.

Late in the year, systems engineers undertook jointly with Raven Industries Inc., for Langley a new program to explore the feasibility of balloons to recover spent booster rockets or spacecraft for reuse. The program calls for numerous aircraft drops of 20- and 50-foot experimental balloons in 1967.

To help NASA's Marshall Space Flight Center better determine cabin sizes of lunar shelters and work capacities of lunar explorers, Honeywell human factors scientists conducted the first mock scientific expedition in a tiny simulated vehicle. Two NASA subjects successfully lived and worked in the cabin for 18 days.

In avionics systems, the company's unique helmet-mounted weapons sight was selected by Lockheed-California Company for the Advanced Aerial Fire Support System (AAFSS) combat helicopter under development for the Army. The electro-optical sighting system requires no mechanical linkage between pilot and airframe to aim the guns.

Foremost among many applied research projects completed during the year was the delivery of a laser gyroscope, first to be made of solid fused quartz, to the Naval Ordnance Test Station, China Lake, California. Use of rugged quartz material may open the way to numerous aerospace applications of laser motion-sensing technology.

The Honeywell Radiation Center in Boston, Massachusetts, made a part of Systems and Research Division in 1966, developed a portable all-weather approach and landing system called STATE (Simplified Tactical Approach and Terminal Equipment). Selected for evaluation by the Defense Department to meet requirements for remote combat areas, STATE underwent numerous flight tests by military aircraft and helicopters.

Reconnaissance mapping subsystems using unique Honeywell infrared devices were contracted by the Radiation Center, as were a magnetometer system for the Apollo Lunar Surface Experiments Package (ALSEP) and the star tracker and planet tracker portion of the 1969 Mariner probe to Mars. A laser obstacle detector for helicopters was conceived for the Army Electronics Command.

AEROSPACE DIVISION

The Aerospace Division, aligned to carry out engineering and manufacturing of space and aircraft guidance and control systems and instruments, continued to play a major role on U. S. space missions. The division also markedly stepped up its stake in both military and commercial aircraft fields, and expanded into communications systems and devices for the military.

In manned space programs, Honeywell attitude controls and inertial guidance equipment functioned flawlessly on all 5 1966 Gemini flights, including assisting in the automatic re-entry of the last 2 craft. During 970 hours in space, the inertial measurement unit (IMU) accumulated 280 hours of operating time and underwent 30 in-space start-ups without a failure.

Stabilization and control systems for the Apollo 3-man spacecraft built by North American Aviation passed their first flight tests in suborbital launches from Cape Kennedy in February and September and were to be put to first operating use in manned earth-orbital missions beginning in 1967. Honeywell also was providing advanced cockpit displays and the attitude control handle for the 2-man Lunar Module built by Grumman.

Honeywell technician adjusts flight director attitude indicator, Apollo instrument being produced by the company's Aerospace Division.

Continued active participation in manned missions was assured with the winning of a contract from Douglas Aircraft Company for attitude controls for the Air Force Manned Orbiting Laboratory (MOL).

Moving back into deep space probes, the company won a contract from Jet Propulsion Laboratory for attitude control and scan platform control systems for two NASA Mariner flights past Mars in 1969. Studies of a Mars landing craft also were initiated.

Inertial guidance systems performed spectacularly on Atlas-Centaur rockets, aiming two Surveyor spacecraft on trajectories so precisely that no mid-course correction would have been necessary for the craft to soft land on the moon. Other space vehicles, including the Air Force Burner II, Athena, Thor Delta, Atlas, Titan II, and Sprint antimissile missile, Navy Polaris missile and NASA Scout, were guided by Honeywell control systems.

Major gains in commercial aviation business highlighted the year. A universal model of the Honeywell air data computer was developed and sold to United Air Lines to equip their entire fleet of Boeing, Douglas and Caravelle transports. Boeing began offering the unit to its customers as basic equipment on 707's, 720's and 727's, which also carry Honeywell fuel quantity gaging and engine pressure ratio instruments. Engine instruments were also sold in volume for Douglas DC-8's and DC-9's.

In the military aircraft field, Honeywell won important contracts for automatic flight controls, fuel gaging and engine instruments for the Lockheed C-5A Air Force cargo transport, and for the 5-axis autopilot for AAFSS from Lockheed-California. The company's pulse-type radar altimeter was ordered for the Boeing Vertol CH-46 and Sikorsky CH-53 Marine Corps helicopters and for the Lockheed C-141 Star Lifter. Deliveries continued on General Dynamics F-111A altimeters. The division occupied an additional 100,000 square feet of plant space, largely for expanded computer and altimeter production.

In advanced technology, Minneapolis engineers in June began a study of an automatic control system to help improve flight performance of large military and possibly civilian aircraft of the 1970's. The project was jointly undertaken with Boeing's Wichita Division for the Air Force Flight Dynamics Laboratory to investigate ways to alleviate inherent strains on aircraft structural elements.

Developments in the new technology of fluidic systems continued along a broad front, climaxed by successful flights of an all-fluidic 3-axis autopilot aboard an Aero Commander by NASA's Flight Research Center, Edwards, California. A fluidic rudder control for a high-performance Air Force fighter, and 2 additional Army test instrumentation missiles (TIM) using fluidic controls also flew. Research in high-temperature fluidic sensors produced significant progress for future aerospace instrumentation, and rapid progress was made in development of an all-fluidic jet engine control for the Air Force.

Florida engineers developed the first strapped-down, rather than gimballed, guidance for a spacecraft and delivered it to the Martin Company for the PRIME maneuverable lifting body.

Electrically suspended gyro technology made new headway. The Air Force began flight tests on an airborne navigator in a C-124, and awarded Honeywell a contract to develop a feasibility model of an inertial measurement unit (IMU) using electrically-suspended rather than conventional floated gyros.

Early in the year, a Honeywell inertial navigator and a Johns Hopkins University Receiver helped the Navy demonstrate that aircraft can accurately update positions on long flights by taking fixes on existing navigation satellites.

In other activities, Florida made initial deliveries of the division's ALERT airborne digital computer, and formed a communications systems and devices organization to pursue growing opportunities in military fields.

ORDNANCE DIVISION

The Ordnance Division's Minneapolis operations underwent rapid growth in 1966 in response to rising requirements for conventional safing, arming and fuzing devices, and new developments.

The division acquired an additional 100,000 square feet of space in suburban Minneapolis, and established an ordnance proving ground on 792 acres 40 miles northwest of the city. The patents and certain assets of Livingston Electronic Corporation, Montgomeryville, Pennsylvania, a developer of ammonia-activated batteries for fuzes, were purchased.

Initial deliveries of Mark 46 Model 1 ASW torpedoes were made to the Navy, and plans were completed to begin full-scale production in 1967 as the company's undersea weapons role continued to expand.

West Coast ordnance operations, devoted largely to Navy undersea programs, expanded as well. Two complex electronic training systems were installed by the California Ordnance Center to help sharpen Navy combat ship crewmen and helicopter pilot's readiness to engage in antisubmarine warfare.

Booked later in the year was a $4,200,000 contract to design and develop similar ASW trainers for installation at the Fleet Training Center, Newport, Rhode Island, and the Fleet Sonar School, Key West, Florida.

The company's underwater instrumentation laboratory in Seattle, Washington, underwent the most rapid physical growth in its 15-year history, increasing its capability to advance deep-water acoustic research and sonar signal processing techniques.

An additional 38,000 square feet of office and manufacturing space was built and occupied during the year. Production of ceramic transducers for Mark 46 Mod 1 and Mark 37 torpedo homing systems was initiated. Under a $1,000,000 Navy contract, production continued on AN/UCC-1(V) microelectronic telegraph terminals for fleet broadcast systems.

HUGHES AIRCRAFT COMPANY

In the minds of 30,000 employes of Hughes Aircraft Company, which built the Surveyor spacecraft for NASA's Jet Propulsion Laboratory, the highlight of 1966 occurred on June 1, when Surveyor 1 touched down on the moon.

Surveyor was an unqualified success. The only thing in the entire mission that went wrong—an omnidirectional antenna that did not extend—later corrected itself when it jiggled loose during touchdown.

During the remainder of its first 2-week lunar day, Surveyor sent back to earth more than 10,000 photographs of the moon's surface. Then it went into frigid hiberation during the 2-week lunar night when temperatures dropped to minus 250 degrees. Surveyor survived that night and in July it awoke and started sending more pictures, nearly 1,000 more. Even as late as October 7, after enduring 3 more nights on the moon, it miraculously sprung back to life, and again on November 8, after 161 days of exposure, it turned on to provide several hours of engineering and lunar tracking data.

In addition to its work on the series of 7 Surveyor spacecraft, the company's Space Systems Division had a busy year building Intelsat communications satellites and the Applications Technology Satellites (ATS).

Hughes was building four Intelsat 2 communications satellites of twice the size and 3 times the power of its Early Bird under an $11,700,000 contract with Comsat Corporation. The new "birds" are expected to provide a 2-ocean system of commercial communications by linking ⅔ of the world by television and telephone, and also serve as a voice-link with earth for the orbiting Apollo astronauts during the man-on-the-moon mission.

The first Intelsat had a perfect launch October 7, but its apogee motor failed to kick it into synchronous orbit. Despite this, all communications and command systems abroad the satellite responded perfectly, and the craft was maneuvered into an elliptical orbit which made possible transpacific communications experiments. Meanwhile the Hughes Early Bird and Syncoms 1 and 2 still were operating effectively after totaling nearly 7½ years in space.

The first of 5 ATS's being built for NASA under a $39,000,000 contract was launched in December. It contained a spin-scan cloud camera (developed by the Santa Barbara Research Center, a Hughes subsidiary) which uses the spin stabilization of the spacecraft to provide scanning of the earth. It was expected to generate a new picture of ⅓ of the earth's surface every 20 minutes and provide meteorologists fresh data on rapidly changing cloud formations. The satellite also was expected to enable the first flight test of a microwave phased array antenna as a part of the basic spacecraft communications system.

In January the company announced the formation of the Missile Systems Division at newly-leased facilities at Canoga Park, California, under Dr. Warren E. Mathews, with responsibility for the TOW antitank missile for the Army, the Phoenix missile for the Navy, and the AIM-4D and the Falcon missiles for the Air Force. By year-end, employment at the new facility topped 1,600.

The year brought great progress in the company's program on the Phoenix air-to-air missile system. In April, a Navy F-111B landed at the Hughes airstrip at Culver City to begin a test program with the Phoenix system, and by August the firm announced that installation of the missile control system had been completed on the interceptor 30 days ahead of schedule.

Meanwhile, from an A-3A Skywarrior test bed, the Phoenix missile scored 3 successes out of 3 test launches. First came a success on its first powered flight to prove its compatibility with the test aircraft, then it scored a direct hit on a target drone during its first guided firing, and later it racked up an intercept of a tiny jet drone, all over the Pacific Missile Range near Point Mugu.

In October, Navy Secretary Paul H. Nitze told the House Appropriations Committee that "there is no other fire control and missile system that can compare with the record of detecting targets and intercept of the Phoenix." Rear Admiral W. E. Sweeney, F-111B project manager, calling the system "the most advanced in the world," told the committee: "The fact that this system knocked down a target on its first guided firing we felt was remarkable, at a range exceeding anything we have had before."

Two significant developments of 1966 involved TOW. The Army Missile Command announced it was testing the missile in the severe winter climate of Fort Greeley, Alaska. And Hughes announced a new gyro-stabilized gunsight that would enable gunners to fire the TOW from helicopters and keep a fixed bead on targets despite the copter's vibration and maneuvering. The supersonic TOW (for Tube-launched, Optically-tracked, Wire-guided missile) is steered by electronic signals that are jam-proof because they are sent over hair-thin wires than unreel during flight.

A traveling wave tube (TWT) made by the company's Microwave Tube Division proved a reliable amplifier aboard the NASA Lunar Orbiters that sent back pictures of the moon. The TWT is similar to the Hughes tubes that aided picture transmission from Mars abroad Mariner 4 and from the moon on Surveyor 1.

The same division introduced 2 completely packaged argon ion pulsed lasers as the first products of a new commercial-industrial laser line.

On Memorial Day, Hughes inaugurated a synchronous communications satellite research station —the first privately-owned facility of its kind—at Caddo Gap, Arkansas. Before 75 foreign delegates of the International Telecommunications Union, the company disclosed its new STAR system (Satellite Telecommunications with Automatic Routing)—a "multiple access" concept that will enable many satellite earth stations to communicate simultaneously with one another through one satellite.

A new seagoing communications terminal that joins Navy ships directly with the first military global satellite communications network was displayed and demonstrated for the first time in August. The terminal, built for the Navy by Hughes Aircraft Company's Ground Systems Group, Fullerton, California, has the capability of transmitting instant ship-to-ship and ship-to-shore voice or teletype messages across thousands of miles and "hurdling" them over large masses of land from ocean to ocean and beyond. A total of 7 terminals were to be installed aboard guided missile cruisers and aircraft carriers by early 1967.

Another highlight of 1966 was the unveiling of Hughes-Fullerton's new air-transportable ground-link terminals for military communications through the first military global satellite communications network—a group of random-orbit satellites that were launched in June by the Department of Defense. Several of the terminals were operational at sites around the world, including Hawaii, the Philippines, West Germany and Ethiopia. The Mark 1B terminals were being built for the Army's Satellite Communications (SATCOM) agency. Relatively unaffected by atmospheric or solar disturbances, they provide a reliable supplement to crowded high-frequency radio circuits and limited undersea cables.

In June, Hughes Ground Systems Group was notified by NATO that a consortium of electronics firms, which the company heads, had been named low bidder on a $280,000,000 NATO Air Defense Ground Environment (NADGE) project. NADGE will be the biggest electronics project in Europe and will provide the NATO countries with the most modern air defense system yet devised. The project will provide NATO with a completely integrated early warning and weapon control system extending from Norway to Turkey, within about 5 years.

Production of a lightweight "Manpack" sending-and-receiving radio that provides American GIs with 10,000 individual voice channels over which to send vital battle-zone messages moved into high gear during 1966 at Hughes-Fullerton. The solid-state Manpack, which was being used successfully by ground forces in Viet Nam, is easily carried by one man wearing a standard Army shoulder harness. Because of its 2-to-12-megacycle range and 10,000 channels, enemy jamming efforts are more difficult. Other features are transmission range far beyond line-of-sight, and the ability, unlike most combat radios, to operate effectively on ordinary flashlight-type dry cell batteries as well as on wet cell batteries.

A new division to work on the development of a mobile, surface-to-air missile system for the defense of field armies in the 1970's was organized in May by Hughes-Fullerton. The new unit, called the SAM-D division, was established to focus the talents of key management, scientific and technical personnel on the Army's proposed SAM-D (surface-to-air missile development) program.

Meva Corporation, an electrical contracting subsidiary headquartered at Fullerton, opened a Southern California district office in El Monte, California, for its construction division during 1966. The expansion of Meva's construction arm was the result of increased business activity in the field of interior electrical construction.

Thomas D. McAusland was appointed manager of European marketing efforts for Hughes-Fullerton. He will work out of Hughes Aircraft International Service Company (HAISCO) offices in Paris and will supervise and coordinate the entire reorganized marketing effort in Europe for Hughes-Fullerton.

Hughes Research Laboratories at Malibu, California, where the first laser action was achieved in May 1960, revealed development of a continuous-wave room-temperature ruby laser system capable of output of more than 1 watt and with promise of a high-power single mode operation.

The research laboratories also developed a millimeter-wave amplifier tube with an average CW power output of more than 5 kilowatts. The previous output limit in the millimeter-wave frequencies was a Hughes tube in the 1 kilowatt range, and as recently as 4 years earlier a Hughes 100-watt tube was considered a major advancement.

The most notable achievement of the year for the Santa Barbara Research Center was the faultless performance of its Star Tracker which guided Surveyor 1 to its perfect landing on the moon. The device sought out the star Canopus and used it as a reference point to direct the spacecraft.

SBRC also scored 2 space successes with its radiometers aboard NASA satellites. One radiometer on the Nimbus meteorological satellite was measuring the heat balance of the earth's 200,000,000 square miles to learn how much of the sun's radiation the world absorbs and how much is reflected back into the atmosphere. The other radiometer, an infrared measuring instrument, measured the horizon gradient of the earth on the first Project Scanner.

Hughes International made financial news both in the U.S. and Europe by announcing an agreement under which EMI Electronics Ltd., of England, acquired 49 percent interest in Hughes International (UK) Ltd., of Glenrothes, Scotland, a subsidiary of Hughes Aircraft Company, and changing its name to Emihus Microcomponents Ltd. The move was made to increase capability in microelectronics.

Also, Bofors Elektronik AB, a joint venture of Bofors and Hughes, in Sweden, took delivery of a laser rangefinder developed at Hughes-Culver City for installation on a Swedish "S" tank for army trials and field evaluation.

Hughes and Teleprompter Corporation formed a jointly-owned subsidiary called Theta Communications Corporation to make and sell electronic communications systems, and Hughes acquired an interest in Teleprompter's New York City community antenna television (CATV) system.

Dr. Allen E. Puckett, an executive vice president, was appointed to the new position of assistant general manager under vice president and general manager Lawrence A. Hyland. Other major appointments made during the year were John L. Winkel, vice president of marketing; John D. Couturie, vice president and treasurer; Edwin H. Meier, vice president and manager of the Aerospace Group's Research and Development division; Gorden E. MacDonald, vice president and controller; and Dr. Albert D. Wheelon, vice president of engineering. Dr. Fred P. Adler and William F. Eicher, vice presidents, were named assistant Aerospace Group executives under John H. Richardson.

The company's gross income, which had exceeded $400,000,000 for the prior 9 years, in 1966 topped $500,000,000.

Total employment rose nearly 5,000 to more than 30,000 at the ten Hughes facilities in Culver City, Fullerton, Malibu, El Segundo, Canoga Park, Santa Barbara, Los Angeles, Oceanside and Newport Beach in California, and Tucson, Arizona. Part of the increase in employment was the result of a continuing campaign to recruit scientists and engineers with advanced degrees.

HUGHES TOOL COMPANY

AIRCRAFT DIVISION

Hughes Tool Company's Aircraft Division began delivering production models of its OH-6A Light Observation Helicopter to the U.S. Army in the fall of 1966 on a contract calling for 1,071 machines by the end of 1968.

Two commercial versions of the OH-6A were being produced as the Hughes 500 Executive Transport and the 500U Utility Model.

The OH-6A is the speedy and versatile helicopter that established 23 world records for rotary-wing aircraft. The records were authenticated in October by the Federation Aeronautique Internationale in Paris. Twenty-one were set by Army pilots, covering speed, distance, climbing and sustained altitude, during tests at Edwards Air Force Base, California. Top speed for a straight course was 172 miles per hour.

Two other impressive records were set April 7, 1966, when a Hughes test pilot, Robert Ferry, made history's longest nonstop helicopter flight, 2,213 miles, from Los Angeles, California, to Ormond Beach, Florida, in 15 hours and 8 minutes. Average speed for the flight was 146 miles per hour, although for a period, helped by tailwinds, he averaged 185 miles per hour.

The Army will use the OH-6A for reconnaissance, observation, target acquisition and command control. The craft can carry a 5-man firepower team, plus pilot. It is powered by the 250 horsepower Allison T-63 turbine engine.

Also in 1966, Hughes completed deliveries on an Army contract for 351 primary-trainer helicopters—

the 2-place TH-55A—and was producing additional numbers of the small machine on a follow-on contract, with the total figure to be determined.

The company's already-well-established commercial business in its Model 300 and 280U helicopters showed no signs of slackening, and because of increased military production at its Culver City headquarters, Hughes moved all assembly work on the 300, 280U and TH-55A machines to the San Diego area. It leased the Rose Canyon facility formerly used by the Convair Division of General Dynamics Corporation. Additionally, all production flight testing of both military and commercial machines was moved to leased facilities at Palomar Airport, near Carlsbad.

Other activities at Hughes embraced a production program for the Bureau of Naval Weapons on a high-performance aerial gun system (the 20 millimeter Mark 4 gun pod with Mark 11 gun); further work on the Hughes Hot Cycle rotor system, and advancing efforts on the firm's VTOL Rotor/Wing concept for a 500-mile-per-hour transport aircraft which incorporates the Hot Cycle propulsion system.

Another program of more than passing interest was the Hughes cooperative effort with the Los Angeles County Sheriff's Department, the City of Lakewood, California, and the President's Office of Law Enforcement Assistance, known as Project Sky Knight. This is a 12-month experiment—first of its kind—under which Hughes has made available at cost 3 of its Model 300 helicopters to Sheriff Peter J. Pitchess for day-and-night patrol of Lakewood. The airborne officer on his beat in this case is never more than 150 seconds away from the scene of a crime. Project Sky Knight immediately began paying dividends in crime-deterrence and criminal apprehension, and continues to do so. Its results are being closely watched by police officials around the world.

But the major interest at Hughes, apart from the prime consideration for the OH-6A program, is the yet-to-be-realized impact on the world's commercial helicopter market of the Models 500 and 500U.

Malcolm Harned, senior vice president of the company's aircraft division, predicted that the 2 versions of the unique ship will become the most widely-used commercial helicopters in the world. The craft will do this, Harned believes, because it offers the highest performance, lowest maintenance and most reliability of any light rotary-wing aircraft yet developed.

The outstanding reliability and durability of both the military and commercial machines, says Harned, stem first from the fundamentally simple design and second from the very extensive test program carried out by Hughes and the Army. Seven prototypes were put through gruelling test programs to identify any possible flaws. The production helicopter design has incorporated the results of this extensive background of testing.

The production OH-6A was undergoing even more exhaustive testing by the Army to have it completely ready for combat operations. Scheduled programs included desert-arctic-tropic tests, and accelerated logistics and armament tests. Military requirements call for structural ruggedness far beyond that of any commercial operation, and the Army operates the helicopter at gross weight exceeding by 300 pounds the FAA certificated gross weight at which the commercial user will be flying. The experience derived from all this will make the Hughes 500 the "most proven" light turbine helicopter available.

The OH-6A was also selected as the standard light observation helicopter by military forces of Argentina, Brazil and Colombia.

The Model 500 offers outstanding safety. Autorotational landings are remarkably easy to perform. The ship has a power-off glide ratio of 6 to 1 as compared to about 3 to 1 for most conventional helicopters.

Its ability to cope with weather problems is another important safety feature. The machine can fly through much more severe turbulence than most airplanes, particularly light airplanes. This is the result of high blade loading relative to a fixed-wing aircraft, and the "Flexrotor," a unique Hughes development, which allows the blades to flap without damage when exposed to the most severe gusts.

While Hughes was giving utmost priority to production of the OH-6A for the Army, it was tooling to provide over and above the military requirements several times the commercial production capacity that exists for any other helicopter. The sophisticated tooling and large plant capacity will make possible the delivery of more than 1,000 commercial helicopters per year.

None of the Model 500 or 500U were to be delivered commercially until initial delivery requirements of the Army OH-6A have been met, but first commercial deliveries were being scheduled for mid-1967.

INTERNATIONAL BUSINESS MACHINES CORPORATION

FEDERAL SYSTEMS DIVISION

During 1966, International Business Machines Corporation's Federal Systems Division moved for the first time into a new area of support in the nation's space program as full stage prime contractor for the Uprated Saturn I and Saturn V instrument unit and continued significant support in other areas of the nation's space and defense achievements.

In accomplishing the major goals of Project Gemini, IBM's 59-pound on-board computer was heavily relied upon by the astronauts to accomplish the first docking with an Agena target rocket (Gemini 8) and the first automatic, computer-controlled re-entry (Gemini 11). NASA officials called the automatic re-entry perfect. During the same mission, the computer helped astronauts Gordon and Cooper achieve the first rendezvous and docking ever attempted on a spacecraft's first orbit of the earth. New altitude records and powered flight with Agena thrust were also accomplished toward the end of the Gemini program. Beginning in March with Gemini 8, an Auxiliary Tape Memory (ATM) was used to increase the on-board computer's program storage capacity.

Three unmanned flights of Uprated Saturn I launch vehicles were controlled and monitored by a 3-foot-thick "wafer" called the instrument unit or IU. The IU ring is assembled and fabricated by the IBM Federal Systems Division at its Huntsville facility. The IU ring for the first manned mission had been assembled and fabricated by the IBM Federal Systems Division at its Huntsville facility. This IU ring had been assembled, checked out and delivered to Cape Kennedy well before year-end.

Throughout 1966, IBM personnel turned out and checked IU's for both Uprated Saturn I vehicles and the Saturn V moon rocket. The first unmanned Saturn V launch was scheduled for the first half of 1967, and its guiding IU was shipped in 1966 to the huge vertical assembly building at Cape Kennedy for mating to the live rocket. IBM's IU contract called for 27 rings for 15 uprated Saturn I's and 12 Saturn V's. The role of the IU's—each containing more than 60 components including an IBM-built computer and data adapter—is to guide the Saturn vehicles on a pre-determined path through the issuance of steering commands.

The Real Time Computer Complex at NASA's Manned Spacecraft Center in Houston, Texas, provided vital assistance to the Gemini and Apollo/Saturn space programs. Developed and managed by IBM, the RTCC is the world's most sophisticated real-time information processing systems. During missions the RTCC accepts data from tracking sites around the globe, processes it and sends results for display to mission operations control rooms in seconds.

Programs are tailored for each mission. An essential role of RTCC in 1966 was its calculation of Gemini rendezvous maneuvers. Replacement began during the year of the system's model 7094 computers with more powerful System/360's to meet the increased demands of the Apollo/Saturn flight programs. NASA and IBM also concluded an agreement for continued IBM management of the system through early 1970. Other real-time support by IBM to NASA flight programs was provided to the agency's Goddard Space Flight Center in Beltsville, Maryland.

IBM also contributed to NASA studies looking beyond current manned space programs to orbiting research laboratories which would remain in orbit for long periods of time to conduct extensive research. Last February IBM completed a 16-month study for NASA on an Orbiting Research Laboratory Experiment Program. The study focused on how space could be utilized to help solve some of man's most pressing problems on earth. It was foreseen that surveys conducted by spacecraft equipped with special sensing and phtoographic machinery could help in detecting diseased crops, locating tillable land and obscure water and mineral sources, and in improving weather forecasting.

The Federal Systems Division also won a contract in 1966 to develop a data management subsystem for the USAF Manned Orbiting Laboratory.

An all new aerospace computer series called "4PI," was launched late in 1966. The computer applies design principles of IBM System/360 commercial computers to military and space requirements. The "4PI" series is designed for use in satellites, tactical missiles, helicopters, avionics guidance and control, artillery fire control and aerospace applications requiring high-speed calculations of large amounts of data. One of this series of computers will be used in fulfilling the 1966 contract with the U.S. Air Force to develop an integrated avionics system for the F-111 aircraft, using a specially-designed airborne computer.

Other IBM computers were used in 1966 on the Titan III launch vehicle and on NASA's Orbiting Astronomical Observatory.

IBM continued work on tieing together an advanced national air traffic control system for the Federal Aviation Agency. A system was delivered to the Air Route Traffic Control Center near Jacksonville, Florida. Another was at the FAA's experimental center in Atlantic City, New Jersey. The system is aimed at the development of advanced techniques for air traffic control.

There was continued participation in a number of wide-ranging defense programs, among them: an Air Force program called AFWET, to test the effectiveness of weapons; development of an automated data processing system to solve logistics problems in supplying Marine Corps units in Viet Nam; development of a data handling system to control a high performance space surveillance and tracking radar, and combining automatic data processing communications systems to improve Army command/control functions in the field.

The division, in cooperation with IBM's Data Processing Division, helped establish computer-centered data handling systems for the boards of education of Puerto Rico and several major cities in the United States. These systems can store and process millions of facts quickly and produce the facts necessary for reports and student and teacher record-keeping on a near real-time basis.

The division's engineering laboratory in Gaithersburg announced a new communications device for forward error control in digital data transmission late in 1966. Called DACOR (DAta CORrection), the unique device uses polynomial coding to assure that the correct message can be reconstructed automatically at the receiving end, even if transmission errors have occurred. This breakthrough nullifies the need to retransmit messages that become garbled, thus conserving valuable wire or radio time. Applications are seen in satellite communications, military global communications and many other areas.

Federal Systems Division headquarters and the Federal Systems Center—1 of 4 operating centers of the division—moved to a centralized facility in Gaithersburg, Maryland, during the summer. The Electronics Systems Center, responsible for avionics systems and 4PI and Saturn computer manufacturing, is located in Owego, New York. The Space Systems Center is headquartered in Bethesda, Maryland.

Looking toward future developments, a Center for Exploratory Studies was established in January to perform long-range technical and economic studies on the use of ground-based, airborne and spaceborne information handling systems for meeting Federal Government requirements. The Center's major departments are Advanced Space Systems, Sensors and Displays, Computer Mathematics, Communications and Economic Analysis. CES is headquartered in Rockville, Maryland.

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

ITT U.S. DEFENSE/SPACE GROUP

ITT U. S. Defense/Space Group, a division of International Telephone and Telegraph Corporation, is headquartered in Nutley, New Jersey. Its technological centers encompass data and communication systems and components, aerospace navigation, radar and display systems, electromagnetic surveillance equipment and computer programming services.

In 1966, the work force of the U. S. Defense/Space Group totaled approximately 14,000, of whom 1,800 were engineers.

Segments comprising the ITT U. S. Defense/Space Group are ITT Federal Laboratories, Nutley, New Jersey; Federal Electric Corporation, Paramus, New Jersey; and ITT Aerospace, Tube and Scientific Apparatus Activities, headquartered in San Fernando, California.

ITT Federal Laboratories

ITT Federal Laboratories is engaged in avionics and communications research, design, development and manufacturing. The company is the major technological center of the U. S. Defense/Space Group.

During 1966 ITT Federal Laboratories scored particularly notable achievements in the areas of microelectronic avionic systems development and satellite communication terminals, both spaceborne and earthbound.

The emergence of ITTFL as a major designer and fabricator of avionic systems containing microelectronic circuitry was a significant achievement during 1966. Three technological areas within the division scored successes in microelectronics during the year: Avionics, Communications and the Microelectronics Department.

The Avionics group was awarded a contract by the Air Force for microelectronic Tacan airborne navigation sets for the F-111 aircraft. The short-range military Tacan set's digital circuitry permits a degree of accuracy heretofore unattainable. Development of microelectronic Loran C airborne long-range navigation equipment was completed during 1966. This equipment offers great advances in reliability and size reduction.

Deliveries of Omega navigation receivers the Avionics group is building under Navy contract accelerated during 1966. Both airborne and shipboard units were being fabricated for military evaluation as navigational aids for craft operating anywhere in the world's oceans.

The ITTFL Microelectronics Department in 1966 began "chemofacturing" microelectronic integrated circuit boards and modules for navigation and communication systems designed and developed by the Avionics and Communications groups.

The National Aeronautics and Space Administration in 1966 awarded the Microelectronics Department a contract to study highly advanced methods of packaging the tiny integrated circuits which collectively perform myriad work functions in a microelectronic digital system. The Microelectronics Department expected to be fabricating thousands of microelectronic circuit boards per month in 1967 for ITTFL systems.

The 7 years of experience ITTFL spent in satellite communication research and development and system fabrication were rewarded in 1966 with the granting of multi-million-dollar contracts for both spaceborne and ground-based satellite communication equipment. Under a major contract for satellite-borne equipment, ITTFL was to design and manufacture the communications, telemetry and command equipment for the Communications Satellite Corporation's network of global communications satellites scheduled to be operating in

1968. Each satellite is being designed to provide more than 1,200 high-quality 2-way voice communication channels, or multichannel voice and television service. Four ground terminals for satellite communication were fabricated in 1966. One was installed at Brewster Flat, Washington, to be operated by COMSAT in conjunction with the Intelsat II satellite launched in the fall of 1966.

A similar Comsat terminal, also equipped with an 85-foot-diameter antenna, was installed in Paumalu, Oahu, Hawaii. A third terminal with an 85-foot-diameter antenna will be installed by ITTFL near Madrid, Spain, for Compania Telefonica Nacional de Espana (CTNE), the national telephone company of Spain. This terminal will be a satellite communication gateway to Europe, operating in conjunction with the satellite-borne communication equipment ITTFL is building for Comsat's 1968 Intelsat III global commercial communication network. The fourth terminal is in effect 2 satellite communication terminals in redundant configuration, with 2 42-foot-diameter antennas.

Located on Grand Canary Island, the highly reliable terminal was being installed for CTNE which will lease it to NASA to provide communication services during the Project Apollo manned lunar exploration mission.

Federal Electric Corporation

In 1966, ITT's Federal Electric Corporation started its 11th year as prime contractor for the operation and maintenance of the Distant Early Warning System (DEWline), the Air Force's 3,600-mile network of radar and communications stations extending from Alaska to Greenland.

The DEWline consists of 6 main stations and 27 auxiliary stations situated roughly along the 69th parallel from Cape Lisbourne, Alaska, to Cape Dyer, Baffin Island, Northwest Territory, Canada, and continuing across Greenland to its east coast. Called a 20th-century electronic Paul Revere, the DEWline, manned by more than 1,000 Federal Electric technicians, operates 24 hours a day, right through the lopsided polar cycle of seasons.

Federal Electric Corporation held 3 major space contracts with the National Aeronautics and Space Administration.

As prime contractor at the Kennedy Space Center for instrumentation support services, ITT's service associate serves NASA in the areas of environmental measurements, repair and calibration of test instruments, prototype tracking, data transmission and data reduction, computer operations and programming services. For the Gemini flights in 1966, Federal Electric relayed "Zulu" time to 150 NASA sites at KSC and provided countdown to 80 locations.

Although primarily concerned with Project Apollo, Federal Electric's 1966 activities contributed significantly to the success of all Gemini flights conducted during the year. First, FEC calibrated most of the Gemini test equipment, thereby assuring the smooth functioning of hundreds of delicate instruments upon which the lives of the astronauts depended. Secondly, Federal Electric provided timing and countdown services for Gemini prelaunch activities. Thirdly, FEC handled data reduction of thousands of bits of information telemetered from Gemini, information reporting on the astronaut's physical condition, fuel, oxygen and other key measurements. Fourthly, FEC provided computer programming services for problems arising in the Gemini launch area.

At the Marshall Space Flight Center, Huntsville, Alabama, Federal Electric is prime contractor for reliability support services for the Saturn launch vehicle program. ITT's service associate reviews and evaluates the center's overall reliability programs of center contractors. It also develops reliability management techniques for the center and conducts advanced studies applied to portions of the Saturn launch vehicle program. At the Marshall Space Flight Center, FEC is also responsible for mission support of the vehicle systems checkout division in the Quality and Reliability Assurance Laboratory.

At the Air Force Western Test Range, Federal Electric is prime contractor for the operation, maintenance and management of the range's technical facilities. During 1966 more than 1,500 Federal Electric engineers and technicians performed operational, managerial and support services. They operated and maintained instrumentation facilities at Vandenberg Air Force Base and Pillar Point, California, as well as at Hawaii and Eniwetok in the Marshall Islands. FEC specialists also manned radar, optical and telemetry equipment aboard ten ocean-going range ships operating out of Hawaii and Port Hueneme, California.

Besides providing range safety and instrumentation data in the launch area, Federal Electric also handles inflight and trajectory information and provides impact scoring, recovery data and data reduction on all missile and space shots launched from the Western Test Range.

During 1966, ITT's service associate was also active at the Air Force Eastern Test Range. This involved installing a submarine cable system from Patrick Air Force Base, Florida, to Grand Turk Island in the Bahamas. The system will be used to support NASA and Air Force space and missile programs on the range and will also serve as part of the global network required for manned space exploration.

On October 5, 1966, at Martina Franca, Italy, Federal Electric Corporation turned over to the United States Air Force the European Mediterranean Tropospheric Scatter System, stretching from

Spain through Italy and Greece to Turkey.

As prime contractor for implementing this highly sophisticated communication system, Federal Electric Corporation performed such services as program management, engineering, preparation of equipment specifications, procurement and installation of equipment, routing of equipment from Hampton Roads, Virginia, to the Mediterranean, provisioning of operational and depot spare parts, installation, checkout and alignment of all electronic equipment, documentation of all operations and final testing for USAF acceptance.

ITT Aerospace, Tube and Scientific Apparatus Activities

ITT Aerospace, Tube and Scientific Apparatus Activities, consisting of ITT Electron Tube Division, ITTFL-Aerospace, ITTFL-Fort Wayne, ITT Industrial Laboratories and ITT Industrial Products Division, was organized to exploit more fully the leading technical proficiencies inherent to each company and to broaden business opportunities through diversification and innovation.

In-depth marketing increased in such growth areas as electro-optical devices, apparatus and systems; display apparatus, ordnance, power supplies and systems; aerospace systems, and electronic warfare.

To maintain a position of leadership in the introduction of proprietary products, added emphasis was placed on research and development efforts. The federation provides new avenues for exchanges of information and talents and the utilization of research and development hardware.

Engineers and scientists at ITT Industrial Laboratories developed nighttime cameras (the high resolution infrared radiometer) for the NIMBUS II satellite, launched during the spring of 1966. Also under development was another nighttime picture-taking device for the future launching of the NIMBUS B weather satellite.

Scientists and meteorologists around the world are learning remarkable new facts from information gathered by the ITTFL-developed infrared nighttime camera aboard NASA's NIMBUS I (1964) and II weather satellites, and presented as strip maps extending from pole to pole. Previous picture transmission from satellites had been limited to daytime patch photography of sunlit portions of the earth requiring considerable work to construct a photographic mosaic to study a significant earth area. On the basis of nighttime photos taken by the ITTIL-built camera without the interference of reflected sunlight, the U. S. Geological Survey repositioned Mount Siple, a 10,000-foot-high mountain in Antarctica, used by pilots as a navigational aid. Its location, based on earlier charting expeditions, was found to be 45 miles too far east. Future relief maps will show the corrected location.

The nation's weathermen during 1966 conferred their "Award for Outstanding Service to Meteorology by a Corporation" on ITT Industrial Laboratories in recognition of the usefulness of pictures taken by the nighttime camera aboard the NIMBUS I.

The NIMBUS B project will also include a daytime camera to be designed and developed by ITTIL. Another daytime space camera was being developed for NASA's Applications Technology Satellite (ATS).

KAISER AEROSPACE AND ELECTRONICS CORPORATION

The business of Kaiser Aerospace & Electronics Corporation continued during 1966 to consist primarily of the production of solid fuel rocket motor nozzles, machines aircraft structural components, aircraft precision gears and gear assemblies, the airborne Kaiser Flite-Path (registered) navigational aid and community antenna television (CATV) equipment.

The corporation had a backlog of orders totaling $40,278,000 as of December 31, 1966, compared with $29,100,000 at the end of 1965.

During 1966, more than 100,000 square feet of manufacturing space was added to existing facilities. At San Leandro, California, a 16,200-square-foot expansion increased the numerically controlled machining facilities to more than 56,000 square feet. The San Leandro Plant, winner of the USAF Zero Defects Achievement Award, is one of the nation's leading producers of nozzles for major military missile programs.

In Phoenix, Arizona, a 38,475-square-foot addition expanded the company's electronics manufacturing facilities.

At Palo Alto, California, a new 72,000-square-foot electronics plant was dedicated in December. The new plant continued the manufacturing of the Kaiser Flite-Path system and the associated Kaiser Radar Data Converter, both used by the Navy in the Grumman A-6A aircraft. In addition, prototype production was started on a new navigational aid system for use in both military and civilian light aircraft.

During the year, the corporation acquired the Embe Gear Plant at Glendale, California. Precision gears and hydraulic and electro-mechanical systems were being manufactured for the aircraft and aerospace industry at this plant.

Full ownership of Kaiser-Cox Corporation was assumed at year-end (previous ownership was 50 percent), and the marketing by Kaiser-Cox of CATV equipment produced by the corporation continued. Kaiser Aerospace & Electronics is a wholly-owned subsidiary of Kaiser Industries Corporation.

KAMAN AIRCRAFT CORPORATION

The year 1966 marked a significant turning point for Kaman. The company's growth and diversification program carried Kaman into new fields of activity and the corporation's backlog reached the highest point in its 21-year history.

The most significant development during the year was retrofit and testing of a twin-engined version of the SeaSprite Navy rescue helicopter, designated UH-2C. The work was climaxed when the Navy awarded Kaman a contract to start rebuilding the Navy's fleet of SeaSprites. Kaman was to replace the single GE T58 turbine with twin T58-8's. This adds mission completion margin through increase in the SeaSprite's capability for all-weather flight, engine reliability, hot day and altitude performance.

Sales and activities of the helicopter, airframe, component, and general aviation segments continued at record or near record levels. Kaman was established in recreation, educational equipment, nuclear research and applications, electronics, instrumentation, production automation, remote control systems, and other areas of scientific and technological interest.

Kaman-built helicopters in service continued their record of outstanding service in rescue roles for the U.S. Navy and Air Force, especially in Viet Nam.

Kaman HH-43F Huskie helicopters are the rescue workhorse in Viet Nam and they have been credited with more than 250 saves since entering service there in 1964. Navy UH-2A/B SeaSprites, flying from carriers in the South China Sea with their all-weather capability and long operating range, made pickups of more than 150 aircrewmen.

In 1966, the company won major airframe component production contracts from airframe manufacturers for tactical, strategic and commercial aircraft. These included contracts from Douglas on the DC-8 and DC-9, from Lockheed on the C-5A, and from Grumman for the A-6A and OV-1A.

AirKaman, Inc., a wholly owned subsidiary, is fixed-base operator and handles sales and service of Beechcraft and business jets at Bradley International Airport, Windsor Locks, Connecticut. AirKaman participated in the accelerated expansion of aviation in the area and the general growth of all facets of aviation which they serve.

Kaman Instruments in Austin, Texas, worked on programs with NASA for a cardiac output computer and a cardiac tachometer. The group was also designing and manufacturing components for communications and educational equipment.

Work of Kaman's Nuclear Division in Colorado Springs, Colorado, emphasized studies on weapons effectiveness, vulnerability studies and countermeasures for the Department of Defense. In the commercial field the Nuclear Division completed the installation of the first production application of scintillation analysis to food processing.

In seeking new avenues of opportunity for technological capability and business growth, Kaman diversified into the recreation field with the establishment of a new division known as Ovation Instruments. Ovation announced a line of acoustic guitars and plans for a line of electric guitars, amplifiers and other musical instruments and equipment.

KOLLSMAN INSTRUMENT CORPORATION

Products of the Kollsman Instrument Corporation received wide-spread customer acceptance during 1966. All divisions exhibited outstanding performance, with continuing growth in almost every area.

AVIONICS DIVISION

Increasing business and pleasure travel, and the pressing requirements of national defense accounted for a continuance of an upward trend. Instrument business has multiplied in keeping with the influx of military and commercial orders. Orders from Boeing and Douglas exceeded those placed in previous years, and the backlog for commercial airframe sales continued to grow. An important activity in 1966 was the acceptance and the success of the Air Data Computer (KS-200). The use of air data computers, in pairs, contemplated for all advanced commercial aircraft, represents a significant market. Kollsman's early entry into this new generation air data computer market should assure the company a very significant portion of the market in the years ahead.

Similarly, the company's support of military aircraft increased. Contracts have been awarded for additional C-141 vertical scale instruments. The company received a military air data computer contract, including altitude report capabilities, and contracts for servo pneumatic altimeters, also associated with the Beacon program. Within the next few years all commercial and military aircraft will have the altitude reporting capability and this market, therefore, was of growing significance to Kollsman.

SPACE DIVISION

During 1966 the Space Division was engaged in many development programs of modest size. However, their potential is appreciable, and undoubtedly these programs will grow as have their predecessors. These include a real image projection viewing system to be used as a research tool, now under development for the National Aeronautics and Space Administration. This system evaluates the performance requirements for indirect-type viewing systems and their application in lifting body-type re-entry vehicles. Also under development was an infrared receiver and an integrated sighting telescope for a mobile weapon missile system.

Extensive experience in the advanced optical technology field led to participation in the Nimbus meteorological satellite program. The company developed the unique wide field lens system for the dual purpose of establishing the exposure setting on a satellite camera system and for protecting the camera from excessive solar impingement. Kollsman also was engaged in designing and developing a high-performance steerable optics system for use in conjunction with a low light level TV camera system to photograph the earth from an orbiting satellite.

Successful acceptance of flyable systems associated with the Apollo program, the Goddard experiment package, and star trackers for the Orbiting Astronomical Observatory program reflected the success of a long- and well-planned effort to develop capabilities in this area. The Kollsman developed hand-held space sextants, produced for NASA and the USAF, were successfully flown on the Gemini missions.

The space sextant was used during the flight of the Gemini 12 to navigate to the Agena target satellite, and achieved a successful rendezvous approach. Similar space sextants will be used in the Apollo flights.

One of the most significant and ambitious programs undertaken by Kollsman was the development of a solid-state star tracker for full daylight tracking. This permitted the development of small, lightweight, high-accuracy star tracking systems for space applications.

SYSTEMS MANAGEMENT DIVISION

Among achievements in 1966 was the acceptance and delivery of additional USQ-28 mapping systems to the U.S. Air Force by the Systems Management Division. These systems, installed in Boeing's RC-135A aircraft, completed a successful first phase flight test program which produced extremely high quality aerial photographs.

Work on GEOCON IV mapping camera lenses developed by Kollsman progressed, and the company established capability for production of sophisticated aerial mapping and reconnaissance lenses.

CORPORATE TECHNOLOGY CENTER

The Corporate Technology Center was actively engaged during 1966 in areas of rapidly changing technologies and prepared the ground work for future programs.

The Corporate Technology Center is engaged in the exploration of new laser concepts involving meteorology, simulation, communications, and oceanography. The successful optical laser system for underwater use led to several Navy contracts on underwater TV systems and on a study to develop air-to-underwater communications systems. Kollsman's patented laser weapon fire simulator to aid in the training of tank gunners was being produced in quantity. The company also developed a laser optical alignment system which has an extremely accurate long-range all-weather laser theodolite with an unprecedented capability in precision meteorology. New developments of a solid-state air data computer and solid-state pressure transducer will permit Kollsman to provide high-performance reliable equipment that will be required in new generations of military and commercial aircraft, including the supersonic transport.

The Delphic II data display system provided the Columbia Broadcasting System with a unique presentation for telecasts of the entire Gemini series, and plans were under way for even wider use in the Apollo telecasts. In diversification beyond the electro-mechanical display, Kollsman developed a solid-state display device. Several government contracts, received in 1966, accelerated the development of this new electro-optical display technique that may revolutionize many military and commercial graphic presentations.

CORPORATE ORDNANCE

An example of Kollsman research and development effort was the establishment of a capability to develop sophisticated fuzing systems incorporating optics, gyros and computer techniques which led to significant program activity in ordnance fuzes and safety and arming devices. This capability grew significantly and led to the establishment of a Corporate Ordnance Operations Group. This group was successful in winning production contracts for a variety of ordnance devices. During December 1966, Corporate Ordnance received contracts in excess of $4,000,000 from the Navy and Army for production of large quantities of fuzes and booster assemblies. They are being manufactured at the Tuner Division facility in Melrose Park, Illinois, and at another plant in Bridgeport, Connecticut.

LEAR JET INDUSTRIES, INC.

A new name, further diversification of activities, and continuing growth keynoted the year 1966 for Lear Jet.

By year-end the company had grown to three operating divisions—Aircraft, in Wichita, Kansas; Avionics, in Grand Rapids, Michigan; and Stereo, in Detroit, Michigan—and 2 subsidiaries—Brantly Helicopter Corporation, in Wichita; and Lear Jet International, S.A., in Geneva, Switzerland.

Corporate headquarters were established at Century City, in Los Angeles, California, late in the year, a move which enables each division and subsidiary to retain autonomy of operations, responsible to a corporate staff at a separate location.

Concurrently, shareholders in September approved a corporate name change from Lear Jet Corporation to Lear Jet Industries, Inc., which more accurately describes current and planned diversified programs of the company.

For its fiscal year 1966, Lear Jet reported an annual sales volume of $54,349,000 compared with $8,525,365 a year earlier. Net profit (after taxes) in fiscal 1966 stood at $4,243,380, contrasted with a loss in fiscal 1965.

AIRCRAFT DIVISION

The company retained its lead, established the previous year, in deliveries of turbojet business aircraft to corporate owners.

In March 1966, the Lear Jet Model 24 received Federal Aviation Agency certification under Part 25 of air transport category regulations (formerly CAR 4b).

The Model 24 is a growth version of its predecessor—the Lear Jet Model 23, of which more than 100 were produced and delivered. It includes all basic features of the Model 23, and incorporates a number of new standard items.

Gross weight was increased 500 pounds to 13,000 pounds, and pressurization differential boosted to 8.78 pounds per square inch, providing a 7,000 feet cabin equivalent at the Model 24's normal cruising altitude of 41,000 feet. Standard equipment includes high-energy, anti-skid brakes, FAR-25 approved windshield, and a number of additional items required for certification.

Between May 23 and May 26 a standard, production Lear Jet Model 24 circled the globe in 50 hours and 20 minutes flying time, dramatically demonstrating the great speed, flexibility, utility, and dependability of today's modern new business jet.

The aircraft, N427LJ, carried no extra fuel and was equipped only with standard communications/navigations aids. Throughout the entire trip the Lear Jet was flown fully within its prescribed operational and weight limits.

Officially sanctioned by the National Aeronautic Association and Federation Aeronautique Internationale, world governing authority on record flights the 23,000-mile trip broke or set a total of 18 international records, including the important around-the-world mark. Total elapsed time, including 17 fuel stops, was 65 hours and 40 minutes.

By year-end, operators of Lear Jet Model 23/24 aircraft had flown approximately 100,000 total hours. Based on an average speed of 500 miles-per-hour, the 140 Lear Jets thus far delivered had covered some 50,000,000 air miles.

Symbolic of this high utilization was an award presented by the National Business Aircraft Association to Executive Jet Aviation, which operates 17 Lear Jets, for achieving more than 4,400,000 accident-free miles in a 12-month period. This by far was the highest total of safe-flying miles of any corporate owner in the world during the period.

The prolonged strike affecting 4 major airlines in the summer of 1966 emphasized many advantages of business jet operation. During the 43-day strike period, Lear Jets flew some 10,000 hours, averaging 6-hour days, 7 days a week. Despite these unusually-heavy demands on aircraft and pilots, not one incident was reported.

A new Lear Jet took to the air on its maiden flight in August 1966—the Lear Jet Model 25 Transporter. Seating 10 persons, the Model 25 is 4½ feet longer than its sister ship, the Model 24. Scheduled for certification in the spring of 1967, the Model 25 will have a gross takeoff weight of 15,000 pounds, and feature the same basic flight characteristics as the Model 24.

Largest Lear Jet now under development, the Lear Liner Model 40 airline-corporate aircraft, offers seating for 40 passengers in its airline configuration, and up to 16 in a variety of seating arrangements for the business aircraft market. A full-size cabin/cockpit mockup was completed in September, and hardware for the 95-foot long flying prototype was begun later in the year.

AVIONICS DIVISION

Launched in January 1966, the Lear Jet Avionics Division by year-end had grown to more than 150 employees producing some 15 different aircraft electronics products and systems.

All-new facilities totaling 50,000 square feet were begun in 1966, with planned completion by the spring of 1967.

In addition to producing electronics for the Lear Jet line of aircraft, the Avionics Division markets equipment to the general aviation industry, and late in the year was awarded initial contracts from the Navy for development of a new type airborne vertical gyro system, and from SFENA in France for manufacture in the U.S. of a 2-inch gyro horizon attitude indicator for military applications.

BRANTLY HELICOPTER CORPORATION

In May, Lear Jet entered the expanding VTOL field with acquisition of the Brantly Helicopter Corporation of Frederick, Oklahoma. Producing the popular 2-place Brantly Model B2B unit, and the new five-place Model 305, Brantly is recognized as a leader in the rotary-wing industry.

In November, all Brantly operations were relocated in Wichita to effect increased direct and indirect manufacturing efficiencies. Work continued on future products, including single-and-twin-turbine-powered helicopter models.

LEAR JET INTERNATIONAL, S. A.

To more effectively market the full spectrum of Lear Jet products throughout Europe, the Scandinavian countries, North Africa, and the Middle East, the company in 1966 established Lear Jet International, S.A., with headquarters in Geneva, Switzerland.

LEAR SIEGLER, INC.

In a major step to prepare the company for continued growth, LSI announced a new group vice president concept during the year. As a result of this realignment, 6 domestic product area groups have been established: Avionics, Climate Control, Commercial Electronics, Electronic Systems, Power Equipment and Services group. Following the merger of American Metal Products Company into LSI, approved by the shareholders of both companies on October 25, 1966, and completed in mid-November, a seventh LSI group, called the Industrial Products Group, was formed by 5 of the company's 6 major divisions and subsidiaries. The sixth operating unit of A.M.P. was, by the nature of its product line, assigned to the Power Equipment Group.

With the completion of the merger, the combined sales of LSI and A.M.P., based on pro forma results for the companies' year-end reports, totaled $343,834,000. The combination of the 2 companies not only provides a wider diversification of product lines, it gains a broader and more stable base in a new commercial market. And, as a result, LSI's product mix will shift to approximately 66 percent industrial/commercial/consumer and 34 percent government, from respectively, 52 and 48 percent.

Earlier in the year LSI also extended its capabilities in the aerospace industry with the acquisition of the C. G. Hokanson Company, Inc., of Santa Ana, California, and the Cimron Corporation of San Diego. Hokanson, a leading manufacturer of aircraft and missile systems ground support air conditioning equipment, increases LSI's capabilities particularly in the ground support instrumentation and control systems area. Cimron provides LSI with an entry into important instrumentation market areas with high-quality digital instruments and systems for commercial aerospace application.

LSI AVIONICS GROUP

Astronics Division

Based on its experience and capability in the development and production of All-Weather Landing Systems, (AWLS), the Air Force awarded the division a contract to install an advanced AWLS in a C-123 cargo aircraft. This program, in flight test status during 1966, is designed to evaluate equipment requirements for aircraft making precision cargo drops under limited weather conditions. In a civilian AWLS related endeavor, the division was selected by the Federal Aviation Agency to conduct a 3-phase design, fabrication and flight test program to equip a Convair 880 jet transport with dual redundant autopilot and AWLS. This project will assist the agency in determining basic requirements of future all-weather landing systems.

Additional production orders for the LSI/AWLS were also received during the year, bringing the total number of systems sold to some 120. Fourteen European airlines operating SUD Caravelle jetliners had installed the system by year-end.

Development of instrumentation and automatic flight control equipment to meet requirements for VTOL aircraft IFR operations was in progress at the division. Under a contract awarded by the Flight Dynamics Laboratory of the USAF Systems Command's Research Technology Division, the Astronics Division was to design, fabricate and install the integrated system in a government-furnished CH-3 helicopter. The division will also support the lab in the analysis of all operational problems of VTOL flight under IFR conditions.

During the year, add-on contracts received included orders for automatic flight control systems for the BQM-34A Firebee, jet powered target drone; QH-50 drone helicopter, an antisubmarine warfare craft; and the Navy's new light attack aircraft, the A-7, Corsair II.

Instrument Division

The largest of LSI's aerospace divisions, the Instrument Division, introduced a new family of attitude reference systems designed PAR, an acronym of Precision Attitude Reference. These systems are based on a building block concept that begins with the basic gyroscopic platform, which is in itself a complete self-contained reference, heading, navigation and bombing system. Acceptance of the PAR system concept was evidenced by a contract to provide attitude and heading reference systems for the giant C-5A fan-jet transport.

Included in the new systems put into production during the year were a newly developed flight director system and airborne navigation computer system. Two flight director systems, composed of an improved LSI attitude-director indicator and a flight director computer, are installed on the C-141 for use with the craft's all-weather landing system. The airborne navigation computer system, designated AN/AYA-4, is a digital system purchased by the Coast Guard for air search and rescue work. Utilizing doppler/gyro heading; Loran A, C, or D; VORTAC; and a combination of true air speed, wind direction and velocity, the LSI system provides accurate, instantaneous navigational data.

In the area of spacecraft applications, the Instrument Division delivered its first production attitude indicator systems and rate integrating gyros for the Lunar Module; won its first production contract for electroluminescent, segmented numeric displays for use on the Apollo; and an eleventh-Power System Monitor-instrument was added to the list of instruments supplied by LSI for the Gemini program.

During the year LSI's Laser Systems Center made significant contributions to the rapidly changing field of laser systems development. Based on successful flights of LSI laser radar by University of Michigan scientists in clear air turbulence experiments last year, interest developed in a second-generation unit. This newer PPI (Plan & Position Indicating) laser radar will not only give a return from aerosol particles, but will provide 2-dimensional display of their distance and relative azimuth positions to the radar operator.

Other programs at the Laser Systems Center primarily related to aerospace applications included: a cloud-height or ceiling indicator, combining a laser transmitter and optical receiver as an optical radar system; research on a high-power, CW gas-type laser; and development of the LS-221 Optical Source for use in stop-action photography in connection with hyperballistic wind-tunnel studies.

ELECTRONICS SYSTEMS GROUP

Data and Controls Division

To provide more effective facilities for the division's increased scope of operations, the Data and Controls Division moved into new 85,000 square-foot, air conditioned quarters in Melville, Long Island, New York, in mid-March. The new building, affording considerably more office and production space, enables the division to combine its former Long Island City and Bronx operations under one roof.

Typical of the aerospace-related work in progress at the Data and Controls Division were 3 important programs. First, in the field of power conditioning equipment, the division was awarded a contract to provide special power supply subsystems for the Defense Department's Automatic Digital Network (AUTODIN) communications system. Secondly, on the basis of its accomplishments in radar, the division was conducting a feasibility study of a new digital technique for simultaneous, precision radar range and velocity estimation for future radar systems. And, thirdly, work in military data processing was typified by production of 5 ARCADE (Automatic Radar Control and Data Equipment) systems which utilize LSI 8800 data processors as basic building blocks.

Research during the year at D & C contributed to the improvement of the division's highly specialized power conditioners. The technique called ISOCOR (Isolation of Correlated Noise) was developed to provide effective and economical techniques for the design of static power systems for intricate and wide ranging power requirements.

Electronic Instrumentation Division

In addition to continuing instrumentation and control systems programs, the Electronic Instrumentation Division reported notable achievements in aerospace-related activities during the year. Among these achievements was selection by the USAF to provide a universal telemetry decommutation station at Vandenberg Air Force Base for the Western Test Range. The decommutation station will be a stored program unit capable of handling at very high rates, PCM (Pulse Code Modulation), PAM (Pulse Amplitude Modulation) and PDM (Pulse Digital Modulation) telemetry data. Receiving all normal telemetry codes and formats, the station will decommutate the data, perform the programmed engineering function and provide an output in a format compatible with most large data processing systems.

Long a leader in the field of aerospace and ground surveillance television systems, the division completed development of a new TV camera which successfully passed qualification testing for the Saturn space launch vehicle. A major development program in another important field was also completed during the year with the introduction of an advanced line of signal conditioning equipment, designed primarily for missile test programs.

C. G. Hokanson Division

The acquisition of the C. G. Hokanson Company, Inc., manufacturer of ground support air conditioning equipment for commercial and military aircraft, missiles and spacecraft, accomplished a further expansion of LSI's aerospace market. The new LSI division was the first to design and construct a mobile, high-pressure air-conditioner for military aircraft.

A Hokanson mobile air conditioner played a vital role in the history making success of the Surveyor moon landing by keeping the temperature of the spacecraft's electronic equipment at optimum levels during the long hours of checkout prior to lift off.

In the commercial aviation field, Hokanson mobile air conditioners were being used by 35 of the world's leading airlines to maintain cabin comfort for passengers during airport stopovers. Anticipating the requirements of future aircraft, the division introduced the H-65, which in addition to having enough capacity to cool and heat the extended jets, offers accelerated pull-down for such transports as the Douglas DC-8, Boeing 707, Convair 880 and Super VC-10. This new ground support unit combines 65 tons of refrigeration with heating to 120-150 degrees Fahrenheit with surrounding air temperatures as low as minus 20 degrees.

Cimron Division

Cimron Corporation introduced a new series of digital voltmeters which were setting quality standards in the laboratory and instrumentation fields. In addition, printed circuit board processing equipment developed by the Cimron-directed Norfax subsidiary of LSI advanced the state-of-the-art in circuit board manufacture. This development, called Hydro-Squeegee, is a machine employing hydraulic action to level the solder coating and remove excess solder from printed circuit boards.

POWER EQUIPMENT GROUP

Aerospace Division

The Aerospace Division of LSI's Power Equipment Group was providing the government market with a broad range of power and power control products, including generator systems and components, motors, actuators and servos. In addition to continuing production of these products for such applications as the Boeing 727; the DASH drone helicopter; DC-8; and UH-1 helicopters of the Army and USAF, the division made significant technical breakthroughs during the year.

Developed for application aboard Saturn V was an engine gimbaling servo actuator capable of working over an extreme temperature range of minus 250 degrees to plus 200 degrees Fahrenheit. The entire position system operates in a closed loop with linearity of 0.5 percent or better over the full temperature range. Integrated microelectronic circuits and the highly controllable LSI magnetic particle clutch are incorporated in the unit. Also developed during the year was a new and unique high-speed hysteresis AC motor, capable of operation at up to 150,000 revolutions per minute with torque independent of speed. With both direct and indirect applications to the aerospace industry, this motor, measuring approximately 4 by 5 inches, weighs only 10 pounds.

Romec Division

One of the leading manufacturers of hydraulic and pneumatic systems and components for aircraft, missiles and spacecraft, the Romec Division of LSI recorded impressive achievements over the past year. Highly successful research and development work at the division resulted in the development of low-cost vane pump standards, utilizing ductile iron in rotors and liners, Vega mold blades and powdered metal bearings. A major effort was in progress to demonstrate the feasibility for incorporation of these materials in jet engine lube/scavenge pumps.

Design and development of a booster pump assembly composed of a tank mounted receiver plus 2 plug-in type motor driven pump elements was also among the many research and development programs of the past year. Each element of this new pump assembly can be removed and replaced without draining the fuel tank, dismantling the system plumbing or disconnecting any portion of the electrical system wiring.

In addition to continuing production, ranging from fuel pumps for the UH-1D helicopter, lube and scavenge pumps for the J-85 engine, pressurization sets for the HAWK missile, to test point coupling for the Saturn S-IVC, the division received contracts related to important future programs, including AAFSS (Advanced Aerial Fire Support System) and the supersonic transport.

SERVICES GROUP

LSI Service Corporation

To more closely establish its relationship to the parent company, the former Lear Siegler Service Inc., a wholly-owned subsidiary, changed its name to the LSI Service Corporation early in the year. The subsidiary, which forms the LSI Services Group composed of the Harrisburg, Oklahoma City and Los Angeles divisions and Information Systems Company, continued its rapid growth as one of the nation's leading services organizations.

For the sixth consecutive year, the LSI subsidiary received a contract from the Air Force for aircraft and aerospace system maintenance at bases throughout the world. Similar aircraft services on a world-wide basis were being conducted under a contract from the Army. In addition to providing substantial cost savings, the efficiency of this service system results in numerous other advantages to both armed services. The savings are accomplished by taking skilled men to the operational site, rather than the expensive process of moving the work to the men.

Contract maintenance requirements also showed substantial increase as a result of the phasing-out of some government depot-level operations. To meet these growing demands, the subsidiary's general and clean room facilities were increased to accommodate instrument overhaul work for the 3 Defense Department services and general aviation.

LING-TEMCO-VOUGHT, INC.

With the acquisition of the Okonite Company in January from Kennecott Copper Corporation, Ling-Temco-Vought, Inc., expanded the number of independent subsidiaries in its corporate structure from 3 to 4, 3 of which gained listing on the American Stock Exchange after the acquisition.

The stock of Okonite, an acknowledged leader in the production and marketing of high-voltage power and communications cable, began trading on the exchange July 25 as did LTV Aerospace Corporation's May 2 and LTV Electrosystems, Inc.'s June 13. LTV Ling Altec, Inc., stock is sold over the counter and the parent corporation's on the New York Stock Exchange.

At the end of 1966, LTV had a total of 24,000 employees at the 4 subsidiaries and its research divisions, data processing and computer center, and corporate headquarters. The company's activities extended from space to 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 concert and high voltage cable.

LTV Aerospace, the largest of the Dallas-based aerospace/electronics company's subsidiaries, was prominent in the news during 1966. Its Vought Aeronautics Division made first deliveries of the A-7 light attack bomber to the Navy in October, and the division's XC-142A tri-service V/STOL transport, the world's largest, set 2 world records for that type aircraft: the longest nonstop flight ever, 3 hours and 43 minutes, and an endurance record, 1,080 miles, on the same flight October 7. Aeronautics won contracts to produce the complete tail section of the Boeing 747 jet airliner and modernize and remanufacture the Crusader fighter aircraft being used in Viet Nam. It also was named body structure subcontractor on the U.S. supersonic transport Boeing was competing to build.

In the space field, the 4-stage Scout, developed by the Astronautics Division of LTV Aerospace for a variety of NASA and military service tasks, ran its record to 21 consecutive launching successes through October of 1966. The booster was scheduled for the second San Marco Project launch by Italy early in 1967 and was used in British and French experiments.

The Astronautics Division's Astronaut Maneuvering Unit, a self-propelled, stabilized back pack unit designed to permit an astronaut in a pressure suit to operate like a 1-man space vehicle for assembling and servicing spacecraft in orbit, transferring from vehicle to vehicle and other useful tasks, originally was scheduled for use in Gemini 9 in June, but the extravehicular portion of the flight was cancelled when Astronaut Eugene Cernan's helmet visor fogged up and impaired his vision. One of a family of extravehicular space vehicles under study by the division, the fully qualified and man-rated AMU, was being considered for use in the Apollo program.

Huge fuel and oxidizer containers for the massive Saturn rocket continued to be fabricated by Astronautics. Nine of these containers, each more than 62 feet long, provide 850,000 pounds of fuel for Saturn's first stage engines.

Another LTV Aerospace division, Range Systems, provided engineering, management and technical services at widely dispersed sites from Vandenberg AFB in California to NASA's Kennedy Space Center in Florida. This included technical documentation, graphics, automatic data processing, printing and photography at KSC by approximately 1,000 employees and a computing facility at Michoud Assembly Facility, New Orleans, to support production, assembly and testing of Uprated Saturn I and Saturn V launch vehicles. The Division also was modifying two Navy VC-2 range instrumentation ships to perform re-entry tracking, control and communications as command centers to assist returning Apollo command spacecraft from the moon. The $22,000,000 contract called for designing, installing, testing and checkout of the electronic equipment and the ships' sea trials.

Kentron Hawaii, Ltd., an LTV Aerospace subsidiary, earned a $11,500,000 contract in June from the Navy to maintain and operate the Pacific Missile Range stations: PMR Communications Center, Marine Corps Air Station, Kaneohe, Oahu; the PMR facilities at Barking Sands, Kauai; and the instrumentation complexes on the islands of Johnson, Midway and Wake, plus the USNS Wheeling system. Kentron also carried on during 1966, under other contracts, the operation and maintenance of the Gemini Tracking Station at Kokee Park, Kauai, for NASA; the Nike-X work on Kwajalein, and the Range Development function at Huntsville, Alabama, for the Army Materiel Command.

The Michigan Division of LTV Aerospace, prime contractor for the Army's Lance battlefield missile, received a $10,700,000 add-on contract for the missile system's industrial services program and continued development of the XM-561, a 6-wheeled, articulated vehicle based on the company's Gama Goat and capable of traversing rough terrain previously impossible for wheeled vehicles.

The Greenville Division of LTV Electrosystems, unable to announce specific contracts in many instances due to security restriction, received contracts totaling $21,300,000 from April 1 to June 24, including both classified electronics systems and aircraft modification. The division also was awarded $6,200,000 in follow-on business from the AF for the Airborne Battlefield Command and Control Center (ABCCC), a complete war room designed to enable battle commanders of joint forces to direct all land, sea, and air forces in a combat area while airborne in a C-130 transport or on the ground in a strategic area.

Night fighting in Viet Nam gained new effectiveness in 1966 as the Air Force began testing in a combat situation an airborne light source developed by the Greenville Division. The system consists of a battery of Xenon long arc lamps mounted in an Air Force C-123 transport aircraft; it provides a circle of light 2 miles in diameter which is 4 times brighter than full moonlight with the aircraft at 12,000 feet attitude. The light is 5 times brighter from 5,000 feet, although the circle is still 1 mile across.

Among new 1966 contracts of LTV Electrosystems' Garland Division were $5,300,000 to provide automatic controls equipment for the Boeing 737 commercial jet aircraft on July 6 and a $1,930,000 follow-on for servo-actuators to be used in the guidance and flight control systems for the Air Force's Minuteman II ICBM. This division's 1966 work 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.

Continental Electronics, a subsidiary of LTV Electrosystems, maintained the company's lead in the fields of super-power radar and radio transmission systems. Continental received contracts of $15,000,000 for construction of a VLF radio station in Norway, $2,358,500 from the U.S. Information Agency for 10 250,000-watt high frequency transmitters, and $1,653,479 for 22 100 kilowatt PEP low frequency communications transmitters. It previously produced the Ballistic Missile Early Warning System transmitters which keep constant vigil against enemy attack; the world's most powerful radio installation at Cutler, Maine, which communicates at great distances with submarines under the sea; the Voice of America's systems penetrating Eastern Europe and Asia; and the 30,000,000-watt pencil beam radar system operating at White Sands.

LTV Ling Altec, Inc., acquired Du Mont Laboratories mobile 2-way radio communications business from Fairchild Camera and Instrument Corporation and made it a division of Gonset, Inc., a subsidiary in Clifton, New Jersey. LTV moved both Gonset and the Du Mont operations to Ling Altec headquarters in Anaheim, California. Ling Electronics manufactured powerful vibration and testing equipment for the nation's aerospace programs and Altec Lansing produced top quality high fidelity electronics, recording and studio broadcast equipment, theater and concert hall sound system and specialized public address systems. The LTV University Sound Division of Ling Altec again ranked as one of the major producers of public address speakers, high fidelity speaker systems and microphones.

Okonite, the newest subsidiary, is a multi-product company whose major customers in 1966 were some 2,000 heavy-user purchasers such as electric utilities, independent telephone companies, railroads, heavy industry and industrial construction contractors, and mines.

LTV's exporting efforts prior to and during 1966 were recognized by the Department of Commerce which presented the company with President Lyndon B. Johnson's "E" Award for growth in export sales. LTV increased its exports from $1,000,000 in 1961 to nearly $40,000,000 in 1964.

LTV won President Johnson's "E" Award for export growth, from approximately $1,000,000 in 1961 to $40,000,000 in 1964. Accepting for LTV was board chairman James J. Ling (right); award was presented by Judge Roy L. Morgan (second from right), director of field services for the Department of Commerce. Others are Harry C. Meyers, Commerce's Dallas Field Office director (left), and Earle Cabell, Dallas Congressman.

In the area of research, the Hawaiian Division of the LTV Research Center was expanded some threefold during the past year with increased participation in underwater acoustics, operations research, systems analysis, oceanography and geodesy. The Dallas Division did research in fluid mechanics, gas dynamics, meterology, solid state physics, quantum electronics, optics, information theory, refractory materials, coatings and alloys, electrochemistry, nuclear reactions, radiation detection and space environment, while the Western Division placed emphasis on transducer research, high intensity sound, acoustic standards and communications.

LOCKHEED AIRCRAFT CORPORATION

Lockheed Aircraft Corporation's activities during 1966 reflected diversity in space, in the air, on land, and in underwater environments with particular emphasis on the largest—the C-5—and the fastest—the supersonic transport.

In the year's first 9 months, sales of $1.59 billion were up $313,000,000 from the 1965 total of $1.28 billion. Net earnings for the first nine months were up 15 percent—from $35,800,000 in 1965 to $41,000,000 for the first three quarters of 1966.

Lockheed's greater business volume came from a higher delivery rate on the Air Force C-141 StarLifter, larger spares sales resulting from greater use of C-141 and C-130 Hercules military transports, several avionics modification jobs, and larger space business.

Sixty-four percent of Lockheed sales came from aircraft and related services, with 30 percent from missiles and space work, and 6 percent from other sources. Five percent of sales represent commercial business.

Work continued on schedule at Lockheed-Georgia Company, Marietta, Georgia, on the world's largest jet transport, the Air Force's C-5 logistics transport. Fabrication began in August and subcontracts totaling 60 percent of the aircraft by weight were being awarded in competitive bidding on structural assemblies, major systems, and subsystems to companies throughout the United States, in Canada and in England. Subcontracts for the first 9 months of 1966 totaled $345,000,000.

Lockheed-Georgia completed a mock-up of the 700,000-plus-pound USAF C-5A logistics transport.

The first C-5 was scheduled to roll out of the factory early in 1968, begin test flights in June 1968, and enter operational service with the Military Airlift Command in June 1969. Military Airlift Command had 58 C-5's on order, with options on 57 more.

Refinements during 1966 slightly increased the size of the C-5, to new measurements of 245.9 feet long with a wing span of 222.7 feet, tail height of 65.1 feet, and gross weight of more than 700,000 pounds. Lockheed won the C-5 contract in 1965. It was the first awarded under the Department of Defense's new package procurement concept.

Lockheed began a study of the new revenue generating potential of several commercial versions of the C-5 with U.S. and foreign airlines. These versions adapt to passenger (up to 844), to cargo (up to 330,000 pounds), or a wide variety of passenger/cargo combinations with either 2 or 3 decks.

Lockheed's proposal for a supersonic commercial passenger transport was submitted to the Federal Aviation Agency September 6. The product of 10 years of design effort, the Lockheed concept had a 273 foot fuselage, double delta fixed wing, and 46 foot tail. The design called for passenger capacity up to 300, speed of 1,800 miles an hour, cruise above 65,000 feet, and gross weight of approximately 550,000 pounds.

The C-130 Hercules was still the "bread-and-butter" airlifter in production at Lockheed-Georgia. Production of military and commercial versions continued at approximately 5 per month. More than 900 models of the Hercules had been built by year-end; they were in service in 13 nations, with the British Royal Air Force scheduled to be 14th in December 1966.

A highlight of the year for the Hercules was purchase of 3 aircraft by Delta Air Lines. Designated the L-100, the first Delta all-cargo aircraft went into service in September between Chicago and southern cities. Delta placed its second L-100 into service in October between New York and the South. Its third entered transcontinental freight service in November.

In May, the HC-130H search, rescue and recovery Hercules, developed jointly by Lockheed, the Air Force, and the Air Force's Aerospace Rescue and Recovery Service (ARRS), successfully completed the first personnel pickups in ground-to-air and sea-to-air demonstrations. This service is now worldwide. Another configuration of the HC-130, designated the HC-130P, was scheduled to begin service soon for aerial refueling of helicopters, thus extending helicopter range in combat areas such as Viet Nam as well as for long-range rescue operations.

The Coast Guard took delivery in September of an EC-130E Hercules for calibration and testing of electronic equipment and installations.

A larger, faster air cargo/personnel airlifter, the C-141 StarLifter, entered daily service between bases in the United States and Viet Nam. This 550-mile-an-hour jet transport has set new records for the Military Airlift Command, hauling tons of vital equipment and supplies and thousands of troops to Viet Nam from both the West and East Coasts. Converted quickly in Viet Nam to an aeromedical evacuation configuration, they brought the wounded home from Southeast Asia to California in less than a day's time. Approximately 150 StarLifters were flying throughout the world with the Military Airlift Command. Starlifter production in 1966 reached the rate of 9 per month.

A major step toward increasing Lockheed's business in the commercial airfreighter field was the establishment in 1966 of a full-scale commercial aircraft sales organization and the launching of a global marketing campaign for the company's family of commercial airfreighters: the Lockheed-100, Lockheed-200 and the Lockheed-500; the proposed commercial version of the C-5.

The company-owned Hercules completed European, African, Asian, and Latin American tours during 1966. Commercial Hercules began hauling heavy oil rigs and mining equipment in Alaska and Canada with Alaska Air Lines, and moving copper daily for export and bringing back petroleum and other vital supplies to landlocked Zambia in the service of Zambian Air Cargoes, Ltd. The successful operation of these first commercial Hercules in Zambia resulted in the purchase of 3 additional Hercules by the Republic of Zambia. Pacific Western Airlines of Canada also ordered a Hercules.

Lockheed's demonstration StarLifter commercial airfreighter in September completed a 29,000 mile flight around the world to show its capabilities to government agencies, shippers, and industries.

Production rate on Lockheed's JetStar executive transport continued at approximately one and a half a month. Deliveries and orders for JetStars passed the 100 mark. Work on the new Dash 8 version was on schedule, aiming toward certification in May 1967. The new JetStar will feature more powerful Pratt & Whitney Aircraft engines, an improved braking system, and a dispatch weight increase to 42,500 pounds.

Lockheed-California in 1966 began development on an $86,000,000 Army program to build and test 10 prototype helicopters of its Advanced Aerial Fire Support System. The primary role of the aircraft will be to escort troop-carrying helicopters in air mobile operation and provide suppressive fires in the landing zones. Lockheed picked 62 firms in 10 states and Canada as initial subcontractors in developing this high-speed compound helicopter.

In June the Federal Aviation Agency certificated Lockheed's Model 286 five-place rigid rotor helicopter, supporting the company's advanced aerial first support system efforts and opening the door to expansion of its rotary wing family.

The Air Force selected Lockheed as one of three companies to receive $300,000 study contracts for the FX advanced fighter with improved air-to-air and air-to-ground capabilities to be introduced in 1972. A vertical takeoff fighter for U.S. and German use was also studied.

Tactical Air Command F-104 Starfighters again saw service in Viet Nam to help meet increased activity by Communist MIG fighters. The Air Force began evaluating a Lockheed proposal for producing quantities of an advanced Starfighter. Two F-104's were modified to serve as flight test prototypes of the new F-104S interceptor version. Italian firms will build 165 of these under license. This new F-104S weapon system has a higher thrust engine than earlier F-104's and is equipped with the Sparrow air-to-air missile. Demonstrations continued in Germany of catapulted and rocket boosted launches of F-104G's.

New Zealand's Royal Air Force received its 5 P-3B Orion antisubmarine patrol planes, capable of missions up to 17 hours. The P-3B's, with more power in their engines than original Orions and equipped with Bullpup missiles, were also being delivered to the U.S. Navy. Lockheed's second export customer, Australia, forwarded to the U.S. Navy its letter of acceptance for purchase of 10 P-3B's. Lockheed began preproduction engineering work on the even more advanced P-3C Orion. And Lockheed was 1 of 3 companies that completed study designs for a new Navy carrier-based antisubmarine warfare plane.

Deliveries of SR-71 strategic reconnaissance planes to the Strategic Air Command continued. Lockheed carried on flight tests of its companion 2,000-mile-an-hour YF-12A interceptor and worked on improvements for its fire control and missile system.

Under the fourth in a series of contracts with the National Aeronautics and Space Administration, Lockheed-California studied the feasibility of a step-by-step approach to developing a reusable orbital passenger transport making maximum use of existing hardware. And under its third Air Force contract on the aerodynamic maneuvering re-entry vehicle, Lockheed developed a preliminary design for an unmanned research vehicle having extensive maneuvering capability.

In space work, Lockheed's versatile Agena set a series of milestones in 1966.

Agena performed its docking role with Gemini 8 in March with the world's first joining of two vehicles in space. After separation, the Agena remained in orbit for further docking and rendezvous exercises with Gemini 10. Another Agena launched July 18 was the second vehicle in these Gemini 10 maneuvers. An Agena spacecraft also joined the

Gemini II astronauts in space, boosting their Gemini spacecraft to a new orbital altitude record of 850 statute miles, and returning them to a lower orbit.

Other Agena uses included:

Providing the second stage booster for NASA's Orbiting Astronomical Observatory and placing the 3,900-pound payload in near perfect orbit.

Launching NASA's Orbiting Geophysical Laboratory into elliptical orbit.

Launching Pageos, beginning the geodetic satellite program to establish a global network of 69 spherical triangles obtained by observations from ground stations.

Helping orbit the Nimbus 2 weather satellite.

Providing the second stage booster for the Lunar Orbiter on its way to orbit the moon.

Lockheed Missiles & Space Company won 1 of 3 NASA contracts for study of an applications technology satellite program to flight test spacecraft for communications and meteorology and to perform other scientific experiments. And the company started a year-long NASA study to provide basic data for lunar explorations and equipment in the 1970's.

Lockheed was selected by NASA in May as 1 of 2 firms to conduct $1,200,000 studies of the integration of Apollo applications program experiments and equipment needed for a series of manned space missions. They would use technology and equipment developed for the Apollo lunar landing program.

Lockheed also signed contracts with the Junkers firm of Germany to participate in developing a satellite to be launched in 1968 by the European Space Research Organization, representing German, Belgian, French, and British companies.

In other areas, Lockheed entered the final round of competition for the Navy's fast deployment logistic (FDL) ship system. Two other competitors were awarded identical $5,300,000 contracts to develop final proposals which were to be evaluated for an award decision in June 1967. Lockheed Shipbuilding and Construction Company's FDL team included Gibbs & Cox, leading marine architectural firm, and Bechtel Corporation, a prominent industrial engineering and construction organization.

The Navy in April selected Lockheed Missiles & Space Company to design and construct the Navy's first submarine personnel rescue vehicle. Construction will mark the first phase of development of an operational submarine locating, escape, and rescue system. The vehicle will be able to operate for 12 hours at 3 knot speeds 3,000 feet below the ocean's surface. A specific operational requirement is a 24-hour response time to a submarine disaster anywhere in the world. The vehicle will be 44 feet long, 8 feet in diameter, and weigh approximately 50,000 pounds. This size and weight permit it to be carried, fully assembled, in a C-141 StarLifter transport. Information learned from construction of the prototype—expected to be completed by early 1968—will be used in building five additional rescue vehicles.

Lockheed's own research submarine Deep Quest, as a result of highly successful pressure hull tests, will be able to reach depths of 8,000 feet instead of the previously announced 6,000. Deep Quest was scheduled to go into the waters off San Diego early in 1967.

Lockheed received a Navy contract for a Polaris improvement program called Antelope that represented a significant increase in sales. England launched the first of 4 nuclear submarines designed to fire Polaris missiles.

Work on Poseidon, being developed as successor to the Polaris underwater launched ballistic missile, was steadily under way. In September initial development tests on Poseidon missile components were successfully completed.

Lockheed Propulsion Company completed a series of Air Force test firings of full scale, 3-pulse solid propellant rocket motors, subjected to alternate minus 75 degree cold and 200 degree heat and 2½ days of vibration. The tests simulated the environment for an air launched missile.

Other significant 1966 accomplishments included:

Delivery to the Navy of the first of 3 guided missile destroyer escorts, the USS Brooke.

Establishment of an organization to extend Lockheed's work in designing and developing limited warfare tactical missile systems. Candidates for this new Lockheed product line include an antitank weapon, antiradar and other air to surface missiles, and non-nuclear warhead systems that would permit existing strategic deterrent missiles to take up a tactical warfare role.

Delivery to the Navy of computer-controlled training systems which can simulate the actions of an entire antisubmarine warfare task force. The trainers are key elements in the Navy's modern tactical training facilities in Norfolk, Virginia, and San Diego, California.

Development of a world-wide communications system which uses the moon as a relay for ship-to-shore messages. The system is called Moon Bounce, and it beams teletyped messages from ships at sea to the moon from which they bounce back to short-based ground stations.

Initial development of an advanced, multi-function helicopter radar system which will give military and commercial helicopters an all-weather capability.

Development of a radar system for antiaircraft guns mounted on Army tracked vehicles.

Discovery of a long-life water repellent coating which won for 2 Lockheed-Georgia Research Laboratory scientists an award by Industrial Research

Magazine for one of the most significant new technical products in 1966.

Lockheed Missiles & Space received an $80,000 contract from the Texas Hospital Association to provide a computerized disaster casualty management system with the objective of improving, through organized planning, survival rates in crises. It received a $131,000 contract from the Atomic Energy Commission to study centralization of data processing at its Nevada Test Site.

Under a 1-year study program for the Mayo Clinic, Lockheed was attempting to find ways by which computers can relieve physicians of many routine tasks to speed up patient care. And under a new contract with the Los Angeles-Orange County Red Cross, Lockheed will computerize blood inventory reporting to minimize blood outdating and speed distribution of blood to hospitals.

Lockheed's board of directors in January elected William R. Wilson, director of Lockheed operations in Washington, vice president of Lockheed in charge of public relations. He succeeded John E. Canaday, who had headed Lockheed's over-all public relations programs since he joined the corporation 27 years ago as its first public relations manager. Willis M. Hawkins, after serving for nearly three years as assistant secretary of the Army for research and development, returned to Lockheed in July to resume the post of vice president—science and engineering. Gordon Lill, former director of Project Mohole and a Lockheed research advisor from 1960 to 1964, returned to Lockheed in July as a corporate senior advisor in development planning. William A. Stevenson, vice president of Lockheed Missiles & Space Company and assistant general manager of its Missile Systems Division, was elected a corporate vice president and appointed president of Lockheed Propulsion Company.

At the end of the third quarter, Lockheed had about 89,500 employees at nine operating companies, associated bases, and offices. Company facilities covered more than 23,800,000 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, 2 outlying U.S. territories, 3 British colonies, and 26 nations throughout the world.

THE MARQUARDT CORPORATION

During 1966, The Marquardt Corporation significantly enhanced its technological and marketing posture throughout its areas of activity—rocketry, advanced airbreathing propulsion, manufacturing, aerospace equipment, and research.

New milestones were achieved in space rocketry as the result of Marquardt's increasing participation in major space programs. From the company's Rocket Engine Systems Division, space rocket engines were qualified and were in full production for NASA's Apollo and Lunar Orbiter programs.

Marquardt's Model R-4D 100-pound thrust velocity control rocket engine was being produced under subcontract to The Boeing Company for the NASA Lunar Orbiter. On the Lunar Orbiter missions during 1966, this radiation-cooled bipropellant engine effectively performed its required functions, executing precision firings for critical mid-course corrections, orbital adjustments, and photo orbit injection maneuvers. The successful operation of the engine enabled the Orbiter spacecraft to achieve its required translunar trajectory and accomplish the lunar orbits for photographing the surface of the moon. These photographs, together with surface photographs returned to Earth from soft-landing Surveyor spacecraft were providing vital information required for the selection of safe landing sites for Apollo astronauts.

Marquardt 100 pound thrust rocket engines, used in Apollo and Lunar Orbiter spacecraft, are assembled and inspected under sterile clean room conditions.

Marquardt's Model R-4D engines were also used in actual space operations on NASA's first Apollo suborbital flights during 1966. These engines were developed and were being produced for the reaction control systems of the Apollo Service Module and the Lunar Module. A total of 32 R-4D engines, 16 engines per module, are used on each Apollo spacecraft. In contrast to the 4 or 5 "starts" required during Lunar Orbiter missions, the R-4D clusters on Apollo are required to start and re-start many thousands of times, for short, milli-second bursts or for longer duration firings. On the Apollo suborbital flights, the Marquardt engines were programmed to fire to execute ullage maneuvers, Command and Service module separation, and pitch, roll, and attitude maneuvers.

Research and development in advanced airbreathing propulsion programs continued during 1966, with preliminary flight test activity beginning on Scramjet and the Low Altitude Short Range Missile (LASRM) propulsion systems.

Marquardt's Scramjet engine (supersonic combustion ramjet) was being "cold" launched at Vandenberg AFB to check out aerodynamic stability and verify separation of booster and vehicle at required altitude and speed. Scramjet ground testing was continuing at the Marquardt Jet Laboratory in Van Nuys, California. The company was also conducting investigations of "non-hydrogen" fuels for Scramjet, as well as research and development of a number of promising new engine concepts, including composite ramjet-rocket combinations.

On LASRM, an integral ramjet-rocket concept being tested at Holloman AFB, the initial phase of flight testing with a prototype vehicle was completed, using an F-100 aircraft.

Marquardt's manufacturing division at Ogden, Utah, acquired a number of significant component and subassembly contracts during 1966 which have expanded the company's production activities. Among the new work was a major government contract for the production of nozzle and fin assemblies for the 2.75-inch air-to-ground rocket. Marquardt-Ogden was also producing engine stator blades for the Air Force C-5A program, fuse adapters for the Army's T-46 bomb, and other components and subassemblies for a number of major defense and space programs.

Additionally, at Ogden, the Air Force-Marquardt Jet Laboratory was undergoing a major expansion to accommodate advanced propulsion systems testing. The new test operation, known as Hypersonic Propulsion Applied Research Facility (HPARF), will be a national facility with a capability for propulsion systems tested beyond Mach 9.5 and 180,000 feet.

In the area of aerospace equipment, Marquardt augmented its aircraft accessory lines with the acquisition of the complete ram air turbine and ice detector product lines from the Allison Division of General Motors Corporation. More than 15 configurations of ram air turbines were added to Marquardt's lines. These units are used to provide emergency and auxiliary electrical and hydraulic power to various military and commercial aircraft. The Allison ice detection device is a pressure probe which is used to sense icing conditions in aircraft engines.

In advanced research, Marquardt was engaged in propulsion, rocketry, re-entry physics, fuels and materials, and facilities programs through its ASTRO Division operations at Van Nuys, and through its subsidiary, General Applied Science Laboratories, Inc., in New York. In addition to advanced hypersonic propulsion studies for Scramjet and other composite propulsion systems concepts, the company was conducting a study for the Air Force aimed at the development of large scale, low cost test facilities for advanced airbreathing engines. The objective is to develop a test facility for airbreathing engines in the Mach 6 to 12 regime.

The company's research operations were also engaged in preliminary research for the Air Force on a solid-state associative memory concept. The effort was based on a follow-on to the feasibility of using electro-optical elements for the implementation of an electronic memory device which can perform multiple arithmetical operations simultaneously by associative techniques. Marquardt was providing systems design studies, materials research and fabrication processes development.

At GASL, Marquardt's New York subsidiary, a new relay-operated sampling oscilloscope, which features fully automatic programming, was introduced. The subsidiary also expanded the capabilities of its Mark II Transient Measurement System with the addition of a variable time span and automatic gain control.

At year-end 1966, Marquardt employed approximately 2,500 personnel. The company was maintaining 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 Tarzana, California.

MARTIN COMPANY

BALTIMORE DIVISION

At Baltimore the year 1966 marked the close of Gemini, the most spectacularly successful space program in history, and the start of one of the most promising and exciting–maneuverable lifting re-entry vehicles.

The flights of Gemini-Titan 8 on March 16, GT-9 on June 3, GT-10 on July 18, GT-11 on September 12, and GT-12 on November 11 were 100 percent successful as were the five previous manned flights in 1965. The launch vehicle, built in Baltimore, not only performed flawlessly on every flight, but its reliability in checkout and countdown enabled the Gemini program to accomplish 10 manned flights with 20 astronauts in orbit in the remarkably short span of 21 months.

This success brought the company a share of the honors when the 1966 Robert Goddard Award and the 1966 Collier Trophy were presented to the Gemini team.

By year-end, the Gemini work force had shifted to the Baltimore Division's other major programs which included maneuverable lifting re-entry vehicles, aircraft, nuclear, and a variety of other aerospace manufacturing programs.

The first flight vehicle for the Air Force's PRIME (SV-5D) lifting body program was delivered to Vandenberg Air Force Base in November with flight across the Pacific Missile Range scheduled for approximately the turn of the year. This 7-by-4 foot dolphin-shaped spacecraft was the first of 4 such vehicles which during 1967 was scheduled to demonstrate their ability to maneuver at hypersonic speeds from orbit through re-entry to a precision recovery point.

The PRIME vehicles, developed for the Air Force Systems Command's Space Systems Division, are entirely covered with a Martin-developed ablative material and equipped with jet thrusters for maneuvering in space and convential flaps for atmospheric maneuvering. Launched atop Atlas rockets to an altitude of about 100 miles, the PRIME vehicles fly a re-entry course of nearly 5,000 miles at speeds ranging from 17,000 miles per hour to about 1,600 miles per hour (Mach 2) at 100,000 feet where a drogue chute is deployed. This slows the spacecraft's speed sufficiently to release the main chute and an aerial recovery is made at a precise location. This precision recovery after a maneuverable re-entry gives the system its name of PRIME, an acronym for Precision Recovery Including Maneuvering Entry.

The remainder of the flight profile from Mach 2 speed at 100,000 feet will be flown by PRIME's companion vehicle known as PILOT (SV-5P). This full-scale manned version of the SV-5 lifting body shape also was being built by Martin for the Air Force under contract to the Aeronautical Systems Command at Wright-Patterson Air Force Base. PILOT, an acronym for *PI*loted *LO*wspeed *T*est, is actually a supersonic airplane with a rocket in its tail and no wings. Dolphin-shaped like the smaller PRIME vehicle, PILOT measures 24 feet in length and is 10 feet across its tail fins. It will be dropped from the wing of a B-52 at an altitude of 45,000 feet, where it will rocket to an altitude of 100,000 feet and a speed of Mach 2. From that point, it will fly a maneuvering course to a precision landing at conventional airplane landing speeds.

In addition to the 1 rocket plane being built under Air Force contract, Martin was building 2 identical lifting body vehicles with jet engines (SV-5J) for use as flying trainers.

Other lifting body programs involved a study for NASA to determine the cost, crew size and complexity of a flight research program using NASA's HL-10 lifting body configuration. The study considers whether such a research vehicle should carry 1, 2, 4, 6 or 8 crew members and whether it should be launched on a Titan II, Titan III or Saturn rocket.

Under still another NASA contract, and as an outgrowth of Martin materials development, the company has developed a silicone ablative heat shield material which can be sprayed on a flight vehicle. Martin also contracted for flight test of the material on the X-15, portions of which were coated with the spray-on ablator.

Aircraft programs focused on research and design effort inthe area of close support and small cargo V/STOL aircraft, modification of existing aircraft, and extensive aircraft manufacturing under subcontract to other firms.

One contract having considerable significance to the division's lifting body work called for the modification of 2 F-106 fighters to Variable Stability Trainers (VST). Transformation of these aircraft includes installation of flight controls and an onboard computer which enable the plane to perform like a number of other aircraft, including the F-111, X-15, and lifting body craft like the SV-5 PILOT. The trainers, being modified for the Air Force Aerospace Research Pilot School at Edwards Air Force Base, will simulate in flight an entire stable of different aircraft while actually involving only 2 planes.

Aircraft manufacturing work included production of major assemblies of the UH-1 "Huey" helicopter for Bell Helicopter Company, the CH-47A Chinook for Boeing Vertol, and horizontal stabilizers for the Douglas DC-8 jet transports.

Nuclear activity in Baltimore saw introduction in 1966 of the first privately developed nuclear generator for commercial marketing. Called the LCG-25 (Low Cost Generator-25 watts), the 3,000-pound device, which resembles a farmyard pig, is guaranteed to produce 25 watts of electrical power for 5 years. Ideal for remote applications where power is scarce or manning difficult, the nuclear "pig" comes in land and undersea models at prices ranging up to $63,230. The Naval Electronics Laboratory purchased a generator to power oceanographic measuring equipment on lonely Fairway Rock in the Bering Strait, off Alaska.

The year also saw completion of construction of the world's first and only floating nuclear power station, the MH-1A reactor mounted in a jumboized liberty ship. At year's end, the MH-1A, berthed at Ft. Belvoir, Virginia, was undergoing final testing prior to turnover to the Army Corps of Engineers. Capable of producing 10,000,000 watts of electricity to disaster areas or in wartime situations, the MH-1A could provide electricity for a city of 20,000 people.

Work also began on SNAP-29, the newest and most powerful space nuclear generator yet designed. Under contract to the AEC, Martin will build the SNAP-29 system to provide 500 watts of electrical power for manned and unmanned space requirements of both NASA and DOD. The system is nearly 10 times more powerful than existing space generators. It is powered by polonium-210.

Delivery also was made of the first pair of SNAP-19 generators for ground testing on the Nimbus-B weather satellite which NASA planned to fly in 1967.

In terrestrial systems, Martin continued work in development of the Terrestrial Unattended Reactor Power System (TURPS) under contract to the Army and the Air Force. TURPS is a 100 kilowatt direct conversion system designed to power remote installations. It combines the technology Martin has pioneered in both radioisotopic thermoelectric systems like the SNAP generators and nuclear reactor systems.

Two Martin-built reactors set all time military records for continuous operation during 1966. The PM-1 plant powering an Air Force radar station atop a mountain at Sundance, Wyoming, set a record of 3,355.5 hours of continuous operation on August 8, 1966. Then, on October 7, the PM-3A reactor supplying power to the U.S. scientific base at McMurdo Sound in the Antarctic, topped that record by operating 3,390.4 hours without shutdown.

During 1966 Martin also unveiled a compact, fluidic navigation device which a foot soldier can wear on his belt. Designed to enable a man to determine his position regardless of such blind conditions as darkness, dense jungle and bad weather, the navigator, called a ManCAN (Man-Carried Auto Navigator), frees the operator from dependence on ground or astronomical observations and requires no computations.

In late 1966, NASA awarded Martin a contract to build an Apollo lunar surface drill. The drill will be used by the Apollo astronauts for removing core samples three meters below the lunar surface. Holes left by the drill will be filled with thermal sensors.

ORLANDO DIVISION

In 1966, Martin's Orlando Division continued to emphasize and invest in programs and facilities aimed at broadening its capabilities for development and production of tactical missile, electronics and communications systems.

Major contracts were won for work on the Army's Pershing ballistic missile system; the Army's Sprint antimissile missile; RADA (Random Access Discrete Address) telephone-type tactical radio communications system; the Bullpup air-to-surface missile, including work on aircraft, ground and supporting equipment; and the Walleye TV-guided glide bomb for Navy and Air Force tactical aircraft. Martin at Orlando also became CDP subcontractor on the SAM-D air defense missile system.

A 40 by 40 foot model, equivalent to 20 square miles of a wide variety of topographical features, provides targets for optical guidance systems at Martin Company's new Guidance Development Center, Orlando, Florida.

Substantial investment in research facilities continued at Orlando during 1966. A new $2,000,000 guidance systems development laboratory was completed early in the year. Expanded 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. The armament facility was virtually doubled in size and capability during 1966.

Areas of major research 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 1966 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 were activated by the end of 1966.

Improved ground support equipment for the Pershing system was in full development during 1966. Under the Pershing 1-A system, as the development program is known, several changes will be made to the ground support equipment used in counting down and launching the missile. The biggest outward change will be from tracked to wheeled vehicles for transporting the firing unit. Increased mobility and reliability, less vibration and lower maintenance costs are expected to result from the shift to wheels. Other major Pershing 1-A system improvements center in a new programmer-test station and a new erector-launcher.

Under another contract awarded in 1966, improved missile components were also being developed for the Pershing system.

A series of annual practice test firings from off-range sites in southeastern Utah into White Sands Missile Range, New Mexico, continued 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 stationed in Europe as well as those U.S. units headquartered here, since there are no suitable range facilities in Europe.

The Sprint missile, one of the major components of the Army's Nike-X missile defense system, continued in development at Martin's Orlando Division, subcontractor to the Bell Telephone Laboratories.

Sprint will be 1 of 2 interceptor missiles used in the Nike-X system. The other is the long-range Zeus. Both are designed to kill not only ICBM warheads, but also those of submarine launched intermediate range ballistics 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 ones. In addition, through use of Sprint and new radars, the Nike-X system will be able to engage numerous targets simultaneously.

In March 1966, Martin Company was selected by the Army as a second production source for Shillelagh antitank guided missiles. The $1,525,506 contract won by the company was for the establishment of Shillelagh production facilities and for a number of missiles to qualify the facilities for large-scale production. Shillelagh is a gun-launched guided missile system. It is planned as the main armament for the General Sheridan Armored Reconnaissance Airborne Assault Vehicle, some of the M-60 current Main Battle Tanks, and the U.S.-FRG Main Battle Tank for the 1970's.

The Shillelagh 152 millimeter gun launcher can fire either a missile or a conventional round of ammunition. The missile is guided to its target by a command system mounted on the vehicle and is capable of maneuvering in flight to hit a moving target. Used for front-line attack and infantry support, Shillelagh will give soldiers increased firepower against armor, troops, and field fortifications.

Martin continued development of an advanced battlefield communications system that combines the ease of dial telephone-type operation with the mobility of a vehicular radio. Called RADA, the system 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 second phase of the contract, under way at mid-year, entails the design, fabrication, and testing of preliminary "breadboard" circuits to establish the feasibility of combining first phase solutions into practical circuits.

All the capabilities of wired dial telephone systems, and more, are planned as integral to the system. RADA would provide for priority service among selected subscribers, conference calls, and area warning. Further, it would afford complete privacy of communication between sender and receiver. It is designed to be extremely portable and adaptable to all military vehicles. RADA would operate on either vehicular 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 allotted 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 on 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 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 air defense technology and packaging techniques become increasingly sophisticated, system modifications were engineered and introduced into both BIRDiE and Missile Master. This work continued through 1966.

BIRDiE processes and distributes target information about manned aircraft to guide 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 over-all air defense network. 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.

Martin Company in January, 1966, received a $12,000,000 production contract to produce the Navy-developed Walleye television-guided glide bomb for use on Navy and Air Force tactical aircraft. Another $11,200,000 contract was awarded in July for first year follow-on production. Work was being performed at Orlando.

Walleye is a highly-accurate, 1,100-pound weapon with no propulsion. It has a high explosive conventional warhead and provides the pilot with a "launch and leave" capability, since once the self-guidance system in the weapon locks on target, the pilot can launch it and take any necessary evasive action. A ram-air turbine provides the electric and hydraulic power necessary to operate the guidance control system. A television monitor in the cockpit permits the pilot to lock the weapon on target.

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 at Orlando: A, B, and Nuclear Bullpup. Martin's 1966 Bullpup effort was centered on development and production of ground handling equipment, aircraft-installed equipment, aerospace ground equipment, and trainers.

DENVER DIVISION

A broad variety of activities, ranging from a pair of historic space flights by Martin Company-built space boosters to facility expansion and increased spacecraft and space systems research, highlighted operations at Denver during 1966.

On June 16, the Titan III-C Standard Space Launch Vehicle with its dual solid-propellant booster motors generating 2,400,000 pounds of thrust, carried 8 satellites into a 21,000-mile, near-synchronous earth orbit. The satellites were the vanguard of a worldwide military communication network. The flight marked the heaviest payload ever carried into the synchronous corridor, and tied the record for the number of satellites carried to any altitude by a single rocket.

The flight was followed on July 29 by the successful maiden launching of Titan III-B, newest member of the Titan family of space boosters. The vehicle employs the first 2 stages of the Titan main vehicle, with man-rating systems omitted, and will accommodate a variety of upper stages, including Agena, Transtage, Centaur, and other high energy upper stages.

Martin Company at Denver, systems integrating contractor for the Titan III Standard Space Launch System program, builds the main vehicle airframe and the Transtage spacecraft upper stage. The company also is systems integrating contractor for Titan III-B's first 2 stages, builds the main airframe, and supplies the flight control system.

Executive management of both programs is under the Space Systems Division of the Air Force Systems Command.

Facility expansion was marked by construction of a $5,000,000 thermal vacuum chamber installation capable of simultaneously duplicating vacuum conditions, the extreme cold, and sunlight radiation intensities as far away as 300 miles in space. The facility will be a key tool in Martin Company's expanding spacecraft and space systems activities.

More than $250,000 went into equipment and construction of a 4,000-square-foot addition to the company's Inertial Controls and Development Laboratory. Twenty thousand square feet of floor space also was added to the aerospace complex's Engineering Development Laboratory building, increasing the 3-story structure's capacity to more than 80,000 square feet of space.

A milestone was reached during 1966 when Martin Company used single charges of high explosives to produce the first 10-foot-diameter, 1-piece space booster propellant tank domes. The joint Martin Company-Denver University Center for High Energy Rate Forming received a $450,000 contract from the Army for continuing explosive forming research. The agreement added another year to the existing 3-year, $1,000,000 contract under which the company-university organization was established in 1965.

Space research projects conducted at Denver included propulsion and pressurization system development, zero-gravity phenomena in liquid fuels, liquid hydrogen and fluorine applications, inertial controls development, space rendezvous and docking, acoustic environment, and development of a new technique for simulating astronaut extravehicular activity in the company's space operations simulator.

An astronaut suspended on a servo-driven carriage in this simulator undergoes body actions and reactions closely resembling those experienced in the weightlessness of space.

Other projects included studies of the most economical ways of increasing the life spans of future spacecraft; studies of the relative merits of horizontal and vertical takeoff of reusable space vehicle systems; design and development of advanced space control systems; continuing study of wind-induced oscillations on the Saturn rocket; study of all launch facility modifications for 11 Uprated Saturn I, Saturn V, and intermediate Saturn vehicle configurations; continued analytical studies and experiments with air augmented rocket vehicles; and studies of integration of experiments and experiment equipment in space vehicles and spacecraft for manned Apollo Applications missions.

CANAVERAL DIVISION

Martin Company's Canaveral Division specializes in flight test and launch operations at Cape Kennedy. From its establishment as a full division in January 1958, through 1966, it had conducted 190 launches of major space systems.

During 1966 the division managed 2 launch programs: the modified Air Force Gemini-Titan II used for NASA's manned Gemini missions, and the

Air Force Titan III Standard Space Launch System, most powerful rocket in the nation's military inventory.

Five Gemini-Titan II launch vehicles and 4 Titan III-C's were erected, checked out and launched by Canaveral Division personnel.

The year began on the heels of one of the greatest launch demonstrations in space history, Gemini 7 and 6, when the division launched two manned vehicles from the same complex only 11 days apart during December 1965.

Precision launching was refined to an art during 1966 when rendezvous launch windows decreased in time, dropping eventually to 30 seconds and finally to only two seconds for the launch of Gemini II.

Earlier in the year, crews launched a Titan III-C on one of the most demanding and successful unmanned missions ever attempted in space. The Titan placed 8 satellites (7 military communications satellites and a gravity gradient test satellite) into a preplanned near-synchronous orbit some 21,000 miles above the Earth's equator with pinpoint accuracy.

With crews on the scene since 1951, Martin is the oldest continuous aerospace tenant at the Cape. Since 1951, the company has test flown 11 separate missile and space systems and activated 14 launch facilities. Programs conducted by the division 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 (RIAS), Martin Company's basic research center, performs fundamental studies in biosciences, materials science and physics.

In May 1966, the Institute reported experiments toward developing a new technique to detect life in space. Dr. Bessel Kok, in a paper read at the Committee on Space Research (COSPAR) Seventh Annual Space Symposium in Vienna, Austria, described the method, which traces the transfer of oxygen-18 from inorganic compounds to water. He pointed out that without help from living cells, inorganic compounds do not spontaneously exchange oxygen-18 with water. Therefore, there is little chance that a device based on oxygen-18 exchange would signal false indications of life on other planets.

Kok said that the device is simple, can use the explored planet's own soil as a cell nutrient, and is relatively immune to the high temperatures associated with the sterilization of interplanetary spacecraft.

In other biosciences programs, RIAS photosynthesis experiments examined the role of manganese in the evolution of oxygen in green plants, and chemosynthesis studies sought to understand the manner in which hydrogen bacteria transfer energy. These photosynthesis and chemosynthesis efforts should prove valuable in developing closed ecology life support systems for extended space missions.

The RIAS ceramics group, formed in 1965, received support from the Army Research Office at Durham, North Carolina, and the NASA Office of Advanced Research and Technology. During 1966, the group acquired a high-pressure induction crystal grower, a high-vacuum annealing furnace, and high-temperature mechanical testing equipment.

The objective of this group is to improve the high-temperature strength and low-temperature ductility of such potentially useful materials as titanium carbide and vanadium carbide. The NASA-sponsored studies deal with the high-temperature mechanical properties of pure and alloyed ceramics, and the Army investigation seeks information on how the mechanical properties of ceramics are affected by their electronic structure.

Electron microscope studies of the interactions of boron and dislocations in titanium carbide provided an understanding of the tenfold increase in strength (at 1500 degrees Centigrade) when titanium carbide is doped with boron. These studies suggest promising approaches to producing superior high-temperature materials for aerospace applications.

Another RIAS materials group continued studies intended to clarify the important role that environment plays in determining the strength of a structural component. For example, the behavior of technologically important titanium, aluminum, and copper alloys was being studied to find out why they sometimes fail under relatively low stress when exposed to certain aqueous salt solutions.

Studies of the chemical and metallurgical factors involved when solid metals are embrittled by liquid metals already have shed light on materials problems that may be encountered in advanced nuclear reactors, where liquid metals may be used as coolants. The objective of this work is to understand the embrittlement mechanism so well that it will be possible to prevent this type of failure by making appropriate alloying additions to the solid metal or the liquid metal environment.

RIAS physicists initiated experiments using an ion cloud release technique for studying the geoelectric field intensity and wind velocity at altitudes of 140 to 200 kilometers.

Studies of the physical mechanisms involved when metastable or high-energy compounds burn has led to a technique for modifying and controlling the decomposition of explosives and oxidizers.

Quantum chemistry studies of high-energy compounds were continued during the year. These studies are centered on techniques for predicting chemical and physical properties, such as bonding, reactive behavior and stability, before such compounds are actually synthesized in the laboratory.

RIAS research on ion transport is directed toward understanding how electrically charged particles flow through charged membranes, studies that may contribute to new water desalinization processes.

Experimental observations at RIAS of electron-phonon interactions in semiconductors are expected to have an effect on the development of microwave delay lines or very broadband amplifiers and modulators.

McDONNELL COMPANY

The year 1966 was one of substantial accomplishment for McDonnell Company. The Gemini program was completed in highly successful fashion, and increased orders for the multi-service Phantom resulted in substantial increases in production and delivery rates. In addition, significant progress was made during the year in developing the MAW anti-tank/assault weapon for the U.S. Army.

The EROS Aircraft Collision Avoidance System was received with a great deal of interest by the government and by several major airlines. EROS was operated throughout the year in the Phantom flight test program adding to an already substantial base of operational experience with this collision avoidance system.

Five manned NASA Gemini spacecraft missions were completed successfully in 11 months, culminating in the final Gemini splashdown of Gemini 12 during 1966. These spacecraft achieved long duration missions and developed techniques in rendezvous and docking, extravehicular activities and orbital maneuvers that had to be proven before the Apollo manned expedition to land on the moon could proceed.

On November 3, the first test flight of a Gemini modified for the Air Force was successfully flown. This unmanned suborbital flight tested the structural integrity of the Gemini heat shield with an entrance and exit hatch in it. McDonnell converted the NASA Gemini 2 for this test. When the Gemini spacecraft is flown in conjunction with the Air Force Manned Orbiting Laboratory (MOL), astronauts will transfer through this hatch from the Gemini into the laboratory after they are in orbit. The Air Force program is expected to use Gemini B spacecraft well into the 1970's.

In order to make best use of Mercury, Asset and Gemini experience, in 1966 McDonnell pioneered with its own funds studies related directly to future space programs planned by both NASA and the Department of Defense. This research included advanced orbital spacecraft, laboratories, military systems in space and lifting re-entry vehicles capable of performing logistic and ferry functions for the support of manned space activities in near-earth and synchronous orbits and on lunar shuttle missions.

McDonnell received a contract from NASA to build an airlock which would make possible the use of a spent stage of a Saturn I rocket as a manned space laboratory.

The concept of adapting one or more tanks of a spent launch vehicle stage as habitable quarters for crewmen has received considerable attention in the past few years. Protagonists of the concept cite numerous advantages accruing from the performance of space experiments inside a large controlled volume. The hydrogen tank of the S-IVB stage of the Saturn IB launch vehicle for Apollo has a volume in excess of 10,000 cubic feet and has diameter and length dimensions which make it suitable for use as such a space laboratory. The McDonnell airlock is the unit providing, in addition to the airlock itself, the necessary docking provisions, reactants for electrical power generation, and life support system to permit activation and operation of the S-IVB hydrogen tank as a manned space laboratory for missions up to 30 days duration.

Voyager is an important program planned by the National Aeronautics and Space Administration for the unmanned exploration of the planet Mars, including an unmanned instrumented spacecraft to land on Mars by the year 1975. In fiscal 1966 McDonnell expended 141,484 man-hours of work at a cost of $1,335,570 on studies related to Mars exploration, and in fiscal 1967 the company projected expenditures of 213,850 man-hours at a cost of $2,122,500 of company money developing an instrumentation package to explore that planet.

Work on the McDonnell Boost Glide Re-entry Vehicle (BGRV), under contract with the Air Force, was accelerated during 1966. Progress was made on the airframe and specialized equipment required to flight demonstrate this new concept.

During the year, McDonnell successfully proved the soundness of its original concept for the Medium Antitank/Assault Weapon (MAW). As a result, the Army awarded the company several significant contracts for engineering development lasting through 1968, after which there appeared a good probability of a very worthwhile production contract. The objective of the Engineering Development Phase is to achieve a low-cost, highly reliable, highly producible missile that can be built economically in the large quantities required by U.S. ground forces. The MAW is a self-contained weapon to be used by infantrymen against tanks and armored vehicles. Its light weight (27 pounds) and simplicity will provide a substantially increased capability to front line troops with a minimum of specialized training.

McDonnell-funded studies were being carried out on surface-to-surface missiles that can be used for shore bombardment by the Navy and for the close support of combat units by the Army. These missiles employ a guidance system developed by company engineers. Air-to-surface missiles for use against land and sea targets to meet Navy and Air Force requirements also were being studied.

The performance of the F-4 Phantoms in defense of the free world continued throughout the year to generate pilot reports on the aircraft's unmatched versatility, high reliability, easy maintainability, outstanding safety records and its unique capability for multiple missions. On land and sea, in Europe and in Southeast Asia, the Phantom continued to do an outstanding job.

Delivery of Phantoms in all versions reached an all-time high, and the production rate was expected to climb further in 1967. Seven models of the Phantom were in production during 1966, including 3 new models: the F-4D for the Air Force, first flown in December 1965; the F-4J for the Navy and Marines which made its first flight in May 1966; and the F-4K with Rolls-Royce Spey engines for the British Royal Navy, first flown on June 27, all ahead of schedule. The first F-4M for the Royal Air Force made substantial progress toward its first flight scheduled in 1967.

The F-4J, successor to the F-4B, has more powerful and more efficient engines, a more powerful and versatile radar, miniaturized communication and navigation systems, more fuel, larger wheels and tires for forward area runway operations, and reduced landing speeds.

The Air Force announced in October an initial procurement of 99 F-4E Phantoms costing $272,000,-000. The F-4E, like the C and D series, is a twin-engined, 2-place fighter capable of performing air superiority, close support and interdiction missions of the tactical forces using conventional or nuclear

McDonnell was using an F-4 Phantom as a test-bed for mating the General Electric Vulcan cannon to the USAF/Navy fighter. USAF ordered a cannon-equipped F-4E.

munitions. The F-4E will have an internally-mounted M-61A1 20-millimeter gatling gun, an improved fire control system and engines with increased thrust. Fiscal year 1966 funds were released for the initial procurement of the 99 aircraft.

Both the Navy and the Air Force will continue to program procurement of the Phantom through 1971. The flexibility inherent in the Phantom design provides additional growth potential in the basic aircraft as new weapons, new propulsion systems and new electronic systems become available.

The first production crew modules developed by McDonnell for the General Dynamics F-111 became operational during the year. The revolutionary cabin provides the crew with a controlled "shirt sleeve" environment throughout the flight range of the aircraft and also a system for escape and survival in the event of emergency.

As a result of a competition, McDonnell was 1 of 3 awarded a small contract in fiscal 1966 for study and design work on a new antisubmarine warfare aircraft for the Navy.

McDonnell during the year continued studies of aircraft that can fly in the earth's atmosphere at hypersonic speeds. This work was financed both by the company and by contracts with NASA and the Air Force. Investigations during the year included extensive design studies of feasible aerodynamic and propulsion configurations, wind tunnel tests, laboratory tests on fuel tanks at cryogenic temperatures, and tests on materials and structural components at elevated temperatures. McDonnell was 1 of 3 companies awarded a contract in October for preliminary design studies of a Scramjet by the Air Force's Aeronautical Systems Division. The Scramjet is a hypersonic airplane using ramjet engines. In addition to preliminary design of the aircraft, the contract provides for studies of possible military uses for the vehicle, matching the aircraft and missions.

The aircraft collision avoidance system developed by McDonnell performed successfully throughout the year as an operational system during production checkout flights on Phantoms. By year-end, well over 2,000 flights with the collision avoidance system aboard had been accomplished, making the system, known as EROS (Eliminate Range Zero System) the only such operational system in existence. Research on the system began in 1960 under company sponsorship and funding.

EROS provides a 60-second warning to aircraft converging at speeds up to 4 times the speed of sound, or alternately warns of aircraft 1½ miles distant. The pilot is warned of impending collision by a "beep" received in his headset and, simultaneously, a cockpit display provides the pilot with instructions to climb, descend, level off or hold altitude in order to avoid collision. The system operates only among aircraft which have the Mc-

Donnell equipment installed. It can accommodate as many as 1,000 aircraft at a time within a 150-mile radius.

The key to EROS is a new technique for synchronizing time and frequency of many airborne stations. Participating aircraft are equipped with clocks that are accurate to 1/10,000,000 of a second. These clocks are synchronized automatically every 2 seconds. A patent on the EROS synchronizing technique was received by McDonnell in May.

During the year McDonnell conducted an experiment with the Naval Laboratory in which, for the first time, an atomic clock on the ground was synchronized with another atomic clock in a McDonnell aircraft to within 1/10 of a microsecond using the patented McDonnell resynchronization technique.

In the operation of the EROS system, each aircraft takes its turn transmitting a radio signal every 2 seconds at an exact instant known to all other aircraft. By measuring the time delay between the time of transmission by 1 aircraft and reception by the other, the computing system in the receiving aircraft automatically calculates the distance between aircraft. The rate at which this distance is changing is immediately determined by the frequency of the radio wave received. The radio signal also indicates the altitude of the transmitting aircraft.

To strengthen its competitive position and maintain a matching pace with the growth in sales and employment, expenditures for company sponsored research and development in fiscal 1966 were increased by 31 percent over the previous year, with approximately 1,300 engineers and scientists at work on these programs.

Physiological monitoring studies, conducted by McDonnell aerospace medical scientists in conjunction with the space program led to the development of a critical patient monitoring system being evaluated with patients by a St. Louis hospital.

In plasma physics, investigations continued throughout the year in re-entry heating simulation and protection, including entry into a Martian atmosphere. The problem of communications blackout during re-entry, caused by the electron concentration in the plasma sheath surrounding the vehicle, was being studied by seeding plasmas with varying amounts of water and other liquids. Arc-jet propulsion was investigated, supported in part by a NASA contract. Liquid metal propellants were being studied for use in spacecraft.

Electro-optics research continued into the lateral photovoltaic phenomenon for possible application to missile tracking and guidance systems. Use of photoconductors was being studied with possible application to light amplification and data display.

Lasers were being studied for use in holography, with possible applications including reconnaissance.

Research under way in the new Reconnaissance Laboratory included study of optical, electro-optical, and electronic techniques for data extraction, correlation, storage, retrieval and display particularly as applied to the military reconnaissance field.

Research in radiation effects was being pursued to achieve a better understanding of the mechanism whereby electromagnetic radiation interacts with materials. Techniques and equipment for analysis by X-ray diffraction and fluorescence were the subject of an effort to develop tools in the field of non-destructive testing and analysis.

Phenomena associated with the operation of electronic devices at very low temperatures were being investigated. These have possible valuable application to achievement of higher performance in a variety of new communication and reconnaissance systems.

To keep the company in the vanguard of flight simulation, McDonnell built a large and versatile simulation facility, including a human performance laboratory. Studies in this laboratory will advance knowledge of human performance and physical anthropology, and will provide information about crew capabilities and environmental needs, design of crew accommodations and other information of value in aerospace vehicle design. A large digital and analogue computer complex with interface connections to a variety of peripheral simulators, both spacecraft and aircraft, is included. A target acquisition and tracking simulator is used to perform reconnaissance missions from aircraft and orbiting spacecraft.

The company's advanced material fabrication facility, used to develop techniques and processes for fabricating aircraft, spacecraft and missile structures utilizing advanced structural materials, was considerably enlarged. Accomplishments of this facility included: fabrication of a beryllium rudder for investigating the suitability of this material for load carrying aerospace structures; methods for bonding titanium; oxidation-resistant coatings for the protection of materials at elevated temperatures; and electron beam welding techniques for manufacturing structural components utilizing tantalum, titanium and columbium. A number of these techniques and processes were being introduced into the experimental production of test vehicles such as ones made to withstand exceedingly high temperatures.

MENASCO MANUFACTURING COMPANY

Menasco made a very determined effort during 1966, as it had in the three prior years, to gain a major portion of the new landing gear market. This was accomplished. The backlog at year-end was the highest in the history of Menasco. This backlog is excellent in terms of size, program timing, customer diversification, and potential for growth.

Menasco was participating in the following programs: Bell UH-1B Helicopter program; Boeing Minuteman Shock Isolation program; Boeing 707-120, 320, 720, 727 aircraft and the CH-46A helicopter programs; Douglas DC-9 and Saturn programs; General Electric re-entry program; General Dynamics F-111A, F-111B and FB-111 programs; General Dynamics F-102, F-106, B-58 and Atlas programs; Ling-Temco-Vought A-7A and F-8U programs; Lockheed C-130, C-141, P-3A and JetStar programs; McDonnell F-4K program; Northrop T-38 program.

Menasco experienced major difficulties in acquiring trained manufacturing personnel, but was particularly successful in its program of developing skilled personnel. Approximately 300 trainees were at work in the California and Texas Divisions. The picture processing manufacturing technique, which has long been used at Menasco, facilitated the assimilation of untrained personnel and a substantial increase in output without a significant reduction in productivity or a significant increase in scrap and rework.

In 1966 Menasco added 100,000 square feet of manufacturing area in the Burbank and Fort Worth-Dallas facilities. With this expansion, the Texas Division acquired a new 60,000 square foot facility in the Fort Worth-Dallas area. This plant was to be operated as an off-site facility primarily to meet the demands of helicopter rotor component programs which require continuous as opposed to interim usage of equipment. Most of the machinery for this additional plant was to be furnished by the Government.

Menasco invested in excess of $750,000 for new machine tools and equipment. In addition, it committed $500,000 for heavy duty custom built machine tools, the need of which had been limiting productive capacity. As needs develop and as resources permit, additional facilities are to be acquired pursuant to a long-range facility program.

Menasco continued to participate in the Air Force Facilities Modernization Program. This program is pointed at improving the national industrial base by providing newer and more sophisticated equipment required for aircraft and missile components of high strength and exotic alloys made to ever closer tolerances.

Menasco was accelerating its efforts to participate in product areas related to its established technological and manufacturing capabilities. It was engaged in building shock isolators for the Minuteman Missile base hardening program. Menasco also entered into an agreement with a major supplier of railroad equipment under which it developed and started manufacturing railroad draft gear which will materially reduce property losses incurred in the movement of rail cargo. The company was also continuing to make feasibility studies on the utilization of its shock media technology for the development of safety features for highway vehicles.

NORTH AMERICAN AVIATION, INC.

In 1966 North American continued to strengthen its position as a center of invention, research, development, and manufacture of advanced products. In varying stages of design, production or improvement were such items as nuclear power plants—some as small as a 5-gallon can, others as large as a city block; the most powerful and most reliable rocket engines in the free world; microminiaturized guidance systems that set new standards of accuracy and endurance; specialized vehicles to carry men to the moon, to hypersonic speeds at the edge of the atmosphere, and to the ocean depths.

This growing diversity of programs continued to require new or modernized facilities. By year-end, major plants, test sites, or field offices were established in 26 states and 12 foreign locations. Among important new facilities were a 2-story Materials Laboratory to facilitate early company-wide use of new materials and fabrication processes, and a Structural Machining Center where many advanced machines were being installed to fill needs for large metal parts throughout the corporation.

Results during the year reflected intensive activity in many programs of high technical challenge and critical importance to the nation's interest. Significant among these was the company's major share in the Apollo-Saturn programs to land Americans on the moon by 1970. As the principal contractor in the lunar effort, North American's responsibilities include the Apollo spacecraft and service module, the second stage of the Saturn V launch vehicle, and the rocket engines of all 3 stages. Formidable technical requirements of the Apollo-Saturn programs were being fully met and the company passed the halfway mark in the total project.

The Minuteman II ICBM guidance and control system demonstrated excellent performance in all launches, and most of the production program still lies ahead. The Sabreliner executive transport continued to win sales as fast as they were produced. In the OV-10A light armed reconnaissance aircraft program, a large production order for the Air Force and Marines was received.

During the fiscal year the company was awarded 278 contracts for new business with a total value of $363,000,000 and with a much higher value in prospective production contracts. In addition, North American was awarded a total of 187 new follow-on contracts or contract amendments having a total value of $1,811,000,000.

Notable new business awards included the Condor air-to-surface guided missile and the Mark II aircraft avionics system.

While maintaining its leading position in defense and space contracting, North American was also applying its technical capabilities to the development of other markets—both governmental and nongovernmental. To focus certain of these efforts, two new corporate organizations were established: Ocean Systems Operations and Life Sciences Operations.

North American arranged for 1967 take-over of the Navy landing at Long Beach, California, to become the home of the company's Ocean Systems Operations.

In Ocean Systems, work was started on a submersible that will operate as an efficient workboat to depths of 2,000 feet. It will have effective undersea manipulators that were developed by the company and are considered to be more advanced and versatile than any in operation on existing submersibles. Also in development was an ocean-bottom scanning sonar that uses a special silicon-sealed, acoustic lens of great range, power, and directional sweep. The company was also performing research and development in deep diving submarines; search, rescue, and salvage submersibles; advanced automatic navigation for such craft; undersea habitats; Navy torpedos, mines, and other ordnance and sensing devices for antisubmarine warfare; marine equipment for oil drilling and exploration, and other products.

Life sciences capabilities opened many new product possibilities in health, medicine, and human factors. Research and development in this many-sided field pointed to new business opportunities in such areas as artificial heart pumps and kidneys, field medical laboratories, automatic communication and information handling for hospitals, recovery of animal food from waste water, purification of waste water for agricultural and industrial use, improved artificial limbs, programmed instruction including teaching machines, better sensors and instrumentation for diagnosis, and many others.

During the year, North American announced its intention to penetrate markets for advanced industrial products through acquisition, thus further promoting a better balance between government and commercial sales.

North American continued development of the reactor for the nation's largest single project in space nuclear-electric power generation, the SNAP (Systems for Nuclear Auxiliary Power) 8 program, jointly sponsored by NASA and the Atomic Energy Commission. The SNAP 10A reactor completed a scheduled 416-day endurance ground test, breaking all records for continuous full-power operation of a nuclear power reactor.

In the field of central station power, the company continued development of the Heavy Water Organic Cooled Reactor (HWOCR), which uses heavy water as moderator and an organic material as coolant. In the joint program with Combustion Engineering, Inc., to develop a HWOCR for the AEC, conceptual designs were completed for central station plants of 500- and 1,000-megawatts capacity, and component testing got under way. The basic characteristics of this type give it an outstanding potential for generating economical electrical power in very large plants, and also for use in future large dual-purpose plants to produce power and desalt sea water. Moreover, its efficiency promotes conservation of the nation's limited uranium ore resources.

During the year, the company advanced its position as a major supplier of fuel assemblies for experimental and test nuclear reactors. Assemblies consisting of plates containing uranium fuel were being fabricated for the AEC's Advanced Test Reactor and Experimental Test Reactor, and for another installation to be operated by the Japan Atomic Energy Research Institute. The company was also exploring means of penetrating a much larger and growing market for resupply of fuel for central station power reactors.

Five major aircraft models were being delivered to the government during 1966.

A contract was received for production of 185 OV-10A aircraft for the Air Force and Marines, and for critical items in 38 additional aircraft. A twin-engine turboprop airplane, the OV-10A is the first ever specifically designed for close-support use in limited warfare. Its basic configuration is readily adaptable to growth versions for other missions.

The company was also producing T-2B twin-jet trainers used throughout the Naval Air Basic Training Command, and was converting A-5A attack bombers to RA-5C tactical reconnaissance aircraft, which have been operating in Southeast Asia since

1964. Deliveries of both types were expected to continue for a considerable time.

In the T-39 Sabreliner program, a newer version was developed as a possible mission-support aircraft; production continued on the commercial Sabreliner executive transport. Altogether, 271 T-39's and Sabreliners had been delivered to military and commercial customers by the end of the year.

In another program, the company was converting hundreds of its propeller-driven T-28's for use in Southeast Asian countries connected with the U.S. Military Assistance Program.

The XB-70A and the X-15 continued to provide invaluable data on supersonic and hypersonic flight. In the XB-70 research program, magnetic tapes have recorded almost 8 billion items of data from 798 data sensors in every part of the aircraft, providing new knowledge on aerodynamic, structural, and subsystem performance at 3 times the speed of sound. Among XB-70A achievements were more than 30 minutes of sustained Mach 3 cruise and more than the targeted number of flight hours—both of which earned incentive bonuses.

The 3-vehicle X-15 research program continued to provide data for advanced engine and structural concepts in the near-space environment. Velocities of eight times the speed of sound were made possible through X-15 modifications, so that future experiments can further explore the characteristics of hypersonic flight.

In other endeavors, North American was working actively on configuration studies for the Navy's next-generation carrier-based fighter/attack aircraft and for a new antisubmarine warfare aircraft. Preliminary design studies were completed for an advanced Air Force tactical support fighter and technical support on this program is continuing.

A company-built V/STOL (Vertical or Short Takeoff and Landing) model, largest in existence, was being tested at NASA's Ames Research Center. Test operations continued with the FS-1 "Hover-buggy," the only free-flying VTOL aircraft simulator. In progress, also, was work on a contract to develop and test a VTOL flight control system.

All Apollo manned launches scheduled will be powered by North American engines and will employ spacecraft built by the firm.

In the Apollo-Saturn programs, a nationwide network of some 20,000 companies and 300,000 workers had, by year-end, delivered millions of components (500,000 functioning parts in the Apollo command and service modules alone).

The planned series of 12 Apollo flights was scheduled to get under way with 1967-68 flights scheduled to qualify all elements of the Saturn-Apollo vehicles and provide flight experience for astronauts before the climactic manned mission to the surface of the moon and back.

Formal qualification tests were completed for both the first stage F-1 and the hydrogen-fueled upper stages J-2 engines.

Besides its 5 J-2 engines, the S-II second stage of the lunar launch vehicle utilizes 8 solid propellant motors developed by North American. Installed around the base of the stage, these small motors settle propellants in the tanks prior to ignition of the main engines.

A cluster of 8 company-built H-1 engines launches the first stage of the Uprated Saturn I, which sends Apollo astronauts on earth-orbit flights in preparation for lunar voyages. In the 3 1966 unmanned launches of this 2-stage vehicle, the engines performed perfectly and demonstrated outstanding reliability in all phases of testing.

Re-entry control engines produced by North American—and proven in the 2-man Gemini spacecraft—steer Apollo's command module as it brakes itself during re-entry through the atmosphere.

Twelve of them were successfully used in August's flight of the unmanned Apollo spacecraft command module, which also carried 5 company-built space guidance units that helped control the spacecraft as it employed guided re-entry for the first time.

The Condor missile, representing one of the company's principal new contracts, is an advanced air-to-surface, television-guided weapon that will enable Navy carrier-based aircraft to achieve much greater bombing accuracy while avoiding flight over heavily defended targets.

In addition, the company continued production or development of motors for 5 other military missile programs.

Solid-propellant rocket motors continued to be produced in volume for the Navy's radar-guided air-to-air Sparrow III and Shrike. In one of the most extensive development programs ever undertaken for an air-launch propulsion system, the company successfully tested more than 60 solid-rocket motors for the Phoenix missile, to be used on the F-111 tactical fighter.

Completing development was a storable, prepackaged liquid propellant engine for the Army's new tactical ground-to-ground Lance missile. The variable-thrust Lance has improved range, explosive power and accuracy over the standard front-line missiles now in use.

Antitank missiles in development scored repeated hits on targets when air-launched in flight tests. The technology achieved in this program looked promising as the basis for small, television-guided missiles that can be carried in quantity on tactical aircraft. In this endeavor, North American's responsibilities included propulsion, guidance, and vehicles.

Electronic systems designed and produced by the firm are important elements in most of the free world's nuclear deterrent systems, including the

Minuteman ICBM, Polaris submarines, and Hound Dog air-launched missiles. They are also used in several major tactical weapon systems of the U.S. and its allies, and in the Apollo space program.

Company-built equipment automatically navigates nuclear submarines and ships; automatically monitors the readiness of missiles and guides them in flight; and is airborne daily in 4 major types of military aircraft to give accuracy to their navigation, maneuvering, and firepower.

In the field of microminiaturization, the first extensive use of microelectronics in an operational system was in the company-made guidance and control system and auxiliary equipment for Minuteman II intercontinental ballistic missiles.

Most of the functions of the lightweight computer in a Minuteman II are performed by 2,144 of these integrated-circuit chips that together weigh less than a 1/10 of an ounce. Yet the computer has 2½ times the capacity of its predecessor.

The Minuteman III ICBM guidance and control system, being developed by the company as a follow-on to its current Minuteman program, will be the first of a new generation of advanced-performance strategic missiles. This work includes an improved computer, a new flight control system for the third stage engine, and a post-boost control system to guide the warhead after burnout of the mainstage engines.

The Mark II avionics system for the F-111 aircraft, awarded to the company during the year, includes a radar, computer, autonavigator, and other microelectronic equipment to perform all the sensing, analyzing, display, navigation, and computation functions of the aircraft. Through microminiaturization the system provides more capability than previous systems, reliably and at comparatively low cost.

Autonavigators designed and built by North American are standard equipment on the Navy's atomic submarine fleet. They combine precision gyroscopes, accelerometers, a computer that measures and remembers a vessel's movements in all directions, and actuators that correct any deviation in its course. Thus they continuously report and correct its speed and position to a very small fraction of a mile. Other versions have applications in quick-strike tactical aircraft, transport aircraft, surface ships, and spacecraft.

The company also continued production of high-speed preflight checkout equipment for various aircraft, missiles, and aerospace systems.

North American was performing a number of research and technology contracts related to development of new materials to withstand exotic environments or provide greater structural strength.

Under new contracts with several customers, the company began supplying stabilized superconductive wire and cable made of titanium-niobium alloy for large-volume magnets and other applications requiring greatly improved conductivity at low capital and operating costs.

In a program supported by government contracts as well as by company funds, substantial progress was made in developing the toroidal aerospike rocket engine, features of which provide high-performance at upper altitudes while introducing greatly improved low-altitude performance. Through consequent gains in fuel efficiency and burning time, the engine type could put large satellites into orbit with a single stage. A complete thrust chamber in the 250,000-pound-thrust range was scheduled for test firing early in 1967.

Mars and Venus manned flyby missions were among the long-range space projects being explored by company scientists, with the prospect of extending still further the use of modified Apollo-Saturn systems. Also in research were guidance and control equipment for the Voyager unmanned spacecraft for a Mars landing. Beyond these efforts, the firm was performing research applicable to a manned landing on Mars or Venus, and unmanned flights to the outer planets, expected in the future.

North American was also cooperating with Harvard University on a study for NASA of a manned orbiting solar telescope that will be launched by a Saturn-Apollo system.

In an industrial product area, the company was in the early stages of developing a large-scale electronic data file capable of storing 2 billion bits of information, which could also find widespread use for rapid information retrieval in the financial, medical, legal, and educational professions.

In laser research, lasers were used to measure earth displacements as minute as 1 millimeter over a 13-mile range. It was believed that this capability may be utilized in earthquake-predicting devices for installation along faults near population centers.

Advanced research and development was being performed on the fast breeder reactor concept that produces more fuel than it consumes during operation—regarded in the industry as the most efficient power reactor concept.

At its Nuclear Field Laboratory in California, the company was building a major facility to produce plutonium fuel elements which will support its work in this field.

In 1966, important progress was made in the technology of magnetohydrodynamics, a means for direct conversation of energy into electricity. Also in the direct conversion field, the company was working on an experimental 100-watt thermoelectric power source for the Air Force.

At year-end, total employment at North American's 7 divisions—Autonetics, Atomics International, Columbus, Los Angeles, Rocketdyne, Science Center, Space and Information Systems—was approximately 94,000. Total floor area amounted to about 23,255,000 square feet.

NORTHROP CORPORATION

The end of 1966 saw Northrop's employment figure climbing toward 20,000, the highest since 1963 and indicative of the record fiscal year in which sales, earnings, and backlog of orders reached new highs. Earnings in fiscal 1966 were 21 percent higher than the previous year's; sales amounted to $357,278,295, an increase of nearly $18,000,000, and the backlog stood at $574,000,000, double that of FY 1965.

These results reflected to a considerable extent only the beginnings of continuing business, the initial portions of long-term programs. An example is the design and production for the Boeing Company of the major fuselage section of the 747 jumbo jet airliner. Sales on this program were expected to exceed $100,000,000 a year beginning in 1969-70 and lasting over a period of years. But only $111,000,000 of this is included in the FY 1966 backlog figure.

The Boeing 747 subcontract program was a highlight of Northrop's aircraft activities during the year. Aircraft research, development, and production to form the largest of Northrop's five major product areas. Aircraft sales in the fiscal year totaled about $170,000,000, with a backlog of more than $340,000,000. Commercial aircraft work accounted for $151,000,000 of the backlog; military the rest.

In the military area Northrop aircraft were ordered or programmed for modernization of more than 10 allied air forces throughout the world. Deliveries of the F-5 supersonic tactical fighter were made to Iran, Korea, Greece, the Philippines, the Republic of China, Turkey, Thailand, and Ethiopia under the U.S. Military Assistance Program. Norway received F-5's under a direct purchase plan, and Canada and Spain were to build the airplane under license agreements with Northrop.

Late in 1965 the U.S. Air Force sent an F-5 squadron (called Skoshi Tiger) to Viet Nam for evaluation of combat tactics. In April of 1966 the USAF announced that the squadron would be permanently assigned to Viet Nam and that additional F-5's would be deployed there. Combat reports on the F-5 stressed high maneuverability, low vulnerability to ground fire, and low maintenance requirements.

The year 1966 marked the completion of the fifth year in which USAF cadets used the Northrop T-38 Talon supersonic trainer to earn their wings. Production of T-38's, the world's only supersonic trainer and by actual performance the safest trainer ever, continued at Northrop Norair. A total of more than 900 Talons had been produced or were programmed. Forty-six were on order for the German Air Force for training student pilots in the United States. The National Aeronautics and Space Administration ordered a total of 24 Talons.

In the area of advanced aeronautical research, a unique test vehicle was built by Northrop in cooperation with the NASA Ames Research Center. Its purpose was to study the phenomena of exhaust gas ingestion and jet-induced effects associated with a large-scale composite jet VTOL fighter configuration. The study may produce design criteria for development of future supersonic VTOL fighter-type aircraft.

In another field of aircraft, radio-controlled target drones, Northrop Ventura completed a flight model of its new NV-105 aerial target in 1966. The drone was then delivered to the military services for extensive evaluation. Contracts for several million dollars worth of KD2R-5 target drones and related equipment were received from Brazil and Argentina.

Northrop's penetration of the vast advanced communications field was indicated by its fiscal 1966 sales mark of more than $50,000,000 and backlog of nearly $70,000,000 in such systems and equipment. At year-end the company looked forward to the prospect of annual sales close to $100,000,000 in the field within the next few years.

Most of this involves design and installation of large communications systems, with some development and manufacture of special types of communications equipment. Volume in this area has doubled over the past five years. To illustrate the stature of this business, Northrop's subsidiary, Page Communications Engineers, Inc., received a $71,000,000 contract for major work in Southeast Asia, the largest single contract ever awarded by the Army's Defense Communications Command.

Northrop Page is one of the few communications companies with the experience and know-how to undertake communications systems assignments of this magnitude anywhere on earth. During fiscal 1966 it installed communications networks on every continent. In addition, in the broad new field of satellite communications, Northrop Page was pacing the industry in the design, technology, and performance of comsat mobile earth stations which transmit and receive information relayed by satellite.

Other specialized communications work was in progress at other elements of Northrop, such as the United States Underseas Cable Corporation of Washington, D. C., of which Northrop is a one-third owner.

In mid-summer, the Boards of Directors of Northrop and The Hallicrafters Company of Chicago approved the acquisition of the latter by Northrop. The Chicago components firm, which was to be operated as a wholly owned subsidiary of Northrop, was expected to complement and strengthen Northrop's business in the communications field.

Of comparable size, importance, and activity during 1966 was Northrop's electronics activity, with a backlog of nearly $100,000,000 and sales of more than $70,000,000. The company's broadly based programs in this field, largely through the Northrop Nortronics Division, include automatic test equipment, inertial navigation and guidance systems, gyroscopes, accelerometers, and other precision sensing devices.

The division was awarded the highly sought contract to develop and build the doppler-inertial navigation equipment for the Air Force C-5A fanjet cargo transport. Northrop's system, to be produced for the Lockheed-Georgia Company, prime contractor on the huge new airplane, will be the heart of the C-5A guidance system. The system will be extremely lightweight, weighing approximately 200 pounds, and accurate, with an allowable error of only 1 nautical mile per hour.

This navigation system is the forerunner of an entire new generation of airborne navigation equipment for transport aircraft at Northrop. In addition, the division was developing a small airborne computer that matches the computational ability of large data processors. Northrop Nortronics was also a pioneer in large-screen information display systems, a vital aid to command and control operations. Several of these Vigicon display systems were sold to the Navy, Air Force, and NASA during the year. The company also received a $4,000,000 contract for a new joint service program called TIPI (Tactical Information Processing and Interpretation) to develop a system to provide military commanders faster and better battlefield information.

Application of automatic test equipment built by Northrop for the Navy's Polaris missile program was extended to certain Navy surface ships and the Navy's Poseidon program during the year. The surface ship application, called TEAMS, for Tactical Evaluation and Monitoring Systems, resulted in a $7,323,000 contract from BuShips. It called for design, production, and installation of the checkout system aboard 26 of the Navy's new 1052-class antisubmarine warfare destroyer escorts.

Work neared completion during the year on star-tracking equipment to be part of navigation systems aboard range tracking ships for the Apollo moon program. A major optical development proved out during the year was Northrop's ALOTS (Airborne Lightweight Optical Tracking System) which tracks and photographs missiles and spacecraft from an airplane during early stages of the space vehicle's flight. In related electronics areas, Northrop continued its development of ships' inertial navigation systems, voice warning and monitoring systems, and other optical and tracking systems.

Northrop spacecraft landing systems continued their unblemished record during 1966 by returning 10 Gemini astronauts safely to earth. These advanced parachute systems, and those for the Mercury program, traveled more than 14,500,000 miles in five years, and brought back every one of America's space pioneers. Work on the earth landing system for the 3-man Apollo moon spacecraft continued during 1966 as these 3-parachute systems exhibited their reliability on early flights of the program.

Included in Northrop's space activity was the company's work with NASA on test flights of its 2 wingless lifting body vehicles. The M2-F2 was flown more than a dozen times in the summer and fall and then fitted with rocket motors for more advanced, boosted flights. The second of the 2 unique gliders built under joint development and production programs with NASA, which conceived the basic designs, is the HL-10. It was being readied for test flights later in the year.

Northrop Space Laboratories in Hawthorne, California, was awarded a $981,000 contract from the USAF Office of Aerospace Research for a third OV2 research satellite. Known as the OV2-5, it will be launched in the same manner as its predecessor, as a "bonus" payload on a development flight of a Martin Titan III-C space booster. The OV2-5 will be put into a synchronous orbit at 19,323 miles altitude to gather data on solar effects in deep space.

In other space activity Northrop was working on portions of the Mariner vehicle to be launched to Mars in 1969. The work, being done for Caltech's Jet Propulsion Laboratory, included design and construction of the spacecraft structure and mechanical subsystems. During 1966 Northrop increased its space design and development and its research work in both physical and life sciences.

The company was studying methods of protecting men and equipment against several forms of radiation in space. It was developing, under contract to NASA, a hand-held drill for use in exploring the moon's surface. Northrop was also involved in several important support operations at NASA facilities at Huntsville, and Edwards AFB. In a joint venture with the Houston firm of Brown & Root, Northrop was performing all Operations and Maintenance Support Services for the Manned Spacecraft Center.

Expansion of the company's ordnance systems and weapons work during 1966 represented the maturing of research and development carried on at Northrop for a number of years. Typical is a contract for more than $5,000,000 worth of ground handling equipment and airframe components for Hawk surface-to-air missiles to be supplied by Raytheon to the government of Saudi Arabia. Northrop produced Hawk components and subsystems as a subcontractor to Raytheon for many years. Under the new contract Northrop was manufacturing airframes, launchers, loaders, missile wings, elevons, and hydraulic actuators for the missile system at its Nortronics Division facility in Anaheim, California.

A significant increase in orders by the company's subsidiary in Asheville, North Carolina, was received during the year. Work being done at Northrop Carolina included development and production of flares for nighttime illumination of battle areas, underwater demolition kits, rockets, and chemical warfare products. The subsidiary also developed and, through hundreds of test firings, proved the nation's first fully controllable, solid-propellant rocket motor. The device has applications in the nation's space program as well as in warfare. Northrop Carolina also developed a small self-consuming rocket motor for use above populated areas.

PACIFIC AIRMOTIVE CORPORATION

At the close of the 1966 9-month period, Pacific Airmotive Corporation reported a 44 percent increase in both sales and profits over the same period in 1965.

A third Cessna aircraft distributorship was added to PAC's corporate structure during 1966 with the purchase of the assets of Wood Air, Inc., Phoenix, Arizona. A new organization, Arinada Aircraft, was formed and the state of Arizona and Clark County, Nevada, now augment the territories of California, western Nevada and Baja California already served by PAC's subsidiaries Business Aircraft Distributors and Airflite, Inc.

Over 900 new Cessna aircraft were purchased by Pacific Airmotive in 1966 for distribution to the 64 dealers in the company's territory.

A $10,000,000-plus contract was received by Pacific Airmotive from Allison Division of General Motors Corporation to convert North Central Airlines' fleet of Convair 340/440 piston-powered aircraft to Allison turboprop power. The contract provided PAC's Aircraft Division with Allison-Convair conversion work up to the last quarter of 1968, at a level of 4 conversions per month. In addition, a contract to perform 8 Allison-Convair conversions for Lake Central Airlines was awarded to the division.

As the exclusive conversion agency for the Allison-Convair program, Pacific Airmotive delivered 26 conversions to various airlines, corporate customers and the Air Force during 1966. A total of 82 conversions have been completed since the program's inception in 1958 when PAC engineered, flight tested and certified the modification.

FAA certification of the PAC rain repellent system for the Sabreliner was received in July. Pacific Airmotive designs, manufactures and installs the aircraft windshield rain repellent systems under an exclusive license to The Boeing Company. Airlines ordering systems installed on their fleets in 1966 included Eastern, Delta, Swiss Air, Frontier, American, Aloha, SAS, Alitalia, Overseas National, U.T.A., Pan American, Ethiopian and Cathay Pacific. In addition to the Sabreliner, PAC-designed systems are certificated for Convair 240/340/440/580/880/990, DC-6/7/8, Jetstar, Fan Jet Falcon, BAC-111, DH-125, Gulfstream and Electra aircraft.

Twenty bare hull Fan Jet Falcons, equipped with temporary navigation and communications systems, were ferried across the Atlantic from the Avions Marcel Dassault plant near Bordeaux to PAC's Aircraft Division in Burbank, where the aircraft were completed by the installation of customer-specified electronics and interiors. Five additional Falcons received other PAC post-factory installations and modifications during the year. Pacific Airmotive is sales agent for the Falcon in the U.S. under agreement with Pan American World Airways.

PAC's entry into the jet-powered aircraft field, the Turboprop Tradewind, received FAA certification in May. Completely remanufactured around the proven Twin Beech airframe, the Turboprop Tradewind is a 7- to 13-place aircraft powered by 2 Pratt & Whitney Aircraft PT6A-20 turboprop engines, rated at 579 equivalent shaft horsepower each.

PAC's turboprop Tradewind, a remanufactured airplane engineered around the Twin Beech airframe, was certificated in May.

An agreement was signed by Pacific Airmotive to distribute the general aviation Trophy Line of avionics products manufactured by the Radio Division of The Bendix Corporation. The Trophy Line includes 5 communications, navigation and air traffic control systems. Other new distributor agreements with Mitchell Industries, manufacturers of the new Century Series autopilots, and the Battery

Division of General Electric Company were consummated during the year.

In August, Trans International Airlines ordered initial provisioning of spare parts for their DC-8 fleet from the Aviation Products Division.

Pacific Airmotive developed a program tailored for regional and local carriers in which PAC will lease engines to meet emergency requirements, saving the carrier the cost of maintaining its own spare engines. PAC ordered 6 JT8D engines for use in customer DC-9, 727 and 737 aircraft. The Engine Division's JT8D program also included maintenance kits suitable for routine line station work and kits for heavier maintenance.

A long-term engine service contract was signed with Continental Air Lines providing for repair and overhaul service of Continental's entire jet fleet. Other exclusive, long-term overhaul contracts were awarded PAC by Syrian Arab Airlines, Hawaiian Airlines, Olympic Airways, Bonanza Air Lines and Wardair Canada Ltd. Standby contracts were signed with Western Air Lines, Seaboard World Airlines, Trans International Airlines, World Airways, Pacific Southwest Airlines, Qantas Empire Airways, The Flying Tiger Line and Frontier Airlines.

The Engine Division received a contract from North American Aviation for accessory overhaul and repair for the Air Force J57 engine overhaul program.

With the addition of an avionics maintenance and service department, PAC's east coast aircraft maintenance base at Westchester County Airport, White Plains, New York, was expanded during the year. The base provides service support to all types of business aircraft.

PHILCO-FORD CORPORATION

AERONUTRONIC DIVISION

Philco-Ford Corporation's Aeronutronic Division, Newport Beach, California, marked 1966 as one of the most successful in the division's 11-year history. At year-end, employment had reached an all-time high of 5,300 persons working on well over 100 prime contracts with the government's space and defense agencies.

Change was a major factor at Aeronutronic during 1966.

On the corporate level, Philco Corporation became Philco-Ford Corporation in October. The announcement was made at a press conference held by Ford Motor Company Board Chairman Henry Ford II, and Philco-Ford President and Chief Executive Officer Robert O. Fickes.

Earlier, Philco-Ford established its 11th division, the Space and Re-entry Systems Division. Aeronutronic's Re-entry and Space Operation and the

Employment reached an all-time high at the Newport Beach, California, facility of Aeronutronic Division of Philco-Ford.

company's WDL Division's Space Vehicle Operation were integrated to form the new division. Established in 1956, Aeronutronic is engaged in the manufacture of weapons systems, weapons defense systems, advanced radar and tactical reconnaissance systems, propulsion products, and research and development of advanced defense and tactical weapons systems.

Production of the Army's Shillelagh antiarmor guided missile system and the Chaparral air defense guided missile system continued as Aeronutronic's major efforts in national defense. Production of Shillelagh at a government-owned manufacturing plant at Lawndale, California, began in late December of 1965 with the award of a $72,800,000 contract. During April 1966, the Army awarded Aeronutronic a $6,400,000 contract for initial tooling and production of the Chaparral system.

Shillelagh is an extremely accurate fully guided tactical missile and the main armament on the General Sheridan armored reconnaissance airborne assault vehicle. Aeronutronic was also adapting the Shillelagh system to the M60, America's principle tank, and the missile was scheduled to arm the joint U.S.-Federal Republic of Germany (FRG) Main Battle Tank. The U.S.-FRG Main Battle Tank will be operational in the early 1970's.

Shillelagh, which successfully completed stringent testing at 3 Army sites across the nation during 1966, was awarded a Type Standard A Classification by the Army Materiel Command in mid-year. The Type Standard A Classification is given to Army material items determined to be the most advanced and satisfactory to fill a given Army need.

Chaparral is a ground-to-air missile system utilizing the Sidewinder 1C air-to-air missile system in a ground-to-air configuration; during 1966 it was in production at Aeronutronic's Anaheim manufacturing plant. Chaparral is 1 of 2 major weapons systems being produced by the Army to provide field commanders with low and medium air defense in forward battle areas as part of newly organized Air Defense Battalions. In addition to Chaparral, the new battalions will be equipped with the Vulcan, a 20 millimeter automatic gun.

Another major defense business area at Aeronutronic during the year was the Ordnance and Electromechanical Operation, responsible for a wide variety of defense products including high strength armor, automatic grenade launchers and cannons and ballistic missile reaction control valves.

The Operation was engaged in the production of a high strength steel armor, mounted aboard the Army's CH47A "Chinook" helicopters by an Aeronutronic team sent to Viet Nam in early 1966. Another major delivery of the armor was made by Aeronutronic to the Navy for installation on River Patrol Boats in Viet Nam.

The armor, manufactured under a patented Ford Motor Company process called Ausform, shatters bullets on impact with an extremely hard front face and absorbs the impact shock with a highly tensile back face.

Development and production of automatic grenade launchers and cannons also became a major product area during 1966. Under contract to the Army Weapons Command, Aeronutronic was producing M75 grenade launchers and barrels, XM129 grenade launchers and the XM140, a 30 millimeter automatic cannon. The 3 weapons were being produced for installation aboard tactical aircraft including helicopters, and they can be mounted aboard other vehicles including river patrol boats and troop and personnel carriers, or can be produced in a ground mount configuration for tactical ground force use. Aeronutronic completed delivery of first production models of M75 to the Weapons Command in late 1966 and also delivered XM129 and XM140 development models for field test.

Ordnance and Electromechanical Operation was in production of hot gas reaction control valves operational in the Minuteman intercontinental ballistic missile system. The valves operate by emitting hot gases which prevent roll of the second stage rocket engine of the Minuteman II. Aeronutronic, in late 1966, also received contracts for prototype development and evaluation of hot gas reaction control valves for Poseidon, the Navy's new fleet ballistic missile system scheduled to supplement the Polaris A-3.

Aeronutronic's Radar and Intelligence Operation completed a major centralization, and at year-end it was fully housed at its 39,000-square-foot Santa Ana Engineering Facility in Santa Ana, California.

Radar and Intelligence Operation conducted business with a wide variety of governmental and private customers in the fields of advanced radar, reconnaissance systems and advanced sensors. One of its programs included development of advanced radar systems for oblique angle reconnaissance, making possible the photography of large areas without over-flight. Advanced cryogenics, data display systems, intelligence processing, advanced electronics, and image computing systems were among a wide variety of programs under way within the Operation.

Aeronutronic also maintained a strong supporting research capability during 1966. Its Applied Research Laboratories conducted applied research in materials structures, bio-sciences, solid state physics, gas dynamics, radiation physics, energy conversion, data processing and communications, advanced weapons guidance systems and a wide variety of additional programs for government space and defense agencies.

PIPER AIRCRAFT CORPORATION

Piper Aircraft Corporation increased both dollar and unit volume in 1966, although both fell below expectation due to a 7-week strike at the beginning of the sales year. An extensive recruiting program raised the employee level to an all-time high as production space doubled at Vero Beach and nearly 150,000 square feet were added to the Lock Haven plant.

W. T. Piper, Sr., President and Chairman of the Board, continued his efforts to increase production, service facilities and continuing programs of education for the public and people in the industry. Piper continued its participation with U.S. Jaycees in the Piper Airpark Program initiated several years ago. The program advocates landing facilities in every community and states that the United States needs at least 50,000 airports.

Piper's sales of over $80,000,000 represented an increase of 50 percent over 1964 and 18 percent over sales of $68,000,000 in 1965. Barring a general setback in the national economy, the company anticipated that 1967 would see a sales increase exceeding either 1965 or 1966.

At year-end, total investment in property, plants, machinery and equipment approximated $15,000,-000, compared to $9,000,000 in 1964. Additional machinery and equipment on order for 1967 delivery were valued at $1,150,000.

Floor area in Piper's Lock Haven, Pennsylvania, and Vero Beach, Florida, plants totaled nearly 1,-200,000 square feet, up from 800,000 square feet in 1964. With the number of employees having risen in that period from 2,900 to more than 4,300, the 2 plants had ample floor space, equipment and manpower to produce a minimum of $144,000,000 worth of aircraft annually.

In line with the sales emphasis on the Piper Quality Dealer, the development group was concentrating on a continually improved line of products with a staff of nearly 300 assigned exclusively to engineering and experimental work. To cover the market adequately, Piper was developing more and better models from the bottom of its intended category, the 2- to 4- place Cherokee 140, to the top, the turbine-powered Navajo.

The new Piper Navajo, which went into production in 300 horsepower normally aspirated and 310 horsepower turbocharged versions, is a 6- to 8-place twin-engine plane with a top speed of 260 miles per hour. Suggested price of the Navajo 300 is $89,500. The Turbo Navajo, which includes oxygen, is $97,390. Later the Navajo will be available in a pressurized turbocharged piston engine and turbine powered pressurized model.

Piper was continuing its policy of no annual model changes, with the new developments being worked into the assembly line as they are perfected.

Piper officials forecast an average annual market increase of 14 percent for the general aviation industry for the next 10 years. General aviation has historically done better than the total gross national product, which has averaged only 3.6 percent increase in the past 10 years.

Piper expected to deliver 6,000 new aircraft in 1967, a 39 percent increase over the 4,319 aircraft delivered in 1966. The increase will be reflected throughout the entire Piper line. Piper has dominated the twin-engine aircraft market ever since it introduced its first twin, the Apache, in 1954.

Cherokee production at Piper's Vero Beach, Florida, plant continued to show remarkable growth. Starting with an initial production of 83 Cherokees in 1962, its first year, the Vero Beach facility had produced more than 7,000 aircraft by year-end and expected to produce 4,019 in 1967.

Piper's international sales reflected consistently increased penetration in overseas markets to the extent that the export of Piper aircraft and accessories more than doubled from 1964-1966. In 1966, Piper delivered a total of 969 aircraft overseas and spare parts and accessories exported in support of Piper planes brought the export sales figure to nearly 25 percent of Piper total sales. The company expected to deliver some 1,400 aircraft overseas in 1967.

In 1966, Piper announced a Work and Fly program for high school graduates. The program was designed to help Piper acquire needed production workers and to help provide trained pilots for the industry. The program proved extremely popular and by year-end Piper had 20 aircraft and 15 instructors at its 2 plants to handle its company flight training program. A total of nearly 500 employees were flying. At Lock Haven, Piper maintained a fleet of 11 aircraft and 7 flight instructors, and at Vero Beach there were 9 aircraft and 8 flight instructors. The only problem encountered was obtaining Cherokees for training. The demand for the popular, all-metal, low-wing model was so great that Piper was unable to buy any of its own new aircraft for the program and had to purchase used Cherokees on the open market.

Piper aircraft again figured prominently in record and race efforts. The Powder Puff Derby and Women's International Air Races were won for the fourth straight year. Bernice Steadman of Flint, Michigan, flew a Comanche 260B to victory in the Powder Puff which saw Piper aircraft taking 8 out of the first 10 places.

June Douglas repeated her 1965 victory in the International flying a Cherokee both years. Four out of the first 5 places in the International were taken by Piper.

Fran Bera, 7-time winner of the Powder Puff Derby set her sights on a different type record and set an altitude record in the Turbo Aztec of more than 40,000 feet.

Shelia Scott, a former British actress who has won a number of European races with Comanches, set an around the world record in the Comanche B, traveling more than 31,000 miles.

Max Conrad circled the globe in a Twin Comanche to help promote interest in the 1967 World's Fair, Expo '67.

Piper made advertising news in 1966 when it placed, at its own cost, local advertising in newspapers in local communities having Piper dealers. The program concentrated on the $5 Special Introductory Flight Lesson which Piper pioneered several years ago and which has since been adopted by other companies in the industry. The program was so successful that it will be continued in 1967.

Continued emphasis on quality dealers and quality service was helping the field organization build stronger organizations. In addition to service schools already in operation, Piper instituted an AutoPilot Specialist School at Lock Haven.

On the international scene, Indianapolis 500 winner Graham Hill, moved into a Piper Aztec to join countryman Jim Clark, the 1965 winner.

PNEUMO DYNAMICS CORPORATION

Military and commercial aerospace activities in 1966 continued to set new records in terms of new business booked at Pneumo Dynamics' Cleveland Pneumatic Tool (CPT) subsidiary and its National Water Lift (NWL) Division.

Receipt of an award by CPT to help design and to manufacture the nose and main landing gear for the Boeing 747 jet airliner was a major development for the world's largest designer and producer of landing gears for commercial and military aircraft.

Follow-on orders for the Douglas Aircraft Company's DC-8 and DC-9 maintained CPT's record of supplying landing gears for every model of the Douglas transport series since the DC-4. A quantity of landing gears was produced for the Boeing 707 and the new Boeing 737 twin-jet aircraft. CPT has supplied landing gears for nearly all variations of the Boeing 707 transport. The subsidiary was also producing landing gears for the twin-engine Grumman Gulfstream II.

Production of aileron flight control servo assemblies for the Boeing 727 and the DC-9 was continued at NWL facilities. This Pneumo division also designed and developed the aileron and elevator primary flight control servo actuators for the Boeing 737. In addition, flight controls were being supplied for the C-130 and C-141 series, and production was continued on high temperature jet engine components for various models of General Electric's J79, J85/15, J93, and Pratt and Whitney Aircraft's TF30 jet engines.

Other commercial aircraft for which Pneumo furnished systems, devices or components included the Convair 880 and 990, Lockheed JetStar, and General Electric CJ-805 and GE-1/4 jet engines.

In military aircraft, CPT was supplying components or complete landing gear for the Ling-Temco Vought F-8 D/E Crusader, the Lockheed C-141A StarLifter, the Grumman A-6A, E-2A, C-2A, and S-2E, the North American XB-70, T-2B, and OV-10A, and the McDonnell F-4B, C, J, K and M. The subsidiary was also producing wing flap tracks for the Lockheed C-141A, and spare parts for nearly 30 models of military aircraft.

Pneumo was also supplying components for the Boeing B-52, KC-135, Boeing Vertol CH-46A, Cessna T-37, De Haviland CV7A, Fairchild C-123, General Dynamics F-111, Kaman H-43, Republic F-105, Sikorsky CH-53A.

Quantity production of NWL's aircraft weight and balance system (STOW) was initiated under an Air Force contract to retrofit all C-130 aircraft. STOW, which measures an aircraft's gross weight and center of gravity and is an integral part of the aircraft, was developed at NWL's Instrumentation and Control Operation in Grand Rapids, Michigan. Plant expansion which tripled I&C's floor space was completed late in the year.

NWL was supplying 12 separate components for the Gemini space capsule. It was participating in the Apollo, Surveyor, and Lunar Orbiter programs; the Apollo program will utilize over 35 NWL components. Landing gear shock absorbers for the Surveyor moon probe were designed and manufactured by NWL. Surveyor's NWL-produced shock struts were pictured in the first photograph sent back from the moon. The Dual Axis Rate Transducer (DART), developed and produced by Instrumentation and Control was further developed for future missile and space applications.

Pneumo supplied systems and components for AIM-47A, AQM-37A, Gemini-Titan, Transtage, LM (Lunar Module), MMU (Modular Maneuvering Unit), Polaris, Poseidon, Sprint, and Titan II.

CPT has become a major producer of both plastic and metal nozzles for the Minuteman II and Scout programs. Production of large fuel line components for the Saturn Booster, and structural rings for the Agena and Apollo projects was continued at CPT.

In addition to facilities expansion for STOW at NWL's Grand Rapids plant, Cleveland Pneumatic acquired additional aerospace production machine tools, and committed for a new Engineering Test Center which the company believed would be the most advanced landing gear functional test facility in the world.

RADIO CORPORATION OF AMERICA
DEFENSE ELECTRONIC PRODUCTS

The Radio Corporation of America in 1966 maintained its position as one of the world's largest and 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 5 separate divisions specializing in a variety of areas vital to national defense and space technology.

Aerospace Systems Division

The Aerospace Systems Division at Burlington, Massachusetts, through its diversified talents and comprehensive systems engineering capabilities, has contributed significantly to the state-of-the-art by means of government- and company-sponsored studies and field support of major aerospace systems and reliable products.

During 1966, ASD, under contract to Grumman, was working on the Rendezvous Radar, Transponder, and Landing Radar for the Lunar Module vehicle. ASD was also building under Grumman contract 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 controls the descent engine of LM throughout the power descent to the moon, turning the engine on and off and controlling the intensity and direction of its thrust. Its mission complete with the touchdown on the moon, the DECA will be left behind with the remainder of the LM descent stage.

ASD was under contract to the Army Missile Command for the Land Combat Support System (LCSS) program. This includes all studies, investigations, design, engineering fabrication and modifications of test equipment which will provide complete field maintenance capability for the Tow, Lance, and Shillelagh Missile Systems. Depot Installation Maintenance Automatic Test Equipment (DIMATE), developed by RCA for the Army Electronics Command, and installed at Tobyhanna, Pennsylvania, has proven the capability of automatic test systems to troubleshoot assemblies of Army electronic systems. It has reduced conventional electronic testing time by as much as 75 percent. A second DIMATE system was being built for the Army for installation at Sacramento, California.

ASD built and delivered the AN/TSQ-47 system for the Air Force. The AN/TSQ-47 is an Air Traffic Control/Communications System designed for use by the Air Force Communications Service Mobile Squadrons to support advanced air bases in a tactical employment, newly acquired air bases under combat conditions, temporary replacement or supplement to a fixed facility, and training and mobility exercises.

The AN/APN-155 Low Level Altimeter was developed under contract for McDonnell Company and qualified for use in the F-4 high-performance jet aircraft. It has been a highly successful solid-state equipment, put into production in 1965, and its excellent acceptance resulted in 1966 follow-on orders for additional units.

The Aerospace System Division is currently conducting research programs and is delivering products using laser devices. ASD performed a Laser Design Concept Study for the U.S. Navy. In this study, a high-energy, short-pulse laser system employing frustrated total internal reflection isolators was investigated. This resulted in a high-power missile-tracking laser system. ASD was awarded a contract by the U.S. Army for the design, fabrication, and testing of a quantity of Laser Rangefinder systems. Under contract to the Naval Air Development Center, ASD developed a Blue-Green Laser Transceiver Unit for use under water.

ASD is doing additional development work for the Air Force on the AN/FSR-2 Optical Tracking System to further refine this space tracker.

Astro-Electronics Division

The Astro-Electronics Division, also known as the RCA Space Center, has achieved an excellent reputation for the design and fabrication of long-life unmanned spacecraft and spacecraft systems. Located near Princeton, New Jersey, this division is a leader in the development of weather satellites, communications satellites, scientific satellites, lunar and interplanetary space systems and subsystems. AED has set outstanding records for spacecraft performance in orbit. The actual lives of more than 30 AED-built spacecraft all exceeded mission requirements. Operational life for these spacecraft totals more than 5,000 days, equal to 13 years of useful activity in space and a reliability standard unmatched in the industry. Spacecraft built by AED include 10 TIROS experimental and semi-operational weather satellites, 3 ESSA operational weather satellites, 2 Relay communications satellites, a SERT (Space Electric Rocket Test) space platform, and a number of classified spacecraft.

Engineering model of the Lunar Module antenna is tested in a vacuum chamber at RCA Space Center.

For the 1966 Lunar Orbiter program, AED built the communications and power supply systems, under contract to The Boeing Company. AED also assisted Boeing in spacecraft design, systems engineering, environmental testing, and on-site technical support.

The division also supplied major systems for the Nimbus weather satellites. This program, with NASA's Goddard Space Flight Center acting as manager and prime contractor, is concerned with the second generation of experimental weather satellites. AED is responsible for a major part of the Nimbus hardware, providing 2 different television subsystems, video and infrared tape recorders, solar cell power supplies, and video ground station equipment. All of the Nimbus spacecraft systems built by AED operated successfully on the first two satellites.

Two Relay communications satellites, built at the RCA Space Center, completed more than 5 years of operational service. The division was engaged in several studies for both the Communications Satellite Corporation and NASA. These include advanced communications satellites, voice broadcast satellites, and deep space communications satellites.

Developmental activities of the division covered a wide variety of spacecraft and spacecraft systems. These included unmanned earth natural resources satellites, ultra-high resolution television sensors, infrared sensors, dielectric tape cameras, advanced data storage and processing systems for spacecraft, spacecraft stabilization systems, spacecraft antennas, solar and other power supplies and system requirements for a world weather watch.

AED also made contributions to the manned spacecraft program. Under contract to North American Aviation, a miniature, lightweight television camera was designed and built for use in the Apollo Command Module during the early earth-orbit flight tests. The 4½-pound camera is the first to make extensive use of integrated circuits. The division also built a TV scan-converter for use with its Apollo camera and performed studies and subsystem testing for RCA's portion of the Lunar Module. In addition, AED undertook studies for the manned spaceflight program in the areas of color television and two types of power supplies.

During 1966 Astro-Electronics Division played a key role in 5 important spacecraft launches. The ESSA I and ESSA II operational weather satellites, built by AED for NASA and the Environmental Science Services Administration, were successfully placed in orbit on February 3 and February 28. These satellites represented the world's first global operational satellite system. On October 2, a third ESSA satellite was successfully orbited to provide additional weather coverage capability. ESSA III carried a pair of RCA Advanced Vidicon Cameras on an operational mission for the first time. On August 10 and November 6, the first 2 Lunar Orbiters, carrying RCA communications and power supply subsystems, were launched and subsequently placed on station around the moon.

As the Astro-Electronics Division looked toward the future, it planned to pay increased attention to developing those spacecraft and space systems which return practical benefits to the nation. Continued development and improvement in weather, natural resources, and communications satellites were planned, along with new technology that will lead to greater scientific knowledge of the earth, planets, and stars.

Communications Systems Division

The principal facilities of the Communications System Division (CSD) are located in Camden, New Jersey; New York City; and Tucson, Arizona. These comprehensive facilities house a complete engineering organization capable of effective project management and comprehensive systems and product engineering through all phases of design, development, and manufacturing.

The headquarters facilities of CSD in Camden during 1966 employed over 6,300 engineers, scientists, technicians, and manufacturing personnel in a fully-integrated design, development, and fabrication facility devoted to handling a wide variety of defense and space electronics work. Located on the Delaware River in the Port of Philadelphia, CSD is immediately accessible to trucks, rail, or sea transportation. Housed in several buildings with a combined floor space of 1,400,000 square feet, these facilities contain the engineering, manufacturing, support and administrative activities of the Division. Specialized engineering laboratories of CSD in Camden include: Light Communications Equipment, Heavy Communications Equipment, Digital Communications Equipment, Recording and Television Equipment, Command and Control, Advanced Communications Technology and Communications Systems.

CSD's Camden Manufacturing Plant was operating several unique production facilities for space age electronics. Among the most important of these is the CSD "White Room" which is utilized for the production of ultra-reliable electronic equipment for such programs as Minuteman. This facility consists of a 20,000-square-foot area where temperature and humidity are rigidly controlled and where the dust content is kept at an extremely low level. Another unique Camden manufacturing capability is the Multilayer Printed Circuit facility. The Camden Plant also has an advanced full-automated manufacturing facility.

The Communications Systems Laboratory located at 75 Varick Street in New York City employed, during the year, 186 scientists, engineers and technicians. Total floor space is 50,000 square feet. Charged with the responsibility of devising new concepts in communication techniques and systems, the laboratory's function is to provide additional technical strength supporting the general operations of CSD.

The Tucson Plant facility is located on a 100 acre site in Vail, Arizona near Tucson. Over 17,500 square feet of floor space was devoted to 1966 manufacturing and engineering support operations.

CSD was working on a number of large-scale military programs involving diverse skills and capabilities. A salient example of production competence was demonstrated by the delivery of over 3,000 racks of equipment for the Minuteman Sensitive Information and Support Information Network. This prime equipment and its associated spares were delivered on or ahead of schedule.

CSD was also engaged in programs for the design, development, and production of communications for Government applications including communications techniques and concepts. This large and diversified area encompasses the development and production of communications transmission and terminal equipment and systems for submarine, shipboard, manpack, vehicular, fixed plant, aircraft, missile, space/ground, and space vehicle applications.

The Radio Corporation of America has long been a leader in advanced tactical military communications. Some of the equipment being supplied to the U.S. government during the year include:

AN/PRC-25, a sophisticated tactical FM radio set for the Army and several international customers. It is a battery-operated manpack FM receiver-transmitter which provides 2-way voice communication over distances up to 10 miles.

AN/PRC-62, an advanced microelectronic radio set, a single sideband high frequency unit designed for use by combat and combat support units. It is capable of being transported and operated by a single man, and consists of a receiver-transmitter unit with a lightweight rechargeable battery power source, antenna and headset.

AN/ARR-69, developed under the sponsorship of the Navy as a completely solid state auxiliary ultra-high frequency radio receiver.

AN/ARC-108, an ultra-high frequency voice receiver-transmitter designed to provide auxiliary or emergency communications in military aircraft. The set mounts in the aircraft console in a space normally occupied by a control box alone. The low power drain, excellent sensitivity, and moderate power output make it especially applicable as an emergency set.

AN/ARC-97, designed for the Navy, a completely contained automatic airborne radio repeater set which extends the range of 2-way ultra-high frequency communications beyond line of sight.

AN/ARC-104, a microelectronics high frequency single sideband radio set for long range communications, developed under contract to the Navy. The design of this advanced integrated electronics set features maximum use of the most advanced microcircuits and techniques.

CSD was also very active in supplying heavy communications equipment for U.S. military services, including the following:

AN/TRC-97/97A, being supplied to both the Marine Corps and the Air Force under a major contract with the Navy. It is a complete tactical communications facility suitable for multichannel voice, teletype or data traffic with high reliability and performance. The equipment is designed for unattended operation and utilizes solid-state circuitry throughout for high reliability and easy maintenance. The system is light weight, compact, and easily transportable. It can be set up for operation in 1 hour by 2 men.

AN/GRC-50, a tactical microwave radio relay set designed and produced for the Army to provide line-of-sight communications in intermediate or forward area military operations.

CSD was serving as a major subcontractor to The Boeing Company for the Minuteman Sensitive Command Network, Status Authentication System, Improved Encoded Launch Enable System, and the Trajectory Accuracy Prediction System. CSD was also providing engineering services and equipment modification to Boeing on the Minuteman Force Modernization Program.

Automatic Digital Network (AUTODIN), a vital link in the Air Force world-wide logistics-data communications network, is the world's largest and most advanced operational data communications system. Under contract to Western Union, RCA-CSD designed, developed, produced, programmed, and installed the automatic digital message-switching and circuit-switching equipments and magnetic tape subscriber terminals for AUTODIN/ComLogNet. The present AUTODIN contract represents the third major enhancement and expansion of that network.

CSD was also involved in several major space communications programs, the most important being:

Apollo communications for which CSD was designing, developing and manufacturing the VHF voice communications equipment. A VHF set consisting of 2 receivers and 2 transmitters was being provided for both the Command Module and the Lunar Module. These equipments provide voice and data communications link between the Lunar Module, the Command Module, and the extra-vehicular astronaut.

Lunar Module Communications Subsystem. CSD, under contract to Grumman Aircraft Engineering Corporation, was supplying the complete Lunar Module Communications Subsystem consisting of S-band transceivers, S-band power amplifiers, VHF transceivers, a signal processor, and the S-band steerable antenna. Major effort on the Lunar Module Communications Integration Program is devoted to interface definition and control, and to detailed testing and performance evaluation of the communications equipment when operating as an integrated subsystem.

Gemini Telemetry Transmitter and Recorder. RCA-CSD provided the telemetry transmitters and recorders used in the Gemini missions.

Space Video Recorder. CSD was developing for NASA a video recorder for possible space applications.

Missile and Surface Radar Division

The Missile and Surface Radar Division (M&SRD) is located on a 433-acre tract at Moorestown, New Jersey, where the highly advanced radar net, BMEWS, was designed, developed and manufactured for installation at 3 widely separated sites in the Western Hemisphere. In 1966, M&SRD built and installed for the Air Force a large tracking radar at the Clear, Alaska, site.

From the installation of the first precision monopulse tracking radar, the XN-1 at Patrick Air Force Base in 1957, M&SRD has designed and produced a family of 71 such radars of ever-increasing sophistication and capability. In 1966, they were installed at locations around the globe, both on land and at sea. The standard RCA AN/FPS-16 and its transportable version, the AN/MPS-25, are precision C-band instrumentation radars 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.

RCA's successful implementation of TRADEX has led to the award of contracts on PRESS by Lincoln Laboratories. These contracts provide 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.

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. Contracts were being awarded for this equipment for both U.S. and 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.

Under the Apollo Re-Entry Ships Program, M&SRD developed the first precision tracking radar to use integrated circuits for all essential electronic functions—CAPRI. This instrument will have the general capability of the AN/FPS-16 radar, except that the user will have a number of options in the pedestal and antenna subsystems. The resultant savings in space, weight and power make it easily adaptable for installation on board ship, in a trailer or in small one-story buildings.

The first major Real Time Ground Support System for space missions to use integrated circuits was installed on the Eastern Test Range in 1966 by M&SRD. It consisted of four ground stations at Antigua Island, Ascension Island, Grand Bahama Island and Pretoria, South Africa, and a control station at Merritt Island Launch Annex near Cape Kennedy. The system will enable flight scientists to select and call up various telemetry data from space vehicles while they are in flight down the Eastern Test Range.

M&SRD developed the first truly lightweight radar for use by combat infantrymen in detecting moving targets and directing small arms fire in all weather and visibility conditions. It can detect man-sized targets at ranges up to 500 meters, defining range within a few meters and angle within a few degrees. A communication mode is also provided enabling 2 units to set up a secure voice link in ranges to 1,000 meters. The RCA Two-Pound Radar is an all solid state system, using the latest in integrated circuits and miniature electronics.

A 2-part program for advancing the effectiveness of air defense cover for tactical naval units was under way at M&SRD. In one of these, a far-reaching evaluation of existing equipment was made and a significant program of improvements including new systems integration concepts and hardware put into effect. The other, a long-range study, recommended state-of-the-art improvements in both components and system integration to provide increased effectiveness for naval air defense in the future.

To enable astronauts on the moon to communicate with earth, a 10-foot parabolic antenna weighing only a couple of pounds was needed. To meet this specification, a completely collapsible erected structure of metallized cloth was developed. It packs into a cylinder only 3 feet long and 10 inches in diameter and erects automatically with no assistance from the operator, yet its contours are within the very fine tolerances needed to direct a beam of energy efficiently from the moon to the earth.

West Coast Division

The West Coast Division, established in 1965, has 2 facilities—one in Van Nuys, the other, the Aviation Equipment Department, in West Los Angeles, California. The Van Nuys facility of WCD has been the leader in the development of special purpose computers, random access memories, displays, electronic countermeasure equipment, and secure communication systems since 1960.

One of the major products of the Van Nuys facility is the Saturn Ground Computer System for NASA's Marshall Space Flight Center. This system provides real-time control, checkout, and monitoring of digital and analog data from the Saturn systems. Major equipments in the data processing system are the 110A computer and the Saturn IODC display, which provides a visual presentation of alphanumeric and symbolic data in tabular and graphic formats. Other major special purpose data processing programs at WCD have included automatic checkout and launch control equipments for the first operational intercontinental ballistic missile and data processors and displays for the Ballistic Missile Early Warning System.

During 1966, the Division was engaged in 2 other data processing fields: message switching systems and radar data processing. United Airline's Electronic Switching System, installed in 1965, accommodates the airline's total teletype message traffic. It automatically processes and distributes all received teletype message traffic, including "interline" messages exchanged with other airlines. It distributes flight plan messages and forwards output traffic of the reservation system. A similar system, AIRCON, was being designed and manufactured for RCA Communications, Inc.

The 4100 Series computers, key equipments in the message switching system, are also used for processing radar data on the Atlantic and other missile ranges.

Other major developments in the Information Systems field were displays and random access memories. The Model 3488 and Model 70/568 Mass Memories store approximately 5 billion bits of data. These mass memories are the largest and most economical in terms of cost-per-bit on the market. Design and development of modern drum and trillion-bit memories are also in progress, with protoyptes of each under development.

WCD continued to be the major supplier of displays to RCA's Electronic Data Processing Division. Displays are capable of presenting 480 characters in many different formats. The displays, used for communicating with computer systems, utilize standard 11OV-60 cps power and can be connected to the computers by standard telephone lines. They can be, therefore, situated at any convenient location. The latest displays employ integrated circuits.

Paralleling the Division's working in information storage, retrieval, and processing were its outstanding efforts in Electronic Countermeasures. The Division has been a major developer and supplier of deception-jamming equipments to the Navy. The Electronic Warfare group was engaged during 1966 in engineering and manufacturing programs for Radio Frequency Oscillators and Amplifiers. In addition, the Electronic Warfare and Advanced Systems group was having considerable success in study programs on high density power supplies, the utilization of integrated circuits in ECM programmers and new electronic warfare concepts. The Division was merging its capabilities in ECM and Information Systems to provide full electronic warfare system capability.

The Division was also active in the production of standard fuzes, the development of new fuzes, and such avionics equipments as navigation control panels and distance measuring equipment.

The Aviation Equipment Department is devoted exclusively to the design, development, and manufacture of airborne electronic equipment for commercial aircraft. The leading producer of weather radar, the Department's customers include most of the world's commercial air carriers and many business aircraft owners, operators, and manufacturers. During the year, the Department introduced a lightweight, low-cost weather radar bringing the safety of storm avoidance to the smallest twin-engine aircraft, and it was developing a new generation of weather radars for the upcoming giant jets and supersonic transports. In addition to weather radar, the Aviation Equipment Department was building Distance Measuring Equipment (DME), Air Traffic Control Transponders, including the new AVQ-65 which is suitable for any aircraft operating in the air traffic control environment, and other airborne electronic equipment.

ROCKWELL-STANDARD CORPORATION

AERO COMMANDER AIRCRAFT DIVISIONS

In a number of ways 1966 was a record year for Aero Commander Aircraft Divisions of Rockwell-Standard Corporation.

Flying around the world, Jet Commander N1966J established 21 world speed and distance records. Flying around pylons and over specified courses, the new single engine Aero Commander 200 claimed 4 world speed records and came in first in every racing event which it entered.

Record growth in employment (over 2,000 people), facilities (in excess of 700,000 square feet) and sales volume (over $60,000,000) were the major factors of the most outstanding year of growth ever experienced by Rockwell-Standard's Aircraft Divisions.

Production of the 2 new single engine models, the high wing, 4-place, Aero Commander 100 and low wing, 200 mile-per-hour Aero Commander 200, built steadily forward to capacity at the new 200,000 square foot Aero Commander-Albany Division plant in Georgia.

Further expansion of the Aero Commander line into agricultural aviation was made late in 1965 with the addition of the Texas based Aero Commander-Olney Division, which manufactures the big Snow Commanders. With over a 44-foot wing span, powered by a 600 horsepower engine and capable of carrying over 2 tons of payload, the Snow Commander is the largest ag-plane in production.

The Aero Commander 1966 line included the utility category Aero Commander 500 U; the 11-place Grand and Pressurized Grand Commander; the 290 mile-per-hour propjet Turbo Commander; and the 500 mile-per-hour Jet Commander. During 1966 the Jet Commander was certified to Category VI landing minimums and approved for flight at

45,000-foot altitudes in a continuing program of new certifications for the transport category aircraft.

ROHR CORPORATION

New generations of multi-engine aircraft plus advancing manufacturing technology were major factors in the continuing upward trend in program activity at Rohr Corporation.

The year 1966 was highlighted by substantial expansion of manufacturing facilities and a sizeable boost in the company's engineering work force to keep pace with design and material requirements. The number of trained engineers employed increased 65 percent during the year and a further increase of 40 percent was anticipated in 1967. In manufacturing there was continued emphasis on numerically-controlled machines, with addition of such equipment as a tape-operated 5-axis bridge type milling machine, a 6-axis automatic riveter, and a tape-operated radical draw form stretch machine. Other major equipment installations include an automatic loading system for a 25,000-ton press and a 10-foot boring and drilling machine with a 42-foot horizontal travel, a 13-foot vertical travel and 4-foot horizontal spindle shake.

The company policy of in-plant design and fabrication of some new equipment was continued to assure a higher degree of compatibility with Rohr manufacturing techniques and cost savings.

Capabilities of Rohr's Data Processing Center were strengthened with addition of advanced computer equipment such as the IBM 360-50 large-scale mass storage computer, plus data link to Univac 1107, with application to engineering, scheduling, cost and manufacturing control functions.

Facilities also were expanded to keep pace with the growing activity of the company.

Major areas of expansion included 3 warehouse buildings totaling 143,800 square feet constructed for the company on a lease basis. Construction at corporate headquarters, Chula Vista, California, included 18,200 square feet of additional engineering space. Major additions at the Riverside plant were a 4,000 square-foot X-ray facility for improved quality assurance, a modern cafeteria building and a 12,000 square-foot addition to the metal bonding facility, reflecting growing activity in this phase of operations. A 5,000 square-foot warehouse was completed at the Auburn, Washington, plant. With the increases during 1966, the company at year-end occupied 2,669,409 square feet of floor space on 511 acres of land.

The company's Space Products and Antenna Divisions marked new achievements in their respective fields and in the area of flight Rohr was participating in virtually every major multi-engine transport aircraft program. Aircraft production covered a wide range, with the bulk in engine nacelles and pylons, a basic Rohr specialty. In addition to power plant assemblies, Rohr was producing fuselage sections, stabilizers, elevators, thrust reversers, struts, ailerons, landing gear pods and doors, cargo petal doors, wing-to-body fairings, flight and ground spoilers, wing joint fittings, adhesive bonded structures of brazed stainless steel and honeycomb panels.

Under a letter contract with Boeing, Rohr was proceeding with plans for production of pods and pylons for the big 747 airliner and work also was under way for manufacture of the nacelle and pylon for Lockheed's 700,000-pound airlifter, the C-5A. Engine assemblies were ordered for the Douglas Super Sixty series DC-8's, the DC-9 and the Grumman Gulfstream II business jet.

Production continued on aft fuselage sections for the Boeing 707 and other components for the 720 series commercial transports, the Lockheed C-141 StarLifter military logistics transport, the P3-B Orion sub hunter used by the Navy, the C-130 propjet logistics airlifter and the Jetstar business-military aircraft. Rohr was also producing aft fuselage and empennage components for the Grumman E-2A Hawkeye early warning and intercept control plane and trailing edge panels for the McDonnell F-4B attack plane.

A highlight of 1966 in the Antenna Division was dedication of the big 210 deep space tracking antenna, which Rohr built at the Goldstone Deep Space Station in California's Mojave Desert for Jet Propulsion Laboratory and NASA. The instrument was turned over to JPL, the operating agency for NASA, on April 21.

Two 85-foot high gain antennas that will serve in the worldwide communications satellite network also were erected at Brewster Flat, Washington, and Paumalu, Hawaii. At year-end, the company was completing the last of 6 large Cassegrain Horn reflectors, ground system equipment for the Comsat network. Antenna Division projects also included continued production of microwave relay antennas and completion of a complex testing structure for a classified advanced weapons system.

Rohr's Space Products Division continued to contribute to the Air Force Space Systems Division's feasibility program on flight-weight prototype solid rocket motors.

On January 15, a 1,000,000 pound thrust second stage motor, with Rohr components, was successfully test fired for the Air Force. Rohr provided a 35-foot-long, 156-inch diameter motor case, fabricated from 2 previously fired segmented cases at a savings of more than 50 percent. The re-use procedure gave the Air Force new information on 18 percent nickel maraging steel, an alloy newly adapted to large solid rocket motor use.

Rohr also provided a 156-inch submerged nozzle for a successful test firing of a filament-wound third stage motor developed by Thiokol Chemical Corporation's Wasatch Division in Utah. The year's projects included fabrication of the largest solid-fueled rocket motor manufactured to date. The nozzle was for a 260-inch rocket engine developed by Aerojet General Corporation.

In other product areas, the division was selected to design and fabricate 3 deep-submergence fiberglass reinforced plastic pressure vessels of advanced geometric design for the Navy's Electronics Laboratory in San Diego.

RYAN AERONAUTICAL COMPANY

The spectacular soft landing of Surveyor I on the moon symbolized Ryan Aeronautical Company's emergence in 1966 as a major source of Space Age electronics systems as well as target drone systems while the San Diego firm continued development of advanced concepts in vertical take-off aircraft.

Perfect functioning of the Ryan Radar Altimeter and Velocity Sensor System enabled the unmanned spacecraft to touchdown so gently that all instruments remained intact for mission experiments. The

Ryan officials inspect company-built Radar Altimeter Doppler Velocity Sensor System, a key element in Surveyor soft-landings.

Ryan system provides guidance to the flight control and vernier engine systems, thereby governing orientation and rate of descent.

As the first Surveyor reached the moon, Ryan accelerated development of another electronic marvel, the radar landing system that will guide the Apollo Lunar Module to the lunar surface with two American astronauts before the end of this decade. The first flight configuration model was delivered early in 1966 for integration into the prototype vehicle produced by Grumman Aircraft Engineering Corporation. In mid-year, the first flight test model was completed and tested in a Navy/NASA helicopter and a T-33 jet trainer "rehearsing" the descent, hover, and landing of the Lunar Module. And before year-end, the first system for actual flight in space—aboard Lunar Module I, an unmanned earth-orbiting mission—was delivered.

Meanwhile, testing of the Ryan/Army XV-5A fan-in-wing Vertifan research V/STOL entered a new phase at Edwards Air Force Base, California, with pilots of all 3 military services performing flight evaluations. Nearly 130 flight hours in 336 flights were logged to demonstrate the plane's high performance jet capability in excess of 500 miles an hour, combined with helicopter-like agility, and ground erosion and environmental tests were successfully conducted in varying conditions of terrain, including sod, alfalfa fields, plowed dirt, a parachute drop zone, a standard Army "membrane," and the unprepared desert floor.

The XV-5A's performance was further enhanced by a 4-month modification program, followed by tests that demonstrated a significant new potential use by the Navy and Air Force, for rescue of downed pilots in ocean and jungle areas, where speed of approach and getaway is paramount.

As additional follow-on orders assured production into 1968 of Ryan's subsonic Firebee, a new generation of the free world's most widely used jet target drone, the Supersonic Firebee II, entered initial fabrication stages. First flight tests of the prototype were scheduled for mid-1967 at the Naval Missile Center, Point Mugu, California. Being built for the Naval Air Systems Command, the Firebee II has a designated speed of 1,000 miles an hour, and will be coupled to the existing Firebee's basic features to utilize many of the same electronic components, thereby reducing developmental costs of the growth-version target.

The subsonic Firebee continued to break records, as the Army perfected a ground launch system capable of catapulting the drone with a 1000-pound payload, and the Navy set an all-time gunnery mark by downing one of the remote-controlled "birds" at an altitude of 60,000 feet, 25 miles from the missile-launching Seventh Fleet flagship, USS Oklahoma City, operating off Okinawa. Ruggedness and watertight integrity of the Firebee were demonstrated with recovery of a target in the Pacific more than 2 years after it disappeared following a "kill" in gunnery exercises off the California coast.

An increasingly important role was performed by the Ryan Firefish, the Navy's first waterborne, remote-controlled target boat, developed to perfect marksmanship of gunners seeking out speedy, evasive patrol and torpedo boats. After numerous "kills" by ships and aircraft since they went into operation in 1965, the Firefish became a primary target for the first time during Fleet exercises in the summer of 1966, when 43 ships and thousands of men were engaged in drills of the Southern California coast that tested anti-PT boat preparedness. A Belgian firm was named manufacturing and sales licensee for Firefish craft overseas, and the British Navy ordered the vessels for evaluation at its Singapore base.

The Ryan Electronic and Space Systems facility continued production of automatic ground velocity indicators for Navy helicopters, and low frequency receivers to be used in conjunction with the Navy's world-wide OMEGA Navigation System were ordered by the Navy Ships Systems Command. The Navy also scheduled trials of a Ryan sink-rate Doppler system designed to record "hard landings" on aircraft carriers, which could cause otherwise undetected structual damage to aircraft.

Ryan solar panel structures were built in 1966 for the GEOS earth-mapping satellite and Mariner '67, designed for an exploratory mission to the planet Venus. Ryan previously had built such structures to capture the sun's energy for Mariner II in a Venus mission several years ago, and for Mariner IV during its space journey to Mars in 1965. A new Department of Defense Gravity Experiment (DODGE) satellite, scheduled for launch in early 1967, was to carry Ryan solar panel structures of an advanced design.

Applications of Ryan's unique Flex Wing received further impetus in 1966 with award of Army Aviation Materiel Laboratories contracts for additional flight testing and evaluation of the manned XV-8A Fleep, a light STOL "flying truck," and for testing and fabrication of the unmanned Precision Drop Glider System. Both are designed to deliver critical cargoes to combat troops in rugged, unimproved areas. The Flex Wing represents a new class of flight vehicles using wings of flexible material, attached to a keel and leading edge members which form a V-shape, kite-like surface supporting a fuselage or cargo platform suspended below the wing.

The sharply increased volume of new business sent Ryan payrolls at its three San Diego plants to more than 4,000 at year's end, compared to a low of 1,575 early in 1965, and nationwide recruiting was conducted to meet anticipated continued expansion in 1967.

SOLAR — A DIVISION OF INTERNATIONAL HARVESTER COMPANY

Wide acceptance of Solar's gas turbine-powered auxiliary power systems in airliners and business-jet aircraft, expanded sales of military APU's for use in helicopters, and continued pioneer work in the development and manufacture of advanced aerospace components and systems marked the year in aerospace for Solar.

Solar contributions to the Saturn-Apollo program grew to the point where the Division was making components for every stage of the moon vehicle. For the first stage, Solar was producing ducting and pressure lines for fuel, pressurization, and hydraulic systems, plus engine heat exchangers; for the second stage, propellant pressurization and vent lines, plus flexible metal hose and bi-metallic joints for engine controls; for the third stage, further bimetallic components; for the instrument unit, coolant manifolds, accumulators, and heat exchangers; and for the Apollo and LEM manned capsules, the main communication antenna structures and the beryllium components and structures for the SNAP-27 nuclear auxiliary power plants.

Solar was fabricating aircraft components such as the stabilator slotted leading edge and boundary-layer-control ducting for the McDonnell F-4 jet. Solar in 1966 accelerated its expansion and diversification into the commercial aerospace business by producing more jet-engine components, a field that relies on the Division's capabilities in the handling of high-temperature and exotic metals. Engines for which Solar was making parts power the AAFSS compound helicopter, the C-5A heavy logistic aircraft, the SR-71, prototype SST, the CH-53 helicopter, and the 707/720, 727, DC-8, and DC-9 commercial jet liners.

Several significant advances were made in fabrication technology, especially in the field of joining modern metals. Electron beam welding equipment and techniques were uprated to produce thick-section titanium welds for the AAFSS helicopter development program. High-temperature brazing technology continued to be advanced for the joining of beryllium, titanium, and the refractory metals. Further sophistication of diffusion-bonding techniques was achieved. Advanced materials research included development of protective coatings of refractory metals and superalloys, especially those viewed as SST engine candidates, and study of the interstitial sink effect.

Solar was deeply involved in the study and development of composite materials and was evaluating these materials for use as aircraft engine, turbine, and compressor materials. New efforts were begun to develop metal matrix composite materials for potential structural application. Nonmetallic items under laboratory study included viscoelastic dampening materials and high-temperature plastics and adhesives.

The other major element of Solar's business, the manufacture of gas turbine engines, continued in 1966 to make contributions to the aerospace industry.

Solar's Titan gas turbine auxiliary power units were used in every major U.S. military cargo helicopter. Helicopters transporting troops into battle zones in Viet Nam were relying on the 80 to 105 horsepower Titan engines to restart main engines and operate all hydraulic and electrical systems. This enables the troop and equipment carriers to operate wholly independent of ground-support installations when necessary.

Solar in 1966 continued to expand its position in the commercial auxiliary power unit market with substantial orders for F-27, FH-227, Fan Jet Falcon, and JetStar systems. Solar APU's were flying with Mohawk Airlines, Allegheny Airlines, Ozark Airlines, Northeast Airlines, and a host of executive operators. Improvements in the APU system included incorporation of a greatly improved evaporator for ground air-conditioning. The commercial Solar auxiliary system provides self-contained electrical power in addition to ground air-conditioning, freeing aircraft from reliance on ground-support equipment.

Expansion of Solar's gas turbine manufacture into a leased 200,000 square foot facility in the Rose Canyon area of San Diego in the spring of 1966 opened further space for aerospace-component production in the firm's main plant along the San Diego waterfront. The Division announced plans for construction of a new turbine manufacturing plant on 118 acres in the City of San Diego Industrial Park on Kearny Mesa.

New development and fabrication facilities completed in 1966 included shops for honeycomb-structure fabrication, dissimilar metals joining, and fabrication of beryllium components. Space, equipment, and scientific personnel were added to Solar's research activity.

Solar employment continued to climb, reaching 3,600 by the end of 1966. Throughout the year, Solar pushed a widescale recruiting drive that was to continue into 1967, and Solar President Herbert Kunzel said employment would exceed 6,000 by 1970.

SPERRY RAND CORPORATION

Major Sperry Rand divisions continued to play an indispensable role in aviation and space-flight, fields that especially demand flawless performance and reliable service. The Corporation was involved heavily in developing and producing navigation instruments, landing aids, automatic flight controls, radiometric devices, computers and hydraulic systems for aerospace.

SPERRY DIVISIONS

On Long Island, the Sperry Gyroscope Division, a pioneer in the design and development of microcircuited systems, progressed with its development of new equipment and systems employing these new advanced techniques.

One prime effort was Sperry's Integrated Light Attack Avionics System (ILAAS). Under contract to the Naval Air Systems Command, Sperry was producing prototype equipment which will, for the first time, fully integrate navigation, flight control, weapons delivery and displays into a single, responsive flight system for advanced Navy attack aircraft. Among the goals set by Sperry were high reliability and maintainability for fleet use.

Sperry's Loran radio navigation system development continued and joint Air Force-Army testing of Loran-D, a tactical system, got under way at Eglin Air Force Base, Florida. This new system will enable ground and air forces to operate on the same exact-position reference information, thus enabling aircraft to locate ground targets within yards. As a result of Sperry's work in this field, a new lightweight, portable Loran receiver was developed for use in forward areas by ground forces. It is compact enough to be carried by a single man.

During the year, deliveries to the Air Force of the AN/ARN-78 first microcircuit Loran-C receivers continued. The all solid-state receiver is the first to enter Air Force inventory. It has 5 times the reliability of any comparable receiver, and is less than ⅓ the weight. A commercial version of this receiver was also selected for use on the Anglo-French Concorde Supersonic Transport.

Also in the commercial aviation field, Sperry's SGN-10 Inertial Navigation System for commercial jetliners began a series of flight tests for FAA certification, expected by early 1967. Pan American World Airways ordered the SGN-10 for its entire 707 fleet and it was performing well on both Atlantic and Pacific flights. This system is a complex of sensors and an airborne computer which enables the pilot to navigate without ground aids. The SGN-10 was also ordered by Middle East Airlines, Alitalia, Lufthansa, and the British Air Ministry for evaluation.

In space, NASA achieved some remarkable firsts. Its Boeing-built Lunar Orbiter I became the first U.S. spacecraft to orbit the Moon, take pictures of the far side and pictures of earth. Sperry's Inertial Reference Unit (IRU) played a key role in that successful mission. The unit, part of the craft's attitude control system, responded to more than 600 commands during the month-long mission to stabilize the camera platform, shut down the spacecraft's rocket engine at the proper moment to achieve orbit and in changing orbit twice, and to aim the craft to transmit signals back to earth.

Meanwhile, other space programs continued at Sperry's Long Island facility. Critical navigation equipment, accelerometers, were manufactured for both the Apollo Command and Lunar Modules. For the Nimbus satellite system, Sperry was developing the Rate Measurement Unit (RMU), and several other advanced study projects for the national space program were also being conducted.

On another front, Sperry continued engineering support services for NASA's Goddard Space Flight Center's Test and Evaluation Division. The task includes the management programming operation and maintenance of the data collection and analysis system.

Also in the missile and space field, the Navy placed in operation the first microcircuited instrumentation radar—the Sperry AN/FPQ-10—at San Nicholas Island, part of the Pacific Missile Range. The radars are used for precise tracking of missiles and aircraft. The FPQ-10 was also being installed at the Underwater Test Range in Hawaii.

Sperry Gyroscope Division continued to advance the state-of-the-art in laser and infrared technology in its Electro-Optics Group; managed the vital

Engineer operates experimental system for feasibility studies of phased array laser radars developed for the USAF by Sperry Rand's Electro-Optics Laboratory.

navigation system for the Navy's Polaris submarine program, and began work to improve the already-precise Polaris navigation system for the Poseidon missile. The company moved more solidly into the field of deep submergence with important contracts to give the bathyscape Trieste II extended capabilities in navigation and control, and another for the design and development of the instrument and control system for the NR-1, a nuclear-powered, deep-diving research craft. A third effort was under way to provide system engineering support on development of the Navy's deep submersible rescue vehicle. The latter effort involves development of a new craft to permit rescue of surviving submarine personnel under all weather conditions, under ice caps, and at depths as great as present submarine collapse depths.

The Sperry Rand Space Support Division at Huntsville, Alabama, continued contract support services to the Marshall Space Flight Center. The Division also was awarded a contract for engineering support from the Jet Propulsion Laboratory. JPL has prime responsibility under NASA for unmanned lunar and planetary exploration.

The Sperry Phoenix Company Division in Phoenix, Arizona, doubled its share of the aerospace equipment market in 1966. Construction of an addition to the plant, increasing its size from 253,420 square feet to 366,758 square feet, was completed during the year. Employment increased to 2,820 during 1966.

The Division was producing automatic flight control systems for most of the commercial jet aircraft, including the Douglas DC-8 and DC-9, the Boeing 727 and 737, and the Fairchild Hiller FH-227. In the corporate aircraft market, Sperry Phoenix was producing flight control systems for the Lockheed JetStar, the Grumman Gulfstream II, the Hawker Siddeley DH-125, the FanJet Falcon, the HFB-320, and the North American Sabreliner.

For the military, Sperry Phoenix was producing flight control systems for the Lockheed C-130 and the Grumman A-6A, E-2A, and OV-1.

The Division was making Gyrosyn® Compass Systems for the Douglas DC-8 and DC-9, the Boeing 707, 727, and 737, the Lockheed C-130, C-141, F-104G, the Bell UH-1B and AH-1G (Huey Cobra), the Hughes OH-6A (LOH), and the Boeing Vertol CH-47A Chinook, as well as many executive aircraft. A new compass system—designated the ASN-75—was being produced under a Navy contract for installation in the North American COIN aircraft.

A major milestone in all-weather landing operation was achieved by the Division when Pan American made the first fully automatic landing of a 727 aircraft in Berlin on a regular passenger revenue flight. The new system, developed jointly with the Boeing Company, is called the SP-50 LWMP. With this system, an airline with trained flight crews is authorized by the FAA to make approaches under weather conditions of 100 feet cloud ceilings and forward visibility of one-quarter mile and may continue to touchdown automatically. In addition to Pan American, the new Sperry-Boeing system was procured by Braniff and National Airlines. Sperry Phoenix also successfully introduced a new integrated instrument system and flight director computer designed for Category II lower weather minimum operations. This system has been certified for the Douglas Series 60 DC-8 and DC-9, and the Boeing 727.

During the year, the Division developed a landing system for tactical aircraft, utilizing UHF ranging techniques. The new system was demonstrated successfully and was undergoing evaluation by the USAF.

New automatic flight control systems making extensive use of microcircuits were produced for the Boeing 737 and the Douglas Series 60 DC-8. The first system for the 737, known as the SP-77, was delivered to Boeing during the year and was scheduled for flight testing in 1967. The SP-30AL Automatic Flight Control System was certified for Category II operation in the largest American jet transport, the DC-8-61.

In addition, Sperry Phoenix designed and built a flight control system for the re-entry vehicle PILOT for the Martin Company. Emergency communication homing beacons were used in the Gemini flights during 1966.

Development, production, and on-time delivery of a diversity of products for use in all parts of the world and for space applications are significant of "Sperry Utah 1966."

During the 10th anniversary of Sperry Utah's development, production, and delivery of the Sergeant Artillery Guided Missile System, Sergeant continued to fulfill an important defensive role with the U.S. Army and with Federal Republic of Germany forces overseas. Contracts for Sergeant system electronics updating, for additional quantities of tactical Sergeant missiles, and for system engineering services assured a full logistics pipeline of Sergeant equipment in support of field commanders and their troops.

A team of 30 Sperry Utah engineers, technicians, and their families returned home following completion of "Project SCAMP III." The 18-month project took the Sperry team to Europe for 1 year, and various assignments in the U.S. for 6 months, to work with Army and West German troops updating deployed Sergeant missile systems. The project was highly praised by the military, and as a result of SCAMP III, the Sergeant Ground Support and Training Equipment was returned to 100 percent serviceability and operational readiness.

In 1966 the Army Weapons Command accepted delivery of initial helicopter machine-gun mounts produced by Sperry Utah. The first of more than 1,000 units ordered were delivered only 83 days after receipt of the order. The mounts will permit the addition of machine-gun fire power aboard the UH-ID Iroquois and the CH-47 Chinook helicopters for protection during troop carrier missions and the evacuation of the wounded.

Developed by the Army Tank-Automotive Center, the Sperry-built U.S. Army Tank Gunfire Simulator is a stainless-steel tube which clamps to the tank gun barrel. It is an electronic device designed to duplicate the sound, flash, and smoke of tank and artillery weapons. Its purpose is to reduce the cost of training while achieving battlefield realism for combat troops in field exercises. Blank ammunition costs $8 to $11 per round, depending on size; simulator cost per round is approximately 30 cents. Further savings are realized by prolonged life of the weapons and reduced maintenance efforts at the end of firing activities. Sperry Utah was to deliver more than 500 simulators to ATAC.

Another Sperry Utah product is 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 permit viewing of astronauts and their spacecraft during simulated space flight training operations.

Sperry Utah activity at NASA's Kennedy Space Center in Florida also included the design and installation of radio frequency transmission systems which are used in the checkout of the Apollo spacecraft's Lunar Excursion Module and Saturn V communications systems. The contract for this system was awarded by the Canaveral District of the Army Corps of Engineers.

In a record 7-month paper-to-product contract commitment, Sperry Utah delivered to the Army Weapons Command the first of more than 300 helicopter grenade launcher systems. The scope of this work included fabrication and assembly of the launcher sighting station, turret, turret electronics, mechanical controls, and ammunition stores and handling equipment. The M-5 Armament Subsystems can be aimed and remotely controlled by the pilot or gunner and can fire 40-millimeter grenades at a rate of 240 rounds per minute. Developed by the Army's AWC, the grenade launcher in its turret is mounted on the nose of the UH-1B Iroquois and the CH-47 Chinook helicopters. Full-scale production of the M-5 at Sperry Utah was started on completion of the Aberdeen tests in mid-November.

Bearing a striking resemblance to missiles is the Air Force's TDU-9/B supersonic tow target. After several instrumented ground and flight tests conducted by the Air Force at Eglin Air Force Base, Sperry Utah was given approval to proceed with production and targets were being delivered to the Air Defense Command at Tyndall Air Force Base, Florida, to be used for weapon system validation, combat aircrew training, and evaluation of air-to-air tactics.

In the intercept area, the pilot plays-out the 170-pound 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 at it, which include the Sidewinder, the Falcon, and the Genie rocket. Reel-in of the 170-pound target is accomplished prior to landing the tow aircraft. Studies were in process by the division for further modifications in an extended product improvement program sponsored by the Air Force.

Another innovation is VIPRE-FIRE (Visual Precision Fire Control), a hands-off, air-to-ground helmet sighting system which allows a pilot or gunner to fire at a target merely by looking at it and pressing the trigger. Through this one single act of normal visual acquisition, the weapon system is brought to bear on the target, irrespective of the aircraft's airspeed, altitude, or flight path. Ideal for helicopters, which require a pilot's undivided attention, the system can easily be adapted to existing weapon systems and aircraft as well as to those of the future. VIPRE-FIRE is so simple to use that in recent demonstration firings from a helicopter, untrained observers using the system for the "first time" scored constant hits on ground targets.

Acting as a "third eye," Sperry's HOTAR (Hold Target) using the helmet sight from VIPRE-FIRE in conjunction with a simple computer enables the pilot to quickly reacquire or hold a target sighted on a previous pass. Once the initiate button is pushed, HOTAR provides the pilot with signals for holding the target during maneuvers for attack even if the target passes behind the aircraft and out of sight for any period of time. The HOTAR system can be adapted to both fixed and rotary wing aircraft.

To accomplish aircraft "test check-out" accurately yet rapidly enough to maintain the highest degree of availability, Sperry Utah has developed the Multi-Station Automatic Avionics Test System (MAATS). From airlines experience, items that show 6.5 hours test time can be tested by MAATS more accurately, safer, and faster—in only 30 minutes. MAATS is configured in 3 test stations—Analog, Pneumatic, and RF (UHF-VHF) including ATC transponders and Distance Measuring Equipment—supported by a central control station which is computerized and capable of handling the full test load of 9 test stations simultaneously. A fourth test station for weather radars and other equipment in the same frequencies regime will be available. MAATS also provides for diagnostic tests and repair, and as an added feature provides diagnostic self-test.

Sperry Electronic Tube Division, Gainesville, Florida, continued to supply all power klystrons used in TACAN and VORTAC air navigation systems. In 1966, the Division developed new klystrons and traveling wave tubes and began high volume production for many airborne ECM, navigation and fire control systems. These significant programs include the: RF-4C, F-111, F-4, F-105, A-6A, A-7A, B-52, YF-11A, C-124, C-130, C-135, and C-141 aircraft, and the Phoenix and GAR-9 missiles. The Division also introduced a line of microwave power packages which convert 28 volts DC to microwave frequencies under the extreme environmental conditions of aerospace applications.

The Sperry Microwave Electronics Division, Clearwater, Florida, continued to supply flight line checkout equipment for the multi-mode radars in the A-7A Corsair II and the RF-4C Phantom II. Similar equipment, radar performance analyzers, was to be delivered to General Dynamics Corporation for flight line check of the attack and terrain following radar subsystems in the F-111A. The primary design requirement of these equipments is to meet the maintainability and quick-turnaround-time standards set for these aircraft.

Work was in progress on an analog and digital Card/Module Tester for Mark III SINS and a digital version for ILAAS. The division also was developing module subassembly testers for use on the Mark II SINS program.

Among the other test equipments in production for the Air Force were the ALM-47 ECM test sets, AN/UPM-29 radar test sets, and the AN/APN-232 altimeter test sets.

The decision to update the radar systems in the B-58 Hustler resulted in an award for the division to recommend, and ultimately develop and manufacture, the AGE equipment for the search radar being redesigned by Raytheon.

Self-contained, completed instrumented vans capable of performing spectrum surveillance and radar beacon checkout functions were delivered to the Air Force Eastern Test Range for use on its various stations.

During the year, 2 AN/AAR-33 Airborne Microwave Radiometric Systems for iceberg detection were delivered to the U.S. Coast Guard for use by the International Ice Patrol. By adding these radiometric systems to their existing equipment, the Coast Guard is able to detect icebergs and other shipping hazards from high altitudes at relatively high speeds through fog and rain.

Other active programs in this field, under flight test in 1966, were microwave radiometric systems for missile terminal guidance and terrain mapping.

For the Navy's Versatile Avionic Shop Test System (VAST), the division developed and was manufacturing a series of computer-programmable microwave signal generators. These microwave synthesizers are full automatic state-of-the-art devices producing high quality RF signals, suitable for testing the most advanced avionic systems.

Advanced research in ferrite devices and materials development and manufacture were carried on in continuing company-sponsored and military funded programs. One of the products resulting from this research activity was the microwave acoustic delay line. These delay lines were being built into the APN-232 altimeter test set, and were being used in testing radar altimeters by altimeter manufacturers and commercial airlines.

Scheduled for year-end delivery were cryogenically cooled parametric amplifier systems, to be incorporated into the NASA Unified S-band (USB) system, a part of the tracking and communication network for the Apollo program. The paramp systems were to be located at 85-foot dish antenna sites for amplification of signals received during the lunar phases of the mission.

Digital phase shifters in various frequencies were developed and tested for phased array and early warning radars, and research and development programs included Air Force contracts. Solid state sources were developed and quantities delivered both to industry and the military.

SPERRY RAND RESEARCH CENTER

At the Sperry Rand Research Center in Sudbury, Massachusetts, an air pollution study led to the development of a new passive radiometry method to measure atmospheric temperatures from the ground. This method promises to eliminate the balloons and radiosondes now needed to detect smog-producing temperature inversions. The outgrowth of a second atmospheric study was a laser-based technique which offers the first practical method to measure visual range along aircraft glide paths. Using a new ultrasonic method that reduces power requirements a thousandfold, the Center modulated a laser beam to demonstrate the usefulness of the technique for optical communications and for processing radar data. Semiconductor device work produced a diode which oscillates at microwave frequencies when connected to a direct current source. The diode can serve as a simple, reliable local oscillator in large radars or as the entire RF output section in a hand-held battlefield surveillance model. System scientists analyzed wide-band and high-resolution radars, and they developed new methods to evaluate vocoder systems.

UNIVAC DIVISION

Continuing advances in data processing and in the aerospace field marked another active year for Sperry Rand's UNIVAC Division. Highlights of the year were introduction of major product lines, continuing contract work in the space field, and significant developments in technology.

UNIVAC attained a milestone in its $37,000,000 contract to supply Air Force base supply computers with the shipment of its 100th UNIVAC 1050 computer system. The shipment represented completion of nearly two-thirds of the original contract.

In June, UNIVAC made the largest multi-product announcement in its history with the introduction of a new series of integrated computer systems. The first members of the new UNIVAC 9000 series were the UNIVAC 9200 and UNIVAC 9300. The systems incorporated the latest in technology including a plated wire memory and integrated circuitry.

In the large scale aerospace and scientific computing field, UNIVAC's largest commercial system, the 1108, found wide acceptance among government and industrial users. Significant orders included the NASA Manned Spacecraft Center, Marshall Spaceflight Center, Lockheed Missiles and Space Company, The Boeing Company, U.S. Naval Ordnance Test Station, Goddard Space Flight Center, DuPont, General Dynamics, and United Aircraft Corporation.

In August, UNIVAC was selected to provide aerospace computers for the Air Force's Titan III space booster. The $10,000,000 contract from A.C. Electronics Division of General Motors called for UNIVAC to provide production quantities of the 1824 computers for the Titan III guidance system. The highly miniaturized 1824 weighs only 80 pounds.

UNIVAC also was awarded a contract from the Marine Corps to provide a Tactical Data Communication Central, a high-speed air command and control system developed to modernize Marine combat air control during amphibious operations.

In the nation's space program, UNIVAC continued to play a key part with vital communications processing equipment for the National Aeronautics and Space Administration. With the conclusion of the Gemini program, UNIVAC provided advanced communications processing systems for the complex Apollo lunar landing mission. UNIVAC 494, 418 and 1230 systems were installed in the worldwide tracking network maintained by NASA.

UNIVAC's pre-eminence in the air transport industry was underscored during the year with major computer orders from Air France and the Scandinavian Airways System for worldwide reservations and management information systems for the respective lines. In addition, Eastern Airlines, one of the nation's first with such advanced computing equipment, ordered additional UNIVAC real-time computing systems for its Data Center in Charlotte, North Carolina.

Accompanying these installations and orders, a number of significant developments in unit record equipment, data communications as well as advanced internal memory systems marked another growing year for UNIVAC as well as for data processing technology.

VICKERS INCORPORATED DIVISION

Major production for 1966 at the Vickers Incorporated Division included Minuteman Flight Control System components for both stages; hydraulic systems and components for the Douglas DC-9 and the 60 Series DC-8; Boeing 700 series, and the BAC BC-10 airliner. In addition, the Division produced hydraulic engine starters and substantial amounts of other hydraulic equipment for the Bell UH-1 and Sikorsky CH-46, CH-47, and CH-53 helicopters. Due to escalation of the Viet Nam conflict, these particular planes brought about a considerable increase in Vickers production during the year.

During the latter part of the year, a major program began for the A-7A.

Programs in prototype production stages included: a major part of the hydraulic components for the Lockheed C-5A, the largest military transport to be built, which may use more hydraulic horsepower than any plane except the XB-70; Vickers hydraulics for elevation and azimuth control on the launcher to aim the Chaparral heat-seeking missile to protect front battle areas from aircraft; high-temperature pneumatic components for the attitude system of the Poseidon missile; a contract to supply the hydraulic engine starter and hydraulic power packages for Lockheed's new combat helicopter, the AAFSS (Advanced Aerial Fire Support System).

SUNDSTRAND AVIATION DIVISION OF SUNDSTRAND CORPORATION

Throughout calendar year 1966, Sundstrand Aviation Division of Sundstrand Corporation, Rockford, Illinois, continued as a leader in aircraft secondary power systems. Adding to its stature as the world's leading supplier of constant speed drives, Sundstrand Aviation also made further progress on diversified product lines designed to serve military and commercial systems ranging from underseas to outerspace applications.

Building on its in-depth undersea experience during 1966, Sundstrand continued to provide the power plant and tankage system for the Mark 48 Torpedo, an advanced ASW weapon. The scope of the current contract includes the design, development, and manufacture of a Development Prototype Torpedo (DPT) and a Production Prototype Torpedo (PPT). The DPT phase was in the final stages of completion and the PPT design was begun in the fall of 1966. The system was being evaluated through in-water torpedo tests at the Naval Torpedo Station at Keyport, Washington. These tests, which were approximately one-third complete at year-end, demonstrated design excellence for the power plant and tankage.

Sundstrand Aviation also held several other contracts for research into turbine technology and advance torpedo propulsion systems.

On the land, Sundstrand Aviation continued development work on the new Dual-Mode Transmission for applications on both military off-the-road vehicles and commercial trucks and buses. Testing of prototype models in Sundstrand trucks and on military tracked vehicles was well under way during 1966. Commercial truck manufacturers were completing plans to begin testing in early 1967.

In the spring of 1966, Sundstrand Aviation received a contract from the FMC Corporation, San Jose, California, for production of a prototype hydrostatic steer system to be applied to their armored amphibious personnel carrier, the PX-12.

Sundstrand Aviation maintained its leadership in aircraft accessory drive systems during 1966. Constant speed drive production work began on many contracts originally awarded to Sundstrand during 1965. In addition, a number of new programs were under way, helping to make 1966 the most successful year in Sundstrand Aviation's history.

Outstanding among the new business was the contract from Lockheed-Georgia for constant speed drives to be applied to the huge C-5A military transport.

The application of Sundstrand CSD's to a new version of the Dassault Mirage reflected the company's growing interest in the smaller jets, especially executive transports, being sold throughout the world. Sundstrand research vigorously pursued during 1966 new solutions for the aircraft electrical problems inherent in the frequency-wild or DC systems often used on these smaller craft.

Testing of Sundstrand constant speed drives for application on the Canadian version of the F-5 together with a follow-on buy of drives for the F-4 program further evidenced Sundstrand's interest in applications on airplanes with lower KVA requirements.

The order of magnitude improvements in reliability and long-life of the new Sundstrand AGD constant speed drive is best demonstrated by the favorable reception given Sundstrand's retrofit proposal by many of the world's airlines. The plan called for retrofitting existing fleets with the new drive. Eleven of the world's most distinguished airlines accepted the program.

In other aircraft accessory system areas, Sundstrand Aviation was participating in both Lockheed and Boeing's SST programs. Sundstrand constant speed drives were proposed to both airframe manufacturers on their futuristic designs. In addition, Sundstrand was funded by Lockheed to conduct further studies on SST hydraulic pumps and motors and by Boeing to build an accessory drive gearbox.

In guided missile and space technology, Sundstrand Aviation made remarkable progress throughout 1966. An example of the success of Sundstrand's miniature missile power units (MPU), small, turbine driven, electrical, hydraulic, or combined electro/hydraulic power sources providing short bursts of energy for missile-borne equipment, was the Certificate of Merit awarded Sundstrand by the Sperry Gyroscope Company. This award was made for Sundstrand's MPU research as part of the Sperry contracted program.

Sundstrand was also active in MPU proposal efforts on the Poseidon and SRAM missiles.

In other space and missile activity, Sundstrand research teams continued work on an organic rankine cycle engine under contract from the Atomic Energy Commission.

Work progressed during 1966 on the new Sundstrand Aviation Research and Development Center at Rockford, Illinois. When completed in 1967, the new center will house all of the administrative, engineering, and scientific facilities recently consolidated in Rockford. The consolidation, completed in the summer of 1966, brought together all Sundstrand Aviation engineering and technical personnel formerly in Rockford and Denver. Sundstrand's Denver facility continued to expand as a manufacturing plant.

THIOKOL CHEMICAL CORPORATION

In 1966, Thiokol Chemical Corporation celebrated its 25th anniversary in rocketry. As with the preceding years, it was one of progress and accomplishments in many areas.

In big boosters, there were firings at the Wasatch Division of 120-inch and 156-inch diameter motors in February and April, respectively. The 120-inch motor, developed and tested by Thiokol under contract to the Air Force Ballistic Systems Division, used a 25-inch throat, submerged omniaxial nozzle and demonstrated a high performance propellant system.

The 156-inch motor, utilizing a fiberglass reinforced plastic case, was designed and tested as a potential upper stage for future launch systems. It generated more than 325,000 pounds of thrust during a 110-second burn time. A significant achievement of the test was the successful demonstration of a high expansion ratio, submerged fixed nozzle with liquid injection thrust vector control. Over 40 percent of the nozzle was submerged in the case, a technique that increases the amount of solid propellant without increasing the motor's over-all length.

Another unique feature of the test was the use of an 83-foot-long diffuser tube to simulate high atmospheric conditions.

In another area of solid propulsion technology, Wasatch successfully test-fired 5 flight-weight restartable motors in a program designed to demonstrate Thiokol's ability to produce a solid propellant, air-launched rocket motor with a start-stop capability. Subjected to temperatures ranging from minus 75 to plus 175 degrees Fahrenheit, the motors were test-fired at the minus 75 degree reading, one of the most severe temperature conditions to be encountered by a solid-fueled motor.

In June, the 100,000,000th pound of PBAA solid propellant rocket motor fuel was mixed at Wasatch, which has supplied propellant for such propulsion systems as Genie, Bomarc, Mace, Matador, large boosters, and the first stage Minuteman.

Completion of the basic contract for research and development of the Minuteman first stage motor was announced after a successful 9-year effort which helped prove the value of large solid propellant motors. Production of first stage motors was scheduled to run into 1972.

In other programs, Wasatch received 2 development contracts from the Air Force Rocket Propulsion Laboratory, Edwards AFB, California, for continued work in the area of thrust vector control for large solid propellant motors. Under the first contract, the Division was developing a hot gas valve thrust vector control system for submerged fixed nozzles, in which the valve diverts the motor's hot gases through the side of the nozzle into the main exhaust stream to achieve thrust deflection. The second contract calls for Wasatch to develop and demonstrate an omniaxial flexible seal nozzle for thrust vector control. A static test of the new TVC system on a 156-inch diameter motor was scheduled for the spring of 1967.

In a third program, Wasatch passed a major milestone in a corporate-funded effort to develop a thrust-modulated solid motor with a successful static test in September. The test demonstrated Thiokol's ability to reliably extinguish and restart a solid motor on command, and to vary the motor's thrust on command.

Progress in air-augmented rocket propulsion was marked by the Huntsville Division with the successful launch of a ducted rocket from the U.S. Naval Missile Center, Point Mugu, California. Called the Solid Propellant Augmented Rocket Motor, SPARM, the program is sponsored by the USAF Directorate of Armament Development, Eglin AFB, Florida.

During the year, the Huntsville Division announced the successful test firing of the second stage motor for the Army's Improved Zeus antimissile missile. The Army's Nike X project office called the full duration static test a complete success. The Huntsville Division has the propulsion development contract for all 3 stages of the Improved Zeus, a longer and heavier version of the missile that has successfully intercepted incoming ICBM target nose cones.

One of the major highlights of the year combined the propulsive power of solid and liquid engines in the historic touchdown of Surveyor I on the moon in June. Thiokol's Elkton Division provided the retro power with its main Surveyor retro engine, and the Reaction Motors Division provided the vernier liquid engines for attitude and velocity control. Both systems worked perfectly in this tremendously successful landing.

In addition to its contributions to the Surveyor soft landing, Reaction Motors continued to produce packaged liquid engines for the Bullpup air-to-surface missile. It also received a multi-million dollar contract from North American Aviation, Inc., for the development of an advanced packaged liquid engine to power Condor, a new air-to-surface missile.

In space propulsion, Reaction Motors successfully pulse-fired its C-1 Radiamic engine at the Marshall Space Flight Space Center in a vertical-up attitude at a simulated altitude in excess of 200,000 feet. This followed a series of firings at Reaction Motors' own facilities which exceeded 14 hours in duration.

Reaction Motors noted 2 significant anniversaries during the year: the founding of Reaction Motors in 1941, and the tenth anniversary of the YLR99 powerplant for the X-15 research aircraft. The engine, which has powered over 125 missions, is throttleable and one of the most sophisticated liquid rocket engines ever built.

In sounding rockets, the Astro-Met Division in 1966 established itself as a leading supplier of reliable off-the-shelf vehicles and hardware available to sounding rocket users. In addition to Nike-Tomahawk sounding rocket systems procured by Douglas Aircraft Company, the Sandia Corporation, NASA's Goddard and Marshall Space Flight Centers, and the Air Force Cambridge Research Laboratories, the Division supplied rocket launchers to the Sandia Corporation and to the Army for several research projects. Astro-Met was also under contract to the University of Michigan to fabricate omegatron gauges for measuring atmospheric temperature and density. The Division also developed an improved mesospheric temperature measurement device, as well as a successful ion-bulk motion measurement unit.

Rapid expansion and modification characterized the Longhorn Division in 1966 as U.S. efforts in Viet Nam required increased production rates of 60- and 81-millimeter and 4.2-inch mortar shells as well as 105- and 155-millimeter artillery rounds. Production of solid motors for the Nike Hercules and Sergeant weapons systems also continued during the year.

The year marked the end of the first quarter-century in the rocket business for Thiokol; but, more importantly, it also witnessed the continuing expansion of a broad base of activities on which to build the next 25 years of growth and progress in rocket propulsion for space and defense.

TRW INC.

For Cleveland-headquartered TRW Inc., 1966 was a year of accelerated demand for a greater variety of jet engine parts and components, of deeper involvement in scientific, military and commercial space programs, and of increased requirements for missile systems, subsystems and related hardware.

During the year, TRW contributed heavily toward advancing space and spacecraft technology. Of the 97 spacecraft produced by TRW since the advent of the Space Age, 20 were still producing useful scientific and engineering data for NASA and USAF in October. Among those launched in 1966 were:

OGO III. Designed, built and launched by TRW, the NASA-sponsored Orbiting Geophysical Observatory was the third such vehicle designed and orbited for the systematic study of the earth and its space environment.

The OGO can carry up to 50 scientific experiments and operate in orbit for 1 year or more. TRW launched OGO I in September 1964. Its payload included 20 experiments designed to investigate solar flares, atmospheric composition, magnetic fields, cosmic rays and other phenomena. OGO II, launched a year later, carried 20 experiments into polar orbit. OGO III contained 21 experiments. Three additional OGO launches were planned.

Initial Defense Communication Satellites. The first 8 of these medium-altitude telephone-relay spacecraft were launched from 1 vehicle by the Defense Department in June. These will serve as the nucleus of a world-wide military communications system. An additional launch was planned for early 1967. TRW, one of the concept originators, provides 6 major subsystems for each IDCS.

Pioneer 7. This drum-shaped solar orbiter began its elliptical trek around the sun on the Mars side of earth in August. The 140-pound craft collects data on magnetic fields and plasma, while its older sister, Pioneer 6, measures the same phenomena from a vantage point on the Venus side of earth, 30,000,000 miles closer to the sun.

TRW entered the commercial communications satellite field in 1966 with the award of a $32,000,000 contract by the Communications Satellite Corporation. The Comsat contract called for TRW to design and build 6 third-generation satellites, each of which will accommodate more than 1,200 two-way telephone links or 4 television channels. Four spacecraft will be delivered by 1968 to become part of Comsat's INTELSAT III system, the world's first global communications satellite system. Satellites 4 and 5 will incorporate subsystems built by 9 European and Asian companies.

In the manned spacecraft area, TRW engineers and analysts produced the "roadmap" along which the astronauts in Gemini 10 orbited earth and performed multiple rendezvous with 2 Agena boosters. A similar mission plan was to be formulated by TRW for the early-1967 Apollo 204 flight, the first scheduled manned flight of the man-on-the-moon Apollo program.

TRW also delivered special demodulating equipment for all the stations in the world-wide Apollo tracking network. These units sharply distinguished between transmitted signals and spurious radio frequency noises that originate in electronic equipment and in space itself. The first flight test of the radiation-hardened Space Ground Link Subsystem was completed successfully in October. This subsystem uses the latest microelectronic techniques and incorporates all of the tracking, telemetry and control functions into a single unit that earlier had been 3 or more separate systems. The Air Force expected SGLS to become the basis for a uniform ground link system that will be used in all USAF spacecraft of the future.

In another Apollo-support program, TRW delivered to Grumman Aircraft Engineering Company the first flight models of the descent engine and the Abort Guidance System for the Lunar Module. The engine, a thruster variable in 10-1 ratio (from 1,000 to 10,000 pounds of thrust), will allow Apollo astronauts to make a soft helicopter-like landing on the lunar surface. TRW's Abort Guidance System also incorporates the most advanced microelectronic and computer techniques. It is designed to take over the guidance chores of the LM if the primary guidance system malfunctions.

TRW participated in the hardware program for the Uprated Saturn I space booster, which was launched for the first time in February. The company supplied reaction control thruster engines for the fourth stage and a coolant pump.

In addition to new spacecraft and related hardware projects, TRW added to its space power activities in 1966. TRW experience in building 3 major subsystems for the Mariner 4 program led to a contract from the Jet Propulsion Laboratory for the power conditioning system for the Mariner-69 spacecraft. This system not only includes the solar-cell subsystem for generating raw electricity but also the computer-controlled conditioning and distribution of the refined and regulated voltages required by the on-board electronics. The company's Equipment Laboratories in Cleveland continued the long-range development of an advanced reactor-heated Mercury Rankine Power Conversion unit that uses a turbo-alternator to produce 3 kilowatts of auxiliary power in space for 1 year.

The MRPC, formerly identified as SNAP-2, completed 4,700 hours of fault-free continuous testing early in the year. The unit was scheduled for the start-up of a 10,000 hour test in December. A 2-year contract for the development and test of 2 prototype boiler and condenser systems for space power use was also awarded to TRW late in the year.

During 1966, TRW continued to provide systems engineering services to the Air Force on the ballistic missile program, services that have been supplied since 1954. In addition, TRW was assisting the Air Force in the site activation of its Wing Six Minuteman forces. The project includes a combination of missile engineering and installation construction engineering.

In other defense areas, Bell Telephone Laboratories commissioned TRW to develop special vehicles and instrumentation for re-entry measurement instrumentation program. For the Army, TRW was to integrate boosters and equipment required in the SPARTA portion of Project Defender, and special re-entry vehicles were to be launched from a site in Australia to determine the effectiveness of detection and measuring systems.

The systems engineering experience TRW gained through the U.S. ballistic missile programs continued to be applied to a variety of other defense projects. For example, the Navy extended TRW's contract for providing systems engineering and integration support for the antisubmarine warfare program. Tasks under this contract range from equipment evaluation to equipment integration aboard ships, airplanes and satellites and to the development of procedures for testing and evaluating Navy ASW equipment and systems. TRW also directs systems engineering techniques toward the development of a computer-oriented data management system for the Army in support of its Advanced Aerial Fire Support System—the AAFSS, a new compound helicopter being developed by Lockheed Corporation. In still another area, TRW joined a team headed by Litton Industries to work on the early phases of a program called the Fast Deployment Logistics Ship System, a new kind of shipyard capable of serially producing a revolutionary type of ship to transport a wide variety of military cargo and/or personnel.

The missile-program disciplines of systems engineering also proved their usefulness in many non-space, non-defense projects of 1966. For example, TRW won a contract from the State of California which called for the development of a systems approach to the efficient utilization of land throughout the state. The system will consider such diverse elements as residential and industrial housing, recreational areas, highway construction, police and fire protection, and utilities as well as population and geographic location trends.

The systems approach to commercial and civil projects was also being applied by TRW to oil exploration under Long Beach. And similar techniques were being applied to studies of future water sources for the city of San Bernardino, a data management system for the city of Redondo Beach and for the efficient allocation of funds collected through the United Crusade. In addition, TRW received a contract from the Province of Alberta, Canada, to provide engineering consulting services for the planning of an $88,000,000 medical health center that will take 8 years to complete. The new center will bring under single operational management an amalgamation of health sciences, medical research, medical education, preventive medicine and clinical treatment facilities.

The fast-paced growth of TRW's space activities was matched by facility expansion. TRW's California-headquartered Systems Group, for instance, occupied 3 partially completed buildings on a 110-acre site in 1962. By the end of 1967, the Group will occupy 13 buildings on this site and, counting other sites in California (San Bernardino, Vandenberg AFB, San Juan Capistrano and 5 communities surrounding Redondo Beach) and those in Houston, Cape Canaveral, and Washington, D.C., will have a total facility capacity of nearly 3,000,000 square feet of engineering, laboratory and manufacturing space.

Rising orders for jet aircraft parts, airframe castings and missile components have also prompted TRW to expand plant facilities elsewhere in the country. For instance, TRW in 1966 completed a 70,000 square foot plant addition in Minerva, Ohio, and took a long-term lease on 150,000 square feet of additional manufacturing space at nearby Alliance. As a result of order build-up, employment at TRW plants making aircraft parts in Ohio and Pennsylvania jumped about 30 percent during the year.

In addition to orders for substantially increased quantities of engine parts, booster pumps and airframe structural components for such planes as Boeing's 707, 727 and 737, and Douglas' DC-8 and DC-9, TRW won important new business with a share of the production requirements for the world's largest jet cargo carrier—Lockheed's C-5A—and biggest commercial passenger plane—Boeing's 490-seat jet 747.

For the initial 58 C-5A's on order, TRW was to supply fuel booster pumps (24 per plane), landing gear door actuators (using TRW's new propietary roller gear drive and gear-forging techniques) and a unique pneumatic control system that will allow the 728,000 pound jet to "kneel" to take on cargo.

For the 747, TRW was to produce the jet's main engine pumps, some turbine blades and other components for the aircraft's Pratt & Whitney engines.

TRW also had orders to make fuel booster pumps for a new supersonic jet target drone and the Army's revolutionary helicopter, the AAFSS (Advanced Aerial Fire Support System).

The company's ordnance activites gained new impetus during the year, following the announcement that the Army Weapons Command had purchased TRW's new 25 millimeter multipurpose automatic cannon for field testing. The lightweight dual-feed weapon was designed to give U.S. vehicles "standoff ability" against 23 millimeter weapons carried by Russian vehicles. The British and French governments also ordered the new TRW 6425 cannon for field evaluation tests.

UNITED AIRCRAFT CORPORATION

United Aircraft operated at an accelerated pace in 1966. To meet growing demands for its military and commercial products, it stepped up production, expanded facilities, and increased employment.

Through higher levels of development and manufacturing, the corporation bolstered its position as a leading supplier of equipment for winged flight, principally jet engines, helicopters, propellers, and airborne radar.

In rocketry, its solid-propellant boosters and liquid-propellant engines functioned successfully in Air Force and NASA launches. The company made deliveries of space hardware in its role as a Project Apollo contractor. It achieved increased success in programs to apply its aerospace skills to other fields, such as electrical power generation, rail transportation, and marine technology. And it carried out research and development across a broad span of forward activity.

New facilities providing about 1,000,000 square feet of floor space were completed and occupied during 1966. At year end, additional construction was in progress, as were extensive programs to modernize capital equipment. Employment rose throughout the year, climbing past 80,000, as production schedules were raised to meet mounting customer requirements.

In a move expected to help Pratt & Whitney Aircraft expand its turbine-engine production capacity, United Aircraft and Hawker Siddeley Canada Ltd. in September announced plans to form a new Canadian aircraft engine and industrial turbine company, to be known as Orenda Ltd. The new company will be formed from the Orenda division of Hawker Siddeley Canada, which will own 60 percent of the stock, United Aircraft owning the remaining 40 percent.

The corporation's central research organization, United Aircraft Research Laboratories, advanced its work over a widening range of basic and applied programs in 1966. It improved its process for production of continuous boron filament and received the largest single boron order ever placed when the Air Force ordered a ton of the promising new structural material.

The Research Laboratories intensified studies of gaseous nuclear core rockets suitable for flight within and beyond the earth's atmosphere. Potentially high-performance engines of this type offer the possibility of single-stage-to-orbit or near-planet capability. In line with its continuing interest in rocketry and hypersonic air-breathing propulsion, the laboratories carried out investigation of the supersonic combustion ramjet (scramjet) concept for the Air Force. With contractual support from the Atomic Energy Commission, work went forward on a new technique for producing an extremely pure, high-temperature plasma by employing a high-intensity laser. The process could provide new knowledge applicable to efforts to achieve thermonuclear fusion.

In quantum physics, the Research Laboratories devised a method for generating and measuring extremely narrow, high-peak-power laser pulses only one-ten-trillionth of a second in duration.

United Aircraft carries out product development and manufacturing through 7 divisions. Because each operates autonomously, with its own product lines and technical interests, detailed activities of the corporation are reported separately in the following columns under the names of the divisions. They are: Pratt & Whitney Aircraft, jet and rocket engines, marine and industrial gas turbines, fuel cells; Hamilton Standard, propellers, electronics, accessories for spacecraft and aircraft, controls; Sikorsky Aircraft, helicopters and other advanced vertical-lift aircraft; Norden, guidance, navigation, radar, and other electronic systems; Vector, telemetry and communications equipment; United Technology Center, solid-propellant boosters and advanced space propulsion systems; United Aircraft Corporate Systems Center, systems design and development.

PRATT & WHITNEY AIRCRAFT
DIVISION OF UNITED AIRCRAFT CORPORATION

Pratt & Whitney Aircraft's JT9D engine was chosen in 1966 for the big Boeing 747, a new jetliner capable of carrying 490 passengers faster and cheaper than today's subsonic planes.

The company-financed JT9D, developing 41,000 pounds of thrust, represents a new turbofan technology. It utilizes advance cycle and design concepts which have been under development for 6 years. It has an 8-foot diameter inlet—almost twice that of the 18,000-pound-thrust JT3D turbofan, the workhorse of the long-range Boeing 707 and Douglas DC-8 commercial jet fleets. Yet it is only 125 inches long—9 inches shorter than the JT3D.

The Boeing 747, scheduled to be delivered first to Pan American World Airways in late 1969, will precede and complement the United States supersonic (SST) program.

For the SST competition, Pratt & Whitney Aircraft designed and developed the JTF17, a twin-spool turbofan with duct heating, rated at more than 60,000 pounds of thrust. This engine was run for the first time March 31, just 9 months after work was begun. In August, the engine was operated at full SST speed and altitude conditions—Mach. 2.7 and 65,000 feet—in the company's high-altitude test facility at the Florida Research and Development Center. By early September, the engine became the first supersonic transport engine to complete 100 hours of testing—one of the objectives of the FAA Phase II-C SST contract.

Ninety-eight domestic and foreign airlines either have ordered or have been operating aircraft with Pratt & Whitney Aircraft engines. A total of 488 aircraft ordered between January 1 and October 1 included 66 four-engine Boeing 747's with JT9D engines, and 76 Douglas Super Sixty Series DC-8 aircraft powered by JT3D's, the world's most widely used turbofan.

Of the 488 aircraft, 106 were 3-engine Boeing 727's and 143 either twin-engine Douglas DC-9's, Boeing 737's, or Sud Aviation Super Caravelles, all powered by JT8D turbofans.

The JT8D, which develops up to 14,500 pounds of thrust, was also being used under a Swedish license program whereby Svenska Flygmotor was developing a Mach 2 afterburner version for the SAAB 37, or Viggen, supersonic multipurpose combat aircraft.

The twin-engine F-111 fighter-bomber flew for the first time at Mach 2.5 July 9. The variable sweep wing F-111, built by General Dynamics with Grumman as the principal subcontractor, is powered by the TF30, the world's first afterburning turbofan. This engine is in the 20,000-pound-thrust class. A bomber version of the F-111, designated FB-111, was also planned.

A non-afterburning version of the TF30 powers the single-engine Navy A-74 Corsair II built by Ling-Temco-Vought. By mid-October this plane had accumulated 1,675 flight hours in 1,151 flights, and was formally accepted by the Navy for fleet trials.

A basic version of the TF30 engine, designated the JTF10, was under development by Société Nationale d'Etudé et de Construction de Moteurs d'Aviation (SNECMA) in France, where it is known as the TF306, and used in the Dassault Mirage III-V, a supersonic vertical-lift tactical fighter.

Development continued at the Florida Research and Development Center on the J58 turbojet engine for the Air Force Mach 3 YF-12A and SR-71 aircraft built by Lockheed. The YF-12A, powered by twin J58s, is the holder of 9 world speed records. The J58 is in the 30,000-pound-thrust class.

The JTF16, an advanced, air-breathing demonstrator engine, was under development for the Air Force as part of the advanced manned strategic aircraft (AMSA) program, and was also being used in studies related to a lift-cruise engine for a vertical takeoff and landing (VTOL) aircraft.

The Lockheed C-141 StarLifter, a jet transport powered by 4 TF33 (JT3D) engines, each developing 21,000 pounds of thrust, continued to set records in daily logistics flights to Viet Nam.

TF33 turbofan engines, delivering slightly less thrust, are the powerplants for the Boeing C-135B and the B-52H missile platform bomber. A wide variety of aircraft are powered by other Pratt & Whitney Aircraft engines. 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 larger J75 powers the Republic F-105, and the Convair F-106. The J52 powers 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 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. One commercial JT12 version in production develops 3,300 pounds of thrust instead of 3,000.

Reliable performance of the engines continued to be reflected in the lengthening time between overall (TBO). The JT3D turbofan reached 9,000 hours by September, the highest for any aircraft engine in the world. The JT4 commercial version of the J75 turbojet reached a TBO of 8,000 hours, and the JT8D 5,300 hours. All began with an 800-hour TBO. Total military and commercial operating time of all the division's jet engines exceeded 100,000,000 hours.

In the steady effort to extend the life of its jet engines, Pratt & Whitney Aircraft's Advanced Materials Research and Development Laboratory invented a process to produce jet engine components in the form of individual alloy crystals. The superior material produced in the new casting process is judged four times as durable as conventionally-cast material. It was to be tested in jet engines of varying sizes.

Pratt & Whitney Aircraft's RL10 rocket engine played a key role in the nation's space effort when 2 of the liquid hydrogen-fueled engines helped boost the Surveyor 1 spacecraft to an historic soft-landing on the surface of the moon. An advanced version of the RL10 was being developed.

Work at the Florida Research and Development Center continued in the field of high pressure rocket engines to power the next generation of launch vehicles. In October, the Center revealed a 2-position nozzle concept for the RL20 high pressure engine that will provide a shorter engine and higher specific impulse for future space vehicles.

Production of fuel cell powerplants for the Apollo program continued. The PC3A-2 fuel cell powerplant, designated Powercel as a registered trademark, will provide on-board electrical power and drinking water for the Apollo astronauts. An unmanned Apollo moonship with 3 P&WA Powercels abroad, was launched three-quarters of the way around the earth August 25 in a test. The fuel cell units each produce between 563 and 1,420 watts.

A new fuel cell powerplant, largest of its kind ever built, was successfully operated during the year, with air and natural gas as the reactants instead of hydrogen and oxygen. This fuel cell, producing 4,000 watts of electricity, was developed

Pratt & Whitney Aircraft was supplying Powercels, trademark name for its fuel cell powerplants, for the Apollo spacecraft.

for Columbia Gas System, which will evaluate the potential importance of fuel cells to the natural gas industry. The division also developed, for the Army Signal Corps, a portable unit that operates on gasoline.

More non-aviation applications for jet engines were developed by the division's Turbo-Power & Marine Department.

Four compact power generating stations, each powered by 8 FT4's, modified versions of the J75 engine, were ordered by Southern California Edison Company to provide electricity for homes and industries in Southern California during peak periods of demand. The transaction represented the largest single sale of such P&WA gas turbine power units. The first unit was scheduled for commercial operation in March 1969, and each unit will provide a normal capacity of 132,000 kilowatts. Worthington Corporation will provide the free turbines in the units.

The new Southern California Edison Company units will be the fifth installation of this type in the United States. One unit was operating at a Public Service Electric and Gas Company plant in New Jersey, and 2 more units were scheduled for early installation. The fourth 8-engine unit was to be set up at Baltimore, Maryland, in 1967.

The 32-knot Royal Danish Navy frigate, Peder Skram, powered by 2 GG4 (JT4) jet booster engines with STAL-LAVAL free turbines, was accepted in March for NATO patrol duty, and a sister ship, the 354-foot Herluf Trolle, was to undergo sea trials in 1967.

Seven ocean-going U.S. Coast Guard cutters, each equipped with 2 FT4 (JT4) engines for high-speed boost power, were to be delivered in 1967-69 as part of a fleet modernization program. The first of the 2,800-ton ships, the Alexander Hamilton, built by the Avondale Shipyards in New Orleans, was to be followed by a second 378-foot cutter, the Dallas.

A modified JT4 engine, coupled with Pratt & Whitney Aircraft power turbines and designated FT4, is the primary powerplant for a deHavilland Royal Canadian Navy hydrofoil.

In addition, the Canadian government ordered 4 new DDH 280 helicopter-destroyers, each to be powered by 2 FT4 engines for high speed and 2 FT12's (JT12's) for cruising speeds. Both engines can operate on diesel fuel. The marine propulsion system was engineered in Canada by United Aircraft of Canada Limited.

The Royal Canadian Navy became the first navy to decide to use warships of destroyer type with all gas turbine powerplants. The first DDH 280 destroyer was scheduled to go into service in 1970.

The American Export Isbrandtsen Lines and the Sun Shipbuilding and Dry Dock Company were under contract to build and operate a 25-knot "roll-on, roll-off" ship for the Navy's Military Sea Transportation Service (MSTS). This ship was to be powered by 2 FT4 engines, each developing 20,000 horsepower, marking the first use of Pratt & Writney Aircraft aviation-type gas turbine engines as the primary source of power in a shipboard application.

The swift, 672-foot-long ship, the 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.

Three FT4 powerplants also were installed during 1966 at the Dow Chemical Company's chemical complex in Pittsburg, California, to produce both electric power and steam. This installation marked the first time the P&WA jet engines were used for primary, or base load, electrical power production.

Field service operating experience on the installed units in industry and marine applications exceeded 370,000 hours at year end.

In June, Pratt & Whitney Aircraft officially reoccupied the former Connecticut Advanced Nuclear Engineering Laboratory (CANEL) at Middletown, Connecticut, and began turning it into a facility for producing jet engine parts, and for engineering development, testing and research. The 1,000-acre facility, with a total floor space of 730,000 square feet, now known as the Pratt & Whitney Aircraft Middletown plant, was purchased from the Government.

A new materials center and an assembly building also was placed in operation during 1966. These buildings and more office space construction added nearly 1,000,000 square feet to the existing 4,800,000 square feet of engineering, manufacturing, and office space in East Hartford.

Employment at the end of 1966 exceeded 50,000 persons.

HAMILTON STANDARD
DIVISION OF UNITED AIRCRAFT CORPORATION

Contract awards to build environmental controls for the Air Force Manned Orbiting Laboratory (MOL) and accessory equipment for the Boeing 747 jetliner, entry into the heat pump business, and continued development of advanced propellers highlighted Hamilton Standard's activities in 1966.

Development of the MOL system for Douglas Aircraft, prime contractor for the 2-man laboratory, included a study into the choice of either oxygen-helium or oxygen-nitrogen as the vehicle's atmosphere. Preproduction life support backpacks, which Apollo astronauts will wear on the lunar surface, were delivered to NASA. Manned testing of the pack under simulated space-environment conditions continued at Hamilton Standard.

First flight hardware of the Apollo lunar module's environmental control equipment was delivered to Grumman Aircraft, builder of the LM. It was installed on the first LM vehicle scheduled to undergo unmanned test flight in 1967. Hamilton Standard added a heart augmentation pump to the bioscience and technology product line of its Space & Life Systems department. The pump is designed to assist in the emergency treatment of heart attack victims. It was acquired, with all technical marketing, and patent rights, from Sundstrand Corporation.

Work progressed on development of oxygen-recovery systems under separate Air Force and NASA programs. This regenerative equipment, using different techniques for reclaiming oxygen from carbon dioxide, is important to future manned spacecraft designed to fly 6 months and longer.

Hamilton Standard was selected to develop and produce fuel controls for the jet engines which will power the giant Boeing 747 airliner. Quantity production of controls was carried out for the powerplants of the Douglas DC-9 and Boeing 727 commercial transports, the Sikorsky SH-3A anti-submarine helicopter, McDonnell F-4 jet fighter, and more than 15 other different aircraft. Hamilton Standard delivered the 50,000th fuel control it has produced since it entered the field in 1952.

The air inlet control developed for the Navy's F-111B variable-wing fighter successfully passed its first flight test in automatic operation. Production of these hydromechanical controls continued for both the Air Force and Navy versions of the F-111.

Lockheed-California awarded the division a contract to develop the pusher propeller for the Army's Advanced Aerial Fire Support System (AAFSS) helicopter. The tail-mounted propeller, using Hamilton Standard advanced fiberglass blade and integral gearbox design, will supply additional propulsion during high-speed flight. A contract also was received to produce 3-blade propellers for the Handley Page Jetstream business aircraft. This same small propeller model was supplied for the Turbo Commander executive aircraft and the North American OV-10A counter-insurgency plane.

The advance high-thrust propellers on the Ling-Temco-Vought XC-142A tilt-wing transport performed well during extensive flight testing at Edwards Air Force Base, California. Two new propellers being developed for the Navy—the tandem-bladed variable camber and integral gearbox models—successfully completed flight test. Titanium marine propellers were delivered for the Plainview, a hydrofoil ship which the Navy will evaluate for anti-submarine and other high-speed sea missions. A contract was received from Martin-Orlando to produce ram air turbines that supply the hydraulic and electrical power which operate the television guidance system on the Navy's Walleye bomb.

During the year Hamilton Standard increased its activities in environmental controls for commercial aircraft. It was awarded a contract to manufacture cabin pressurization systems for the new Boeing 747 transport. This equipment is similar to the electronic system developed for the Boeing 737 short-haul airliner. Development work progressed on the advanced heat exchangers for the air conditioning system on the Anglo-French Concorde supersonic transport. One of these heat exchangers is designed to use the aircraft's fuel for cooling purposes. Environmental control equipment was produced for the Ling-Temco-Vought A-7A, Northrop T-38 and F-5, Lockheed JetStar, and Douglas A-4E and TA-4E aircraft.

The division's electronics department continued to supply power supplies for Shillelagh tank-fired missiles and T-38 and F-5 aircraft and cabin temperature controls for the Grumman A-6A jet and P-3A turboprop airplanes. The Ground Support Equipment department completed delivery of propellent-servicing trailers for the Saturn launch vehicle's S-IVB stage and meteorological vans to Air Force bases all over the world. It received a contract to produce still-photo vans for the Air Force.

In a space simulation chamber, a technician protected by a space suit successfully tested a hand-held electron beam welder developed by Hamilton Standard for NASA, which is looking into the possibility of using such a tool for spacecraft repairs and assembly in flight. A new partial vacuum electron beam welder was developed and marketed for high-production uses. The new model reduces welding-cycle time from minutes to seconds.

Being tested at simulated 380,000-foot altitude is Hamilton Standard's experimental hand-held beam welder, under development for space repair and assembly tasks.

In the fall of 1966, the Space & Life Systems department moved into a new 165,000 square foot wing added to Hamilton Standard's main plant at Windsor Locks, Connecticut. Construction of a new electronics plant progressed at Windsor Locks, with occupancy scheduled for early in 1967. It was to add 200,000 square feet of engineering, laboratory and production facilities.

SIKORSKY AIRCRAFT
DIVISION OF UNITED AIRCRAFT CORPORATION

Sikorsky Aircraft in 1966 headed toward new company production records as measured in airframe pounds, with average monthly production during the second half of the year almost twice as high as the average monthly production for the entire year of 1965.

Five basic helicopter models rolled off the assembly lines for delivery to all U.S. military services, foreign military services, and commercial operators in this country and abroad. The number of employees on Sikorsky's payroll rose during 1966 by about 1,500 to nearly 10,000.

Although most helicopters produced by Sikorsky in 1966 were delivered to the military services, commercial sales remained steady. Ten helicopter airlines in 6 countries used Sikorsky helicopters as passenger and cargo carriers. Sikorsky helicopters also were used in construction and for supplying offshore oil drilling rigs.

The 4 turbine-powered models in production were the S-65, the S-64, the S-62, and the S-61. The S-58, a single-piston-engine helicopter developed more than a decade ago, was still being produced at Sikorsky in limited numbers.

The S-65, called the CH-53A by the Marine Corps, was turned out on an accelerated production schedule to lead all other models. The big assault transport passed Board of Inspection and Survey tests at the Naval Air Test Center, Patuxtent River, Maryland, in late summer. Six were flown cross-country to the Marine Corps Air Facility at Santa Ana, California, in September to launch a 30-day fleet indoctrination program. Actual service deployment was scheduled for late 1966.

The CH-53A is a twin-turbine helicopter able to carry 38 fully equipped troops. A rear cargo door and winch permit easy loading and unloading. The CH-53A achieved speeds of better than 230 miles an hour during the testing. The aircraft flew at gross weight of 42,000 pounds, far above Marine Corps specifications.

The Air Force showed its interest in the S-65 by ordering a long-range rescue version, the HH-53B, for use by the Aerospace Rescue and Recovery Service. The HH-53B will carry an external rescue hoist and jettisonable, external fuel tanks and an aerial refueling system. Deliveries were to begin in 1967.

HH-3E (S-61) helicopters, called Jolly Green Giants for their green camouflage by the men who fly them and by those who are rescued by them, were used in 1966 with great success in Southeast Asia by the Aerospace Rescue and Recovery Service. HH-3E's, with auxiliary fuel tanks, flew deep into North Viet Nam to pick up downed fliers. CH-3C versions of the S-61, used by the Air Force in Viet Nam as utility vehicles, mixed rescue work with lifting assignments, carrying everything from 105 millimeter howitzers to downed aircraft.

CH-54A Flying Cranes (S-64) were used by the Army's 1st Cavalry Division in Viet Nam to carry troops, fuel, supplies, vehicles, guns, and other aircraft. Four CH-54A's had recovered more than 100 aircraft, some behind enemy lines, by midsummer. Flying Cranes moved 155 millimeter batteries because no other helicopter in Viet Nam could lift the heavy howitzers. CH-54A's also carried special pods for hospital, communications, and command post use to front line positions.

Sikorsky SH-3D practices sonar work in Long Island Sound before delivery to Spanish Navy.

The Army ordered additional CH-54A's in 1966 with modifications to fit combat requirements. The first aircraft in the new order were scheduled to be delivered in 1967.

Navy SH-3A's, antisubmarine versions of the S-61, also were active in the Asian theater. Flying from carriers in the waters off Viet Nam, SH-3A's made daring rescue flights in storm and darkness, refueling from surface craft, evading both terrain and enemy guns to pick up downed fliers. One SH-3A picked up a Navy pilot from a life raft in the heart of the harbor at Haiphong in North Viet Nam.

SH-3A's continued as recovery vehicles in the nation's space program. Gemini astronauts learned to expect the helicopters overhead almost as soon as their spacecraft splashed down in the Atlantic. Air Force HH-3E's were assigned as emergency rescue vehicles at Cape Kennedy.

Submarine-hunting SH-3D's (S-61), with newer, more powerful engines and improved sonar equipment, were first delivered to the Navy in 1966. RH-3A's, the mine-countermeasure versions of the S-61 helicopter, were delivered to both Norfolk and San Diego late in 1966 to put into practice mine-countermeasure techniques learned at the Navy's Mine Defense Laboratory in Panama City, Florida.

The Coast Guard used the HH-52A (S-62) helicopter, with single turbine engines, to increasing advantage in time of floods, hurricanes, ship wrecks, and fires, to help the injured and ill at sea, and to find lost men and missing vessels.

HH-52A's were used to complement new Coast Guard cutters built with helicopter landing platforms. Deck hangers were fitted to Coast Guard ice-breakers, too, for HH-52A storage. Coast Guard helicopters were active both above the Arctic Circle and below the Antarctic Circle.

The Coast Guard made plans for larger, twin-turbine HH-3F (S-61) helicopters scheduled to be delivered in 1968.

UH-34's (S-58), veteran workhorses with piston engines, were active in Viet Nam, where they were in service long before other helicopters. They were used by the U.S. Marines and Vietnamese Air Force as rescue and transport vehicles.

These were the active aircraft in Sikorsky's 1966 production schedule: the S-65, represented by the CH-53A and HH-53B; the S-64, represented by the CH-54A; the S-62, represented by the HH-52A and several commercial versions; the multi-purpose S-61, represented by the SH-3A, SH-3D, HH-3E, CH-3E, RH-3A, and by the S-61N and S-61L, commercial passenger versions; and the S-58, represented by the UH-34D.

Powered by twin-turbine engines, the S-64 and S-65 are in the helicopter heavyweight class. The twin-turbine S-61 series is in the medium class, and the single-turbine-engined S-62 and piston-powered S-58 are in a lighter class.

On the commercial scene, Los Angeles Airways continued to set passenger records in 1966 and received its sixth S-61L. For the second time in commercial aviation history, S-61N's were flown across the Atlantic to join Helikopter Service A.S. in Norway for offshore oil rig support. Commercial S-62's were used in the waters off Alaska for the first time to service oil rigs.

Research and development programs included work on the S-61F, a compound helicopter with wings and auxiliary thrust tested under joint Sikorsky-Army-Navy sponsorship. The number of blades, the amount of twist, and the position of wings were subjects of experimentation in 1966. The aircraft flew at speeds of nearly 250 miles an hour.

Plans for a growth version of the military S-64 Skycrane, for a Skylounge version to carry commercial passenger traffic, and for a commercial version of the S-65, in both standard and growth design, were presented in detail. Refinements were added to a stowed-rotor concept, long studied at Sikorsky. The finished design could operate as a helicopter at slow speeds, then could tuck in main and tail rotors to exceed 500 miles an hour as a fixed-wing aircraft. An advancing blade concept (ABC) helicopter—an aircraft with rigid blades and twin rotors on a single axis—was first proposed in 1966. Speeds of 350 miles an hour were forecast. Blades of titanium and fiberglass, 40 feet in diameter, were readied for wind tunnel experiments.

Sikorsky designs did not end at Sikorsky. Licensees in five countries were producing Sikorsky-developed helicopters. In 1966, special agreements were made with companies in England and Italy to manufacture SH-3D's in those countries.

NORDEN
DIVISION OF UNITED AIRCRAFT CORPORATION

During 1966, Norden division of United Aircraft Corporation increased its activities in the design, development and production of advanced airborne radar systems and won significant contracts to produce pilot displays for new high-performance aircraft.

Norden received the largest single contract in its history in February from Lockheed-Georgia Company for development and production of multi-mode radar equipment for the Air Force C-5A jet transport, which will be the world's largest aircraft when it becomes operational in 1969.

The award gave Norden a dominant position among electronic firms in the design and manufacture of airborne radar equipment that provides all-weather capability to tactical aircraft. The Norden multi-mode radar in the C-5A will feature high-resolution ground mapping, automatic low-level terrain following, terrain avoidance, weather warning and beacon operation. It will help enable the Air Force to deliver the heaviest Army equipment directly from the U.S. to locations anywhere in the world and land on relatively unprepared fields.

Norden flight simulator enables engineers to arrange and evaluate display formats produced through a contact analog display system.

The C-5A contract stemmed from the division's production of radar equipment for the Grumman A-6A Intruder, an all-weather attack aircraft in service in the Far East, and for the integrated helicopter avionics system (IHAS), which gives all-weather capability to the Sikorsky CH-53A heavy assault helicopter.

This was the second year the carrier-based Intruder, whose mission is low-level penetration, served in Viet Nam. Using Norden radar, the aircraft's 2-man crew can seek out targets obscured by night or weather conditions. Targets and geographical features can be "seen" by means of cockpit viewing screens which provide a visual representation of the ground and air below and in front of the aircraft. Accompanying Norden computer equipment provides the crew with continuous flight data. Norden also produces ground test equipment to support these radar systems.

An outgrowth of the A-6A radar systems, but lighter than its predecessor, is the radar Norden developed for Teledyne Systems, prime contractors for IHAS. The IHAS radar is designed to maintain automatically a predetermined clearance altitude, permitting the helicopter to fly in the "nap of the earth," regardless of weather conditions. This radar was field tested in July, and it was to become operational on the Marine Corps CH-53A helicopter during 1967. The radar is adaptable to other types of helicopters as well as fixed-wing aircraft.

Norden's experience in the video field expanded during the year with the winning of 3 important display contracts. In October, Norden received the second-largest contract in its history from North American Aviation's Autonetics Division for the development and initial production of dual head-up, vertical situation, and multi-sensor displays for the Mark II avionics system. The displays will be incorporated in Mark II for use in the Air Force F-111A tactical fighter, being built by the Fort Worth Division of General Dynamics. The Mark II, a new generation avionics system, will give the F-111A pinpoint navigation and weapons delivery accuracy through inter-related aircraft navigators, target ranging and moving target detection radars, navigation and weapons delivery computers, and sensors and displays. The F-111 with Mark II improvements will be able to penetrate more safely and find and destroy targets more easily.

The division earlier in the year received a contract from Sperry Gyroscope division of Sperry Rand Corporation for development of vertical situation displays in the new integrated light attack avionics system (ILAAS), to be used in advance versions of the Navy's A-7 attack aircraft. ILAAS will be the first fixed-wing aircraft avionics system to fully integrate the functions of navigation, central control, communications, weapons delivery and displays through a computer control complex. It is designed as an over-all system, emphasizing maintainability, operability and reliability. When equipped with ILAAS, the A-7 will become the fleet's primary attack aircraft for meeting future tactical requirements. Norden also won a contract during the year from Teledyne to produce similar display systems for IHAS.

The division's work in the field of specialized microcircuitry continued during 1966. Under contract to Autonetics division of North American Aviation, Norden is supplying general purpose amplifiers, featuring unique dialectric isolation, and linear and digital circuits for the Minuteman ICBM. Another Norden circuit, a sense amplifier, was fabricated to interrogate the high-speed magnetic memory core of the Apollo moon vehicle's guidance computer. In addition, Norden delivered initial quantities of linear amplifiers for the Poseidon missile/electronics system.

In March, General Dynamics-Pomona awarded Norden a contract to manufacture gyro optics assemblies for Redeye antiaircraft missiles. Redeye, the world's smallest guided missile, is designed to be carried into combat on a soldier's back and fired from his shoulder. The weapon will be used by the Army and Marine Corps. Norden for several years has been a supplier of parts for other General Dynamics-produced surface-to-air missiles.

Norden's increased business during 1966 created the need for hundreds of additional personnel in engineering and manufacturing. The division's over-all employment increased by 51 percent; in the last quarter of 1966, by 10 percent.

UNITED TECHNOLOGY CENTER DIVISION OF UNITED AIRCRAFT CORPORATION

Significant progress in solid, liquid, and hybrid rocketry was accomplished by United Technology Center during 1966.

Solid achievements included further successful flights of the Air Force Titan III-C, for which UTC produces the entire booster stage, including the 120-inch, segmented rockets which provide more than two million pounds of liftoff thrust. In addition, work was begun under an Air Force contract for Titan III/Manned Orbiting Laboratory (MOL) long-lead hardware for solid rocket motors.

Smaller solid-propellant rockets also came in for their share of attention at UTC. While sales of the FW-4 upper-stage motors used on Scout and Delta vehicles continued to grow, the company announced development of a rocket which delivered performance higher than that of any known rocket of comparable size employing a nontoxic solid propellant.

A similarly advanced liquid-propellant upper-stage engine was successfully tested during 1966. Its specific impulse is nearly 23 percent higher than rockets presently being flown. The new engine could double the payload of some U.S. launch vehicles now in use.

In the field of hybrid rockets, UTC demonstrated a high-energy engine with wide-range throttling ability and combustion efficiency of more than 94 percent. A small, back-pack size rocket using water as an oxidizer was also successfully test-fired. Two important contracts—one for flight demonstration of a hybrid-powered target vehicle, the other for a hybrid technical feasibility demonstration—were awarded to UTC by the Air Force Rocket Propulsion Laboratory. The target vehicle would be the nation's first flying hybrid. The feasibility demonstration could lead to scale-up fabrication of an engine with 200,000 pounds of thrust.

While UTC was producing and developing new rockets, milestones were reached in other areas. Several advances in propellants included UTREZ, a solid-propellant binder now used with advanced oxidizers, which maintains its integrity over a wide temperature range for long periods, and can increase performance as well.

A method of steering large solid rockets by injecting air from the atmosphere into the nozzles was devised, and UTC continued its program to develop more economical and simpler techniques of fabricating large steel rocket cases.

Not all of the company's 1966 highlights occurred in the air or on the test stand. On April 13, UTC celebrated the fifth anniversary of the dedication of its multimillion-dollar facilities in Santa Clara County, California.

That observance came one day after UTC Division President Barnet R. Adelman accepted the United Aircraft Corporation's Board of Directors' Trophy on behalf of the division, for outstanding engineering achievements in design and development of the Air Force Titan III-C booster rockets.

The company presented a full-scale cutaway replica of the world's first large, segmented solid-propellant rocket to the Smithsonian Institution. The model now stands in the Smithsonian's National Air Museum.

The year also marked UTC's diversification into production of a reinforced plastic mortar material called Techite. An outgrowth of fabrication of large glass rocket cases, Techite pipe had been installed in both sewage and drainage systems by year-end, and UTC was surveying facilities for mass production. Other aeospace-related projects included continuing research and refinement of a UTC-developed synthetic food substitute.

VECTOR
DIVISION OF UNITED AIRCRAFT CORPORATION

Vector made continuing progress during 1966 in its transition from a producer of standard telemetry components to a totally integrated producer of both microelectronic equipment and complete systems. Microelectronic circuitry was introduced in the full product line of telemetry and communications equipment. The equipment is used in aircraft, missiles, satellites, manned spacecraft, and missile test-range instrumentation and communication systems.

By year-end, all Vector telemetry transmitting equipment both of the analog and the digital types was being supplied in microelectronic form. This provided significant reductions in size, weight, and power consumption, as well as a 10-fold increase in reliability. The introduction of microelectronic circuitry into the full product line was achieved by the expansion of the output of the division's Solid State Laboratories, which produces transistors, hybrid circuits, and integrated circuits for use within the division. Several types of transistors, particularly the high-frequency, high-power types, were also marketed commercially.

In addition to telemetry transmitting and receiving systems supplied for a number of Air Force, Navy, Army and NASA programs, equipment was supplied to customers in Italy, France, England, Germany, and Sweden for aircraft and missile programs.

The division introduced a full line of pulse code modulation data reduction and processing equipment for ground application at test ranges and data reduction centers.

Under a subcontract with Raytheon, Vector was designing and building significant portions of the communications system to be installed in the Air Force Weapons Effectiveness Testing System at Eglin Air Force Base, Florida. Subcarrier oscillators, designed and built by Vector, landed on the moon in the Surveyor I spacecraft. Vector continued the development of new electronic products and systems for the monitoring of cardiac patients and for general physiological monitoring of patients undergoing intensive hospital care.

Vector's new 200,000 square foot facility at Trevose, Pennsylvania, was expected to be in operation early in 1967. This facility is designed for the development and production of microelectronic circuits and equipments.

UNITED AIRCRAFT CORPORATE SYSTEMS CENTER
DIVISION OF UNITED AIRCRAFT CORPORATION

Development of a lightweight, high-speed, gas turbine-powered passenger train, production deliveries of strapped-down inertial guidance assemblies for the Apollo program, and major progress in the field of information and environmental systems highlighted the year at United Aircraft Corporate Systems Center.

The high-speed TurboTrain, utilizing aerospace technology in its design, was to enter service in the United States and Canada early in 1967. The TurboTrain is powered by ST6 gas turbine engines produced by United Aircraft of Canada Limited. The ST6 is based on the PT6 turboprop engine which powers many aircraft and helicopters. Hamilton Standard division is providing the air conditioning for the train.

The bi-directional TurboTrain has an interior like that of a jetliner—individual reclining seats with fold-down tables, carpeting, and air conditioning that exhausts directly above each passenger seat. The fully articulated TurboTrain has a new pendulous banking system which, with a low center of gravity and guided axles, enables it to round curves with passenger comfort and safety at speeds up to 40 percent faster than conventional trains.

The division was awarded a U.S. Department of Commerce lease-maintenance contract early in 1966 to provide 2 3-car trains which will operate between Boston and New York as part of the government's high-speed ground transportation program. Canadian National Railways ordered 5 7-car trains for the Montreal-Toronto run.

The division undertook a number of new projects during the year in the field of information and environmental systems. It continued as the system contractor for the Air Force 433L system, aimed at improving weather data collection and forecasting in support of military aviation. It also branched out into other areas in information and environmental systems. Among several new contracts acquired were 2 from the Library of Congress. The first was for assistance in development of a pilot project for distribution of cataloging data in computer form on an experimental basis to a group of selected participating libraries throughout the country. The second was for the first 3 phases of a planned 7-phase program to automate the library's bibliographical operations. The State of Connecticut also awarded the division a contract to plan the initial development and implementation of a Connecticut Library Research Center. Other contracts were received in specialized areas of information and environmental systems, including applications in the intelligence field.

During the year, United Aircraft Corporation consolidated its inertial guidance program in the Corporate Systems Center, including the production of gyros. The year saw lightweight, strapped-down guidance systems become a reality. A strapped-down system is one in which instruments are fixed rigidly to the vehicle instead of being mounted on a stabilized platform. Such systems offer advantages in weight, power consumption, reliability, cost, and flexibility of operation over earlier gimballed systems. Production deliveries began of inertial sensor assemblies for the abort guidance system of the Project Apollo Lunar Module.

In May 1966, the division demonstrated a lightweight, primary guidance system for space vehicles. It consists of an inertial measuring unit and a general-purpose aerospace computer. This was the first demonstration of a high-precision, strapped-down guidance system using such a computer.

A program was undertaken to design and build an experimental model of a new type of computer for deep space probes. This computer, based on the modular concept, will be light in weight and will operate on low power.

Corporate Systems Center continued to apply aerospace technology to the marine industry. An 80-foot-planning boat powered by 2 Pratt & Whitney Aircraft FT12 gas turbine engines, each developing 3,200 horsepower in continuous operation, was completed and put through sea trials. The vessel, named the Double Eagle, was developed as a prototype crew boat for the off-shore oil industry. It is driven by 2 Hamilton Standard titanium super-cavitating propellers, designed especially to withstand the stresses resulting from high-speed operation. The boat was operated at speeds greater than 50 miles per hour in test runs. The deck of the air conditioned passenger cabin is suspended on air springs, automatically controlled to absorb shock in high seas.

WESTINGHOUSE ELECTRIC CORPORATION
AEROSPACE DIVISION

A highlight of the year for the Aerospace Division of the Westinghouse Defense and Space Center was the successful employment of the division's rendezvous radar in NASA's Gemini program.

The Westinghouse system incorporated a concept known as cooperative radar, which calls for the use of 2 companion units with 1 of the units being carried by each of the rendezvous vehicles. Total weight of the 2 units is less than if they were combined in a single radar installed in 1 vehicle. The 2 units composing cooperative radar are the radar interrogator, installed in the Gemini spacecraft, and the transponder, installed in the Agena target vehicle. The interrogator sends out questioning pulses which fan out at a 60-degree angle. When the transponder receives one of the pulses, it replies and a "lock-on" light is illuminated on the astronaut's panel. The radar is capable of making contact at distances up to 250 miles.

Among other Aerospace Division space projects were a space radio, a lunar altimeter and a lunar television camera.

To permit communication between astronauts in the vacuum of space or on the moon, Westinghouse was developing a small radio communicator for the Research and Technology Division of the Air Force's Systems Command. The system consists of two separate units, the helmet transceiver which contains all of the electronics, and a power and control unit. In operation, the control unit is worn outside the space suit. The transceiver has 2 receiving channels and 7 transmitting channels. The system operates in the 290 to 300 megacycle range with a maximum line-of-sight range of about 1 mile. Three development models were delivered to the USAF.

For NASA's Marshall Space Flight Center, the division was developing a lunar radar altimeter to aid astronaut transportation over lunar terrain. Molecular electronic functional blocks, which comprise 80 percent of the altimeter's circuits, make it more reliable, smaller and lighter than a unit employing conventional components. Altitude range is from 100 to 60,000 feet. A unit was delivered to NASA for field tests and compatibility demonstrations.

The division also delivered to NASA a model of an Apollo lunar television camera. The portable camera has a primary scanning rate of 10 frames per second with 320 scan lines. It has a second mode of operation in which the scanning rate is 0.625 frames per second. This extremely slow scanning rate will enable more detailed observation of the moon's features by scientists on earth.

The division was building for NASA long, slender booms for antennas and supports in space. The booms start out as compact rolls of flat metal strips which, as they are unrolled, curl into tubes. Research results indicate that it is possible to build booms 10,000 feet long with diameters of ½ inch. Applications for the booms include antennas, deployment of equipment or instruments from spacecraft or underwater vehicles, and coupling spacecraft in flight. Tapered booms can also be made strong enough to act as columns for erectable structures on the moon or under water.

A 1966 program was ADMOR (Advanced Development Molecular Radar), a follow-on to Westinghouse's earlier work on MODOR (Molecular Doppler Radar). Both are semiactive missile homing radars. MODOR was principally significant in that it was believed to have been the first all molecular radar built. ADMOR differs from MODOR in that it is a semipackaged system and contains significantly more sophisticated signal circuitry.

During 1966, the division was studying, under contracts with NASA and the Department of Defense, orbital light illumination for military and nonmilitary purposes. The division believed that, when this concept is fully developed, it could lead to man's ability to better control his environment, especially in the areas of climate control, increased crop yields, communications and artificial illumination.

SURFACE DIVISION

The Surface Division of Westinghouse Defense and Space Center developed a system for rapid, accurate recording and display of vital airspace control information in a tactical situation. Called TAC-MAP (Tactical video Mapping), the system is compatible with radar plan position indicators. Compact, lightweight, rugged, designed for quick installation and connection, it requires no specially trained personnel. With existing video mappers, time is lost in preparing a map for display on plan position indicators. TAC-MAP overcomes this drawback. It uses the Westinghouse slow scan vidicon camera which is synchronized to a radar trigger pulse and produces a video map or other desired information for display on associated plan position indicators. The unit weighs 150 pounds and has a volume of 18.7 cubic feet. It is packaged in a sturdy transit case measuring 36 by 30 by 30 inches.

The division also developed a general purpose digital data processor, the DPS-2402, specifically designed to meet military requirements. The new unit has a response time of 2 microseconds. It uses 24-bit words and a stored program. Unlike commercial models 3 times its size, usually operated under closely controlled environmental conditions, it is capable of withstanding unusual shock, vibration, temperature extremes, salt spray and humidity. The first DPS-2402 was to be installed aboard the Royal Canadian Navy's new high-speed antisubmarine hydrofoil, the FHE-400, to provide split second processing of information for the complex electronic equipment which controls the ship's weapons system.

Surface Division was producing a new, high reliability, all solid-state antenna coupler, the KMS-101A, an advancement over the KMS-101 which was evaluated for performance by several government agencies and accepted as a standard unit. Value engineering applied to the KMS-101 resulted in the new version with no sacrifice of performance.

Under USAF contract, Westinghouse Defense and Space Center's Surface Division was modifying 3-dimensional tactical radar systems. The modified system (below), some 60 percent lighter and more reliable, is designated AN/TPS-48.

Due to the simplified circuitry of the KMS-101A, an increase of 80,000 hours mean time between failures was expected.

Under an Air Force contract, the division was modifying AN/TPS-27 3-dimensional tactical radar systems, reducing their weight by about 60 percent. Despite the large weight reduction, no decrease in performance capability of the long range surveillance and interceptor control radar resulted. After modification, the radar carries the designation AN/TPS-48.

UNDERSEAS DIVISION

Among the year's major events at the Underseas Division was certification by the Naval Ship Systems Command of the Westinghouse Deepstar-4000 submersible. The certification qualified the vehicle for unrestricted operation to depths of 4,000 feet. Actually, on the certification dive of May 15, Deepstar-4000 reached a depth of 4,100 feet. The dive included 1 hour of speed, power and maneuverability tests as well as systems functions checks.

Deepstar-4000 is the first of a family of submersibles. The second, Deepstar-2000, was under construction during the year and scheduled for completion late in 1967. Plans for a third vehicle, with a design depth of more than 13,000 feet, were undergoing engineering evaluation and an early start on construction was anticipated. The ultimate goal is a 20,000 foot depth vehicle.

Underseas Division was conducting simulated experiments in deep-sea diving, aimed at increasing depth range and diving time in undersea work. As part of a long range program, 2 experimenters completed a dive of 4 days duration in a special pressure chamber. They were subjected to pressures as high as those found at a water depth of 400 feet, about 200 pounds per square inch, in the 27-foot-long, 7-foot-diameter steel chamber.

The division also outfitted with some $500,000 worth of electronic equipment the Coast and Geodetic Survey's most advanced deep sea research ship, *Oceanographer*, a $7,000,000 floating laboratory. The equipment installed, developed by the division, was an automatic data acquisition system which enables the *Oceanographer* to carry out a wide range of oceanographic, geophysical and hydrographic surveys in addition to pinning navigation fixes and gathering weather information. Underseas Division was to similarly equip a sister ship, *Discoverer*, later in the year.

SYSTEMS OPERATIONS

In July, Westinghouse Defense and Space Center delivered to Marshall Space Flight Center an evaluation model of a lunar drill, 1 or 2 designs being studied by NASA for possible use on post-Apollo manned lunar surface exploration missions. The drill, hollow-core rotary type, is designed to enable an astronaut to pull 5-foot-long, 2-inch-diameter core samples to the surface from depths of more than 100 feet. After every 5-foot drilling operation, the astronaut pulls up on the outer drill casing, causing an inside wedge-shaped ring at the bit to tighten. The tightening action breaks the core sample and the inside barrel containing the core is then hoisted up on a wire. The wire-line method permits the drill and outer casing to remain in the hole, saving drilling time and preventing possible cave-ins.

Under contract to the National Science Foundation, Westinghouse was studying a way to build a unique man-made floating research island to conduct better and longer Arctic research expeditions. Cornerstone of the new approach is the concept of a drift hull research platform outfitted with a small nuclear power plant and able to withstand the often devastating pressure of Arctic ice floes. The research platform would have quarters to house 45 men and stock several years' food supply. In addition to a number of laboratories, it would include medical and recreational facilities, an electronic equipment repair shop, a machine shop and a hanger for aircraft and snow-clearing equipment.

In June, the Defense and Space Center was awarded contracts to train nearly 400 Peace Corpsmen for assignments in Micronesia, Chile and Iran. The programs involve technical skill training in addition to language and cultural instruction.

AEROSPACE ELECTRICAL DIVISION

During 1966, the Aerospace Electrical Division continued to maintain its prestige of being the manufacturer of most reliable electric power systems for commercial and military aircraft. In addition, the production of deep submergence propulsion systems made AED a significant factor in the underseas market. AED has complete capability for producing light-weight, compact electric power systems for aircraft space surface and underseas vehicles. The Aerospace Electrical Division's long experience in electric motors is reflected in their production of DC and AC motors for numerous aircraft applications such as fuel pumps, blowers and fans, gun actuators, air compressors, armament accessories and radar equipment. A great deal of enthusiasm was shown by prospective customers toward the (PEGS 60-400) *P*ortable *E*ngine *G*enerator *S*ystem. The PEGS concept utilizes a unique new prime mover, a rotating combustion (WANKEL) engine with an advanced design AC electrical system on a unified system basis. As such, the PEGS concept offers advantages in utilizing lightweight, compact aircraft design concepts.

The Aerospace Electrical Division designed, developed and tested the AC electric power system for the multi-mission, bi-service F-111 aircraft. The system provides the primary electric power source for aircraft. AED demonstrated performance reliability by a 5,000-hour system test. Such test exceeded the specified mean time between failures by 189 percent at 90 percent confidence level. The test supported excellent field operation results achieved by this equipment at the airframe manufacturer and on flight test.

Extensive effort in Research and Development of Nuclear Electric Technology was also being undertaken at AED. Major emphasis was being directed toward materials for power conditioning equipment. In addition, development of technology needed for high power, modular electric power supplies was expected to provide basic modules which can be added together to provide the necessary electric power as the space vehicle system or mission requires.

Major developments were accomplished in lightweight, multiple and single output, fully static DC power supplies for 60 cycle and 400 cycle input applications. These power packages use newly developed transformers up to 15 percent lighter than conventional transformers and highly reliable electronic components. Output power is precise, regulated and controlled to any degree required by the application. Applications include the C-130, C-141 and the F-4 series.

The 737, F-111 and F-4 aircraft were using a new line of a.c. power relays using magnet latching instead of mechanical latching. Special features include lower weight (up to 30 percent), higher interruption capacity (up to 5000 amperes), higher reliability (more than 50,000 hours MTBF), and easy maintenance. Both unsealed and hermetically sealed relays for 20 to 120 KVA systems were available.

Major advancements in the state-of-the-art were accomplished during 1966 by the development of SCR controlled test stands with ratings up to 200 horsepower capable of testing all existing or anticipated airborne power generators, constant speed drives, along with many other types and kinds of electrical and hydraulic power equipment. Design resulted in equipment up to 50 percent lighter and smaller, up to 20 percent more efficient, requiring little or no maintenance and much less auxiliary equipment. Initial applications were aboard Navy aircraft carriers.

Multiple purpose power systems analyzers were developed for the DC-9, 707, 720, and 727 aircraft. These portable units, with interconnecting adapters, permit positive location and identification of a power system fault on the aircraft and also provide check-out and test capabilities in the repair shop. This advance allows considerable reduction in test equipment required by operating organizations.

ASTRONUCLEAR LABORATORY

In March, the Astronuclear Laboratory received a $1,000,000 contract from the Atomic Energy Commission for continued development of a compact space device to convert heat into electricity. The Laboratory had built and tested for hundreds of hours several prototype units. The units are cylindrical in shape, about 2 inches in diameter and 20 inches long; they operate on the principle of thermoelectrics. The ultimate aim of the program was to build a tubular thermoelectric module capable of withstanding the rigors of space flight while providing electricity to power communications and other systems on manned or unmanned space vehicles. The module would use heat from a Space Nuclear Auxiliary Power (SNAP) system or a radioisotope for conversion into electricity.

Another contract, from the Navy's Facilities Engineering Command, called for a generator that would convert radioisotope heat to electric power and operate continuously and unattended for 5 years at sea depths down to 20,000 feet. The unit was scheduled to be completed at year-end, then turned over for evaluation to the Port Hueneme, California, Naval Civil Engineering Laboratory.

For NASA, the Laboratory developed an electron beam welder to make high quality joints without enclosing the workpiece in a vacuum. In addition, the new device was designed so that the electron beam welding head can be brought to the work rather than having to move the work under the welder.

MARINE DIVISION

In June, the Westinghouse Marine Division received a $2,500,000 order to supply propulsion machinery and controls for 4 large ferries linking Seattle and the Olympic Peninsula in Washington. Westinghouse electric generators and propulsion

Westinghouse Marine Division developed a 23-foot collimating mirror for Jet Propulsion Laboratory's space simulator. The mirror is used to produce an intense beam simulating solar radiation conditions.

motors, driven by 4 2,250 horsepower diesel engines aboard each boat, will enable top speeds up to 20 knots. Late in the year, the Marine Division shipped the first shipset of switchgear, propulsion controls and panelboards to the shipbuilder.

The division also shipped the first 16 of 64 Polaris missile launchers for United Kingdom naval ballistics missile submarines.

For Jet Propulsion Laboratory's space simulator at Pasadena, California, the division built a 23-foot collimating mirror, the largest in the free world. The spherical mirror will be used to produce an intense beam simulating solar radiation conditions in the simulator.

RESEARCH LABORATORIES

Among 1966 studies under way at Westinghouse Research Laboratories were investigations of supermagnets as protection against radiation in space and creation of plasma by laser beam.

In the former experiment, scientists were studying the possibilities of using superconducting magnets to deflect the charged particles that rain upon a vehicle in space. These magnets create intense magnetic fields from negligible amounts of power. One question has been whether the supermagnets themselves could survive space radiation. In a series of experiments for NASA, Westinghouse scientists placed superconducting materials in the high vacuum and ultracold conditions they would encounter in space and gave them massive doses of radiation. The radiation, deuterons produced by a cyclotron, was thousands of times greater than the maximum flux of energetic protons from a solar flare or the flux of the inner Van Allen radiation belt. Measurements were then made of the changes in superconducting properties caused by the high energy particles and experimenters concluded that the effects observed would not constitute a problem in space applications of superconductors.

Other scientists reported a key experiment in plasma physics in which they created a hot, electrically charged gas, or plasma, by the beam of a laser, and confined the plasma by means of a specially shaped magnetic field, or "magnetic bottle." The 2 conditions, generation and confinement of a suitable plasma, are the still unsolved problems man faces in his attempts to achieve controlled thermonuclear power.

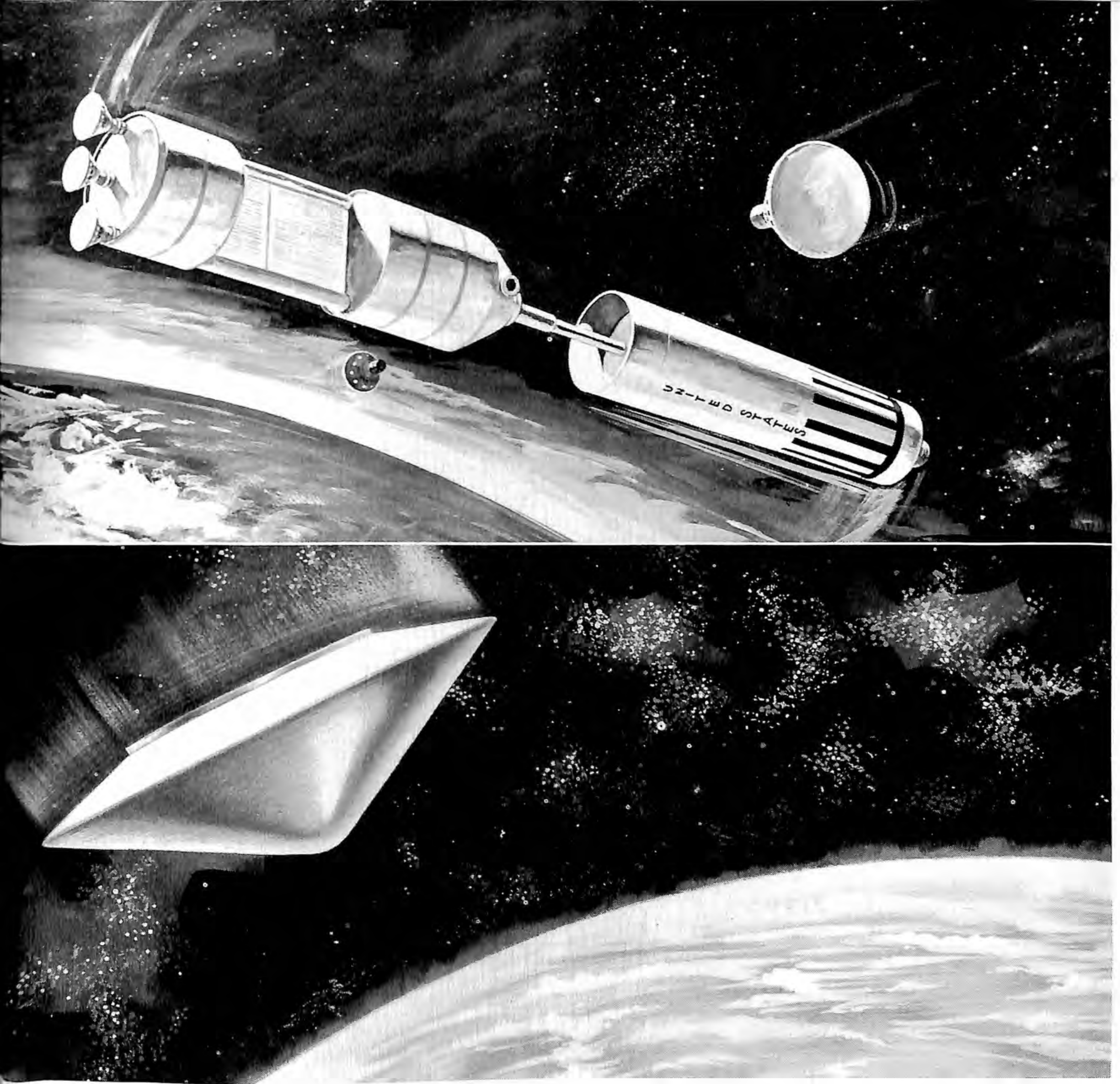
Grumman's across-the-board Space Capabilities 1967-1977

PRESENT LM WORK

Construction of all vehicles scheduled for 1967 delivery is well under way. We have already delivered the first Lunar Module to Kennedy Space Center. This year we deliver to NASA the vehicle scheduled to land on the moon. We are confident of meeting the goal of landing a man on the moon safely before 1970.

ADVANCED SPACE MISSIONS

Grumman has spent over three years studying the application of our Apollo/LM vehicles to a variety of earth orbital, lunar orbital and lunar surface missions. Also, their relevance to scientific earth resources, communications and logistics missions. We've expanded the scope and intensity of studies in planetary probes, advanced scientific satellites, military applications, lunar bases, re-entry vehicles and manned Mars missions.



MARS MISSIONS

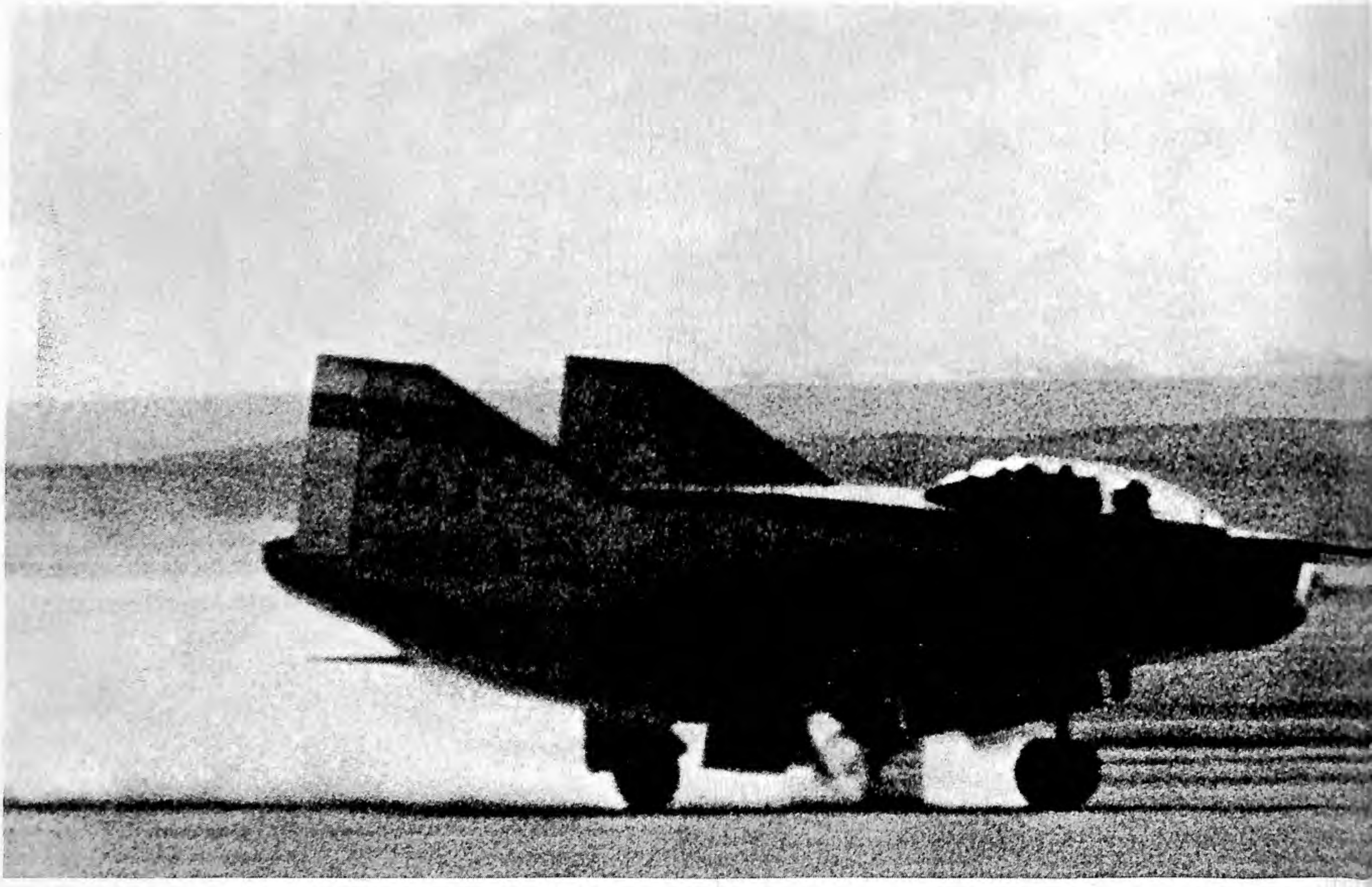
Grumman is engaged in major application research to develop vehicles for soft and hard landings on Mars. Our aim is to make current space hardware and experience pay off for the national space program: to use what we've learned and built in order to achieve maximum success at the lowest practicable cost in the crucial Voyager mission. Before a man can land on Mars, scientists must learn a great deal more about the planet and its environment. This calls for a varied series of probes, orbiters and hard and soft landers.

ORBITAL SPACE STATIONS

Currently under study are space stations with lifetimes of up to five years. And space science isn't the only area to profit from orbital space stations. The knowledge gained filters rapidly into our daily lives. In such forms as earth resources surveys, world-wide educational TV, and greatly improved meteorological data for more precise weather reports.

GRUMMAN *Aircraft Engineering Corporation • Bethpage, L. I., New York*

We built a spacecraft to fly like an airplane.



It just did for the 13th time.

This is the M2-F2. It's a wingless research craft. Someday similar vehicles will shuttle crews and supplies between earth and orbiting space stations.

To come back down, the space ferries will land on airport runways. Just like a plane. So why no wings? Wings are useless in space. And they'd be torn off on re-entry into the atmosphere.

NASA developed the shapes for two of these "lifting bodies." The M2-F2 and HL-10. Northrop designed and built both quickly and at low cost. Yet they meet the highest standards of quality and reliability.

The M2-F2 shown here was dropped from a B-52 at 45,000 feet. So far, four pilots have successfully put the M2-F2 through maneuvers to test its flight behavior.

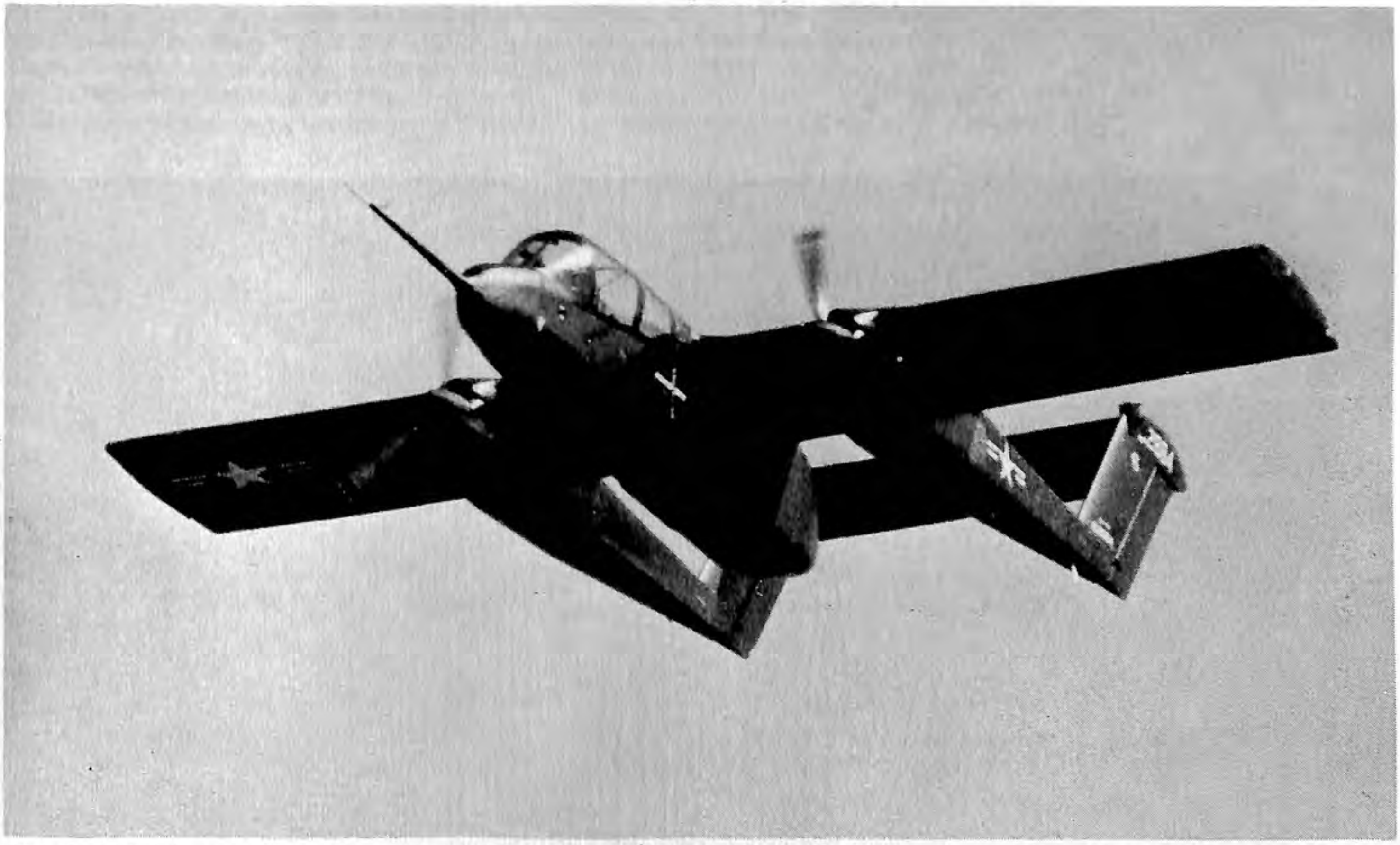
The Northrop space ferries are being tested at subsonic speeds. Rocket engines will soon boost them to 80,000 feet and twice the speed of sound, before they glide back down to earth.

So when you see your first space ferry, remember: It went up like a rocket but came down like a plane.

NORTHROP

Production go-ahead:

North American's OV-10A, with AiResearch T76 turboprops.



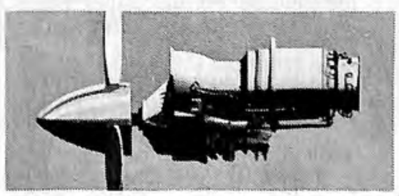
The OV-10A is now in production. Its engines, selected by Department of Defense and North American Aviation, are T76 turboprops.

These 715 hp AiResearch engines help give the OV-10A outstanding performance for forward air control, light armed reconnaissance, helicopter escort, and other missions.

In addition, T76 military turboprops have a built-in capacity to meet future demands for substantial power increases; engines of higher horsepower are well along in development.

A commercial version of this engine is already operating in the environmental extremes of Southeast Asia, and is demonstrating outstanding performance and reliability.

Write: Aircraft Engine Sales, AiResearch Manufacturing Company, Phoenix, Arizona 85034.



GARRETT

AIRESEARCH MILITARY AIRCRAFT PROPULSION

WE'VE GROUPED TO GIVE YOU THE MOST ADVANCED AEROSPACE ELECTRONIC SYSTEMS.

General Precision has assembled the peak technologies of our age to advance the frontiers of electronics.

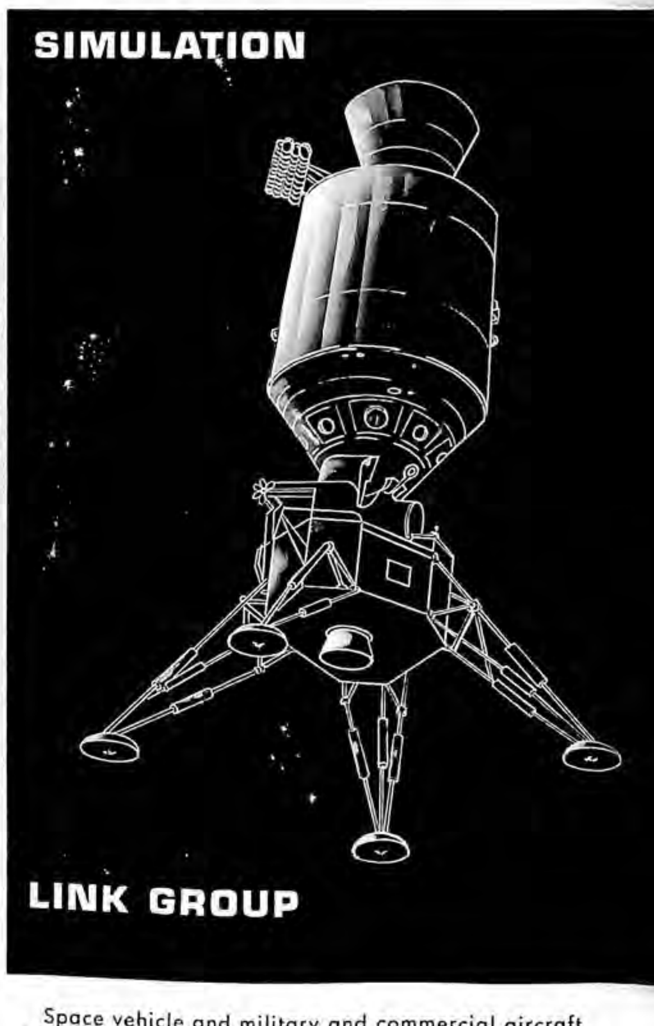
In four operational areas, our Aerospace, Link and Librascope Groups and Tele-Signal Corporation offer a primary source of experience for industrial and military programs.

AEROSPACE GROUP—comprised of Kearfott Products, Kearfott Systems and GPL Divisions—has to its credit such successes as the Stellar Inertial Guidance System (STINGS), the Low-Cost Inertial (LCI) System, and the world's most advanced, miniature Doppler radar navigation system. The Kearfott name is synonymous with synchros, servos, gyros, and inertial platforms and systems.

LINK GROUP—is the world's foremost organization in aircraft and space vehicle simulation and training. It is producing the Apollo-LEM simulation complex which is training astronauts for the journey to the moon and return.

LIBRASCOPE GROUP—is the recognized leader in anti-submarine warfare weapon control systems. It has produced such systems for the ASROC and SUBROC missiles and is now working on the Mark

Navigation, guidance and control systems. Navigation computers—digital, analog and hybrid. Gyroscopes, platforms, accelerometers, servos and synchros. Packaged hydraulic and electromechanical control systems. Information handling and data display systems including closed circuit TV.



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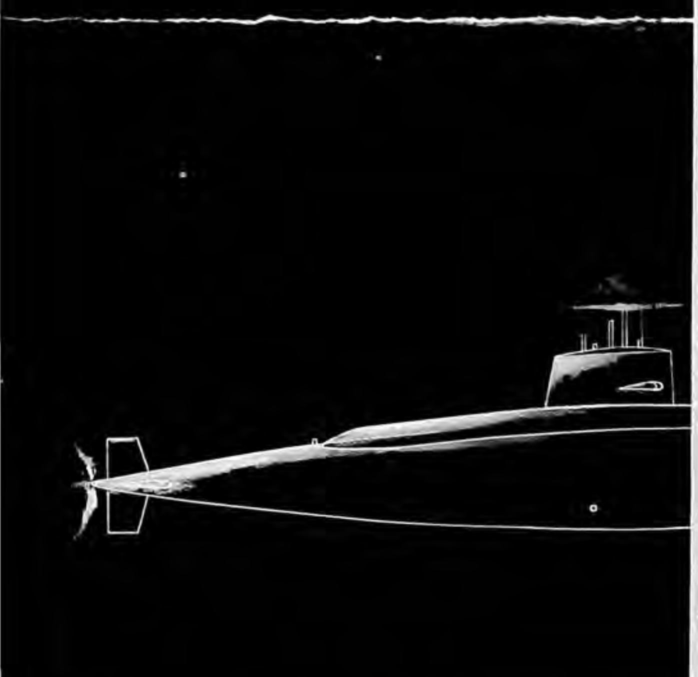

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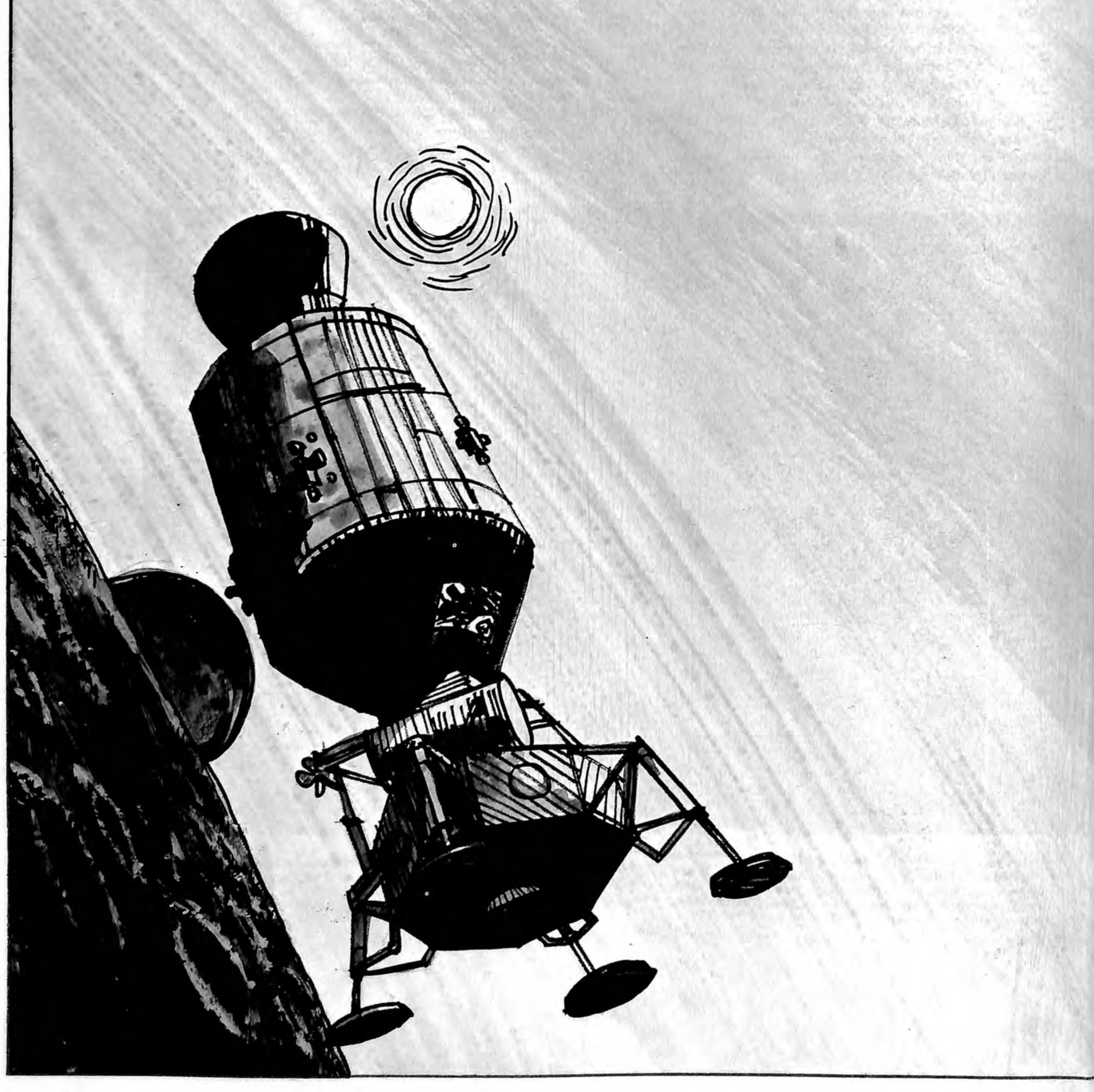

During the fiscal year 1967, ending June 30, 1967, new obligational authority for all government research and development was expected to total \$15.8 billion, a slight decrease from the previous year's total. By far the major portion of the funds was to be obligated for aerospace systems, although a direct dollar breakdown is not possible because some of the agencies involved were involved in both aerospace and non-aerospace research and development. The enormous range of government research and development projects precludes even a catalog listing, but this section contains the highlights of 1966 in those agencies primarily concerned with aerospace research and development. Additional detail on unclassified projects is contained in the individual company résumés in the Aerospace Industry section and in the Reference section.

ATOMIC ENERGY COMMISSION

The year 1966 was an anniversary year for atomic energy. In February, the 25th anniversary of the discovery of plutonium was marked at the University of California at Berkeley. Secretary of the Interior Stewart Udall designated the small lab at Berkeley in which the discovery was made as a National Historic Landmark. In June the first nuclear power generator in space marked its fifth anniversary and continued to provide supplementary power for a Navy navigational satellite. August 1 was the 20th anniversary of the signing of the Atomic Energy Act which brought the Atomic Energy Commission and the Congressional Joint Committee on Atomic Energy into existence. And at midnight, December 31, the Commission became exactly 20 years old.

But the growth of atomic energy did not stop for these anniversaries. More and more applications were found for radioisotopes, testing continued on nuclear-powered rocket engines for space exploration, and electric companies announced plans for nuclear power generators at an unprecedented rate.

Electric utilities continued to adopt nuclear power reactors at a rate that outstripped even the most optimistic predictions. Two new nuclear power plants became operable in 1966, bringing the number of operable plants to 14. The largest was a 768,000-kilowatt power plant which uses steam generated in a plutonium production reactor at the AEC's Hanford plant near Richland, Washington. The power generating facility is operated by the Washington Public Power Supply System in Richland. The nation's first gas-cooled power reactor, constructed for Philadelphia Electric Company at Peach Bottom, Pennsylvania, became operable and began working toward its capacity of 40,000 kilowatts. A 430,000-kilowatt reactor at San Clemente, California, became operable late in the year.

The unexpected surge of atomic power forced a revision of estimates of future nuclear facilities. As recently as 1964 the AEC predicted that by 1970 the United States would have between 6,000,000 and 7,000,000 kilowatts of nuclear electric generating power. But by November 1, 1966, utilities had announced plans for 25 central power reactors with a total capacity of more than 19,000,000 kilowatts. The prediction for 1970 was raised to more than 10,000,000 kilowatts of nuclear power; by 1980 nuclear power is expected to generate between 80,000,000 and 110,000,000 kilowatts, representing about 25 percent of the total national output.

As shortages of water throughout the nation became more critical, more and more areas began thinking of desalting—particularly of nuclear-powered desalting plants—as man's best chance to control his supply of fresh water. Desalting, President Johnson said, "is one of our great hopes for the future, for while our population continues to increase, the amount of water presently available remains the same as it was 5,000 years ago."

The most ambitious plan was for the world's largest nuclear desalting and electric power plant to be located in the Los Angeles area. In August, Congress authorized the AEC to spend $15,000,000 as its part of the project; the Department of the Interior will also participate. The $390,000,000 facility, to be located on a man-made island, will produce 150,000,000 gallons of fresh water daily—enough for a city of 750,000, or more than double the total capacity of all existing desalting plants. In addition to the fresh water, the plant will produce 1,800 megawatts of electric power. A similar type of plant was recommended for the drought-stricken Northeast region in an interagency report to the President.

Radioisotopes and sensitive radiation detection devices spread to several diverse fields in 1966, including snow measurement and pyramid exploration.

A nuclear gauge for snow measurement was developed by the Department of Agriculture, with assistance from the AEC. Using radioactive cesium-137, the gauge measures changes in the water content and density of snow packs over long periods of time. Gamma rays from the cesium pass through the snow to a radiation detector that gives the amount of water and the density of the snow. This information is vital for flood control, water supply and hydroelectric dam operations and may be used in avalanche-hazard prediction.

At the end of the year, radiation detection equipment was being designed to tackle an ancient question: whether the burial chambers of the Pharaohs are hidden in the great pyramids. The United States and United Arab Republic prepared to "X-ray" the Second Pyramid of Chephren, at Giza, with the hope of detecting undiscovered chambers. The scientists will use spark chambers to count cosmic ray muons (elementary particles 207 times as large as electrons) that pass through the Pyramid. Since muons' energy and quantity are reduced as they pass through matter, any voids would register on the detectors. Scientists would then know whether the massive stone structure contained voids—possibly secret burial chambers.

A radioisotope battery that powered a lighthouse in the Chesapeake Bay for nearly 2 years was transferred to the Gulf of Mexico. The 60-watt generator, fueled with 20 pounds of strontium titanate, was moved in April to an offshore oil and gas platform to provide for an unmanned beacon. The device was designed to provide continuous power for at least five years without servicing; conventional batteries powering the Chesapeake lighthouse had to be replaced annually. In the Gulf the generator replaced an identical one that had been removed because of a decrease in power.

Continuing its policy of withdrawing from areas of activity that private industry is prepared to take over, the AEC stopped producing and selling 19 radioisotopes available commercially. Since May 1961 the AEC has withdrawn from producing 36 radioisotopes.

In mid-1966, the first nuclear power generator in space marked its fifth anniversary and continued to provide supplementary power for the Navy's experimental navigational satellite 4-A. The 5-pound, 3-watt generator continued operating intermittently throughout the year. The generator was developed for the AEC's SNAP (Systems for Nuclear Auxiliary Power) program to produce lightweight nuclear electric devices for unattended operation in all environments.

Plans for a radioisotope generator that will be more powerful than any previously planned were announced by the AEC. SNAP-29, to be used in short-lived earth orbital missions, will be fueled with polonium-210 and will produce 400 watts of power. The polonium will emit heat as it decays, and thermocouples will convert the heat directly into electrical energy to provide power for instruments and transmitters.

SNAP-11, a 20-watt radioisotope generator originally designed for lunar applications, completed a 90-day test under simulated lunar conditions at Oak Ridge (Tennessee) National Laboratory. The test was the first demonstration of electric power production from curium-242 in a thermoelectric generator, and it was the largest amount of the radioisotope ever assembled. It operated for 80 days at 235 degrees Fahrenheit, representing the lunar day, and for 10 days at minus 235 degrees Fahrenheit, simulating lunar night.

A SNAP nuclear reactor being ground-tested in California completed a year of generating electricity continuously. The FS-3 was a prototype 500-watt nuclear reactor space power system. During the year it generated about 3,500,000 watt-hours of electricity.

The nuclear rocket program continued testing during the year under the control of the Space Nuclear Propulsion Office, directed jointly by the Atomic Energy Commission and the National Aeronautics and Space Administration. The NERVA (Nuclear Engine for Rocket Vehicle Application) rocket engine underwent a successful "breadboard" engine system test—that is, a test of all engine components arranged for test convenience rather than for flight.

In March, the engine achieved full power for the first time, and on the same day it was restarted and operated for 15 minutes at varying power levels. Its top power was about 1,100 megawatts, roughly equal to 55,000 pounds of thrust under space condi-

In 1966 testing, the NERVA nuclear engine for space use reached full power for the first time—1,100 megawatts or 55,000 horsepower.

tions. Further full-power tests were later made on the reactor alone.

The NERVA reactor, which will propel its rocket by rapidly heating liquid hydrogen and expanding it out a nozzle, is considered man's best opportunity for deep space exploration. One possible use, for example, is a Mars mission for a 3-stage spacecraft propelled by 5 nuclear rocket engines. NERVA is a part of the Rover program of developing nuclear propulsion for space exploration.

The development of a self-contained, radioisotope-powered cardiac pacemaker was begun by the AEC with hopes that the device will treat "heart block," an interruption of the normal stimulus to the heart. The pacemaker would be inserted in the body to stimulate a regular heartbeat.

The radioisotope device, fueled with plutonium-238, would have a minimum lifetime of 10 years, 2 to 3 times that of existing battery-powered pacemakers. Its longer life span would greatly reduce the number of operations required to replace a shorter-lived device.

The first use of a "supermagnet" in full-scale high energy physics research was begun at Argonne National Laboratory near Chicago. The new magnet employs the principle of superconductivity. Superconducting materials are those which lose their resistance to electric current at very low temperatures. The doughnut-shaped device is 24 inches in diameter and has a center hole 11 inches in diameter. In conventional terms, its field is 88,000 times that of the earth's magnetic field.

The 2 major advantages are that it does not waste energy and does not require a large power source while running, as do conventional magnets. Once charged, the supermagnet will function without electrical power as long as it is kept cold. The magnet is being used around a bubble chamber a device used to track energetic particles in liquid. The magnetic field bends the path of a particle in proportion to its speed, and the extent of the bend is measured by photographing at high speed the bubble tracks produced by particles speeding through the liquid.

A supermagnet with the most powerful field yet reported was being tested at Brookhaven (New York) National Laboratory late in the year. Operating at minus 452 degrees Fahrenheit, the Brookhaven supermagnet produced a continuous magnetic field 280,000 times as great as the earth's.

For the first time, scientists in 1966 began directly measuring astatine, a radioactive element that is so scarce that it has never been seen by the human eye. Scientists at Argonne National Laboratory made compounds of astatine, the 85th element, and studied them with a mass spectrometer. The tests were made from 50 billionths of a gram of astatine, which is 2,000,000 times as radioactive as radium.

The University of Illinois, under AEC contract, began construction on a computer with new "parallel" organization, which will permit the computer to read and compare pictures, maps and other materials. The Illinois Pattern Recognition Computer, or Illiac III, is planned to recognize similar patterns in a series of images that would normally require close scrutiny of human eyes.

The AEC dedicated 3 new major research facilities at Oak Ridge (Tennessee) National Laboratory in November: The High Flux Isotope Reactor, designed to produce research quantities of transuranium elements; the Transuranium Processing Plant, for the preparation of target rods for irradiation and purification of transuranium elements produced by irradiation; and the Transuranium Research Laboratory, for study of the chemical and nuclear properties of short-lived transuranium isotopes.

Late in the year, AEC selected the Weston, Illinois, site near Chicago as the location for its proposed 200 billion electron volt proton accelerator. Six sites recommended by the National Academy of Sciences had been under study since March. AEC was to request $10,000,000 in the fiscal 1968 budget for initial design work.

In May, the first pulsating beam of electrons shot through the world's largest linear accelerator, a 2-mile, 20-BEV facility at Stanford University. This accelerator, along with the planned 200-BEV and others, will allow scientists to "see" into the atomic nucleus with ever greater power to gather data about the fundamental building blocks of all matter.

The International Atomic Energy Agency continued emphasizing its safeguards systems to assure that its projects and materials are used only for peaceful purposes. In June, the IAEA extended its safeguards procedures to reprocessing plants, and the United States offered the Nuclear Fuel Services reprocessing plant in West Valley, New York, for the IAEA to develop safeguards techniques.

The IAEA continued to study the possibility of nuclear-powered desalting plants. The United States-Mexican-IAEA nuclear desalting study group met twice in 1966. The United States also began studies for nuclear desalting plants with the governments of Greece and Israel. The United States has offered to share its experience and technology with both countries for the production of fresh water.

Two reactors built under the U.S.-Euratom Joint Program achieved criticality in 1966. They were the KRB, a 237,000-kilowatt boiling water reactor at Gundremmingen, West Germany, and the SENA, a 266,000-kilowatt pressurized water reactor at Givet, France. The 150,000-kilowatt SENN power plant, the first to be built under the joint program, began operation at Punta Fiume, Italy, in 1963.

AEC and the Air Force successfully tested a radioisotope-powered water recovery system for use aboard space vehicles in extended manned flights. About 500 grams of plutonium-238 were used as a direct heat source for the laboratory operation of an experimental water recovery system which converts human fluid wastes (wash water, urine and condensate) into potable water.

The 30-day unmanned test at AEC's Mound Laboratory, Miamisburg, Ohio, began in mid-November and ended on schedule without major incident. Detailed study and evaluation of test data was under way at year-end.

The vacuum distillation-vapor pyrolysis system is designed to operate in either earth or zero gravity environments. The demonstration test was to prove the concept of direct use of isotopes and the dependability of the components during prolonged exposure to a space environment.

Under actual flight conditions, the water recovery device could operate as long as 1 year. The half life of the radioisotope itself is 89 years. However, the scaled-down demonstration device was designed to supply 2 men with drinking water during a 30-day mission, recovering about three-quarters of a pound of water each hour.

The AEC and Department of Defense jointly conducted a non-nuclear safeguard exercise in the Pacific from mid-September to mid-October. B-52 aircraft dropped instrumented test-simulators, simulator-equipped rockets were launched from Johnston Atoll, and other aircraft simulated the gathering of nuclear effects data. The exercises were held to maintain facilities and personnel in a state of readiness for atmospheric testing, if ever required.

The United States continued its underground testing of nuclear explosives, as allowed under the terms of the limited test ban treaty. As of November 1, the AEC had announced 30 weapons-related underground explosions, 19 of which were low yield (less than 20 kilotons).

In mid-year, the 41st and last of the planned nuclear Polaris submarines—the USS *Will Rogers*—was launched, bringing the nation's operational nuclear fleet to 69 vessels—65 submarines, an aircraft carrier, 2 guided-missile frigates and a guided-missile cruiser. A second nuclear aircraft carrier, another guided-missile frigate, a cruiser and 5 attack submarines were authorized in 1966.

The N.S. Savannah, the world's first nuclear-powered merchant ship, completed her first year of commercial service in mid-1966 by exceeding all performance expectations. She carried about $2,000,000 worth of general cargo between the United States and ports in France, Spain, Portugal and Italy. Built by the Maritime Administration and the AEC, the Savannah recently added ports in Libya, Tunisia and Yugoslavia to her ports of call.

The AEC's Plowshare Program to develop peaceful uses for nuclear explosives continued in 1966. Three low-yield underground nuclear tests were conducted at the Nevada Test Site in March, July and November to study the possibility of using similar devices for excavation; in June a low-yield underground test was held to develop a special nuclear device capable of producing neutron-rich isotopes of transplutonium elements in a nuclear explosion.

Two new Commissioners were sworn in in 1966, and a third began his second term with the AEC. Wilfrid E. Johnson, former general manager of the General Electric Company's Hanford Atomic Products Operation at Richland, Washington, began serving the unexpired term of Commissioner John G. Palfrey. Mr. Johnson's term of office was to expire on June 30, 1967. Dr. Samuel M. Nabrit, biologist and educator, began serving the 4 remaining years of a term with the Commission. He had been chairman of the department of biology and dean of the Graduate School of Arts and Sciences at Atlanta University, and since 1955 had been serving as the second president of Texas Southern University. Mr. Johnson and Dr. Nabrit were sworn in at the White House on August 1—the 20th anniversary of the signing of the Atomic Energy Act. Dr. Gerald F. Tape, a Commissioner since 1963, was nominated by President Johnson to a five-year second term. He was sworn in on June 30.

DEPARTMENT OF DEFENSE

The Department of Defense was expected to obligate about $7.3 billion for research and development projects during fiscal 1967, and while the bulk of the funding involved aerospace projects no direct percentage breakdown was available. Highlights of the major research and development programs are contained in the resumes of the individual services which follow. In addition, DOD was expected to obligate some $211,000,000 for exploratory development projects directed by the Advanced Research Projects Agency. Foremost among these projects was Defender, a broad program of research and exploratory development in the field of ballistic missile defense, penetration aids and defense against satellites. For this project, ARPA was to obligate about $119,000,000. Some 40 percent of the effort was to be devoted to the missile phenomenology program, involving measurements of ballistic missile flight phenomena and, in particular, disturbances caused by missiles as they pass through the atmosphere. The program included both full scale and subscale experiments as well as theoretical research; the principal series of full scale tests was termed Project PRESS, for Pacific Range Electromagnetic Signature Studies. Another major portion of Defender was being devoted to the investigation of electromagnetic devices which increase the utility and lower the cost of missile defense systems.

AIR FORCE

During 1966, Air Force Systems Command continued to fulfill its role of rapidly advancing aerospace technology and adapting it into operational aerospace systems. Systems Command's achievements generally fell into 5 major areas, including limited war and support for Southeast Asia operations, the national space effort, new aeronautical developments, advances in technology and the management of Air Force scientific and technical resources. All limited-war actions within Systems Command were gathered under Colonel Calvin W. Fite, deputy for Limited War with Aeronautical Systems Division (ASD), at Wright-Patterson AFB, Ohio. General James Ferguson, who assumed command of Air Force Systems Command on September 1, appointed Colonel Fite to succeed Brigadier General Henry B. Kucheman, who became vice commander for ASD.

In April, Captain Ronald W. Terry was honored at the 20th annual convention of the Air Force Association for developing the venerable AC-47 into an attack aircraft with side-firing General Electric Gatling guns. AC-47's were supporting friendly forces in Viet Nam.

Systems Command announced in May that powerful new long-range weather radars would give Air Force forecasters in Southeast Asia an instant look into the skies almost 15 miles up and more than 200 miles distant. The storm detection radars were procured by Electronic Systems Division (ESD) in response to an urgent Southeast Asia Operational Requirement (SEAOR).

During July, it was announced that a transporter-loader had been developed which can handle the increased weight of conventional bomb loads being dropped on Viet Nam by Boeing B-52 bombers. Research & Technology Division's (RTD) Air Force Weapons Laboratory developed the transporter-loader.

A Southeast Asia environment—complete from sampans to a Viet Cong village hidden by jungle underbrush—was re-created at the Air Proving Ground Center (APGC) for Project Underbrush, Systems Command reported in August.

In the realm of space activities, the Air Force announced in January that the Long Tank Thor—a new version of the space booster—would make its debut during 1966. Systems Command's Space Systems Division (SSD) purchased the Long Tank Thor from Douglas Missile & Space Systems Division to shoulder most of the Air Force's space programs at the Air Force Western Test Range (AFWTR).

In March it was announced that space equipment reentering the earth's atmosphere could be located with unprecedented accuracy by a new airborne camera system. The Airborne Astrographic Camera System was conceived and developed by the Air Force Special Weapons Center (AFSWC) and was being operated by Aeronautical Systems Division, utilizing C-135 aircraft.

Merritt Island Central Telemetry Station (TEL-4) was undergoing engineering checks in March prior to being placed in operational use by the Air Force Eastern Test Range (AFETR). The highly sophisticated equipment was added to AFETR's missile support instrumentation.

A Citation of Honor, the highest recognition the Air Force Association can bestow, was awarded in March to Brigadier General Joseph S. Bleymaier, AFWTR commander, for "outstanding management achievements while directing the development program for the Titan III-C space booster." The 6555th Aerospace Test Wing, Patrick AFB, Florida, received a similar award for its contribution toward placing 10 Gemini astronauts in orbit and helping to achieve the first manned rendezvous in space. In addition, Captain Robert M. Silva of Research & Technology Division's Air Force Avionics Laboratory, received the Theodore von Karman Trophy for science and engineering with his "development of the first autonomous space sextant" used in the Gemini 4 and 7 missions.

On September 1, Systems Command said that the Air Force would make electronic portraits of satellite shapes in cataloging radar images of possible space vehicle shapes. ESD was using the Radar Target Scatter (RATSCAT) installation at the Air Force Missile Development Center (AFMDC) to take electronic measurements of about 2 dozen satellite models.

Two experimental Vela nuclear detection satellites completed their third year in orbit on October 16 to rank as the oldest continuously operating United States spacecraft still providing useful data. The satellites were launched for Ballistic Systems Division (BSD) and the Atomic Energy Commission by an Atlas-Agena space booster.

In November, RTD's Air Force Avionics Laboratory engineers were planning to use the 7 defense communication satellites orbited by a Martin Titan III-C in June for a series of experiments aimed at improving communication systems. ASD technical experts were to help operate specialized equipment installed in a C-121 aircraft to collect data on signals relayed through the satellites between the aircraft and ground stations.

The sixth launch of the Titan III-C successfully boosted a Gemini capsule into a ballistic reentry trajectory on November 3 to test its heat shield. Experiments sponsored by various Systems Command field elements and the Office of Aerospace Research (OAR) also were flown.

In December, the USAF launched a new phase of the START program with the first firing of an unmanned Martin SV-5D spacecraft. Developed as part of Project PRIME (Precision Recovery Including Maneuvering Entry), the SV-5D is a wingless, V-shaped plane with a flat bottom, rounded top and vertical tail fins. It was designed to explore maneuvering reentry from orbital speeds down to about 1,000 miles per hour as part of a program aimed at advancing the technology required to contribute to future decisions in the development of manned and unmanned reentry spacecraft. The first of 4 planned flight vehicles, SV-5D flew a successful mission across the Pacific from Vandenberg AFB and telemetered valuable data, but the craft itself was not recovered.

In the aeronautical systems area, the Air Force, Federal Aviation Agency (FAA) and the National Aeronautics and Space Administration (NASA) began preparations in January for a series of radiation analysis experiments at altitudes where the supersonic transport would operate. RTD's Air Force Weapons Laboratory would fly instrument packages on Martin RB-57F reconnaissance aircraft.

In January, the Air Force announced that successful air-to-air refueling tests—the first involving a helicopter and a fixed wing airplane—had been conducted at Cherry Point, North Carolina. A KC-130F aerial tanker participated with an Air Force CH-3C flown by an ASD pilot.

A series of 9 flight tests at the AFMDC proved the effectiveness of a new device which may simplify current search and rescue procedures. Known as the C-141 Lehigh Crash Position Indicator, the device would be installed in aircraft with tests conducted under ASD's direction.

ASD awarded a contract to Lockheed-Georgia Company to install, test and obtain FAA certification for an all-weather landing system, it was announced in February.

The Air Force stated in March that an 18-month flight research program involving the supersonic North American XB-70 would get under way in the spring. Overall direction of the joint test program involving NASA was being handled by ASD. The XB-70 had been undergoing flight tests for two years at the Air Force Flight Test Center (AFFTC).

In April, the Air Force announced that Martin Company would develop a manned, lifting body vehicle—a revolutionary rocket plane without wings—which will explore the atmospheric maneuverability of future spacecraft. The one-man vehicle, known as the SV-5P, was being built for ASD and was to be flown under Project PILOT, or Piloted Lowspeed Test, in the Spacecraft Technology and Advanced Reentry Test (START) program.

On May 3 the Air Force successfully demonstrated a system designed to rescue downed airmen from most of the terrain in the world. An HC-130H, equipped with the Robert Fulton Company's ground-to-air rescue device, snatched 3 men in 2 separate pickups at the AFFTC.

On May 11 at Marietta, Georgia, the Air Force unveiled a full-scale mockup of the C-5A, destined to be the world's largest jet transport. Development of the C-5A by Lockheed-Georgia Company was being monitored by ASD's System Program Office (SPO).

Systems Command announced in May that a new emergency device to stop an airplane on the runway was under testing. The BAK-11, or Barrier Arresting Component, completed more than 100 successful tests at the AFFTC. It consists of an arresting cable actuated by the aircraft's wheels rolling on the runway. Also in May, it was announced that the XC-142A tri-service V/STOL had successfully landed on the aircraft carrier USS *Bennington*. The vertical, short takeoff and landing aircraft was undergoing extensive testing at the AFFTC.

On July 23, General John P. McConnell, Air Force chief of staff, presented the 1965 MacKay Trophy to YF-12A Test Force members for their record-setting flight of May 1, 1965.

In October, the Air Force announced the award of 12-month study contracts for a high-altitude, hypersonic SCRAMJET-powered cruise vehicle. Three contractors will develop vehicle design concepts with potential military applications under ASD's direction.

On the technological front, three engine manufacturers were awarded contracts for development of a vectored-thrust cruise propulsion system (lift-cruise engine). The work was being performed under contract to RTD's Air Force Aero Propulsion Laboratory.

In March, Systems Command announced that an upward bomb ejection system was being tested by RTD's Air Force Weapons Laboratory. An experimental model was to undergo a series of dynamic tests on a high-speed sled track at the AFMDC.

In May, RTD announced that an engine oil analyzer was being developed to detect aircraft engine wear. The device would detect submicroscopic metal particles without the controlled laboratory conditions now necessary.

The new vivarium (animal facility) housing the Aerospace Medical Research Laboratories at Wright-Patterson AFB, Ohio, was accredited by the American Association for Accreditation of Laboratory Animal Care, it was announced in June.

Electronic Systems Division began preparing in June to ship 58 transportable weather observation and forecasting stations to installations in the United States, Europe and the Pacific for supporting Air Force and Army tactical air operations.

In August, Systems Command announced that a contract had been awarded for developing expendable shelters. Developed for RTD's Air Force Propulsion Laboratory, the shelters will be tested and used by Tactical Air Command.

A Sea-Launched Ballistic Missile (SLBM) detection radar test bed was being used in developing an electronic detection and warning system to keep a protective watch on coastal waters of the continental United States. Electronic Systems Division announced on August 23 that the test bed facility at Avco Corporation's Cincinnati plant would consist in part of a Semi-Automatic Ground Environment (SAGE) system height-finder radar.

The 13th annual Air Force Science & Engineering Symposium was hosted by Arnold Engineering Development Center (AEDC), September 27-29, under joint sponsorship of Systems Command and the Office of Aerospace Research.

In October, Systems Command announced that a revolutionary advance in a pilot's ability to control, select and deliver the wide array of weapons carried by modern high-performance aircraft was expected from a new Integrated Armament Control System (IACS) under test. A prototype of IACS, developed by RTD's Air Force Weapons Laboratory, was being tested by Air Force Special Weapons Center pilots in F-105 aircraft.

RTD's Air Force Weapons Laboratory was operating a continuous-beam gas laser to produce an invisible infrared beam from electromagnetically-stimulated carbon dioxide. Described as the free

USAF technicians check control system of a carbon dioxide continuous-beam laser during installation of the free world's most powerful laser at the Air Force Weapons Laboratory.

world's most powerful laser, it can burn through a high-grade firebrick in 5 seconds.

Bionic scientists of RTD's Air Force Avionics Laboratory developed a machine that could store the film, "Gone With The Wind," on a sugar cube-sized crystal. The Multiple Image Storage Device uses a helium neon laser to bleach a photographic slide onto the crystal.

Insuring the success of these and other programs, Systems Command continued to provide the most up-to-date and effective management of resources. For example, Systems Command began doubling its cost analysis capabilities during January in a major move to supply its decision-makers with even more refined cost implications of possible decisions. As January drew to a close, Systems Command assisted the Air Force in holding two management-oriented Zero Defects seminars at the Lockheed-Georgia Company, Marietta, Georgia.

In January, Master Sergeant John R. Schumann, a rescue and survival technician with Aerospace Medical Division's (AMD) Arctic Aeromedical Laboratory at Fort Wainwright, Alaska, was named the command's outstanding airman for 1965. Captain Terry R. Jorris of RTD's Air Force Avionics Laboratory was named Junior Officer of the Year in February. A scientist in uniform, Captain Jorris did work in pre-launch instrument checkout and astronaut training for the Gemini 4 mission. He also developed a photometer for Gemini 7.

In April, Systems Command reported that 319 unsolicited proposals from the scientific and industrial community had been accepted and funded at a cost of $18,500,000 during the first half of fiscal year 1966. Nearly 27 percent of the proposals received were funded.

In May, the Air Force presented semi-annual achievement awards to 11 contractors including 6 recommended by the Air Force Contract Management Division (AFCMD). A total of 28 firms received the award in the Industrial Zero Defects program.

The second annual Air Force Contractor Cost Reduction Workshop and awards ceremony was held in Los Angeles, August 17-18. The Department of Defense's Contractor Cost Reduction Program reported savings of more than $500,000,000 during July-December 1965 and the Air Force accounted for about half of that total. As 1966 ended, 8 Air Force contractors became the first recipients of the Craftsmanship Award. The Craftsmanship Award is the highest honor that a contractor can receive in the Industrial Zero Defects program.

ARMY

As in previous years, a large part of the Army's 1966 research and development effort was concentrated on the versatile helicopter and associated V/STOL types of aircraft.

A major program in vertical lift research and development was the Advanced Aerial Fire Support System (AAFSS), an integral system which combines an aerial vehicle, its weapons and ground support equipment. Under a contract awarded to Lockheed Aircraft Corporation in 1965, engineering development on the AAFSS, designed for operational use in the 1970's, continued throughout the year. Final configuration of the AAFSS was not determined, but it was decided that the aerial vehicle would be a compound helicopter with a pusher propeller.

In another major program, the Army continued development of the Bell AH-1G Huey Cobra, fast attack helicopter. The Army awarded a production contract for 110 AH-1G's and by year-end the first pre-production model was undergoing test at the Bell plant in Fort Worth, Texas, and the second model was nearing completion. Production versions were to be delivered in 1967.

In its part of a tri-service program, the Army continued active experimentation and study of a variety of V/STOL aricraft, including the Lockheed-Georgia XV-4A, the Ryan XV-5A, the Hawker XV-6A (P. 1127), the Curtiss-Wright X-19, Bell X-22 and the LTV XC-142. The Army was also looking at other answers to the vertical lift requirement, notably the compound or composite-type winged helicopter.

In July, the Army Aviation Materiel Laboratories awarded a contract to Lockheed-California Company for further development of the XH-51A compound helicopter, which has reached speeds of more than 270 miles per hour. The new contract called for investigation of maneuverability, vibration effects and structural loads over the entire speed range.

The Army was also extensively engaged in research and development on helicopter systems and support equipment. At the Army Missile Command, Redstone Arsenal, Alabama, MICOM was developing a variety of missile and rocket systems, together with conventional weapons, for use by armed helicopters. The Aviation Materiel Command had under way a priority program aimed at development of lighter and more effective armor and at aircraft battlefield protection in general. Seeking a safer system for night landings of helicopters in restricted areas, the Army was conducting environmental tests on a 26-pound tricolored projection system at the Tropic Test Center, Panama Canal Zone. The Glide Angle Indicator Light (GAIL) furnishes a continuous beam of separate amber, red and green signal lights, which indicate whether the aircraft is approaching too high, too low or on the desired flight path.

In a joint program with the Air Force and the National Aeronautics and Space Administration, the Army was investigating a potentially significant advance in V/STOL flight, the propulsive wing. This involved wing tunnel tests of a concept developed by Ling-Temco-Vought, Inc., known as ADAM (Air Deflection and Modulation). The propulsive wing uses high bypass ratio turbofans buried in a ducted wing. The high mass-rate flow through the wing can be deflected downward for vertical flight or aft for horizontal flight.

The Army's highest-funded development project continued to be the Nike-X (Western Electric Company) antimissile system, consisting of the Zeus and Sprint Missiles, the Multifunction Array Radar, the Missile Site Radar and other components. Zeus continued in test status at Kwajalein Test Site in the Pacific while Sprint, in an earlier stage of development, was being tested at White Sands Missile Range, New Mexico. Early in the year, the high acceleration Sprint, built by Martin Company, was successfully launched from an underground cell for the first time. By year-end, Kwajalein was being readied for full-scale interception tests of both the Douglas-built Zeus and Sprint. In a related action, the Army was modifying 12 retired Atlas missiles to be used to simulate the various types of warheads the Nike-X system might have to engage. The Atlases were to be fired from Vandenberg AFB through the Pacific Missile Range toward Kwajalein.

The Army's Limited War Laboratory developed a smoke-generating system to screen troops being landed by helicopter in jungle clearings.

Engineering development of the Hughes-built TOW (Tube-launched, Optically-tracked, Wire-guided missile) was substantially concluded. TOW is a heavy antitank assault weapon designed to replace the 106 millimeter recoilless rifle and the Entac wire-guided missile. A production system, TOW started in the fall a series of tests under extreme environmental conditions and severe simulated tactical situations. The tests were being conducted at 5 locations in the United States and Panama. Monitor for the program was the Service Testing Agency, Fort Benning, Georgia.

Also in advanced development, the LTV Lance ballistic missile was being tested at a number of facilities. Field tests similar to operating conditions in a tactical situation were being conducted at Fort Sill, Oklahoma. Air drop tests, initiated in 1965, were being continued with an improved model of the Lance missile system at Yuma Proving Ground, Arizona. At Eglin AFB, Florida, the system was being subjected to environmental tests, which were also being conducted at Redstone Arsenal. At Aberdeen Proving Ground, Maryland, Lance ground support vehicles were pounding over rough roads and steep grades and being launched into a deep lake to demonstrate fording ability.

In engineering development status was MAW, the medium antitank assault weapon being developed by McDonnell Company. McDonnell received 2 contracts totaling $1,950,000 for further development of the wire-guided weapon. At the same time, the Army continued in-house development of a companion system known as DC-MAW, which is directionally controlled without wires.

In advanced development, Chaparral, built by Aeronutronic Division of Philco-Ford, went through a series of firings at the Naval Ordnance Test Station, China Lake, California, then started interception tests in late summer at White Sands. On the first test, Chaparral, which is a Sidewinder IC modified for ground-to-air use, successfully intercepted a Ryan Firebee target missile and met all test objectives.

Redeye also experienced a successful test program, destroying 3 drones on 3 consecutive firings in final development testing at NOTS China Lake. Built by Pomona Division of General Dynamics Corporation, the shoulder-fired antiaircraft missile system also completed during the year the Arctic phase of its service testing at Fort Greely, Alaska and entered the tropical environment service test phase at Fort Clayton in the Canal Zone. A joint Army-Marine Corps program, Redeye was to become a production weapon following completion of the latter tests.

In the spring, the SAM-D (Surface-to-Air Missile, Development) entered a new phase of contract definition with Navy participation. SAM-D is the latest generation of air defense systems designed for battlefield and continental defense roles in the 1970's.

In the fall, the Army Air Defense Command initiated tests of the new Missile Mentor command posts for improved coordination of surface-to-air defenses. Hughes had delivered the prototype Missile Mentor system to the Army in March, less than 2 years after award of the contract. Missile Mentor was scheduled to replace all of the Missile Master and some of the BIRDiE (Battery Integration and Radar Display Equipment) systems in the Army's inventory.

In the space research area, the Army continued its highly successful SECOR geodetic satellite program, being used by the Corps of Engineers to locate the positions of certain Pacific islands and the North American datum. Objective of the program is to improve knowledge of the earth's diameter and to connect all major geodetic datums. The SECOR system was producing accuracies of 1 part in 200,000. During the year, the Army launched 2 additional satellites, for a total of 5. SECOR 6 was launched June 9, SECOR 7 on August 19. To enhance the geodetic satellite tracking program, being conducted by the Army Engineer Geodesy, Intelligence and Mapping R&D Agency (GIMRADA), the Army ordered 2 additional ground stations from Cubic Corporation, which also builds the satellite. The stations were to be delivered early in 1967.

The Army also participated in the Department of Defense's Initial Defense Communications Satellite Program, which moved toward operational reality with the June 16 launch of the first 7 satellites by the Air Force. Five Army ground stations were relaying military test traffic through the 7 satellites. Developed by the Army Satellite Communications Agency, Fort Monmouth, New Jersey, the network's primary stations were at Fort Dix, New Jersey, and Camp Roberts, California. Three transportable communications terminals were located in Hawaii, the Philippines and West Germany.

In support of NASA, the Aberdeen Proving Ground was testing 2 concepts of a vehicle designed for lunar surface mobility. The Mobility Test Article, a 4-wheeled, 1,760-pound vehicle, weighs about 1/6 as much as Molab, the lunar vehicle it was designed to represent. The weight permits wheel-load simulation of the complete vehicle on the moon, where gravity is 1/6 that of earth. The vehicle was undergoing road-load tests, rolling resistance and steering tests. The MTA was constructed by Bendix Systems Division.

During the year the Army continued its program of atmospheric research by gun-fired projectiles. Loading and firing of a record charge of 1,180 pounds of propellant in a 16-inch gun climaxed Project HARP (High Altitude Research Project) on October 6 in Quebec Province. HARP is a joint U.S. Army/Canadian Department of Defense venture. In June, installation of a 16-inch vertical firing gun at Yuma Proving Ground was completed and a flight series fired. Other probes were made at Fort Greely, with a 6-inch gun, at White Sands with 5- and 7-inch guns, and at Wallops Island, Virginia, with 5- and 7-inch guns.

In an organizational move, decision was made to move the Army Aviation Materiel Laboratories from Fort Eustis, Virginia, to Biggs AFB, adjoining Fort Bliss near El Paso, Texas. The transfer to facilities being vacated by the Air Force provides more space to allow for AVLABS expansion. The move was to be completed by December 1967.

NAVY

Among the Navy's research and development highlights for 1966 was continued testing of the trisonic General Dynamics/Fort Worth F-111, which reached the 500-hour mark of its test program at the beginning of the year. By year-end, all 23 of the F-111's built for the research, development, test and evaluation program, including several of the Navy "B" versions, were in flight status. Testing was being conducted at the General Dynamics/Fort Worth plant and at Grumman's Peconic, New York, facility; at Eglin AFB, one plane was being used for full-scale subsystems tests of electronic countermeasures and traffic control.

Another new plane in test status during the year was LTV Aerospace Corporation's A-7A Corsair II, which completed 1 year of testing on September 27. During that year, 13 of the new planes amassed a total of 898 flights and more than 1,300 flight hours. Most extensive testing was carried out at

The Navy continued developmental testing of the General Dynamics/Fort Worth F-111B.

the Naval Air Test Center, Patuxent River, Maryland, where pilots made almost 200 flights involving bomb drops, rocket and gun firings, catapult launchings and arrestments. They dropped aerial mines and bombs ranging in weight from 250 to 2,000 pounds and fired Sidewinder, Bullpup and Zuni rockets.

In September, 8 planes were delivered to the Navy for Board of Inspection and Survey tests. Six went to Patuxent and one each to the Naval Missile Center, Point Mugu, California, and the Naval Weapons Evaluation Facility, Kirtland AFB, Albuquerque, New Mexico.

Additional planes were delivered to the training college at NAS Cecil Field, Florida. Some 600 hours of tests were to be flown at Cecil to insure a contract specification that the plane requires no more than 11.5 hours of maintenance for each flight hour. Carrier qualification tests from a carrier in the Atlantic were also scheduled. In all, 35 company, Navy and Marine pilots participated in the first year's test program and 2 Air Force pilots also flew the A-7A to assess its capabilities.

At Patuxent, the Navy conducted an evaluation of a flight path control innovation known as Direct Lift Control (DLC), using an LTV F-8C Crusader. The concept of DLC allows almost instantaneous lift variations through the use of rapidly variable wing flaps. By deflecting wing lifting surfaces, such as flaps, airplane lift is directly varied in proportion to the direction and degree of flap deflection. This represents an improvement over the conventional longitudinal control system which requires rotating the aircraft with a horizontal stabilizer deflection to change lift on the wing since response time is significantly reduced with DLC.

Also at Patuxent, the Navy conducted the second preliminary evaluation and Board of Inspection and Survey trials of the North American OV-10A light armed reconnaissance aircraft. In tests of the plane's ability to operate from small, unprepared airfields, NATC Patuxent put the plane through its paces over specially prepared strips which resembled a giant washboard. Taxi tests and takeoffs were made at speeds of more than 100 miles per hour. By contrast, a passenger car driven over one of the strips reached its control limits at 12 miles per hour.

In 1966, the Navy initiated development of a new version of its EA-6 electronic warfare aircraft in service with the Marine Corps. Grumman Aircraft Engineering Corporation was awarded a $12,400,000 contract for design and development of a prototype EA-6B, with Airborne Instruments Laboratory prime contractor for electronics. To be used by both the Navy and Marines, the EA-6B will carry a crew of 4, as opposed to 2 in the operational EA-6A. The major design change involves a fuselage stretch of 40 inches. Five equipment pods containing electronic gear will be mounted under the wing, each pod containing a small propeller to drive individual air-driven generators.

In the vertical lift field, the Navy conducted sea trials of 2 V/STOL craft, the Ling-Temco-Vought XC-142A and the XV-6A, U.S. designation for the Hawker P.1127, undergoing tripartite testing by the U.S., the United Kingdom and West Germany.

The XC-142A underwent an intensive 1-day carrier test program on May 16 from the USS *Bennington,* purpose of which was to evaluate the craft for shipboard operations in the VTOL and STOL modes with wind over deck varying from zero to 32 knots. The XC-142A made 44 STOL and 6 VTOL descents and ascents using various glide slopes, approach angles and aircraft wing incidences. Some of the landings and takeoffs were made by an Army pilot who had never before been on an aircraft carrier.

The XV-6A, a jet V/STOL which grosses 15,400 pounds, made 22 flights from the aircraft carrier USS *Independence* and another 11 from the amphibious transport dock ship USS *Raleigh.* This constituted the Navy portion of the XV-6A test program, aimed at demonstrating the feasibility of operating jet-type V/STOL aircraft from carriers or smaller ships with landing platforms (the XV-6A was also being tested by the Army at Fort Campbell, Kentucky, and by the Air Force at Eglin AFB, Florida).

Other vertical lift testing involved new helicopters. At NATC Patuxent, the Navy conducted a series of tests of the Sikorsky RH-3A, a modification of the SH-3A which has the capability of streaming, towing and recovering mechanical minesweeping gear. The helicopter was to be used by the Naval Air Mine Defense Development Unit, Panama City, Florida, in its development program of various other mine defenses. Also carried out, aboard the USS *Lake Champlain,* were the first compatibility evaluations (carrier flight deck landing and hangar deck handling tests) of Sikorsky's CH-53A twin-turbine heavy assault helicopter.

In August, the Gyrodyne QH-50D, latest addition to the drone antisubmarine helicopter (DASH) arsenal, completed 5 months of Board of Inspection and Survey trials. An improved version of the QH-50C, the new model has improvements which enable destroyers to deliver ordnance against nuclear powered submarines at increased ranges and which allow the destroyers to maintain the initiative. Drone launches and recoveries were conducted under various combinations of relative wind heading and velocity. Radio frequency interference tests were conducted by Weapons Systems Test Division. During one period, the drone logged 27 hours flight time in 3½ days. Trials included night, as well as day operations. The QH-50D was provisionally accepted for Fleet service.

During the year the Navy was running developmental tests on a variety of missiles, notable among them Poseidon and Phoenix. Built by Lockheed, the 34-foot Poseidon is the fourth in the family of submarine-launched Fleet Ballistic Missiles. Formerly known as the Polaris B3, it will have approximately the same range as Polaris A3—2,500 nautical miles—but it will contain advances in accuracy and penetrability.

On September 8 the first full scale test of the Navy's Phoenix missile system took place over the Pacific missile range. An A-3A equipped with Phoenix and its control system located a jet target drone on radar, locked on at long range and intercepted it in flight. The Phoenix missile system, designed for use with the F-111B and being developed by Hughes Aircraft Company, consists of the missile, designated XAIM-54A, the Advanced Radar and Missile Control System, AN/AWG-9, and the Missile Bomb Launcher, MAU-48A. XAIM-54A is a long range, high performance weapon with all-weather capability. Data from the radar is processed by a solid-state, high speed digital computer and displayed on a 10-inch cathode ray tube and a 5-inch multimode storage tube.

In space research, the Navy Astronautics Group at Point Mugu was gathering data in a number of areas from the Navy Navigational Satellite System (NNSS). At NAG headquarters, computers accept information from the navigational satellites, digest it and send programmed messages back to the satellites, which in turn relay them to ships and stations around the world. Precise fixes obtained from the system are opening new doors to charting the earth and the ocean's floor; once ship's positions are accurately established, the Navy can accurately chart the bottom of the ocean. From satellite observation, scientists can develop a more accurate concept of the "astronomical unit," which is the distance from the earth to the sun. Once this is firmly established, man will be able to measure accurately the distance to other planets and possibly refine the picture of the solar system. Additionally, new techniques in time measurement will make it possible to use satellites to synchronize time universally.

At Point Mugu, the NAG was updating each satellite twice daily. Reports on the satellites' behavior were being beamed to Mugu from tracking stations in Maine, Minnesota and Hawaii, along with those received from Mugu's own Laguna Peak installation. With such data, NAG was able to predict where the satellite would be at any given time.

In addition to work with the NNSS, the Navy participated in a number of joint space launches with the USAF. Details of these launches were classified.

FEDERAL AVIATION AGENCY

The Federal Aviation Agency's highlight of the year, an 18-month, $220,000,000 effort to design a safe and economically viable U.S. supersonic transport (SST) was completed on December 31, 1966, with the selection of The Boeing Company and General Electric Company as airframe and engine manufacturers respectively. (See Aerospace Events).

Two airframe and 2 engine manufacturers had participated in this effort under government cost-sharing contracts. Lockheed Aircraft Corporation was the other airframe manufacturer, the Pratt & Whitney Aircraft Division of the United Aircraft Corporation the other engine manufacturer. The cost-sharing arrangement was 75 percent government/25 percent industry.

Objectives of the 18-month phase included completion and optimization of airframe detailed designs and extensive testing of wing and fuselage sections. The airframe contractors also built full-scale engineering mockups of their respective designs.

The engine contractors, on the other hand, each built and tested 3 full-scale prototype engines. Pratt & Whitney fired the first of its 3 engines in the spring of 1966 with General Electric not far behind. Each contractor accumulated more than 100 test hours on its engines.

On September 6, 1966, the 4 SST contractors submitted their final design proposals for evaluation by a team of approximately 235 government aeronautical experts. Team members were drawn from the Department of Defense, the National Aeronautics and Space Administration, the Civil Aeronautics Board and FAA. Major General J. C. Maxwell, FAA's Director of SST Development, served as chairman of the group.

Concurrent with this effort, 10 domestic and 18 foreign airlines conducted separate and independent analyses of the competing airframe and engine designs. Each was asked to select an overall design which would best meet his equipment needs.

The government-airline evaluation reports were the basic documents used in determining whether the SST program should move forward into the prototype construction phase. They also formed the basis for selection of contractors to continue in the program.

The government's master plan for development of the SST called for the selection of the Boeing-GE airframe-engine manufacturing team to push ahead early in 1967 with the construction of flying prototypes. Actually 2 prototypes of the same design were to be built, the first to take to the air in late 1969 or early 1970 to begin an intensive flight test program. At about the same time, production development would get under way with the first production model rolling off the line early in 1973. Certification and entry into commercial service would be accomplished by mid-1974.

During the year, the agency was engaged in extensive research and development, an important link in a chain of activities carried on by FAA to achieve its objectives: the safety and advancement of civil aviation in the United States. Responsibility for directing the aviation research and development activities of the agency is delegated to FAA's Systems Research and Development Service, Aircraft Development Service and the Office of Aviation Medicine.

Greater numbers of aircraft in the general aviation category, increased travel by commercial airlines and other facets of the rapidly expanding aviation industry continued to dictate heavy accent on research.

Faster and larger aircraft are carrying record numbers of passengers along the nation's airlanes each year. Projection studies also point to a substantial increase in the number of persons who will be flying their own aircraft during the next few years. With more aircraft flying, FAA's research and development services were planning ahead for the introduction of more reliable and sophisticated equipment to insure the safety of air travel in the fast-paced jet age. FAA engineers were not only solving current problems in aviation, but were also planning ahead so the National Airspace System can accommodate increased traffic anticipated in 10 and 20 years.

The FFA program is geared to utilize the services and talent of the many specialized industries serving the aviation community. The Agency advertises for bids on projects and studies and awards contracts. Agency research and development personnel monitor work done by contractors and supervise the progress of work performed under FAA contracts. To try out new concepts, systems and equipment under laboratory and operational conditions, the FAA maintains the National Aviation Facilities Experimental Center (NAFEC) near Atlantic City, New Jersey. NAFEC, a former Navy air base comprised of nearly 5,000 acres, has developed into the largest civil aviation proving ground in the nation. A staff of about 1,500 persons including engineers and other professional personnel, secretaries, skilled craftsmen and supporting personnel work in 150 buildings at the center.

Experimentation, testing and evaluation of systems and equipment at NAFEC fall into one or more of 11 areas: range instrumentation, air traffic simulation, surveillance radar, navigational aids, communications, air traffic control, aircraft safety, computation, weather, airports and aircraft services.

To carry on the extensive testing at NAFEC, the FAA has installed costly and complex equipment.

An example is the air traffic control simulator system, which permits the duplication of complex air traffic control environments at any airport in

FAA "pilots" at the National Aviation Facilities Experiment Center simulate aircraft flights which show up on radar scopes in an adjoining radar as "blips" or "slashes."

the world. Problems and new concepts in air traffic control at specific localities are solved in this laboratory. In this manner different techniques can be tested experimentally without endangering lives.

Data processing computers are used in systems automation studies. With the automation equipment, engineers can project traffic growth for 1, 5 or 10 years in the future. Plans can be made for installation of additional facilities needed to control traffic by the time such increases occur.

New radar displays incorporating the presentation of flight data in coded alphanumeric formats provide for a look into the future as well as detailed studies of current techniques. Improved methods of acquiring flight data, such as through greater use of the air traffic control radar beacon system, are under continual evaluation. New techniques in runway lighting and marking configurations are evaluated under actual field conditions. Approach lighting systems also are tested. Fire test and blower facilities permit the study of fires similar to those actually encountered in flight. High velocity air guns are used to duplicate the effect of bird and hailstone strikes as well as to study engine ingestion of foreign objects.

A catapult and track installation is used to study the effects of rapid deceleration and sudden stop. Precision aircraft space position data is obtained by an optical, 4-station phototheodolite system. Instrumentation radars also provide for highly accurate measurements during in-flight tests of airborne equipment or guidance systems. Thousands of approaches have been flown to evaluate all-weather landing systems. All-weather landing aids will result in more reliable schedules for the air traveler during limited weather conditions while also enhancing flight safety.

In 1965, the lowest weather in which planes were permitted to land was a 200-foot vertical ceiling and visibility of ½ mile. With new ground equipment installed at 5 airports in the nation, appropriately equipped aircraft may now land if pilots can see the ground from as low as 100 feet vertically above the runway and with visibility of as little as 1,200 feet horizontally. Undergoing evaluation during 1966 was advanced ground and airborne equipment which will permit landings in much lower weather conditions.

Under an extensive "crashworthiness" program at NAFEC, FAA engineers in 1966 successfully operated a jet engine on gelled fuel. The run-up tests were conducted as part of a project to find ways to reduce the fire hazard in aircraft accidents. Engineers said that although the agency's initial effort in using gelled fuel to operate a General Electric J47 engine appeared promising, much more research would be required before in-flight tests could be attempted.

In order to operate the engine, engineers had to devise a makeshift arrangement to force the gelled fuel from a tank 2 feet in diameter and 12 feet long. A bladder inside the tank was inflated with an air compressor to squeeze the gelled fuel into a 2-inch hose leading to a booster pump, which forced it through a similar line into the J47's fuel system. In monitoring the temperature of the gelled fuel from tank to engine, engineers observed a 2 degree rise at the booster pump, a 4 degree rise through the engine fuel pump and a 40 degree rise across the heat exchanger.

The successful tests cleared the way for more advanced research work with solidified fuels. FAA was considering bids for 2 contracts to advance the work in thickened fuels. One contract calls for developing standards for rating the effectiveness of various thickened fuels in reducing fire hazards, and for determining which fuels will work best in jet engines without requiring extensive aircraft and engine modifications. The other contract is to be for a study of the "compatibility" of fuel systems in 4-engine commercial jet transports with gelled and emulsified fuels.

The FAA also planned to enter into an interagency agreement with the Navy Aeronautical Engine Laboratory to study the effects of thickened fuels on the operation of turbine engine components. Also planned for the future was more ground testing with closer observations of engine components in full-scale engine tests. In addition, FAA was to cooperate with the Army in expanded fuel emulsion research.

The 1966 FAA research and development program included projects in the following general areas:

Air Traffic Control

Air Traffic Control System modernization, analysis of aircraft wake turbulence, improvement in airport traffic lighting systems, visibility and ceiling devices unique to aviation, enroute weather analysis and prediction and statistical terminal weather forecasting.

Communications

Short range air-ground communications systems modernization, long range air-ground communication systems, ground-air-ground digital communications, air derived separation assurance including pilot warning instruments and collision avoidance systems, aviation weather system digital data automation, aviation weather detection and measurement and hazardous weather detection.

Navigation

Approach and landing systems: improved instrument landing system (ILS) for Category II operations, ground-based guidance equipment for Category III All-Weather Landing, airborne control and display equipment for Category III All-Weather Landing, and V/STOL approach system. Short Distance Navigation Program: VORTAC system improvements for reduction in errors, development of area navigation equipment, test of equipment and techniques to supplement present rho-theta navigation system and barometric altimetry investigation of static system error and flight technical error to determine aircraft height-keeping accuracy. Advanced enroute (long-distance) navigation systems: self-contained systems and external reference systems. Airport and heliport lighting and marking and obstruction lighting and marking.

Environmental Program

Airport and aircraft fire protection, aircraft arresting systems, airport slotted runways and surface marking materials and control of birds at airports.

New Projects

Airport safety support for advanced aircraft, uninterruptible and stable power for critical facilities, air traffic control separation criteria, weather modification in terminal areas and adverse and hazardous weather designations for air traffic control functions.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Completion of Project Gemini, a soft landing on the moon, and startling new photographs of the earth and the lunar surface highlighted NASA's 1966 activities.

When Gemini 12 splashed down in the Atlantic Ocean on November 15, a major milestone toward achieving the national goal of landing men on the moon within the decade was reached. The crews of Gemini 12 and the preceding 6 Mercury and 9 Gemini manned flights demonstrated that man could withstand the rigors of space, maneuver their craft, rendezvous and dock in orbit and generally carry out activity in the hostile environment.

The 1966 portion of the manned space flight program included 5 missions in the McDonnell-built Gemini spacecraft, which brought the total U.S. manned experience in space to 1,015 spacecraft hours and 1,994 man hours. The missions were:

Gemini 8, astronauts Neil A. Armstrong and David R. Scott, launch and splashdown March 16, 7 revolutions, 10 hours 42 minutes, first docking of 2 spacecraft in orbit.

Gemini 9, Thomas P. Stafford and Eugene A. Cernan, launch June 3, splashdown June 6, 46 revolutions, 72 hours 21 minutes, 2 hours 9 minutes extravehicular time by Cernan.

Gemini 10, John W. Young and Michael Collins, launch July 18, splashdown July 21, 44 revolutions, 70 hours 47 minutes, 2 EVA periods, dual rendezvous with Lockheed-built Agenas 8 and 10.

Gemini 11, Charles Conrad and Richard F. Gordon Jr., launch September 12, splashdown September 15, 45 revolutions, 71 hours 17 minutes, 2 EVA periods, altitude record of 739.4 nautical miles.

Gemini 12, James A. Lovell Jr. and Edwin Aldrin, launch November 11, splashdown November 15, 59 revolutions, 94 hours 36 minutes, record EVA time of 5 hours 37 minutes.

In addition to Gemini, NASA prepared for new manned flights under Project Apollo by checking out the Uprated Saturn I launch vehicle for Apollo earth orbital flights. Three flights were made during the year, all unmanned. AS-201, launched February 26, was a launch vehicle/spacecraft checkout test; AS-203, August 5, was primarily an experiment in observation of the behavior of liquid hydrogen inorbital flight; and AS-202, September 25, was a heat shield test (the shield was also tested on AS-201).

Of the year's unmanned space missions, the most notable was Surveyor 1, which was launched on May 30 to make a soft landing on the moon 2½ days later. A "closed loop" landing system—radar, rockets and a pre-programmed computer—slowed the spacecraft from 6,000 miles per hour to only 3 miles per hour during the descent and Surveyor (Jet Propulsion Laboratory/Hughes) touched down gently in the moon's Sea of Storms. During its operational lifetime, Surveyor 1 sent back to earth more than 11,000 photographs of the lunar surface. A second Surveyor, launched September 20, failed.

Two Boeing-built Lunar Orbiter spacecraft backed up Surveyor in the 1966 portion of the project of photographing possible landing sites for the manned lunar landing. Lunar Orbiter 1 was launched August 10 and Lunar Orbiter 2 November 6; each sent back thousands of photos taken from relatively low altitudes in lunar orbit. Lunar Orbiter 2 made the first close-up pictures (28 miles) of the Crater of Copernicus, one of the most prominent features on the moon's face. This photograph provided the first lunar picture that could be related readily to earth topography. It clearly showed mountains rising 1,000 feet from the crater floor with slopes up to 30 degrees. This photo and others taken by the Orbiters' telephoto lenses were being used in analyzing potential landing areas.

In the field of satellite applications research, NASA launched a new member of the Nimbus family of weather spacecraft and also participated, as launching agent in 3 injections of ESSA satellites with the Environmental Science Services Administration.

Earth-oriented for greater daily coverage than previous meteorological satellites, General Electric's Nimbus 2 was launched May 15 into a near-polar circular orbit at an altitude of 700 miles. On July 15, the spacecraft achieved a major test objective—2 months of 24-hour-a-day operation. During that period, Nimbus 2 took more than 150,000 pictures and received more than 23,000 commands from ground controllers. It continued to operate long after the initial 60 day period, photographing the birth and death of Hurricane Alma and Typhoons Irma and Kitt.

At year-end, NASA was assembling another Nimbus for 1967 launch. A larger spacecraft weighing some 1,500 pounds, the third Nimbus was to carry several new experiments, including sensors, to measure the vertical structure of the atmosphere. With this experiment, scientists hoped to be able to make accurate weather predictions 2 weeks in advance.

The 3 operational launches of weather satellites included ESSA 1 (February 3), ESSA 2 (February 28) and ESSA 3 (October 2). The ESSA spacecraft were advanced versions of the TIROS developed for NASA by Radio Corporation of America. Most advanced of the series was ESSA 3, a cartwheel satellite which rolls along in orbit like a wheel, each of the 2 cameras on its rim pointing directly toward the earth once in every revolution. The cameras use 1-inch-diameter vidicons of the Advanced Vidicon Camera System, tested in the Nimbus spacecraft but being employed operationally for the first time on ESSA 3. ESSA 3 was also the first TIROS-type satellite to carry solar and terrestrial radiation sensors.

A highly successful project in the application field was the launch of the first of 5 Hughes-built Applications Technology Satellites. The 700-pound ATS 1, launched on December 6, was a multipurpose spacecraft designed to handle a number of experiments in the applications area. It transmitted high quality color television between stations located in North America, Asia and Australia, it linked airborne jet aircraft as far away as the Aleutians with ground controllers in the eastern U.S., and it took a series of spectacular photographs of the earth from an altitude of 22,300 miles, including the first space photo of earth to include its natural satellite, the moon. NASA planned a second ATS launch late in 1967, then 3 more in 1968-69.

Among the scientific spacecraft launched during the year was an Orbiting Geophysical Observatory (TRW Systems), which joined 2 similar spacecraft in orbit. Launched June 6, OGO 3 operated almost flawlessly in an earth-stabilized mode for 6 weeks, thereby meeting 1 of 2 main objectives. The other, correlated geophysical measurements within the magnetosphere and in the interplanetary space beyond, was accomplished later in the year.

On June 23, NASA sent into orbit a 100-foot-diameter balloon/satellite called Pageos 1 (Passive Geodetic Survey Satellite) which provided excellent geodetic data.

NASA continued the Explorer scientific satellite program with launches of Explorers 32 and 33. Both returned information about the earth's environment, with Explorer 33 looking at areas in space far beyond the moon. In addition, Pioneer 7, built for NASA by TRW Systems, joined Pioneer 6 in orbit around the sun to continue a program of measurements at widely separated points in interplanetary space over the solar cycle.

The newly-developed Douglas Thrust Augmented Improved Delta blasts off in August launch of Pioneer 7.

The final space launch of the year came on December 14 when a Douglas Thrust Augmented Improved Delta vehicle sent the General Electric-built Biosatellite 1 into orbit. First of a series of such craft, Biosatellite 1 orbited for 3 days to start a large-scale study of basic biology. It was employed to study the effects of weightlessness on various life processes of experimental organisms including pepper plants, wheat seedlings, frog eggs and amoeba. The 7-foot-long, 940-pound spacecraft carried 13 biological experiments.

In addition to orbital and escape trajectory spacecraft, NASA continued to be very active in the area of sounding rocket research. More than 300 sounding rockets were launched as part of NASA's program to measure weather conditions above balloon altitudes and below those of satellite orbits. Another 100 rockets were launched for scientific investigation of earth and space phenomena.

International space cooperation carried out during the year included sounding rocket experiments with Argentina, the Federal Republic of Germany, Brazil, Canada, India, Norway, Pakistan and Spain. In particular, the U.S. cooperated during solar eclipses in May and November with Greece, Brazil and Argentina. An agreement with France was reached for a joint project to collect meteorological data with balloons and satellites.

In the area of launch vehicle development, other than the man-rated Saturn boosters, NASA twice test-fired the hydrogen-powered Centaur, built by Convair Division of General Dynamics Corporation, on Surveyor launches. The vehicle was established as fully operational and capable of placing large payloads on the moon and ready for future interplanetary roles.

Researching toward possible future launch vehicles, NASA's Aerojet-General all-solid propellant rocket motor of 3,500,000 pounds thrust was ground tested successfully. Meantime, a 260-inch diameter motor with 5,000,000 pounds thrust was being readied for 1967 test.

NASA initiated its lifting body research program with glide flights of the Northrop-built M-2 and

The Northrop-built M-2 lifting body research vehicle was flown on 14 1966 glide tests preparatory to powered flights in 1967.

HL-10 spacecraft, wingless vehicles which derive aerodynamic lift solely from their fingernail-shaped bodies. Both were being readied for powered flights early in 1967. The 2 research craft were to be flown at altitudes up to 80,000 feet and speeds of about 1,000 miles per hour, as part of a program to test the conditions spacecraft encounter on return to earth.

In the field of aeronautics, NASA started in the spring a planned 18-month research program involving the USAF's North American XB-70 experimental aircraft. Purpose of the program was to acquire new data on flight dynamics, flight loads, structures, propulsion, air induction, environmental factors and other areas. The program was to be a joint USAF/NASA effort.

NASA also continued its high speed research program with the North American X-15, which set a new speed record during the year. With USAF Major William Knight at the controls, the X-15 made a 9-minute flight with a peak speed of 4,223 miles per hour. This topped the 1962 mark of 4,104 miles per hour.

In addition, NASA continued to be active in the vertical and short takeoff and landing (V/STOL) field. The agency was observing a number of existing craft, conducting wind tunnel research at Ames and Langley Research Centers, and making advanced studies of new V/STOL concepts.

During 1966, NASA increased its tracking facilities around the world in support of manned and unmanned space projects. It also expanded its Technology Utilization Program, the dissemination of information about specific inventions, innovations and discoveries growing out of the overall space research effort.

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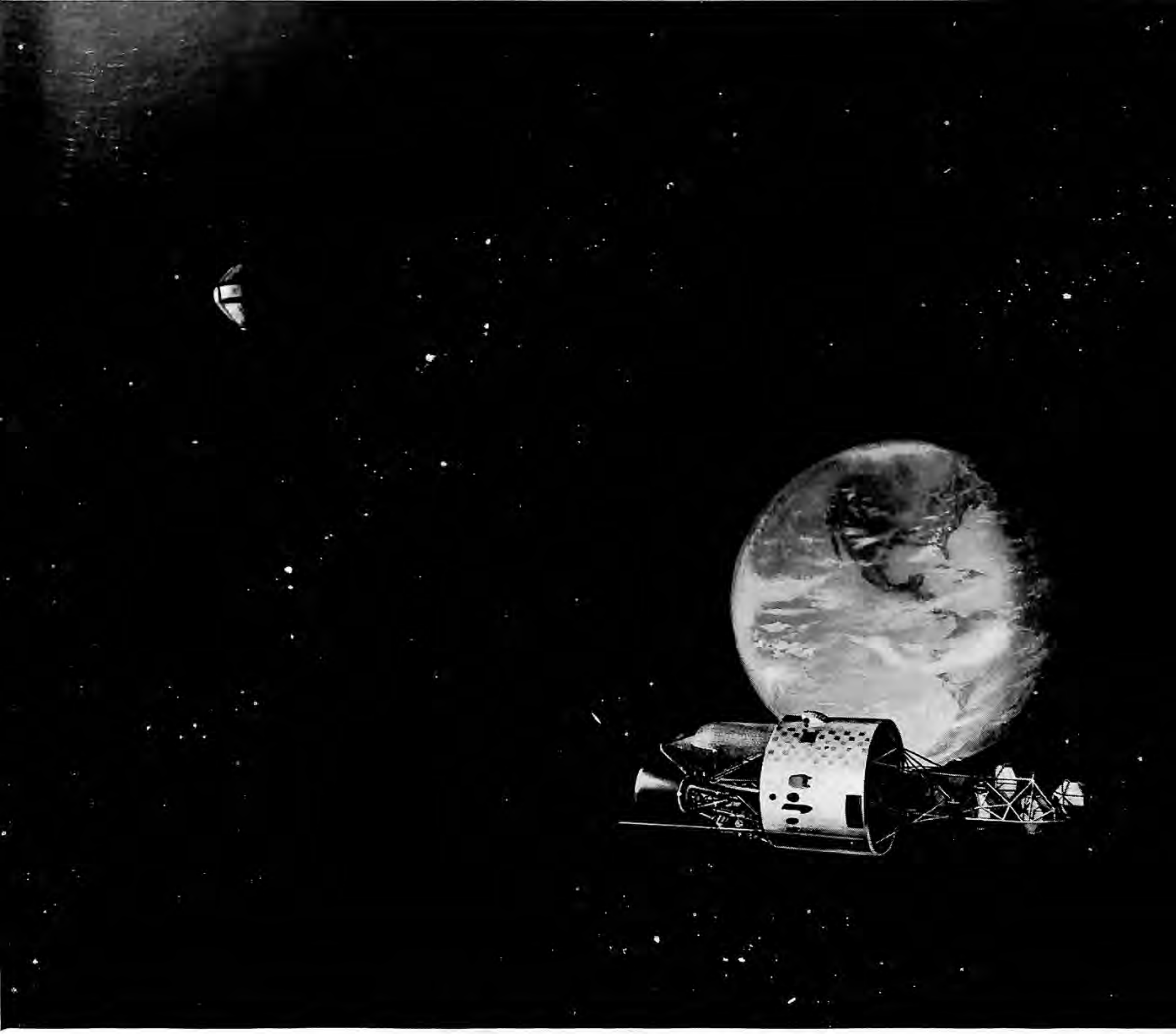

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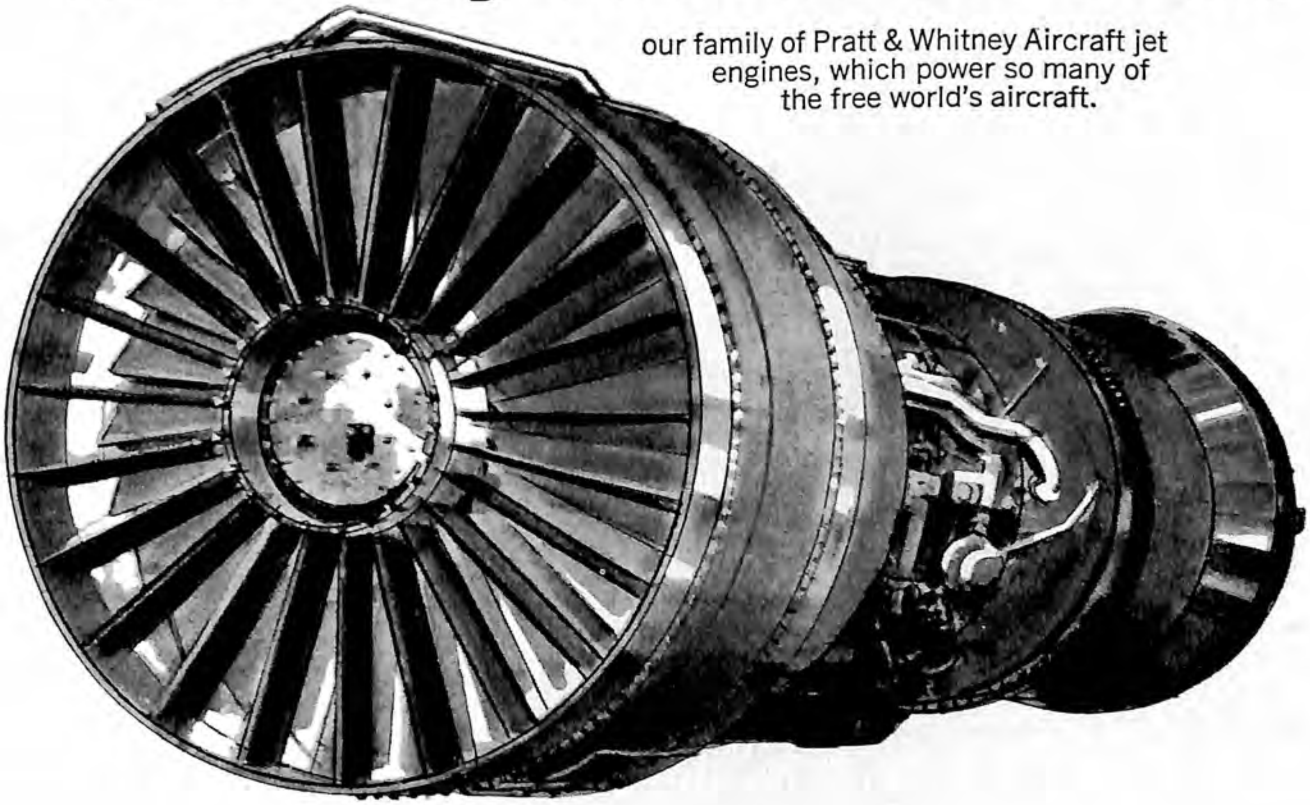

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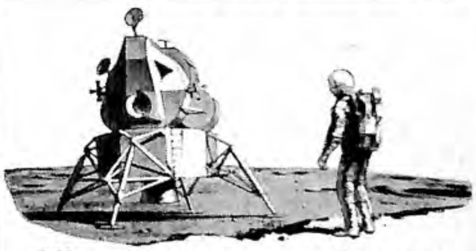
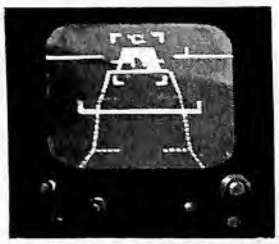
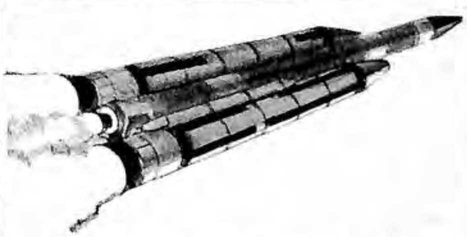
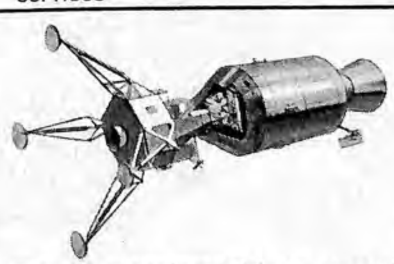
 Life support equipment for space exploration, from Hamilton Standard	 Hard-working Sikorsky helicopters, doing scores of jobs for commercial users and the free world's military services	 Norden airborne radar and pilot display systems for military aircraft
 Solid-propellant rocket boosters, from United Technology Center	 Telemetry equipment for spacecraft, from the Vector division	 Advanced, high-speed TurboTrains, from our Corporate Systems Center

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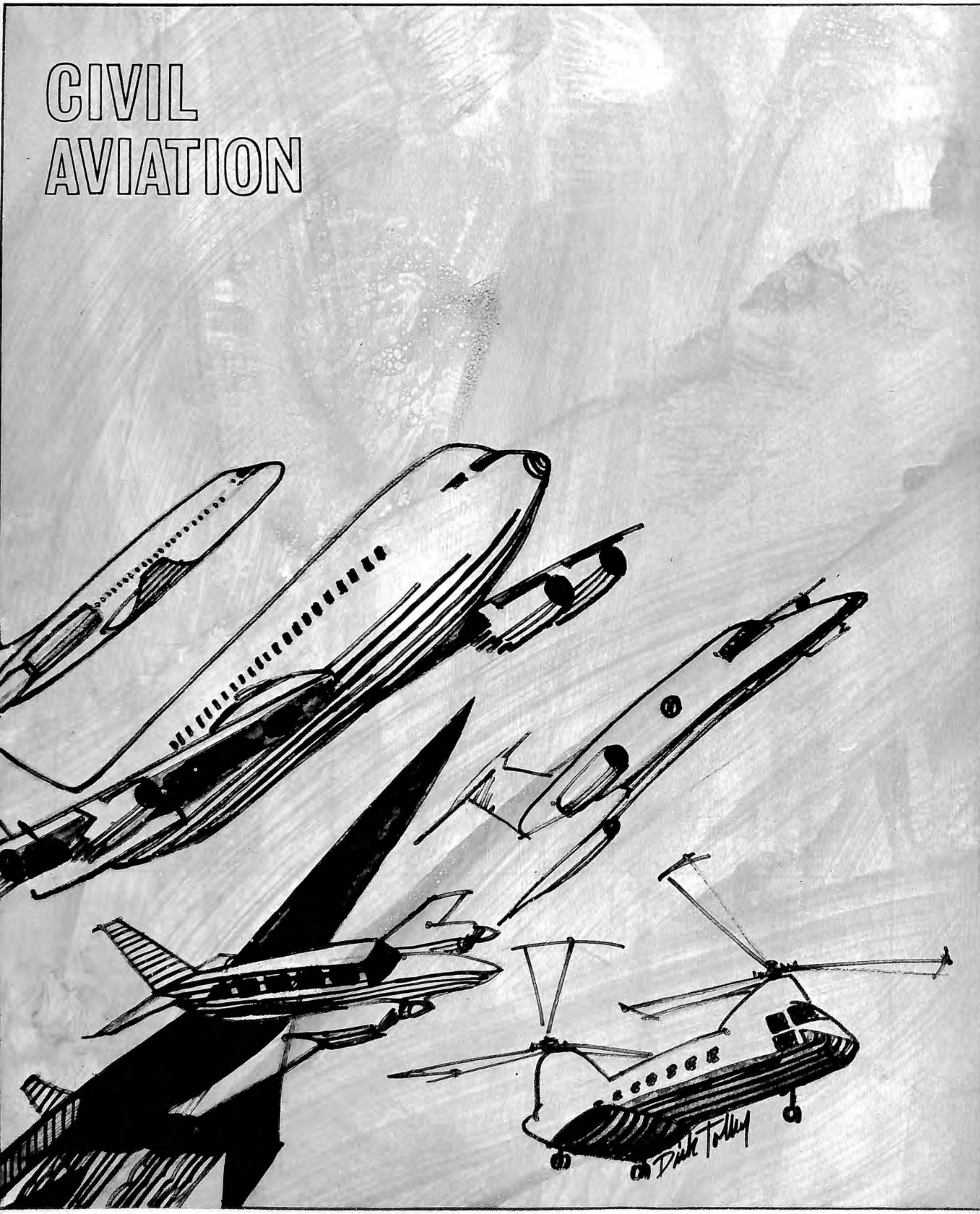


THE AIRLINES

The airlines continued their investment in new equipment during 1966, bringing commitments for new aircraft to $6 billion for the 5-year period 1966-1970. The investment in this 5-year program is roughly equal to the value of all flight equipment in service at the end of September 30, 1966. This means that air transportation will double its investment in just 5 years.

During the first nine months of 1966, the airlines took delivery of 221 new aircraft, valued at $1.2 billion. Orders placed for delivery during the remainder of the 5-year period come to 761 aircraft.

The following tabulation shows a breakdown of deliveries received and scheduled for the 1966-1970 period:

	Jets and Turboprops	Valued at
1966 Deliveries Jan. 1-Sept. 30	221	$1,177,000,000
Scheduled in 4th quarter 1966	81	384,000,000
Total 1966	302	$1,561,000,000
1967	395	2,139,000,000
1968	207	1,223,000,000
1969	46	392,000,000
1970	32	717,000,000
TOTAL	982	$6,032,000,000

Not included in the tabulation is the fact that the local service airlines were planning to convert 63 piston planes to turboprops at an estimated cost of $38,000,000. Also excluded are orders for 31 Concorde supersonic transport planes and tentative delivery positions for 49 U.S. SST's for delivery in the 1970's.

The great majority of the aircraft on order are short- and medium-range jets, underscoring the airlines' program to improve and expand service to smaller communities. Of the 761 new aircraft on order, 500 are twin-engine and 3-engine jet and turboprop aircraft. As of July 1965, only 86 points in the U.S. received jet service. With the continuing emphasis on smaller jet aircraft, 117 points in the U.S. were receiving regular jet transportation at the end of 1966.

The multi-billion dollar investment the airlines were making in new equipment, involving 85 percent of all their earnings, allowed the airlines to reduce fares. In contrast to the inflationary trend that has been running through the national economy, the airlines lowered the average fare per passenger mile 4 percent, comparing the first 6 months of 1966 with the same period in 1965.

Among the reduced fares were the following:

Family Fares. Full fare is paid by the head of the family, ⅓ less for the wife and ⅔ less for each of the children. Significance: a family of 4 traveling across the continent saves over $450.

Visit USA Fares. For $150 foreign visitors have unlimited travel to hundreds of cities across the nation for 21 days.

Discover America Fares. A round-trip fare at a 25 percent discount provided the return trip is not made in the same calendar week as the originating trip and the whole trip is completed within 30 days.

Youth Fares. Stand-by fares for young people between the ages of 12 and 22 at a discount of 50 percent.

Special Fares for the Military. Also at 50 percent below normal fares, servicemen may travel on a stand-by basis and take precedence over youth traveling at the same discount.

For example, at the end of September 1966 more than 9,000,000 servicemen had taken advantage of the airlines' half-fare military program and had saved an estimated $180,000,000 under what they would have paid at full fares.

Commenting on the airline fare reductions in effect during the year, the chairman of the Civil Aeronautics Board, Charles S. Murphy, said: "These reductions in the aggregate will provide savings to the traveling public of many millions of dollars—estimated by the CAB staff to be more than $200,000,000 for domestic air travelers in 1966."

It was estimated that the airlines would carry 112,000,000 passengers in 1966, up 18.2 percent over 1965 and almost double the number they carried in 1961. The airlines registered this increase despite the 43-day mechanics strike in July and August, which represented a loss to the airlines of about 5,300,000 domestic air travelers or 3.7 billion passenger miles (a passenger mile is 1 passenger carried 1 mile). These figures were based on the fact that, up to the day of the strike, airline traffic had been running 25 percent over the same period in 1965.

The airlines planned to expand their jet freighter fleet by more than 160 percent in the next 5 years to keep pace with the accelerating demand for air freight.

As of September 30, 1966, the airlines had in operation or on order 257 jet airliners capable of all-cargo operation. The total cost of these aircraft, including spare parts, was $1.9 billion.

The airlines at year-end were operating 96 jet aircraft capable of all-cargo service with a capacity of 4 billion ton-miles of service per year assuming average utilization of the aircraft. They represented a total airline investment of $718,000,000. Of the 96 jet aircraft, 52 were regular or convertible freighters, 15 were combinations and 29 the quick-change variety.

In 1965, air freight registered a gain of 33 percent over 1964, and for the first 8 months of 1966 it was up 22 percent over the same period in 1965, despite the strike.

The 161 new planes on order will expand the present jet freighter fleet in terms of numbers of aircraft by 167 percent, and provide 6.5 billion ton-miles of capacity per year assuming average utilization of the aircraft. Of the 161 jet aircraft, 88 are regular or convertible freighters, 4 are combinations and 69 are the quick or rapid change variety; 49 of the quick change are medium-range aircraft and 20 are short-range. All other jets are long-range. In addition to the jet orders, there were 2 turboprop freighters on order for delivery in 1967.

Each of the 600-mile-an-hour, 90,000-pound capacity jets represents a near doubling of speed and more than a threefold increase in capacity over the DC-6A, for example, one of the largest of the piston-powered aircraft still used in all-cargo operation. In 1970 a still larger jet freighter, the Boeing 747, will enter service. It will have a 214,000 pound capacity.

In addition to the improved service capability provided by jet freighters, there are other factors that have combined to stimulate cargo growth. Automatic loading and unloading is one such factor. Today freight is loaded and unloaded on huge pallets which slip in and out of the airplane in minutes.

Sorting and assembling loads in terminals has also been automated. A modern air cargo terminal can process half of a freighter load within an hour of departure. This would have been impossible a few years ago. Greater volumes of air cargo support improved pickup and delivery service. Regular daily shipments involving thousands of pounds can now be handled and reliably.

Yet another development is a newly designed family of standard containers for air freight. Airlines expect the newly designed containers to stimulate larger shipments. Incentive reductions averaging 10 percent will be offered to shippers who make use of containers. Those using the containers will also save time, packaging and documentation costs. Containers varying in capacity from 625 to 5,000 pounds, can be loaded at the shipper's own plant and delivered directly to planeside rather than moving through the terminal.

The new aircraft the airlines are adding to their fleets, if needed, could be put to use quickly under the nation's streamlined Civil Reserve Air Fleet (CRAF) program. Under this program, 220 jet and turboprop aircraft are available on short notice to the Department of Defense (DOD). They are capable of providing 8 billion annual ton miles of lift and more than 25 billion seat-miles annually to meet the demand of limited emergency situations.

The airlines in their peacetime role account for 85 percent of all DOD domestic passenger travel expenditures. The last 5 years have witnessed increasing use by DOD of commercial airline service, which has consistently been able to supply the defense establishment the airlift it needs.

AIR ALASKA

The beginning of 1966 saw a new name in the northern sky: Air Alaska, the new title and symbol of Wien Alaska Airlines, Inc., first airline to fly in Alaska. From a humble beginning in 1924 when Noel Wien made the first commercial flight in Alaska using a World War I surplus standard J-1 aircraft, Air Alaska has grown and developed into a position of prominence in Alaskan aviation. With central home offices in Fairbanks, its 1966 route structure extended from the capital city of Juneau in the South to the northernmost community in North America at Point Barrow, and in the west to Nome. Air Alaska serves 85 communities in Alaska varying in size from metropolitan areas to small villages of 15 and 20 people in an area totally dependent on air transportation as the primary means of communication and the only method of delivery of mail and freight.

The year 1966 proved to be the most successful in the airline's history. Revenue passenger miles for the first 9 months totaled 20,216,000, an increase of well over 10 percent compared with a like period in 1965. Total revenue ton miles during this period were 4,349,619, a substantial increase over 1965. Tourist activity during the summer months reached its highest peak, both over Air Alaska routes and the state of Alaska in general. Air Alaska maintained its own staff and ground facilities to accommodate the ever increasing number of tourists in Point Barrow, Kotzebue, Nome, and Fort Yukon.

In anticipation of the state-wide Alaska '67 Centennial celebration commemorating the 100th anniversary of the purchase of Alaska from Russia, Air Alaska increased tourist facilities throughout its system and planned to double the number of tour packages available to the tourist. The company expected an increase in tourist travel by virtue of the fact that Fairbanks was designated as the official centennial celebration site and the location for the exposition grounds.

The year also saw an improvement and expansion of Air Alaska ground facilities. New hangers were built in Kotzebue and Nome, a new terminal building was constructed at Point Barrow and ticket office facilities in the larger towns were moved to more adequate quarters or underwent expansion. The upgrading and expansion of flight equipment was not neglected in the year 1966. Orders were placed for 2 twin-engine turbine powered Skyvan aircraft from Short Brothers in Ireland. The addition of this new equipment will augment the fleet of Beavers and turbine powered Pilatus Porters and will increase the all weather capabilities and reliability of the "bush" fleet. By the beginning of 1967, Air Alaska's multi-engine turbine powered fleet was to be increased to 3 and this total was to reach 5 by the summer of 1967. The year also marked the company's first order for pure jet equipment: one Boeing 737 for delivery in 1968, with an option for a second.

In order to insure continued growth and expansion, application was made to the Civil Aeronautics Board for 2 route extensions into the lower 48. One would extend the Fairbanks-Juneau route to Minneapolis-St. Paul and Chicago and the other would extend the Fairbanks-Juneau run to Seattle via the Alaska city Sitka. Other route applications were being considered for both domestic and international expansion.

AIR CANADA

New routes, new aircraft, and record passenger and freight traffic highlighted Air Canada's activities during 1966. Following successful completion of bilateral negotiations between the Canadian and United States governments early in the year, Air Canada was designated to serve 3 new transborder routes: Montreal-Toronto-Los Angeles, Montreal-Toronto-Tampa-Miami and Montreal-Chicago. Service to Miami began August 1, while dates for inauguration of the other 2 flights were to be established later.

New services were started between Toronto and Freeport, Grand Bahama Island, and between Halifax and Bermuda in December 1965; Frankfurt replaced Dusseldorf as Air Canada's German terminus in April 1966; and new nonstop flights between the Western Canadian cities of Vancouver, Calgary and Edmonton and London, England, were inaugurated in the spring.

A bilateral agreement was signed between the governments of Canada and the USSR in July. Air Canada began operating between Montreal, Copenhagen and Moscow on November 1, 1966, providing the first direct air service between North America and the Soviet Union.

The airline took delivery of 6 Douglas DC-9 twin jets and 2 DC-8 jetliners early in 1966. It had on order 12 extended versions of the Douglas DC-9 for delivery in 1967, and 6 extended Douglas DC-8's for delivery in 1967 and early 1968. Air Canada at year-end operated 18 DC-8's, six DC-9's, 23 Vickers Vanguards and 49 Viscounts over 62,000 miles of unduplicated air routes.

Air Canada took delivery on 6 Douglas DC-9's, awaited 12 extended versions in 1967.

The 72-passenger DC-9's were introduced on the transcontinental routes and to New York City in April and to Miami and other Canadian routes in August.

Air Canada recorded a profit in 1965, for the 12th time in the past 15 years, and forecast another profitable 12 months in 1966. Passengers carried in 1965 exceeded 4,750,000, up 13 percent over the previous year, while air freight traffic increased a gratifying 36 percent to more than 56,000,000 ton miles. In the first eight months of 1966, Air Canada carried 3,-600,000 passengers, an increase of 17 percent over the same period in 1965, while air freight traffic rose 50 percent to more than 78,000,000 pounds during the same period.

To accommodate the burgeoning air freight traffic, the airline constructed one of the most modern cargo terminals of its kind in the world at Montreal, similar to one completed in Toronto the previous year, and other, smaller terminals at Moncton, New Brunswick, and St. John's, Newfoundland.

At year-end, the airline was operating 1 all-cargo DC-8 jet on transcontinental routes and another DC-8 in mixed passenger/cargo configuration across the Atlantic to Europe.

Increased frequency and additional aircraft to meet growing requirements, expansion of services to new areas and maintenance of a sound financial position remained the principal aims of Air Canada, one of the 10 largest international air carriers.

ALASKA AIRLINES

The highlight of the year for Alaska Airlines was the introduction, on November 1, of Boeing 727 fanjet service, the first jet service to the intra-Alaska communities on the company's routes.

The airline also created a new decor for the Golden Nugget Jet depicting the turn-of-the-century or Alaska Gold Rush era, in line with the 1967 Alaska centennial. The new jet interiors feature velvet tufted seats in bright red, antique gold and moss green, red deep-pile carpeting, red velvet curtains and gold braid tassels; stewardesses are dressed in turn-of-the-century costumes. An innovation in airline entertainment was the introduction of recordings of Robert W. Service reciting his own poetry.

In 1966, the company completed a $20,000,000 capital equipment acquisition. In addition to 2 727-C's, Alaska Airlines acquired 1 L-382 Hercules freighter in March and another on June 20.

The company also introduced a unique mobile sales van containing a full-scale mock-up of the

Gold Rush interior decor of the Golden Nugget fanjets. The "sales auditorium on wheels" was to cover the entire nation on an efficiently mapped-out solicitation pattern. Self-contained with its own independent power supply and fully air-conditioned, the Jet-Van has a built-in automated sound system and specially designed projection equipment to show a concise sales film directed to travel agents and airline reservations personnel.

For the 9-month period ended September 30, 1966, Alaska Airlines reported a net profit of $955,-804. This compared with a net loss of $344,168 for the 9 months ended September 30, 1965. For the month of September, the company showed a net profit of $104,005, which compared with a net loss of $30,991 for the same month in 1965. September, 1966, revenues of $1,644,040 represented a 66 percent increase over the same month a year earlier, and the 9-month revenues for 1966 represented a 47 percent increase over the same period in 1965.

ALASKA COASTAL AIRLINES

For Alaska Coastal Airlines the year 1966 was one of many changes. The Board of Directors agreed to shorten the name of the airline in May from Alaska Coastal-Ellis Airlines to Alaska Coastal Airlines, Inc. The airlines was the result of a merger on April 1, 1962, of Alaska Coastal Airlines and Ellis Airlines.

New equipment consisted of the purchase of a Convair 240 which was to be used on the airline's Juneau-Sitka-Annette Island route. This was a change in status for the carrier, since prior to the purchase of the Convair it operated a fleet of 25 amphibious aircraft serving Southeast Alaska from Prince Rupert British Columbia, in the south to Skagway in the north. In connection with the purchase of the Convair, new service innovations included the addition of stewardesses. The airline in its amphibious division uses male cabin attendants. Because of the relatively short distances between the cities served, food service was not planned.

Alaska Coastal Airlines was in the final stage for certification of one of its Grumman Goose aircraft with turboprop power. When completed, the company was to evaluate the performance before making a determination of conversion of its entire fleet of 14 Grumman amphibians.

In connection with the opening of the new Sitka Airport, Alaska Coastal Airlines filed with the Civil Aeronautics Board to extend its route to Seattle.

Other changes included a new look among the sales personnel, conforming to company colors. The male sales agents wear black blazers with gray slacks, while the female sales personnel wear red blazers and gray skirts. The stewardess uniforms will follow a similar style but additionally, for winter wear, ski pants and sweaters.

Alaska Coastal Airlines, in cooperation with Pacific Northern Airlines, filed a special off-season tour fare in its effort to extend the season in Alaska.

During the first 9 months of 1966, the airline carried 128,516 revenue passengers and transported 3,730,323 pounds of cargo and 2,231,692 pounds of mail, flying 1,757,522 revenue passenger miles. This was a substantial increase over the same period in 1965.

Alaska was to celebrate the purchase centennial in 1967, and Alaska Coastal Airlines expected to share with the travel industry one of the best years ever.

ALLEGHENY AIRLINES

The year 1966 was one of growth for Allegheny Airlines, growth that almost overworked the word "record."

Throughout its 13 state system, the regional carrier boarded more than 2,000,000 passengers, up considerably from its 1965 record total of 1,465,141.

Revenue passenger miles climbed from 292,302,-135 in 1965 to more than 428,300,000 in 1966, an increase of nearly 46 percent.

Allegheny also maintained its position as number one cargo carrier among the nation's 13 regional airlines by boarding more than 55,700,000 pounds of air mail, freight and express, outstripping the old mark set in 1965 by about 17 percent.

One of the prime reasons for Allegheny's 1966 growth record was its intensive program to convert to an all turbine-powered fleet. Since June 1, 1965, Allegheny has been adding a turbine-powered aircraft to its fleet on the average of one every 18 to 20 days.

At the end of 1966, Allegheny was flying 10 F-27J Vistaliners, 16 Convair 580 Vistacruisers and one DC-9 Vistajet, along with about eight remaining piston-engine Convair 440's, which were slated for conversion to jet-prop Convair 580's.

Allegheny began 1967 with about 75 percent of its passenger airlift capability being flown with turbine-powered equipment. This percentage was to rise gradually up to 100 percent in mid-1967. Delivery of 100 passenger DC-9 Series 30 fan-jets was to begin during the early summer and 6 were expected to be on hand at year-end.

Allegheny responded to two Civil Aeronautics Board initiated investigations with suggestions on how to improve its route structure.

As part of the Board's New York-Florida Renewal Case, Allegheny asked for nonstop authorities in 5 major markets, all included in its Segment 8, which was being considered for renewal at the same time. These are: Washington-Boston; Philadelphia - Boston; Baltimore - Hartford / Springfield; Baltimore-New York City; and Washington-Hartford/Springfield.

Allegheny also suggested that the Board consider the following route strengthening proposals during the Allegheny Route 97 Investigation:

Lifting of operating restrictions which would permit Allegheny to operate nonstop between Pittsburgh and New York City, and Pittsburgh and Boston.

Addition of Allentown-Bethlehem-Easton, Pennsylvania, service between Pittsburgh and New York City.

Allegheny also asked the Board for authority to serve Chicago's Midway Airport with nonstop flights to and from Cleveland and Pittsburgh.

Among other route applications pending were requests by Allegheny to extend its system south to Nashville, Tennessee, and Lexington/Frankfort, Kentucky, to provide service between these points, Pittsburgh, Cleveland and Detroit; and authority to connect the Ohio Valley cities of Parkersburg/Marietta and Huntington/Ashland with Cleveland and Detroit.

A Board Examiner recommended that Allegheny be authorized to provide service to Toronto, Canada, from a number of cities throughout its system, using Erie, Pennsylvania, as the port of entry.

Continuing the "New Look" program begun in 1965, Allegheny placed new emphasis on Customer Care through a number of innovations.

Among these are Customer Service Representatives, assigned to all DC-9 flights. These young men are drawn from the ranks of experienced station and reservation personnel to provide in-flight advance ticketing, perform other special services and generally monitor the airline's initial jet-operation.

The "New Look" also came to Allegheny's in-flight food service, which was expanded on meal-hour flights to include "snack packs" consisting of sandwiches and shrimp cocktails, in addition to the regular offering of complimentary beverages and cocktails.

Allegheny pilots also took on a "New Look" in 1966, switching to a smartly tailored, charcoal gray uniform, trimmed with silver stripes, newly designed wings and hat crests.

Allegheny lived up to its reputation as an innovator in new customer services last year by becoming the first airline to establish a ⅓ discount, space positive Young Adult fare.

Servicemen can also travel Allegheny at a ⅓ discount, with confirmed space, thanks to a new fare adoted by the airline when the government became concerned about the number of military personnel who were being left stranded by space available fares.

AMERICAN AIRLINES

In many ways, 1966 was the most challenging year in American Airlines' long history. The preceding year had been a record traffic and revenue year. American was faced with not only continuing the upward trend, but with preparing for the rapidly-approaching new stages of the jet revolution.

This meant buying a wide range of new airplanes for specialized markets, and ordering the bigger, faster equipment of tomorrow. It meant applying for extensions of American's long-confined route system, in order to make best use of that equipment. It meant improving services to meet stiffening competition in the major markets. It meant new special fares to open new markets, and new facilities to accommodate the burgeoning passenger and freight traffic.

And it meant realizing adequate profits, in the face of rising costs, in order to meet growing investment needs.

American met all these goals in 1966. The fact that it flew 10,800,000 revenue passengers more than 9 billion miles during the first 3 quarters—up 30.3 percent from 1965—indicated its short-term success. Freight volume for the 9-month period was up to 252,400,000 ton miles, 45.1 percent more than the same period the year before, and revenues for the period set a new high of more than $545,-000,000.

Part of this traffic volume came as an unexpected burden, due to the strike that grounded 5 other carriers in July and August. American was the only transcontinental carrier flying during the 43-day strike. For the strike-affected third quarter alone, revenue passenger miles totaled nearly 4 billion, and freight ton miles exceeded 92,000,000. Under an inter-carrier agreement, American paid $29,-000,000 in mutual aid to the struck carriers.

Looking ahead, the company took 2 vital steps in 1966 to strengthen its future competitive position. In January, it applied for new routes across the Pacific—to Hawaii, Japan and beyond—becoming a major applicant in the CAB's Transpacific Route Investigation. In November, it announced an order for 10 Boeing 747 "jumbo jets," the biggest order to that point by any non-overseas carrier (American also held delivery positions on 6 U.S. supersonics and 6 British-French Concordes).

The transpacific routes were perhaps the most important ever sought by American. The coming supersonics require long-haul overseas routes for effective operations, and American is the only major transcontinental carrier without such routes. The airline, however, is the major domestic carrier of domestic air traffic headed for and arriving from the Far East (where air trade is growing faster than anywhere else in the world). Its proposed routes would link that area with U.S. cities producing nearly 90 percent of all traffic between this country and the Pacific.

Other route applications filed during the year included Toronto-Chicago and Toronto-Los Angeles, and routes between major Gulf State and Midwest points. In August, American was granted permanent rights to serve Acapulco.

American began direct, non-commercial service to the Pacific in November, carrying top-priority goods for the Military Airlift Command. The service started with a new Boeing 707 jetfreighter, 1 of 4 American received during the year.

The freighters were among 52 new jets American put into service during 1966. The new equipment was highlighted by the March introduction of twin-engine BAC 111's (400 Astrojets) on short-haul routes. In mid-December, the airline retired its last piston plane from scheduled service and became an all-jet carrier.

More than ever, the emphasis in 1966 was on the personal and pleasure traveler. In January, American initiated a half-fare Youth plan; in February, a reduced fare for jet coach excursions; in March, a personal credit card. The company's Military Standby Plan was liberalized in August. In addition to several service improvements during the year, the company began work on 2 innovations for the future: first, installation of ultramodern buffets in all 4-engine jets, for improved food preparation and storage; secondly, installation of an advanced inflight movie system.

Heavy promotions were conducted to bring new passengers aboard. The most dramatic of these was the Astrosphere, a huge, inflatable dome that serves as a portable theater. Launched in September, the Astrosphere will tour U.S. shopping centers across the country for the next 2 years, and it was expected to reach about 10,000,000 prospective passengers.

American made great strides in freight-handling improvements during 1966, and several of its freight facilities were enlarged and modernized. The heavy focus on freight derived from the company's expectation that freight revenues will exceed passenger revenues within 2 decades.

BONANZA AIR LINES

Bonanza Air Lines was eyeing the international market as 1966 drew near an end. Service to Mexico loomed as a possibility after the regional service carrier in mid-1966 presented route proposals for consideration at the forthcoming bilateral route discussions between the 2 countries.

Other highlights of the year included inauguration of DC-9 "Funjet" service to supplement the F-27 turboprops with which Bonanza became the first all turbine-powered airline in America, a half-dozen consecutive monthly boarding records, CAB action to set up for hearing 2 separate route strengthening cases, and inauguration of nonstop Las Vegas, Nevada-Grand Canyon, Arizona, service.

Bonanza anticipated marked increases in passenger traffic for 1966: 845,000 passengers (up 26 percent over 1965) traveling 215,600,000 revenue passenger miles, a boost of 27 percent over the year previous.

At mid-year, the carrier completed removal of its general offices and maintenance base from Las Vegas to a new multi-million dollar facility in Phoenix, Arizona, with a loss of less than 10 percent of its employees and none of the supervisors.

CAB Chairman Charles Murphy delivered the keynote speech when the new structure at Sky Harbor Airport was dedicated in June.

While new routes were not discussed during the U.S.-Mexico bi-lateral talks, the 2 countries planned to meet again in late January or early February for discussions limited to the question of new routes.

Bonanza proposed routes from Phoenix through Tucson, Arizona, to the Mexican cities of Guaymas, LaPaz, Mazatlan and Puerto Vallarta, and from Las Vegas through Yuma, Arizona, to Mazatlan and Guadalajara, Mexico.

G. Robert Henry, executive vice president of Bonanza, said the routes would "open a new jet-way between two of the most exciting tourist areas in the western hemisphree and broaden the avenues of exchange between" the U.S. and Mexico. Numerous officials in Mexico voiced support of the proposed routes, including the governors of the Mexican states of Jalisco, Sonora, Sinaloa and the territory of Baja California.

Expedited hearings slated by the CAB were based on Bonanza's subsidy elimination program. Two proceedings were set. One would be limited to (1) nonstop service between Tucson on one hand and the cities of San Diego and Los Angeles, California; Las Vegas and Reno, Nevada; and Salt Lake City, Utah, on the other, and (2) service between Tucson on all cities on Bonanza's 2 northern and its southernmost routes—the 5 cities named above plus Phoenix, Kingman, Grand Canyon, Page and Yuma, Arizona; Cedar City, Utah; El Centro and Santa Ana, California.

In the other proceedings, the CAB was to study Bonanza's bid for a route between Salt Lake City, Cedar City, Utah; Las Vegas, Palm Springs and San Diego. This authority would also permit Salt Lake City-Los Angeles service via Las Vegas.

Nonstop service linking Las Vegas and the Grand Canyon, inaugurated April 1, proved highly successful, with a 14-fold increase in traffic to the Grand Canyon, which Bonanza previously served only from Salt Lake City and Phoenix.

Promotional fares, such as the 'Youth Fare' originated by Bonanza in 1961—first in the industry—

continued as effective stimulants of traffic throughout the Bonanza system in Arizona, California, Nevada and Utah.

For 1967, Bonanza anticipated 1,000,000 revenue passengers, up 18.3 percent over estimated 1966 figures. Revenue passenger miles were expected to climb 16 percent to 250,000,000.

A fourth DC-9 was expected to join 3 already in service at about mid-year, with 2 more, both series 30 models, on order for early 1968 delivery.

BRANIFF INTERNATIONAL

New equipment and new services highlighted the progress of Braniff International in 1966, the first full year of command for President Harding L. Lawrence.

During the year Braniff placed in service 10 new Boeing 727 tri-jet aircraft and 5 Boeing 707-320C intercontinental jets that were ordered soon after Lawrence assumed control of the company on April 5, 1965.

To be introduced in 1967 were 14 additional 727's and 4 707-320C's.

Braniff, the first to introduce the revolutionary new "Quick Change" cargo concept, ordered 18 of its 24 727's in the "QC" model which can be converted between all-passenger, all-cargo or combination cargo-passenger configurations, in 30 minutes.

Jet deliveries in 1966 enabled Braniff to phase out all but 6 of its piston-engine aircraft by year-end. BI planned an all jet-powered operation by mid-1967.

The airline received White House approval in October for a $30,000,000 purchase of Panagra from Pan American World Airways and the W. R. Grace Company. The combined South American operation of Braniff and Panagra, planned to begin the first of the year, will provide service between the U.S. and Panama City, Panama; Bogota and Cali, Colombia; Guayaquil and Quito, Ecuador; Lima, Peru; La Paz, Bolivia; Santiago and Antofagasta, Chile; Asuncion, Paraguay; Buenos Aires, Argentina, and Sao Paulo and Rio de Janeiro, Brazil.

The merger of Panagra into Braniff also will add 8 additional aircraft—3 DC-8 jets currently operated by Panagra and 5 DC-8 Super 62 long-range jets on order—to BI's jet fleet.

Braniff was also prepared at year-end, pending final award by the Civil Aeronautics Board, to inaugurate service on new routes recommended by a CAB examiner in the Pacific Northwest-Southwest Service Investigation.

The examiner's recommendations would extend Braniff's present routes which blanket the Midwest and Southwest beyond Denver to Seattle via Salt Lake City and Portland, and also provide for new segments between Dallas and New Orleans; Tulsa, Wichita and Denver and Kansas City and Denver.

Direct flights would be provided by Braniff between the 3 cities in the Northwest, Seattle, Portland and Salt Lake City, and Dallas/Fort Worth, Houston, San Antonio, New Orleans, Tulsa, Oklahoma City, Wichita, St. Louis, Kansas City and Denver.

Braniff also filed a number of other route applications during 1966, including:

Transpacific routes that would connect most of the major U. S. mainland cities with Honolulu and Hilo, Hawaii; Tokyo and Osaka, Japan; Saigon; Bangkok; Taipei; Hong Kong; Manila; Singapore; Djakarta; Melbourne and Sydney; Auckland; Fiji Island; Somoa, and Tahiti.

First U. S. flag carrier service to the resort island of Cozumel, Mexico.

An extension beyond Chicago to Toronto, Canada, on flights from the Southwest.

New service between the Texas-Southwest area and the Midwest Great Lakes area.

New service between Minneapolis-St. Paul and California.

These were in addition to applications pending in the U.S.-Caribbean-South America Service investigation for East Coast service between New York and Miami, and for service between Dallas and Miami.

The delivery in 1966 of the first aircraft in Braniff's new jet equipment purchases the addition of many new air services, including both cargo and passenger flights.

On August 1, Braniff inaugurated the world's first Boeing 727QC "Quick Change" all-cargo service between San Antonio, Dallas and Chicago. By December, BI's "QC" service had been expanded to include all-cargo jet flights between Houston, Dallas and New York, and combination cargo-passenger jet flights between Newark and Dallas, via Washington, D. C., Memphis and Nashville.

Braniff also inaugurated combination passenger-cargo flights to South America with Boeing 707-320C jets capable of carrying 104 passengers and 33,000 pounds of cargo.

Other operational expansions during 1966 saw increased service to Acapulco, one of the favorite spots with the "in crowd;" new nonstop jet service between Tulsa and New York, Houston and Denver, and Memphis and New York, and the first 1-stop service from Oklahoma City to New York.

Other advances during the year found Braniff:

Introducing the "Air Strip-II" for BI hostesses with new Emilio Pucci-designed print leotards and miniskirts in addition to the haute couture hostess wardrobe unveiled in 1965. Another revolution in hostess outfits introduced include a $1,200 Mongolian fox fur hooded coat issued to hostesses flying

New Emilio Pucci-designed print leotards and mini-skirts were the 1966 additions to Braniff International's haute couture hostess wardrobe unveiled earlier.

in Greenland and Iceland and other cold climes on Braniff's Military Airlift Command contract flights.

Reporting 9-month net earnings of $15,132,496, equal to $2.57 a share, as compared with $6,427,-945 earned in the same period in 1965. Total available seat miles for the first 9 months were up 54.1 percent to 3.7 billion and revenue passenger miles were up 70.2 percent to 2.3 billion.

Establishing Fastcharge, a simple easy-to-get credit plan enabling passengers to charge domestic or international travel either on a 30-day or revolving charge account basis.

Installing, for the first time in the airline industry, a drive-in ticketing and baggage checking facility utilizing 2-way closed circuit television.

Starting contract services in June 1966, for the Military Airlift Command with Boeing 320C flights from the West Coast to Hawaii, Okinawa, the Philippines and Viet Nam. Braniff's MAC service was expanded in July with flights from the East Coast to Greenland, Iceland, Puerto Rico and the Canal Zone.

CANADIAN PACIFIC AIR LINES

Government authority for a daily flight from Vancouver to San Francisco, which was to commence on January 30, 1967, increased the unduplicated route mileage of Canadian Pacific Airlines to 52,604 of which 45,731 were overseas routes. During 1966, another milestone was the inauguration of a once per week direct Toronto to Honolulu flight of 4,733 miles. This was in addition to peak season flights of 10 each week from Vancouver to Honolulu.

At the start of 1966, 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 route from Toronto-Montreal to Amsterdam commenced in 1965. Other routes included 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 Britannias. 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 7 DC-8 jets was to be supplemented in 1967 and 1968 by 4 DC-8 Series 63 jets named "Spacemasters" by the airline. Delivery dates for the 205 passenger aircraft were September, October, November, 1967, and April, 1968.

A $1,500,000 DC-8 simulator was installed at the Vancouver headquarters where DC-6 and Britannia simulators were already being operated. Most routes on Canadian Pacific Air Lines world pattern showed substantial traffic increases in 1966.

CPA recorded an 18 percent increase in passenger revenue during the first 8 months of 1966, and, compared with the same period in 1965, a 28 percent increase in air cargo revenue and a 22 percent improvement in air mail revenue.

Greatest gains were on the North Atlantic, where passenger business jumped 58 percent, cargo 82 percent, and mail 48 percent. This was due partly to commencement of a new service from Eastern Canada to Amsterdam and Rome.

Cargo increases resulted from a stepped-up program in Canada and Europe by sales specialists in this field. Most of the increased cargo loads were from CPA's gateway cities of Rome, Madrid and Amsterdam to Canada.

Allure of warm climates during the Canadian winter continued, with Canada-Hawaii revenue up 32 percent during the first eight months of this year and Western Canada-Mexico revenues up 10 percent.

On the Canada-Tokyo-Hong Kong route, a 17 percent increase in revenue was achieved in the same period due mainly to a 37 percent improvement in cargo business and a 9 percent jump in passenger revenue.

The bustling economic activity in British Columbia was reflected in the 8-month results for the domestic routes there. Passenger revenue increased 29 percent, cargo 32 percent.

With today's jet travellers preferring nonstop service, CPA was to retain a nonstop Vancouver-Amsterdam polar flight and a nonstop Toronto-Rome flight throughout the winter of 1966-67. (Several other flights each week were to have intermediate stops, such as Calgary and Edmonton on the polar route, and Montreal and Amsterdam on the Eastern Canada-Rome route.)

Seasonal increases in flight frequencies were planned between Canada and Europe in the summer of 1967. For example, 2 nonstop services were to be operated from Toronto to Rome and 2 from Montreal to Rome, compared with 1 nonstop from each city in the 1966 summer.

In the detailed planning stage was a new maintenance and overhaul base at Vancouver International Airport. The new facilities were expected to meet the company's maintenance requirements for the next 2 decades, and were to be capable of handling the big jets of the future, including supersonic transports.

CENTRAL AIRLINES

The year 1966 will be remembered as the year of decision and decisive action for Central Airlines.

Early in the year, Central launched into a major "Turnabout" program that was to bring many new looks, equipment and ways of thinking to the airline.

A new image program was introduced to bring a fresh, jet-age look to Central from the ramp agent in Denver to the mechanic in St. Louis, from aircraft exterior to baggage carts, from seat covers to stationery.

Near the first of the year, the fresh new Central Airlines appeared before the public for the first time when Central received the first of its turbine-powered Dart 600 aircraft. The aircraft exhibited a completely new exterior design and interior motif.

The high-fashion stewardess uniform is part of Central Airlines' new look.

The Rolls-Royce engines, providing faster, quieter rides for Central's passengers, proved far superior to the piston-engine predecessors.

For the first time in Central's history, beverages and light refreshments were served on all Dart 600 flights, and the new look of Central appeared all over its system early in the year with the revitalization of all terminal facilities.

The "New Look" program was completed with the design of all-new high-fashion apparel for Central's personnel.

In an effort to improve Central's service, numerous new route applications were filed with the Civil Aeronautics Board for route extension and improvement. Of major significance were the Chicago Entry Case, Route 81 Investigation and Route Realignment Case, and the recently filed Gulf States-Midwest Points Investigation Case.

Despite a loss of 15,000 passengers during the airline strike, Central had a successful year and expected to post a 24 percent gain in passengers carried.

Revenue passenger miles were up 32 percent over 1965 and available seat miles gained 15 percent. These increases were very gratifying since revenue plane miles increased only 9 percent.

Several special fares contributed to Central's record-setting pace in 1966, such as the $15 Return Fare, which can be used to save money any day except Friday or Sunday. The $15 Fare is very simple. A passenger can travel to any point on Central's 6-state system and return home for $15. The farther he travels, the more money he saves. The Military, Clergy, Youth and Family Fares also proved important parts of Central's marketing program.

The most significant factor contributing to Central's growth in 1966 was passenger acceptance of the NEW Central Airlines and the successful introduction of the Dart 600 jet-prop aircraft to 36 communities in Central's 46-community, 6-state system.

In addition to attracting more passengers, the Darts were encouraging passengers to travel greater distances in that the average passenger haul went from 207 miles in 1965 to 222 miles in 1966.

Central saw this pattern of growth continuing for 1967, and its conservative anticipation was a 25 percent gain in revenue passenger miles. The line's biggest plus factor in 1967 is to be the inaugural of DC-9 service in the latter part of the year, bringing pure-jet service to many communities in route area for the first time.

CONTINENTAL AIRLINES

Continental Airlines had under way in 1966 one of the biggest capital expansion programs in its 32-

The Boeing 747 jumbojet figured in Continental's massive $300,000,000 re-equipment and expansion program.

year history, planning an outlay of about $300,000,000 during the 1966-70 period. (The company's total assets at the end of the third quarter of 1966 were $174,000,000). The $300,000,000 was being used for 33 new pure jets, including spare parts and related ground facilities; for maintenance base expansion and construction of a newly completed training center at Los Angeles; for 2 new Link jet simulators; and for a new IBM 360/Model 65 Management Information System.

The 33 new jets being purchased, some of which already had been delivered in 1966, include 2 Boeing 720B's, 17 Douglas DC-9C's, 6 Intercontinental Boeing 707-320C's, 5 Boeing 727-200's, and 3 Boeing 747C superjets. These new aircraft will more than double the company's fleet. Continental also had 3 Concordes on order and reserved positions for 3 American supersonic transports.

Continental won CAB approval to introduce a new "Adult Standby Fare" which allows persons 22 years and over to fly at one-third off the already low economy fare on certain nighttime flights between Chicago, Kansas City, Denver and Los Angeles. Continental pioneered economy fares when it introduced its 3-class-service concept (first class, coach and economy on the same jet) on the Chicago-Los Angeles route in 1962. The adult standby rates went into effect August 1, 1966.

Continental's domestic passenger traffic in September was up more than 30 percent over the same month in 1965, with cargo traffic also up 30 percent.

Overseas contract operations continued to increase substantially, with the company flying 153,000,000 revenue passenger miles in international service (military contract flights to the Orient and commercial charters to Europe) during September, compared with 109,000,000 in September, 1965. Continental was awarded a fixed military airlift contract for fiscal 1967, amounting to about $30,000,000, compared with fixed contracts of $7,500,000 for fiscal 1966 and $2,900,000 for fiscal 1965, the first year the company began MAC operations. On another front, the wholly-owned subsidiary, Continental Air Services, was operating within Southeast Asia providing general aviation services for private construction firms and the U. S. Agency for International Development.

A Civil Aeronautics Board examiner recommended Continental for a major share of the routes at stake in the Pacific Northwest-Southwest Case, and the company hoped to be operating over these routes by mid-1967. Continental also was seeking routes between Los Angeles and Toronto and Chicago and Toronto (a CAB examiner recommended that Continental be granted the Chicago-Toronto segment and the company was hopeful the full Board would grant it that route as well as the Los Angeles-Toronto leg); between California and the Southeastern Seaboard; between Minneapolis/St. Paul, Omaha, Salt Lake City, San Francisco and cities on the present route system.

One of Continental's biggest efforts will be to get commercial routes between the mainland U. S., Hawaii, South Pacific and the Orient. Continental had one of the broadest applications on file encompassing North, Mid and South Pacific proposals, and the company felt its extensive experience in this part of the world through military airlift operations and CAS made it an exceptionally strong contender in this case.

To gear up for greatly expanded jet age operations and to prepare for the forthcoming supersonic age, Continental instituted a realignment of its top executive structure in a continuing program to strengthen its overall management team, Alexander Damm, promoted to senior vice president and general manager, heads up this team under President Robert F. Six. A major part of the new management structure at Continental is the International Affairs Division headed up by Pierre Salinger, vice president, and James L. Greenfield, assistant vice president, both highly experienced in overseas relations. Continental's military contract services are headed up by William R. Boyd, a veteran specialist in overseas airline operations.

Continental continued to lead the industry in jet aircraft utilization, a major indicator of operational efficiency. For example, in international service during July, the company's Intercontinental 707-320C fleet flew an average of 16 hours and 57 minutes a day and during April 1 of these aircraft averaged 17 hours and 23 minutes a day—both all-time highs for the world's airlines. Continental's domestic utilization record was equally impressive, with the company's Boeing jets averaging over 14 hours a day and the DC-9's nearly 12 hours a day in September.

One important indicator of financial stability was that in 1965 Continental secured bank and institutional financing aggregating $98,600,000 on an unsecured basis and at favorable interest rates, marking the first time all of the company's borrowings have been placed on an unsecured basis. On profitability, for the first 9 months of 1966, Continental had net income of $12,600,000 ($3.86 per share) compared to $9,400,000 ($2.43 per share) for the same period of 1965. Third quarter 1966 net was $6,200,000 ($1.91 per share) versus $5,700,000 ($1.79 per share) for the 1965 period. The 9 months results of 1966 marked the best in the company's history. Continental expected 1966 total revenues to be about $157,000,000, compared to $116,000,000 in 1965.

DELTA AIR LINES

Delta Air Lines chalked up another profitable year in 1966, with new records in operating revenues, a progressive expansion of fleet and facilities, and a broader pattern of flight schedules and special fares.

The fiscal year ending June 30 saw Delta's operating revenues top $300,000,000 for the first time, totaling $318,930,000, an increase of 24 percent above last year's $257,460,000. A net income of $34,554,000 for the fiscal year represented an increase of 50 percent over 1965. There were increases in all categories of traffic.

During the year Delta took delivery of its 20th and 21st DC-8 Fanjets and 6 of the 12 DC-9's in service. With 16 Convair 880's, this gave Delta 48 jets in operation at year-end.

The airline also exercised options on 7 "stretched" DC-8's and 12 stretched DC-9's. With 30 DC-9's and 5 stretched DC-8's still to be delivered under previous commitments, the 19 options exercised increased Delta's firm orders to 54 jets for delivery by the end of 1969, representing a quarter billion dollar jet equipment expansion program over the years 1966 through 1969.

At that time Delta's jet fleet will total 103 aircraft, including 14 standard DC-9's (65 passengers), 40 stretched DC-9's (89 passengers), 21 standard DC-8's (133 passengers), 12 stretched DC-8's (195 passengers), and 16 Convair 880's (96 passengers).

Making its inaugural appearance in 1966 was the Lockheed-100 airfreighter, commercial version of the world-famed C-130 Hercules. Delta was the first airline to operate the L-100 propjet in scheduled domestic service, with an initial service pattern on September 15 between Chicago, Atlanta, Orlando, and Miami. By November 1, with 3 L-100's in service, Delta's all-cargo network included 11 cities and provided the first direct all-cargo service between the Southeast and California. The 3 L-100's were expected to add approximately 60,000,000 ton miles of capacity to Delta's freight system.

Delta introduced to service the Lockheed L-100 commercial version of the USAF's C-130 Hercules.

Delta's basic service pattern during the year underwent a vast expansion, highlighted by a great increase in nightcoach service, 40 percent more seats over the Southern Transcontinental Route, a more attractive pattern into the Caribbean, and DC-9 jet service into 9 new cities.

A rising tide of complaints from Youth Fare passengers and parents against the uncertainties of space available travel prompted Delta in 1966 to initiate a Youth Fare program of confirmed space at a fare reduction of one-third. Indications were that the program was highly successful and would be continued.

To boost increased domestic vacation travel, Delta in 1966 also announced new "Discover America" fares that offer roundtrips between all domestic cities for approximately 25 percent below jet daycoach cost. A new "See US" tariff, for foreign nationals visiting the U. S., reduced First Class fares from $300 to $240, and Tourist fares from $250 to $220.

Ground-breaking ceremonies for 2 major facilities in Atlanta—a new training school and an expanded maintenance base—were held during 1966.

The new Ground Training Center, located just off Atlanta Airport proper, will contain 51,000 square feet for classrooms, facility officers, conference rooms, a technical library, and stewardess trainees' housing.

A $6,500,000 expansion to Delta's jet base will add 372,360 square feet to the Atlanta maintenance center, an increase of 90 percent. When construction is completed in 1968, the center will have 18 acres under roof and a total of 781,941 square feet housing six major departments: Maintenance, Engineering, Inspection, Stores, Technical Operations Facilities, and Technical Operations Planning.

Delta was an active participant in 1966 in several route proceedings including the Pacific Northwest-Southwest Service Investigation; Transpacific Route Investigation; Gulf States-Midwest Investigation; and the reopened New York-Florida Renewal Case.

In these proceedings, the issues were single-carrier service between the Northwest and the Southwest, deep South, and Southwest; service between California and the Far East, with specific intermediate points in Hawaii and the Philippine Islands: service to 4 new cities and 5 route segments Delta does not now serve; and service between the Northeast and Florida.

EASTERN AIRLINES

The year 1966 was a period of continued growth and improvement for Eastern Airlines. While net profit for the first 10 months was only $9,500,000, reflecting effects of the 43-day strike by machinists during mid-summer which cost the company over $60,000,000 in lost revenues, traffic towards the year's end showed promising gains and indicated return to the previous level of approximately 17 percent higher revenue passenger miles than the same periods of 1965.

Load factors in particular indicated a more efficient operation, with the monthly average ratio of seats filled to seats available running at their highest levels in a decade. In November, for example, the load factor was 58.6 percent, an all time high for this month, while in April, which was Eastern's busiest month of the year, it reached 66.1 percent.

Various factors contributed to these gains, among them introduction of new jet services over many routes; the new stand-by "Youth Fares" and other promotional discounts; intensive advertising and sales efforts; and the company's determination to make 1966 "A Year of Excellence."

Eastern added 24 more jet aircraft to its fleet of 69 during the year and would have nearly doubled this figure by December 31 had it not been for delayed deliveries on the part of manufacturers, caused largely by military requirements in Viet Nam. The last of the company's 4-engine DC-7B propeller aircraft were sold, and new orders were placed for 5 more Boeing 727 "Quick Change" passenger/cargo "Whisperjets"; 2 more Douglas DC-8-61's and 23 more advanced-model Douglas DC-9-31's.

Eastern arranged $100,000,000 credit with a group of institutional investors during September. Coupled with funds still available from earlier loan arrangements and internally generated revenues, this will help pay for some $325,000,000 aircraft commitments for the next 2 years.

Additionally, Eastern prepared for its future entry into the supersonic age through the signing of commitments for 4 of French/British "Concorde" aircraft and 2 of the SST's to be built in the U.S.

Furthering its intentions to expand routes and diversify operations, Eastern during the year received permission from the Civil Aeronautics Board, with White House approval, to merge Mackey Airlines, with consummation expected by year's end and direct services to the Bahamas by jets from northern cities on Eastern's present routes scheduled to commence January 10, 1967. Also, Eastern acquired by purchase (still subject to CAB approval) the firm of Remmert-Werner Inc., of St. Louis, commercial sales representatives for the North American Aviation's "Sabreliner" executive jet and for the Short Brothers' Belfast-built STOL aircraft, the "Sky-Van."

Contracts were also concluded with the U.S. Air Force and several local service and foreign-flag airlines for engine and airframe maintenance work to be done at Eastern's Miami Base, and 3 more airlines (Ozark, Lake Central and North Central) were added to the 2 others (Mohawk and Allegheny) already sharing the electronic reservations and flight information facilities at Charlotte, North Carolina.

New international routes were inaugurated by Eastern during the year between New York and Acapulco, Mexico; between Toronto, Ontario, and Miami via Buffalo and Tampa; and between Toronto and Washington via Buffalo and Philadelphia. On the domestic scene, non-stop service was also added between Huntsville, Alabama, and New Orleans, Louisiana, and reinstated between New York and St. Louis.

The unique no-reservations "Air Shuttle" service linking Boston-New York-Newark-Washington was upgraded with the introduction of jets on prime sections of certain flights, and major terminal improvements were completed at Newark and Washington National Airports for the benefit of patrons.

Notable also during the year was inauguration, jointly with Braniff as part of its interchange service, of non-stop flights between New York and Lima, Peru, and between New York and Panama City/Balboa, Panama.

Looking to the future, and to Eastern's need for longer routes to balance the shorter hauls it is now obligated to operate, application was made for various additional routes across the Pacific to Hawaii, New Zealand, Australia and Southeast Asia, and previous proposals were further refined and advanced before the CAB.

A Board examiner recommended during the year, in connection with Eastern's pending applications for authority to serve the nation's "Space Age Corridor" between the Southwest and the Northwest, that the airline's routes be extended beyond St. Louis to Kansas City and Denver. Other requests submitted by Eastern for new routes included proposed links between Atlanta-Birmingham-Dallas/Fort Worth; Dallas-St. Louis; Chicago-San Antonio; and St. Louis-Houston; and non-stop rights from Montreal to Tampa and Miami.

Four stations formerly served by Eastern—Beaumont/Port Arthur, Texas and Lake Charles, Lafayette and Baton Rouge, Louisiana—were transferred during 1966 (with CAB authority) to Trans-Texas Airways. In Detroit, Eastern shifted its operations from Willow Run to the new Metropolitan Airport.

Announcement was made early in 1966 of plans for a $34,000,000 expansion of Eastern's computer facilities, with new IBM equipment to be installed at Miami and an improved UNIVAC facility in Charlotte. Plans for a new $1,500,000 cargo handling center in Atlanta were also initiated.

FLYING TIGER LINE

Record revenues and earnings, firm arrangements for a fleet of 10 DC 8-63F jet freighters, a new maintenance base and general office building and ironclad authority to sell blocked space were the highlights of 1966 for the Flying Tiger Line.

For the first 9 months of 1966, Tiger earnings reached $7,844,781 on revenues of $62,562,194 and gross operating revenues for the year were expected to be in excess of $80,000,000. This represents a 239 percent increase for the same period of 1965.

The company also announced arrangements to acquire, through a leasing agreement, 10 DC 8-63F Douglas jet freighters capable of 36 percent more payload than conventional DC-8's and 70 percent more than the Canadair CL-44 Swingtail propjets which the airline was flying on its domestic routes. Tigers' combined fleet of 15 CL-44's, 4 Boeing 707's and 10 DC 8-63F aircraft will give the airline capacity for about $150,000,000 per year of revenue.

In October the U. S. Supreme Court, by refusing to hear further appeals from the major passenger carriers, upheld the Civil Aeronautics Board 1964 decision to award exclusive blocked space authority to the all-cargo carriers. Blocked space is a contract between the all-cargo carriers and a shipper in which the airline guarantees to move a specific amount of freight at least once weekly between 2 terminals for a minimum period of 90 days. The minimum volume of freight is 1,000 pounds per shipment, but both the volume and the frequency of shipment can be expanded according to the needs of the shipper. Under these conditions the shipper earns a discount ranging from 3 to 15 percent below existing airfreight rates.

At a cost of $4,500,000 the new Tigers base at Los Angeles International Airport occupied in mid-February spreads over a total area of 212,340 square feet. Home to more than 1,000 people, the new base is comprised primarily of a 2-story, 38,000 square foot general office building and the largest maintenance hangar of its kind west of Atlanta. A cantilevered structure, the hanger contains 78,200 square feet, sufficient space for 3 Boeing 707 aircraft wingtip to wingtip.

The Flying Tiger Line filed applications with the CAB for a transpacific route to serve the expanding trade between the Orient and the United States. FTL also filed for routes into Memphis, Nashville, Charlotte, Atlanta, New Orleans and Miami. Applications were on file for routes into Toronto and Montreal under the US-Canadian bi-lateral agreements.

FRONTIER AIRLINES

As a result of introducing new passenger-appealing aircraft, innovating new low-cost fare plans and aggressively pursuing new routes, the Denver-based Frontier Airlines has grown ever year for the past 5 and the trend continued in 1966.

For the first 10 months of 1966, revenue passenger miles jumped 55 percent over the same period in 1965. For these 10 months, 274,117,000 revenue passenger miles were recorded compared with 176,-498,000 for the previous year. This amount of travel was performed by 850,785 passengers, a 42 percent growth over the 599,794 passengers using Frontier in the first 10 months of 1965. A good percentage of the revenue passenger mile gain was the result of Frontier's average passenger haul increasing to 322 miles per passenger compared with 294 miles in 1965.

Frontier's earnings paralleled its spectacular growth in passengers. During the third quarter of 1966, net earnings of $817,229 were a 120 percent increase over $370,649 reported for the third quarter in 1965. This was the highest financial quarter in Frontier's 20-year history. At the end of September, 1966, year-to-date revenues amounted to $22,717,000, a jump of 25 percent over the $18,149,000 recorded during the same 9 months of 1965. Net profit for the 9 months amounted to $1,603,000, an 87 percent increase over the $857,500 earned during the same 9 months of the previous year.

Confident that public use of its services would continue to grow throughout its 11-state system and with the hope that new routes and new route authority would give the carrier greater flexibility in its operations, Frontier began scheduled operations with the first 2 of its 600 mile per hour Boeing 727 jets in September and October of 1966. For the first time, Frontier introduced coach service on its system, providing 72 coach seats as well as 24 first class seats in its 96-seat configuration of the 727. Frontier also had a firm order for 3 more of the 727's with delivery planned for April, May and June of 1967. Frontier had an option for an additional 5 727's with deliveries in late 1967 should the option be exercised. As the backbone of its fleet, Frontier was operating 20 jet-prop Convair 580 aircraft carrying 53 passengers at cruising speeds of 355 miles per hour. This aircraft has been a major factor in Frontier's spectacular passenger growth for the past 2 years. The success in attracting ad-

Frontier was finding wide acceptance for its Allison-powered Convair 580 turboprop.

ditional passengers plus low-cost operations and reliability of the Allison powered jet-props have encouraged other regional local carriers to convert their piston powered Convair fleets to the faster, more economical, more appealing CV-580's. The 580's were replacing Frontier's former Douglas DC-3 fleet. The carrier expected to completely eliminate its DC-3 operations by the summer of 1967.

In the comparison of cargo carried, 3,750,000 pounds of air mail represented a 57 percent increase, air express was up 43 percent with 2,100,000 pounds carried and 11,200,000 pounds of freight was carried for a 42 percent increase.

Frontier's comprehensive program of broadening the base for additional air travel through low-cost air fares had the desired effect, generating thousands of new users of the airline's services. In the first 8 months of 1966, nearly 300,000 passengers were ticketed on the basis of Frontier's 12 promotional fares. It also brought nearly $5,500,000 in passenger revenue to the carrier. These special fares included a liberalized family plan usable all 7 days of the week which permitted half fares for wives and quarter fares for children when the head of the family paid his regular full fare. This particular plan generated close to 100,000 passengers the first 8 months of 1966 and brought in close to $2,000,000 in revenue. Other major reduced fares were the youth fare for air travelers under the age of 22, a 30 day round-trip excursion fare, the military standby fare and the Government first-class fare. In the early part of 1966, Frontier also introduced a revolutionary half-fare which could be used by anyone, any day, any age for travel on a half fare standby basis between 20 city pairs on Frontier's system. Less than one half of 1 percent of persons attempting to get on the first flight of their choice had to stand-by for a second flight. The appeal of this new fare has attracted a whole new group of air travelers who had never flown any scheduled airline previously. This group comprised 12 percent of the users of the half fare standby plan. Although this plan was limited to 20 city pairs, 36,000 passengers who produced $650,000 in revenues used the plan during the 7 months that it was available. These fares, as a total, generated an 82 percent growth in passengers and a 90 percent increase in passenger revenues over showings for the same period in 1965.

During the 6 weeks of the airline strike which grounded major airlines across the United States, Frontier was the first carrier to put into immediate operation additional new non-stop operations between major trade centers on its system. It also received Civil Aeronautics Board authority to run a temporary operation between Denver and Las Vegas, Nevada. This made possible a connecting "air bridge" formed with carriers operating between the Pacific Coast and Frontier-served Las Vegas on the West and with carriers in the midwest which connected with Frontier's operations in Omaha and Kansas City. A total of 31 special daily non-stop flights were operated during the strike period which carried close to 60,000 passengers who would have otherwise had to curtail their travel plans. In the meantime, the carrier continued to perform all of its needed air services elsewhere on its 11-state system.

In its plans to develop new routes and to improve service, the carrier was a major contender in Civil Aeronautics Board hearings in a dozen route cases affecting the entire area west of the Mississippi River/Great Lakes. Frontier also applied for new routes to Mexico City/Acapulco and to a half dozen growing vacation areas on Mexico's West Coast.

HAWAIIAN AIRLINES

Hawaiian Airlines in 1966 saw its planned program of expansion materialize into the largest turbine powered fleet operated by any scheduled airline flying in inter-island service.

At year's end, Hawaiian Airlines' total fleet of 13 aircraft included 2 90-passenger DC-9 Royal Fan Jets; 6 640 Convairs carrying 56 passengers each; 3 YS-11's carrying 60 passengers each; 1 combined passenger-freighter 640 Convair and 1 pure freight 640 Convair.

Hawaiian was the first carrier to inaugurate inter-island pure jet service on April 1, 1966. The second 560 mile per hour DC-9 Royal Fan Jet was added on April 25. John H. Magoon, Jr., Hawaiian's president, also announced in 1966 that in the fall of 1967 Hawaiian will acquire 2 additional DC-9's of the Series 30 model, capable of carrying a total of 115 passengers on each aircraft between the islands in jet-age comfort and speed.

To meet the required lift in 1967 prior to the delivery of these 2 DC-9 Model 30's, Hawaiian leased 3 factory-new Japanese 60-passenger YS-11 jet-prop aircraft. These airplanes are very similar to the Convair in design and size and utilize the same Rolls-Royce Dart-10 engine that is installed in Hawaiian's Convair 640's. The lease on these aircraft expires in the fall of 1967 coincident with the first delivery of the DC-9 Model 30.

High passenger acceptance of this most advanced fleet gave Hawaiian a high of approximately 944,000 passengers carried, for a 13 percent increase over 1965. This figure would have surpassed the 1,000,000 passenger mark for the first time in Hawiian's history if the costly airline strike during July and August had not occurred. The impact on Hawaiian Airlines was severe in that the tourist traffic to Hawaii was markedly reduced right at the peak of the tourist season.

The strike affected not only passengers but also dollar volume. Revenues from total passenger, cargo and other sources was estimated in excess of $13,000,000. Assisting the dollar income was the airline's lifting of over 37,000,000 pounds of inter-island airfreight.

Greater freight lift was expected in 1967 as Hawaiian's jet power fleet moves into full operation on all islands. An extended runway and improved airport facilities completed in 1966 on the island of Lanai, served exclusively by Hawaiian Airlines, will assist this growth.

Hawaiian continued its proud record that since November 11, 1929, when scheduled inter-island air service was inaugurated by the line, no fatality has befallen a single passenger or crew member. Nearly 11,000,000 passengers have been carried in that time.

With an eye to possible route expansion, Hawaiian Airlines was intensely investigating the potential of a route west of Honolulu to the islands of Kwajalein and Majuro, continuing through the Trust Territory with stops at Ponape, Truk, the Palaus, Yap, Guam, Rota and Saipan, and continuing to Okinawa and Taipei. Air service through this area was being provided by recurrent annual government contract and it was Hawaiian's conviction that the route is ideally suited to a regional concept with scheduled flights being provided by a federally certificated carrier.

LAKE CENTRAL AIRLINES

Lake Central expanded its service into its ninth state on December 1, when service to Louisville, Kentucky, was inaugurated. The local service carrier was also recommended by a CAB examiner to extend services to Toronto, Ontario, Canada. With the addition of Louisville, Lake Central at the end of 1966 served 46 cities in the Midwest and Appalachian area.

In March of 1966, Lake Central announced a contract with Allison Division of General Motors to convert 8 Convair 340's to prop-jet power. Two of the converted aircraft, designated Convair 580's, were introduced into scheduled service at 11 major terminals during the third quarter of 1966. The third Convair 580 was scheduled for delivery during December, and the remainder were to be delivered during the first half of 1967. In order to accommodate the conversion program, the Convair 340 fleet was expanded from 8 to 10, and Lake Central held an option to convert 8 additional Convair 340's to 580's, for a possible total of 16 of the 55-passenger prop-jets.

Lake Central withdrew from service its fleet of 12 Nord 262's during the middle of August, following 2 in-flight engine malfunctions in which the engines dispersed metal particles which penetrated the fuselage of the cabin. At year-end, it had not been determined when or whether the Nord 262's would be returned to service by Lake Central. Due to the inoperative status of the Nord 262's, and to avoid needless interruption of service, Lake Central returned to service its fleet of DC-3's. Various provisions of the airline's contract with the manufacturer of the Nord 262 protected Lake Central from economic loss while the prop-jet fleet was out of service.

The company's jet equipment program included the purchase of 3 and an option for 3 Boeing 737-200 QC aircraft. The 3 jets on order were slated for delivery the latter part of 1968 and early in 1969. In the interim, the airline will lease 2 Boeing 727's to accommodate the longer haul routes before delivery of the 737's.

During August Lake Central became a participant in Eastern Air Lines' Real-Time UNIVAC 490 computer system. Consequently, Lake Central was able to provide immediate confirmation of reservations on its own flights as well as the flights of 16 other airlines.

Passengers carried during the first 3 quarters of the year increased 19.3 percent over 1965's similar period. Revenue passenger miles were up 26.7 percent, while available seat miles increased 16.4 percent. This resulted in an increase in passenger load factor to 47.3 percent, compared to 44 percent for the first 9 months of 1965. Cargo poundage was up 22.8 percent.

LOS ANGELES AIRWAYS

Los Angeles Airways continued its record of consistent growth and industry achievements during 1966. Passenger traffic for the 10 months through October totaled 264,056 persons carried, an increase of 26 percent over the like period in 1965, despite a major airline strike during July and August of 1966.

On July 12, 1966, Los Angeles International Airways expanded its service to the American Airlines Terminal at Los Angeles International Airport. The initial 5 round-trip flights a day to Whittier, Anaheim and Disneyland were later doubled, and nonstop service to Newport Beach and San Fernando Valley points was included. Service to the Pomona, Riverside and San Bernardino segment of LAA's system is in the planning stages.

A new terminal facility, providing increased personnel staffing and a wide range of airline functions, was completed at the Newport Beach Heliport in August of 1966. Service between Newport Beach and Los Angeles International Airport was increased and 6 nonstop flights added.

An impressive breakthrough in equipment reliability occurred on August 4, 1966, when LAA's latest S-61 aircraft attained 1,000 uninterrupted

Los Angeles Airways' latest Sikorsky S-61 attained 1,000 uninterrupted flight hours in less than 4 months, an impressive commentary on equipment reliability.

flight hours in less than 4 months of service. This unprecedented progress was attributable largely to LAA's 35,000 hours of accumulated service experience with S-61 aircraft, represented by hundreds of modifications engineered and tested jointly by Sikorsky Aircraft, General Electric and LAA.

The retrofitting of LAA's aircraft fleet with the higher rated General Electric CT 58-140 engines continued during the year. Two aircraft with updated engines in service virtually overcame load restrictions during summer heat conditions on the heavily traveled San Bernardino segment.

At year-end, LAA stood as the only helicopter carrier to conduct regularly scheduled operations under Instrument Flight Rules, a factor which greatly improved schedule reliability. With IFR capability at most heliports on all 3 segments of LAA's system, the company's IFR program was nearing 75 percent completion.

As part of the program, LAA's station personnel were being trained in weather observation, and the Anaheim-Disneyland Heliport was designated as a Supplementary Aviation Weather Reporting Station by the U.S. Weather Bureau.

LAA finalized negotiations during 1966 for acquisition of the sixth and seventh S-61 aircraft. The increased fleet capacity is essential to keep abreast of increased traffic projections and to initiate service to newly certificated points in Ventura County.

On October 1, 1966, company President C. M. Belinn announced the appointment of Thomas B. Bell to the position of Vice President-Assistant to the President, with staff responsibilities in the areas of Operations, Maintenance, Engineering and Supply.

LAA had before the Civil Aeronautics Board an application for expansion of its service to cover the entire Southern California megalopolis from Santa Barbara to San Diego. During 1967, LAA hoped to activate a new segment of operation in Ventura County thereby extending its system to include the population centers of the Los Angeles Five-County area, with a population in excess of 10,000,000. Intermediate service points include Thousand Oaks and the West San Fernando Valley area, the cities of Arcadia and Downey, Santa Catalina Island and Downtown Los Angeles. As a result of an expanded route structure, acquisition of additional aircraft and greater schedule reliability through IFR operations, LAA's passenger traffic was expected to reach 400,000 in 1967.

During 1966, LAA contracted to perform feasibility studies of the "Skylounge" project which contemplates the use of a commercial version of the Sikorsky Skycrane to shuttle passengers between downtown Los Angeles and urban points, and including Los Angeles International Airport, in detachable passenger cabins. The cabin is adaptable to ground mobility after landing. The initial feasibility study, jointly funded by the Department of Housing and Urban Development and the City of Los Angeles, was expected to be completed in 1967.

MOHAWK AIRLINES

In January, Mohawk's Board of Directors declared a 2½ percent stock dividend, marking the first time in the company's history that a dividend was paid to stockholders. In February, Mohawk became the first U.S. airline to operate a computerized reservations center from a single location at Syracuse, New York. With a shift of its New

York City reservations operations to Syracuse, the airline developed a capability of handling up to 26,000 calls daily from across its system. In addition, Mohawk became the first regional airline to establish a full-fledged Tour Department to promote on-line and interline tour sales.

The Mohawk route system received a substantial boost in March, when the Civil Aeronautics Board authorized Mohawk to serve Washington, D.C., and Philadelphia from Elmira, New York, giving the airline 2 new, strong southern terminals. The service to Washington began July 1, and Philadelphia service followed on September 15.

By July 1, the airline was beginning the phase-in of a new fleet of 18 FH-227 prop jets, and additional orders had been placed for a total fleet of 10 One-Eleven fan-jets, 9 of which were placed in service by October 1. Route strengthening continued with an approval from the Civil Aeronautics Board to begin Rochester-Toronto service, following pending approval from the Canadian Air Transport Board.

In September, the airline pressed for a new western terminal at Chicago's Midway Airport. Mohawk's proposal would link several New York and New England cities to Chicago with direct jet service via Erie, Pennsylvania.

Practically a separate story itself, the major strike of 5 trunk airlines in July and August pressed Mohawk employees into extra-effort service for both civilian and military passengers. During the strike, Mohawk operated 148 military charters, carrying 5,799 G.I.'s throughout the eastern third of the nation. In addition, 38 civilian charters carried 1,324 passengers during the 6-week strike.

NATIONAL AIRLINES

Highlighting 1966 for National Airlines was the announcement of a $161,000,000 jet fleet expansion program designed to develop the trunk carrier into a major all-pure-jet airline by mid-1968. Orders for 25 Boeing 727-235 "long-body" tri-jets and 1 DC-8 Super 61 stretched jet were included in the program. National also sold all 17 of its Lockheed Electra II's. Addition of the new equipment and phasing out of the Electra's will take place between late 1967 and mid-1968.

At the end of its fiscal year June 30, 1966, National reported a net profit for the period of $21,858,000, a 45 percent increase over fiscal 1965. During the 12 months, passengers enplaned rose 28 percent to 3,983,000, revenue passenger miles were up by the same proportion to 2.97 billion, and capacity, through the addition of 3 Boeing 727 tri-jets in the fall, gained 26 percent to 5.57 billion available seat miles.

As a result of the shutdown of operations caused by the International Association of Machinists' strike beginning July 8, National Airlines reported a net loss of $1,039,000 in the first quarter of its new fiscal year. October net income of $1,135,000, however, overcame the first quarter loss, leaving National with $95,000 net profit for the 4 months ending October 31.

During fiscal 1966, National set an all-time record high in total cargo ton miles carried. The Miami-based airline flew 40,563,142 ton miles of cargo for an increase of 24 percent over fiscal 1965.

National continued to conduct its extensive and specialized advertising and sales promotion programs and in the summer inaugurated a new $7,000,000 advertising program centered around Florida, the company's home base and hub of its route system. As 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.

The carrier, during 1966, filed for a scheduled nonstop route between Miami and London and filed to extend its service in an 11-state area from the Great Lakes to the Gulf of Mexico.

An expanding jet fleet, with the addition of 3 Boeing 727's in the summer, enabled National Airlines to offer more jet flights during the winter, linking Florida with more northern and western cities than have ever before been scheduled by the carrier. The massive winter airlift was to give vacationers seeking sunshine 79 daily flights between Florida and the eastern and western cities served by the airline, plus 36 additional jet flights on days of heavy travel.

A most noteworthy milestone during 1966 was the beginning of construction on a $15,000,000 terminal at John F. Kennedy Airport in New York. Terminal facilities at various other key system cities were being improved. They included Washington, D. C., West Palm Beach, Jacksonville, Houston, Newark, Orlando, San Diego and San Francisco. At Miami International Airport, National put in operation a new training building, a new reservations center and remodeled the main administration building.

By most projections air travel will continue to increase at a rate faster than the national economy during the next 10 years. L. B. Maytag, Jr., president of National, planned to take advantage of this by vigorous promotional efforts and conservative financing approaches.

NORTHEAST AIRLINES

During 1966, Northeast Airlines built its staff, equipment, and facilities toward the goal of making the line one of the strongest air carriers in the United States.

On May 1, F. C. Wiser, former vice president—operations for American Airlines, joined Northeast as its new president. In the following months of the year, the line hired additional personnel in all areas to strengthen customer service.

James O. Leet assumed the position of senior vice president—marketing and customer services. Leet, who came to Northeast from Irish International where he was vice president—North America, is responsible for every phase of Northeast operations which comes into contact with the traveling public including sales, marketing, in-flight services, and ground services.

Northeast added other top executives: G. Ward Hobbs, former head of the Bureau of National Capital Airports and now Northeast's vice president—ground operations; Arthur E. Fairbanks, former United Airlines' New England district sales manager and now Northeast's vice president—New England Region; Edward E. Swofford, former regional director and district traffic-sales manager for Pan American's Pacific Northwest-Alaska Division and now Northeast's vice president—Mid-Atlantic Region; Edwin H. Bishop, former Miami district sales manager for Delta and now Northeast's vice president—Southern Region; Dan A. Colussy, former director of operations administration for American Airlines and now Northeast's director of planning; and Irving T. Tague, former Pan American assistant manager—scheduling and now Northeast's director of scheduling.

In the area of facilities, Northeast opened up completely new sales offices in Miami and Boston, new ticketing facilities in the 2 cities, and a new lobby in New York's LaGuardia terminal. In Boston's suburban Andover, Northeast leased 14,000 square feet in the new Standard International Building for use as a data processing center.

Future expansion plans included additional office and ticket counter space in many of the line's major East Coast cities including a completely new terminal in Boston's Logan International Airport.

Throughout 1966 Northeast received deliveries of new aircraft. The line ordered 8 Boeing 727 standard models seating 110, 6 Boeing 727 stretch models seating 136, 14 Douglas DC-9's seating 115, and 7 Fairchild Hiller FH-227's seating 48, designed to make the line completely turbine powered by the end of 1967. In 1966 Northeast took delivery of 6 standard 727's and 6 Fairchild Hiller FH-227's.

The new 727's enabled Northeast to increase its East Coast-Florida capacity for the 1966-1967 winter season by almost 50 percent. In addition, in September of 1966 the line inaugurated Boeing 727 service between Boston and Washington with 5 round trips daily.

The smaller Fairchild propjets replaced the last of Northeast's 6 Douglas DC-3's and doubled the capacity the line offered to most New England cities. The pressurized comfort and high speed (260 miles per hour) of the high wing propjet should prove to be of major significance in developing the potential New England air travel market.

To market all of this increased capacity, Northeast launched a $1,200,000 fall advertising program "Announcing the Arrival of the Northeast Yellowbirds." All new Northeast aircraft plus the line's original jet fleet of 4 Convair 880's feature a Raymond Loewy/William Snaith designed paint scheme with a bright yellow swath running up from the nose and enveloping the tail. The top of the fuselage is a clean, crisp white. The Northeast logo is set in sharp black on the forward top of the hull as are the initials "NE" on the tail.

In 1966, Northeast's re-equipment program was highlighted by the arrival of 6 Boeing 727 "Yellowbirds."

For the inside of the ships Loewy/Snaith developed an interior which suggests the warmth of a New England autumn. Various hues of golds, browns, and an oatmeal and gray tweed together with off-white bulkheads give the ships a den-like feel. Scrimshaw reproductions, carvings done on whalebone by 19th century New England whalers, further add to the New England flavor of the Boston-based carrier's equipment.

NORTHERN CONSOLIDATED AIRLINES, INC.

During 1966, Northern Consolidated Airlines maintained its upward trend of the past several years. The F-27 performance records for the Rolls Royce engine reached 6,000 hours between overhauls. The nonfatality record continued unmarred although operations covered some tough country and a good deal of NCA's flying was in single-engine equipment. The company was using 2

Grumman Mallards, 4 Pilatus Porters, and 2 Cessna 180's on its bush runs.

NCA's fishing camps were becoming more popular, and in 1966 24 astronauts, their geologists and pilots spent a week in Katmai National Monument conducting studies for their training. Europeans were becoming more and more interested in visiting NCA's fishing camps. Since 1967 marks the Alaska Purchase Centennial, it was expected that there would be an increase in visitors to the state and to NCA's camps.

In 1966 NCA announced the purchase of 1 Short twin-turbo Skyvan. This aircraft was due to arrive late in the year and NCA had an option on a second Skyvan. These aircraft will be used to increase the airlift to all the local villages, since they can land and take off in 2,000 feet or less, and carry a payload of over 3,000 pounds; the rear of the aircraft opens up and it is large enough to run a Volkswagen Microbus into the fuselage. Its speed is that of the DC-3, and it is a full instrument aircraft. The final purchase of new equipment was the Boeing 737-210C, with a capability of a 30,000 pound payload and up to 111 passengers. Its speed is 560 miles per hour. Expected delivery date was in the fall of 1968, enabling NCA to have all mainline fields suitable for this type aircraft, which is in the 5,000-foot class.

Late in the year, NCA applied for an Anchorage-Fairbanks direct route instead of via McGrath, and also an Anchorage-Kodiak route.

OZARK AIR LINES

The year 1966 surely must be considered a year of action for Ozark Air Lines. The first jet aircraft were delivered, jet service was inaugurated, new propjets were delivered, reservations were computerized, and new routes extended Ozark into a new terminal city and another state, Denver, Colorado. It would be difficult to determine one highlight. However, since the jets became an actuality during the time period, they must be considered the turning point that will mark 1966 for years to come.

Ozark received its first new twin engine Douglas DC-9 on May 28. An intensive training program was started immediately, for 2 more were to arrive shortly, and pilots had to be ready for the big, fast aircraft. The first DC-9 put into service was actually ahead of schedule because of the strike of 5 major carriers. Ozark asked for and got approval from the Federal Aviation Agency to fly the jet on an extra flight and charter basis starting July 8. Because of a speeded up training program and a total effort by FAA inspectors, the early start was made possible.

A week prior to the scheduled July 15 inauguration date Ozark Air Lines entered the jet age, providing service to hundreds of persons inconvenienced by the situation.

The next 2 DC-9's were placed in service on August 1 and August 15, providing pure jet service to a total of 15 cities. These 3 new aircraft were flying over 10,000 route miles daily, or about 1/4 of the total route miles flown by a fleet of 34 planes.

Shortly after the first DC-9's were at work for Ozark, the company went to Hagerstown, Maryland, to pick up its first Fairchild Hiller FH-227B propjet. This is a stretched version of the F-27 which has been used on the system for about 6 years. Ozark had 21 of the new planes on order. The first began operation on December 1, 1966, after interior work was completed. Others were to follow until all are flying in 1967.

It is planned that the DC-9 and the FH-227B will phase out all other aircraft in the near future, including the F-27, the Martin 404, and the old standby DC-3.

As flown by Ozark, the DC-9 carries 78 passengers. The FH-227B propjet has a capacity of 48 passengers, an increase of 8 over the F-27 sister ship.

On October 30 a new state, Colorado, and a new city, Denver, were added to the system. Chicago-Denver jet service was inaugurated with 2 roundtrips daily via Waterloo and Sioux City, Iowa, and Sioux Falls, South Dakota. This provided the first non-stop Chicago-Sioux Falls service, and the first direct air link between Denver and Sioux City offering excellent connections to cities throughout Mid-Illinois and Mid-Iowa.

In addition Ozark was authorized a route between Des Moines and St. Louis, providing changes in service for such cities as Ottumwa, Iowa; Kirksville, Moberly, and Columbia, Missouri; and Quincy, Illinois.

One other route was granted between Louisville and Indianapolis. The 2 cities already were served by the carrier, but not directly. This closed a gap on the system, opening Louisville from northern points, and Indianapolis from southern points.

The company also filed applications in the Gulf States-Midwest Points Investigation, and in the Twin Cities-California Case.

All-time high traffic records were consistently broken during 1966, then broken again. As an example, the airline set a record during the first 9 months, carrying 1,080,057 passengers through September. This marked a 23 percent improvement over 1965. The load factor was also up, about 1 percent, from 53.1 in 1965 to 54.2 in 1966.

This was the company's second 1,000,000 passenger year, with the point being reached about 2 months earlier than in 1965, the first year.

During April the all-time monthly high was broken with 124,725 passengers, followed by another high in June of 128,220. This was topped again in September with 130,204 passengers, and preliminary figures indicated a possible new record before year-end. Daily records were broken too, with 5,572 on September 2, and again on October 7 with 5,943 passengers.

To handle the ever increasing loads Ozark took a big step in 1963 and centralized reservation facilities for its major markets. But, with the continued increase of business, this was not enough. In February of 1966 reservations were computerized, cutting process time from minutes to seconds. This speed up was made possible by utilizing Eastern Airlines' 490 UNIVAC Real-Time computer at Charlotte, North Carolina, tied in to Ozark's Central Reservations Office in Peoria, Illinois.

Also, to handle the continually increased passenger demands, Ozark took steps to improve terminal facilities. Chicago and St. Louis waiting, commissary, and maintenance spaces were enlarged. Improvements were made throughout the system as well, as airports moved into new facilities, or gates were enlarged.

Ground hostesses were added to give that extra bit of service to customers in St. Louis, Chicago, Peoria, and the new Denver Gateway. With the new DC-9's fresh brewed coffee and individual snack meals were added.

During 1966 Ozark also doubled its cargo capabilities. A second C-47 "Cargo-Getter" was placed into service over a route system linking 19 Mid-America cities.

Ozark Air Lines had not experienced a passenger or crew fatality in over 16 years of operation, so during 1966 the National Safety Council again awarded the Council's top Award of Honor for an outstanding safety record in 1965. Ozark was one of 4 scheduled air carriers to receive the award.

Because of its size, and continued growth, Ozark found it necessary to add an Industrial Relations Department during the year. With almost 2,000 employees working during 1966, the department became responsible for labor relations, union contract negotiations and supervision of the personnel section.

Ozark started the year 1966 after an outstanding year of progress in 1965 showed a new income amounting to $548,816, or 25 cents per share. The Board declared a 4 percent stock dividend, as it had for several years.

Common stock climbed again, from about $10 in January to about $12 as the year drew toward an end, and the number of stockholders showed a dramatic increase of more than 60 percent during the year. Through the first 9 months of 1966 Ozark's net income was $401,888.

PACIFIC NORTHERN AIRLINES

The merger announcement made jointly by A. G. Woodley, president of Pacific Northern Airlines, and Terrell C. Drinkwater, president of Western Air Lines, highlighted the year for Pacific Northern, the Alaska Flag Line.

The merger, announced on October 27, will bring together 2 of America's pioneer air carriers and will provide through, integrated air transportation the entire length of the North American rim of the Pacific basin from Anchorage to Acapulco.

Pacific Northern connects the Pacific Northwest with Alaska, and serves the areas of 85 percent of the population of the largest state. Western serves the western states as far east as Minneapolis-St. Paul, and from Canada to Mexico.

During the 9 months ended September 30, 1966, Pacific Northern reported net earnings of $2,097,000 or $1.96 per share, the best in the company's history. This compared with net earnings of $776,000 or 73 cents a share for the same period in 1965. For the 12 months ended this period, net earnings, not including special credits of $626,000, amounted to $2,188,000, or $2.05 per share.

Increases of 30 percent in revenue passenger miles and 21 percent in revenue ton miles were reported for the first 9 months of 1966.

Pacific Northern placed an additional Boeing 720 jetliner in service on its Pacific Northwest-Alaska routes in June 1966.

PANAGRA (PAN AMERICAN-GRACE AIRWAYS)

During 1966 Panagra (Pan American-Grace Airways) continued its 38-year record of successful operations and steady growth.

The airline increased its flight frequencies and introduced new nonstop flights between the United

Panagra's Douglas DC-8F, on its first flight from Buenos Aires to Lima, carried 29 tons of fresh meat.

States and the heart of South America's west coast. It set up a completely new service of direct flights between the U.S. west coast and Latin American cities. It inaugurated new and faster flights between several key cities on its South American route. And it retired its last propeller plane, enabling it to offer 100 percent jet service for both passengers and cargo, throughout the wide international area in which it operates.

One of the last 2 propeller planes deactivated was Panagra's DC-7 freighter. It was replaced in August with a DC-8F Douglas Jet Trader, which immediately more than doubled the freight carrying capacity of the airline. The jet was placed in all-cargo service on regularly scheduled twice-weekly flights out of Miami to cities on the Panagra route as far south as Buenos Aires.

The most far-reaching development of the year for the airline was, of course, the completion of arrangements for a transfer of its ownership.

Early in the year Braniff International offered to buy Panagra from its 2 equal owners, Pan American World Airways and W. R. Grace & Co., agreeing to pay each of them $15,000,000. Both companies accepted, and in October the Civil Aeronautics Board and the President of the United States gave approval to the transfer. The process of amalgamating Panagra with the Braniff system was set in motion, with the expectation that the consolidation would be completed by the end of the year. In the meantime, both airlines continued independent operations.

The schedule improvements by Panagra in 1966 included new nonstop flights between New York and Lima and Miami and Lima. The airline's El Inter Americano jets began flying between New York and the Peruvian capital in 7 hours and 40 minutes. The Miami-Lima nonstops cut the time between those points to 5 hours and 10 minutes.

Early in the summer Panagra joined with Pan American Airways to set up a schedule of new direct flights between San Francisco and Los Angeles and key cities in Central America and the west coast of South America. One of these flights carries passengers and cargo to Lima with no change of plane; the others make fast and easy connections in Panama.

The construction of the first jet runway at Cali this past summer enabled Panagra to make major improvements in its service to and from that fast growing Colombian city. The line's DC-8 jets began landing there when fast new direct service was set up between Cali and Lima.

The Cali improvement did away with Panagra's last need for passenger propeller planes, and the final run with a prop-driven DC-7 was made on an epoch-ending flight from Quito through Cali to Panama on June 27.

The airline's operating figures for the year reflected the steady growth of interest in South American travel and the even greater increase in trade between the United States and the rapidly developing countries on the airline's routes. For the first 3 quarters of the year the number of revenue passenger miles flown rose by 5 percent and the number of revenue freight ton miles by 25 percent, as compared with the same period in 1965.

Among the developments in which Panagra took special pride during the year was the recognition it received from COTAL (Confereration of Latin American Tourist Organizations) for its work in promoting Latin American travel. At the confederation's annual congress in Montevideo Panagra was given the Albatros Award for being the transportation company which had shown the best results in this field.

Obviously influential in this award was the fact that Panagra continued to spend a greater part of its income on promoting travel and trade to and from South America than any other U.S. international carrier. In its advertising in U.S. newspapers and national magazines, as well as in its public relations activities, the airline concentrated primarily on publicizing the attractions of the countries it serves.

Special attention was given to skiing in Chile; Panagra was one of the co-sponsors, along with the Chilean Government and the Hotel Portillo, of the annual Ski Carnival at Portillo in August. Fishing in the Chile-Argentina lakes region was played up in films, photos and news stories. The archeological treasures of Peru were covered in photos and text in many releases and feature stories distributed all over the United States. Ecuador got special attention for its amateur bullfights and its scenic bus tours between mountainous Quito and coastal Guayaquil. Other publicity material touched upon seasonal attractions of Argentina, Bolivia, Chile, Colombia, Ecuador, Panama and Peru.

Panagra participated with other organizations in numerous special tours and promotions to focus attention upon South America and attract travelers to the area. The Overseas Press Club of New York was aided extensively in sending a party of its influential writers on a swing around the continent. A group of civic leaders of Cleveland, Ohio, led by the Latin American editor of the Cleveland Plain Dealer, were assisted on a study tour of South American countries.

The airline again made special efforts to encourage travel agents to give greater attention to South America. In conjunction with the American Society of Travel Agents, it conducted a nationwide competition among agents for outstanding efforts in this area and awarded its handsome ASTA El Inter Americano Travel Trophy to the winner.

Panagra cooperated with many leading travel agents in setting up attractive package tours of South America. These included made-to-order excursions for individuals and special groups, independent tours, escorted tours and tours catering to special interests such as gardening, archeology, skiing, fishing and golf.

As in years past, Panagra made numerous contributions in the area of non-commercial public service to the countries it serves. These included flying tons of relief supplies to victims of the Peruvian earthquake in October, awarding travel fellowships to 50 South American students for study at U.S. colleges and universities, and, in cooperation with the U.S. Air Force, providing the top graduate of the air academy in each country it serves with an Award of Honor and a trip to the U.S., where the young officers were guests for a 2-week tour of air bases and key cities.

Challenging passenger and cargo assignments which Panagra handled during the year included making complicated air and land arrangements for Latin American tours by the Philadelphia Orchestra, the Japanese Symphony Orchestra and Music Theatre USA. The latter organization, based in California, required transportation on its South American tour not only for 65 members of the cast and technical crews but the entire paraphernalia, including a circus tent, for theatre-in-the-round productions of 2 entire Broadway musical shows.

PAN AMERICAN WORLD AIRWAYS

Pan American World Airways enjoyed its most successful year in history during 1966. The carrier set new highs in revenue and earnings, while attaining new highs in both its passenger and cargo operations.

Worldwide revenue passenger-miles increased 32 percent and cargo ton-miles jumped 30 percent to new highs. Revenue and earnings continued at record peaks with earnings increasing 62 percent and revenues climbing 26 percent.

During the year Pan Am's jet fleet was increased to 112 aircraft and further additions were planned as both passenger and cargo volume continued to soar and as expansions were made in Pan Am's route structure.

Probably the most important company event during 1966 was Pan Am's announcement that it would purchase 25 of a new type of jet transport—the Boeing 747—at a total cost with spares of about $525,000,000.

The new 747 Superjets will carry 490 passengers in Thrift Class or 378 passengers in mixed Economy and First Class configuration. The cargo hold below the main deck will accommodate 26 containers with a capacity of 16.5 tons for baggage, mail and cargo. The 747 all-cargo type is designed for automated, straight-in nose loading and unloading. It will carry 214,000 pounds of freight, largely in "highway size" containers 8 feet wide, 8 feet high and in 10 to 40 foot lengths.

Incorporating the most advanced technology in aircraft and engine design, the 747 Superjet will contribute a major breakthrough in the progress of subsonic air transportation. Pan Am's 747 order could lead to a worldwide market for 400 of the 747 Superjets. If so, the contribution of the program to the balance of payments would be about $3.4 billion. During 1966 Pan Am's contribution to the balance of payments deficit was about $200,000,000.

The company continued to press forward with its worldwide See America-Sell American Program. This program was undertaken in response to the Federal Government's request for voluntary efforts on behalf of American industry to help ease the balance of payments deficit.

As an important phase of the campaign Pan Am arranged for a number of low cost charters with social and industrial groups in Europe at a round-trip cost per passenger of as little as $165.

In addition to its order for the 747's (the first of which was scheduled for delivery in September, 1969), Pan Am increased its order for the British-French supersonic plane to 8 and held an order for 15 of the American-built supersonic transport. The British-French Concorde deliveries were expected to begin in 1971 and the American SST about 3 years later.

During 1966, Pan Am's 39th year, several historical milestones were reached. On October 22, Pan Am marked the 30th anniversary of the first transpacific passenger flight. Several weeks later, on November 10, the company recorded its 150,000th Atlantic crossing and in October also noted its 100,000th transpacific crossing.

The Pan Am global fleet at year-end was serving 90 lands and employing over 37,000 men and women highly skilled in operations, communications, traffic, sales, service, and related areas. Part of this work force staffed the 129 Pan Am stations which form a global network of 75,730 route miles deployed to handle airlift wherever needed. This system is controlled through the world's largest privately operated communications network, which is responsive to PANAMAC—an extremely high capacity computer.

Pan Am continued to provide the bulk of the military support airlift for the Government. During 1966 Pan Am provided 35 percent of the total international industry CRAF capability. Among the carriers participating in the Military Airlift Command fiscal year 1967 awards, Pan Am provided 37.3 percent of the total CRAF turbine powered capability, more than the next 3 carriers combined.

Since 1953 Pan Am's Guided Missiles Range Division has assisted in the pre-launch planning and preparation as well as the actual launch and post-launch activities of over 1,600 missile space flights at Cape Kennedy. Total investment in range facilities during 1966 was well over $2 billion. Pan Am had more than 6,500 employees supporting these operations.

During 1966 Inter-Continental Hotels, a wholly-owned Pan Am subsidiary, opened 3 new hotels, bringing the total number of hotels open to the public to 34. The first to open in 1966 was the Hotel Siam Inter-Continental at Bangkok, Thailand, followed by the Hotel Bali Beach in Bali, Indonesia, and the Hotel Dacca Inter-Continental, East Pakistan.

Pan Am's Fan Jet Falcon, the twin-jet business aircraft, continued in demand during 1966. The aircraft, which is marketed and supported in the Western Hemisphere by the Business Jets Division of Pan Am, was sold to many corporate customers in the United States and Canada. In addition, Pan Am retains 2 as demonstration models. Pan Am's total order at year-end stood at 115 with an option for an additional 52.

Dividends of 60 cents a share were paid to Pan Am stockholders in 1966. The company has paid cash dividends every year since 1941, a record unequaled in the airline industry.

On July 15, 1966, Pan Am filed with the Securities and Exchange Commission a registration statement relating to its offering of $175,000,000 convertible subordinate debentures due August 1, 1986. The proceeds from the offering will be used by Pan Am for acquisition of flight equipment and, in a lesser degree, for automated ground handling facilities and for expanded terminal and maintenance facilities.

Pan Am, during 1966, sold its 50 percent interest in Panagra to Braniff Airways for $15,000,000. Earlier Braniff had purchased the 50 percent interest of W. R. Grace.

In December Pan Am dedicated its $8,500,000 cargo terminal at John F. Kennedy International Airport, New York. This became the first computerized cargo terminal in the industry.

Other Pan Am highlights during 1966 included:

An evaluation and testing of the world's first commercial airline inertial navigation system.

Lower cargo insurance rates with broader coverage.

Continued reductions in passenger and cargo rates.

Additions in service to help stranded passengers during the mid-summer strike by five U.S. carriers.

By year-end Pan Am's growth had established new records and commitments for the future, and the company anticipated no let-up in every facet of Pan Am's activities.

PIEDMONT AVIATION, INC.

Piedmont Aviation, Inc., enjoyed some of the most outstanding developments in the company's 26-year history during the course of 1966.

In January the company placed an order for 6 Boeing 737 short-to-medium range jetliners and took an option for 6 more. The 737, which Piedmont will operate with first class seating capacity for 90 passengers, will be used primarily in the major traffic markets along the company's 7,000-mile route system. Deliveries were scheduled to begin in March 1968.

Piedmont Airlines' re-equipment program includes 10 Fairchild Hiller FH-227B's, the first of which was delivered in 1966, and 6-12 Boeing 737's (above), for 1968 and later deliveries.

In recognition of the needs of the moderate sized communities Piedmont is certificated to serve, in April 1966 the company ordered 10 new Fairchild Hiller FH-227B twin-propjet airliners. The first of these was delivered in November 1966.

In order to provide jet service to its passengers while waiting for the new aircraft to arrive, Piedmont negotiated a lease for a Boeing 727 tri-jet airliner on a 15-month basis. The leased jet was to be delivered in January 1967.

In April and again in October Piedmont's Board of Directors declared a cash dividend amounting to 10 cents per share on the company's common stock. Piedmont stock reached its all time high of $20 per share in the latter part of April 1966.

Early in July, Piedmont received an Award of Merit from Financial World Magazine's Annual Report Survey. The award was in recognition of the excellence of Piedmont's 1965 annual report to shareholders. The year 1966 marked the fourth consecutive period that Piedmont has received the award.

During the latter part of July, Piedmont Airlines won the National Safety Council's Award of Merit for Aviation Safety for its flight safety record of the previous year. Piedmont's safety record was among the best in the industry.

Effective with Piedmont's September 1, 1966, schedule change, the company instituted a series of new flights to test the market potential for middle-of-the-night airline service. Three flights were offered in the initial series, labeled the "Night Owl Pacemaker" flights. Early reception of the flights was quite gratifying.

In an unprecedented action, the Civil Aeronautics Board on July 6, 1966, issued a "show-cause" order tentatively approving Piedmont's application for service to New York City which had been filed in August 1965. This July order by the Board afforded any interested party 20 days within which to file objections. For perhaps the first time in history, in such a situation, there were no airline objections and the CAB issued the final order authorizing service on September 30, 1966. With 5 round trips daily into LaGuardia Airport, Piedmont began its service on November 15, 1966. Several of the flights were also scheduled to serve Dulles International Airport in Washington, D. C. Thus, Piedmont became the first regional airline to serve Dulles. A number of cities in Virginia and North Carolina were provided with direct 1-plane service on the initial schedule.

On October 18, 1966, the CAB issued an order tentatively finding that the route system of Piedmont Airlines should be extended to Nashville and Memphis, Tennessee. After a provisional period of 20 days during which interested persons might file comments, objections, and motions the Board was expected to set a date for a hearing to determine whether Piedmont should not be granted this authority.

During the first 10 months of 1966 Piedmont Airlines was the only local service carrier in the nation to have all its cities exceed the CAB's minimum "Use It or Lose It" standard of 5 boarding passengers per day at each point. The company, in announcing this industry "first," reiterated its policy of serving each airport on its system with a minimum of 2 daily round trips.

During the first 9 months of 1966 Piedmont established passenger and revenue records that were often supplanted within 30 days by more outstanding records. The net earnings of the company showed an increase of 14 percent over the corresponding period of 1965. Total revenues for the same 9 months were up 17 percent. The Airline Division provided service to 1,201,069 passengers during the first 9 months of 1966 as compared to 940,606 passengers from January through September of 1965, a 27.7 percent increase. These passengers flew 285,685,828 revenue passenger miles, an increase of 36.4 percent over the same period during the previous year. Through November 1966, Piedmont had the highest load factor of any of the nation's 13 regional airlines and higher than many of the larger trunk airlines.

REEVE ALEUTIAN AIRWAYS

During 1966, Reeve Aleutian Airways continued to serve a dozen points on the Alaskan Peninsula, the Aleutians and the Pribilofs and at the same time served the Air Force on a contract basis. Reeve's scheduled service included stops at Anchorage, the home base, Port Heiden, Cold Bay, the Pribilofs, Dutch Harbor, Unmak, Atka, Adak, Amchitka, Shemya and Attu. The USAF job involved services to 20 DEWline sites extending from Point Barrow to Unmak. For this latter service the airline considered the old reliable Curtiss C-46 the best aircraft, and the C-46 was also adaptable to serving the oil industry with bulk cargo shipments.

The general economic growth of the Aleutians during the year, particularly the king crab industry, was highly beneficial to traffic increases over Reeve's regular route, and oil development contributed to increased freight revenues. Reeve looked forward to further increases in 1967.

During the year, the airline operated 4 C-46's, 3 DC-6B's, 1 C-54, 2 C-47's and 2 GR-21's. Reeve was studying medium jets and turboprops as replacements, but decision was deferred after "a long look at national fiscal policies and inflated interest rates."

SFO HELICOPTER AIRLINES

San Francisco & Oakland Helicopter Airlines, Inc., made tremendous progress in 1966. Passenger traffic increased from 130,053 for the first 11 months of 1965 to 214,393 for the same period of 1966, an increase of 65 percent.

Equally important was the fact that for the first 9 months, SFO showed a profit of $9,846 compared to a loss in excess of $200,000 for the same period in 1965. Revenues from contract maintenance of fixed-wing aircraft, from the increased passenger traffic and from additional support from TWA and American Airlines all contributed to this result.

Agreements were concluded with TWA and American Airlines by which these carriers underwrite the cost of SFO's scheduled service and guarantee a profit of at least $9,000 per month. These agreements are for 2 years and TWA and American have the right to extend the agreements for 4 additional 1-year periods.

As part of the same program, SFO was borrowing $1,500,000 with which two Sikorsky S-61's now under lease will be purchased.

Scheduled service to downtown San Francisco was to commence by mid-1967. City authorities agreed to develop a heliport at the Ferry Building, costs of this new service to be underwritten by the airline support agreements. It was expected that downtown San Francisco would become an important traffic generating point. Other potential routes were being studied for future expansion of service. Service was being provided to San Francisco, Oakland and San Jose Airports and to Palo Alto, downtown Oakland, Marin County and Contra Costa County.

SFO's fixed-wing contract maintenance facility was operating near full capacity. It operated profitably while supplying strong maintenance support for the helicopter fleet of S-61's and 1 S-62. Additional maintenance equipment was being purchased and training was being emphasized to expand fixed-wing jet maintenance capabilities.

SFO joined with National Capital Airlines, Inc., of Washington, D. C., in the latter's application for a certificate to operate scheduled helicopter service in the Washington, D. C., and Baltimore areas and to Dulles, Washington National and Baltimore Friendship Airports.

SOUTHERN AIRWAYS, INC.

Southern Airways' 1966 progress accelerated above 1965's record shattering accomplishments as significant gains were made in passenger boardings and cargo. In June, Southern carried its half millionth passenger of the year, the first time this milestone had ever been reached in the first half of the year. A new single day's passenger boarding record of 4,317 persons was set July 1. A new single month's record, 98,516, was also established in July. On October 20, Southern surpassed the 848,149 passengers boarded in record 1965, and each day during the remainder of 1966 a new single year passenger boarding record was set.

In May, Stockholders approved a 3 for 2 stock split and directors announced a cash dividend of 8 cents per share.

In August, Southern announced exericse of its option for the purchase of 3 additional DC-9 Fanjet aircraft for delivery in late 1967 and 1968. This brought to 6 the total on order, at a cost approaching $25,000,000.

An additional Martin 4-0-4 "Aristocrat" was put in service, increasing the fleet to 25, while the DC-3 fleet was decreased from 14 at the year's beginning to 6 in service.

Sophisticated indoctrination programs were inaugurated in preparation for the DC-9 delivery. Technical and flight personnel began extensive training programs at Douglas Aircraft's Long

Southern increased its Martin 4-0-4 fleet to 25 and started preparing for the 1967 arrival of Douglas DC-9's.

Beach, California, plant. Plans were formulated for training programs in Atlanta for all company departments.

New route applications were requested from the Civil Aeronautics Board asking both nonstop and limited stop authority to such points as Dallas-Ft. Worth, Chicago, St. Louis, Detroit, Cincinnati, and Louisville. A new East-West route along the Gulf Coast was requested to directly link 2 system cities, Jacksonville and New Orleans, but adding Tallahassee and Pensacola to other cities served along the Gulf.

CAB granted Southern nonstop authority between Huntsville and New Orleans, making this the longest nonstop segment on the system, 388 miles.

At request of National Aeronautics and Space Administration, new service was inaugurated to the Mississippi Test Facility through the airport at nearby Picayune, Mississippi. This afforded NASA scientific and professional personnel convenient travel to their test site.

On October 30 substantial changes were made in Southern's schedule granting greatly increased service to Mobile, Charleston and Columbia.

At the annual sales meeting in April, the new "Southern Accent on Service" was introduced as the advertising theme to precede the DC-9 arrival and accompany its first year of operation. By October, the new logotype began appearing, the sign of a new Southern.

Southern commenced a "Ticket by Mail" program, enabling passengers making reservations 72 hours in advance to receive their tickets by mail, with payment to be sent after receipt.

New terminals were completed at existing airports in Gadsden, Alabama, Moultrie-Thomasville, Georgia, and Anniston, Alabama.

Southern ticket counters sold Atlanta Braves baseball tickets as a public service, offering the home game tickets throughout its 60-city system.

Southern announced participation in three new credit card plans: Diner's Club, C & S National Bank, and Carte Blanche, adding to already accepted American Express, Southern's local Air Travel and Universal Air Travel cards.

In July, Southern was hard hit by the machinist's strike against 5 other airlines. The company faced a serious traffic loss because of passengers' inability to reach Southern's 10-state area. CAB approval for temporary routes to off-line cities and nonstop authority to on-system cities was immediately granted. Requests by NASA for service to Washington, St. Louis and Orlando were quickly honored with daily flights to those cities. A possible staggering loss in traffic and earnings was offset by rescheduling service, and Southern's traffic during the strike reached its normal projection.

Company management continued to observe advancements in aircraft manufacturing, with an eye toward possible acquisition of prop-jets as replacements for Southern's piston fleet. Passenger and cargo projections for 1966 continued to be exceeded and the goal of "a Million Passengers in '66" was expected to be reached before year-end.

TRANS CARIBBEAN AIRWAYS

Trans Caribbean Airways took some great strides forward during 1966. In November, a permanent certification from the CAB allowed TCA to engage in overseas air transportation of persons and property between New York, Newark, New Jersey and San Juan. The Bureau of Operating Rights of the CAB also recommended TCA for new routes that would allow service to a number of new destinations.

Among those new destinations are Jamaica, Haiti and the Virgin Islands. On December 7th a CAB examiner recommended that TCA be authorized to operate from Washington, D. C., to San Juan.

On December 5, 1966, Trans Caribbean carried air mail for the first time. The U.S. Post Office Department authorized a special flight cachet honoring the inaugural mail flight and more than 50,000 letters bearing the cachet were carried on the first flight.

Passengers at TCA's new terminal will board their flights via glass enclosed bridges which protects them from the elements. The jets they will be boarding will be new, too. In 1966, Trans Caribbean took delivery of the first in a fleet of DC-8 Super 61 fanjets. By the middle of 1967, the company expected to double its mid-1966 capacity. Trans Caribbean planned to operate its DC-8's in a 219-passenger configuration, with 16 first class seats, 33 deluxe tourist, and 170 thrift.

In 1966, TCA introduced a "new look," comprised of new colors—orange, blue and aqua—plus a dashing orange palm tree on the tail.

During the year, the company also introduced a whole series of promotional fares. The most successful of these was the $45 late-night fare from New York to San Juan. In addition, TCA introduced low-cost senior citizen fares, a positive space fare for military personnel on leave and new excursion rates for deluxe tourists. The $45 late-night fare was expanded to every night in the week.

TCA was offering a college seminar on the history, culture, language and customs of Puerto Rico, which in 1966 enabled 120 college students not only to take a low-cost vacation, but also to learn something of the more cultural side of San Juan. This program was hailed by the government of Puerto Rico for pointing up the traditions and proud history of Puerto Rico. For 1967, TCA expanded the program to three seminars in conjunction with the University of Puerto Rico under the direction of Manuel Diaz Soler, Dean of Humanities. The first session was to begin January 27 and last through February 2. Summer sessions were set for June 16 through 25, and August 18 through 27.

In conjunction with Sportsmen's Travel of New York City, the airline is offering a special "Scuba Holiday" trip to the Virgin Islands. For as little as $225, plus round-trip air fare from New York, the would-be skin diver can spend 8 days and 7 nights in the Virgin Islands, along with the use of all necessary aqua-lung equipment, and instructions from an underwater expert. For the experienced SCUBA diver, there are escorted tours through the scenic Virgin Islands' reefs instead of lessons. The SCUBA Holiday package includes the choice of accommodations at either the Sapphire Bay Beach Club or the Pineapple Beach Club, both in St. Thomas.

On the marketing front TCA launched its biggest advertising campaign, for the first time including a major television campaign.

TRANS WORLD AIRLINES

For Trans World Airlines, 1966 was a year of major decision and action on its long-range programs to anticipate the air transportation needs of tomorrow and to provide new and improved services to the air traveling and air shipping public of today.

The year marked the 20th anniversary of TWA's international services, now spanning two-thirds of the globe from San Francisco eastward to Hong Kong. TWA hoped to extend its international service in the Far East with a proposed transpacific route and become a competitive round-the-world U.S. flag carrier.

TWA's application for authority across the Pacific, linking Hong Kong and the West Coast of the U.S. via Taipei, Osaka, Tokyo and Honolulu, was one of the most significant events on the airline's 1966 calendar. During the year TWA acquired additional experience in the Pacific area with daily flights for the Military Airlift Command, transporting men and material between California and Saigon. A TWA crew and aircraft also flew a 29,000 mile charter flights for the press accompanying President Johnson on his historic Pacific mission in October-November. The TWA charter operated round trip from Washington, D.C., to Honolulu, Samoa, New Zealand, Australia, Manila, Bangkok, Malaysia, South Korea and Alaska.

On September 2, TWA placed an order for 28 more Boeing jet airliners, including 12 giant "next-generation" 747's. Total cost of the order, largest in TWA history, was nearly $410,000,000, including spare parts and related equipment.

The announcement was followed in October by distribution to 200,000 frequent air travelers, including 12,000 travel agencies around the world, of a questionnaire seeking the consumer's views on how the interior of TWA's 747's should be designed. Believed to be the largest and most comprehensive passenger preference study in airline history, the survey will help TWA "fit the plane to the passenger."

"Despite all the publicity regarding its near 500-seat capacity, it will not be, at least as TWA flies it, just a larger sardine can," said TWA president Charles C. Tillinghast, Jr. "Configured to about 350 seats, it will achieve new levels of comfort, spaciousness and service to the passenger as well as speed in the air."

Despite an aircraft delivery lag in the latter half of the year, TWA moved steadily throughout 1966 toward one of its immediate goals—to become, early in 1967, an all-jet airline.

Already all-jet on routes throughout the West, TWA replaced piston flights serving many Eastern and mid-West communities with DC-9 twin-jet and Boeing 727 tri-jet schedules. By the end of April, 95 percent of TWA's domestic scheduled passenger plane miles were operated with pure-jet equipment. On international routes, TWA has operated jet schedules exclusively since 1961. TWA also increased its transcontinental nonstop services during the year, providing hourly departures during the day and early evening from New York for the West Coast.

TWA also increased its transcontinental all-cargo jet airlift by 75 percent, adding nine transcontinental round trips for a total of 21 weekly. Four new markets—Kansas City, Detroit, Newark and Hartford-Springfield—were also added to cargojet schedules, bringing the total number of city areas served by TWA jetfreighters to 13.

TWA carried 9,731,381 passengers 10.4 billion passenger miles across its 4-continent system in 1966, for gains of 1.6 and 2.1 percent, respectively, over 1965.

System cargo ton-miles totaled 329,660,000, an increase of 5.8 percent over 1965.

The 1966 growth rate, substantially below recent prior years was attributable to the 43-day strike of the International Association of Machinists against TWA and 4 other major U. S. airlines.

By the end of 1966 TWA had 140 aircraft in its jet fleet, including Boeing Intercontinental and transcontinental 707's, Boeing cargo 707's, Boeing 727 tri-jets, Douglas DC-9 twin jets and Convair 880's.

TWA expected delivery in 1967 of 33 more jet aircraft ordered in 1965 or earlier, including Boeing 727 "Quick Change" jets, convertible from passenger to all-cargo configuration.

The 28-jet order announced by TWA in September 1966 included 9 4-engine jumbo 747's for delivery in 1969-70; 3 all-cargo 747-F's for delivery starting in 1970, and 8 3-engine "stretched" Boeing 727-200's for delivery in 1968, in addition to Boeing 707 Intercontinental, transcontinental and 707-331C's for delivery in 1968.

The 28-plane order of 1966 will expand the TWA subsonic jet fleet to 201 by the early 1970's. TWA also had 16 supersonic transports on order.

TWA advanced its plans for U. S. flag service in the Far East and Pacific with the extension of intercontinental jet schedules beyond Bombay to Bangkok on July 4, and to Hong Kong on October 31. Initial schedules provided 2 round trips weekly between U. S. cities and the Far Eastern points.

TWA also increased Bombay schedules to 3 roundtrips weekly. All flights are extensions of TWA's daily transatlantic flights between the U. S. and Europe, North Africa and Asia. TWA, certificated to Hong Kong by the U. S. government since 1961, received British government approval in 1966.

In mid-1966 TWA added daily nonstop flights to its schedules between the U. S. and Switzerland where it serves both Geneva and Zurich. Also in June, TWA added twice-weekly nonstop service between the U. S. and Greece to its daily schedules at Athens.

In both summer and winter of 1966 TWA scheduled the highest seasonal schedule frequencies in its history.

Extension of service on routes from Europe and North Africa to East Africa, for which the U. S. government granted operating rights to TWA in 1965, awaited completion of negotiations with the respective East African governments.

Elsewhere in Africa, between January 16 and April 10, 1966, TWA participated in the Zambia oil airlift under contract to the Agency for International Development of the U. S. State Department.

On 2- and 3-times daily flights from Leopoldville into Elizabethville, TWA flew a total of more than 31,000 barrels of petroleum products. TWA's operation and the approximately 185 personnel involved were praised by the U. S. ambassador in Leopoldville.

Other 1966 route developments were:

A CAB examiner recommended award to TWA of an unrestricted route linking St. Louis, Kansas City and Denver directly in the Northwest-Southwest route case.

TWA applied for a route authorization which would provide through-jet service from Toronto, Canada, to Chicago, Los Angeles, San Francisco and Kansas City.

TWA applied for authority to provide the first 1-stop service between Florida and Europe.

In October TWA asked the CAB for new routes that would link Dallas, Fort Worth, Houston and San Antonio with the airline's system, proposing new service on routes from Detroit, Chicago, St. Louis and Kansas City to Fort Worth and Dallas; and from Chicago, St. Louis and Kansas City to Dallas, Fort Worth, Houston and San Antonio.

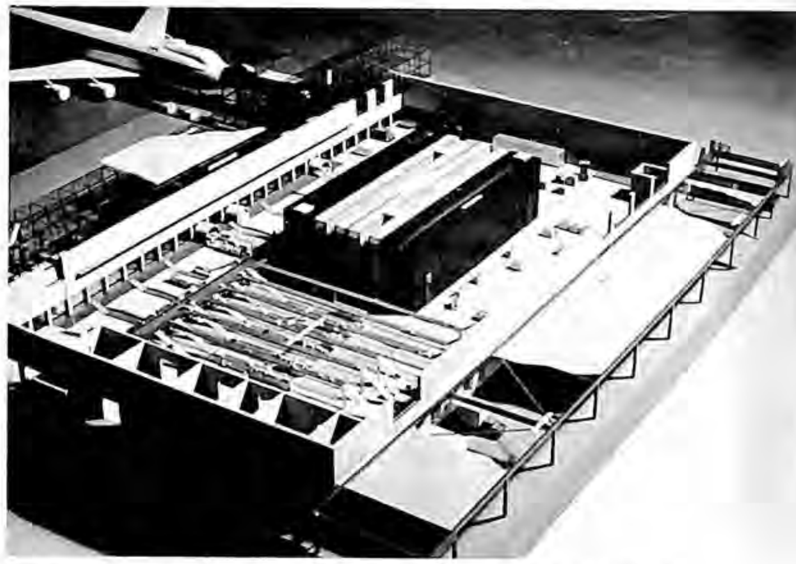
Early in 1966 TWA expanded its "StarStream Theater" in-flight entertainment programming to provide 9 channels of high-fidelity listening on transatlantic and transcontinental flights, including the audio for the wide-screen color movies. Later TWA adapted the ninth channel in the system on transalantic flights to an "Adventures in Travel" program—a lesson in 144 European languages plus travel tips on the country of destination.

In September TWA introduced the "TWA Worldwide Jet Credit Card," the airline's own credit card system for U. S. and international air travel, providing a credit accommodation not previously available to persons in lower income brackets who require credit expressly for travel. The TWA credit card is in addition to other credit card systems honored by TWA.

In its continuing support of the President's "Visit U.S.A." campaign to attract more foreign tourist dollars to the U.S., TWA, in cooperation with the United States Travel Service, flew 32 European and Middle Eastern journalists to this country for a 2-week coast-to-coast tour. TWA arranged a similar tour in 1965.

In November TWA announced plans for construction of a series of fully automated air cargo terminals so advanced they can load or unload a 100-ton capacity cargojet within a half hour. The new C-Jet terminals will be built between 1968 and 1970 at major U. S. and European airports and will be specifically designed to handle the huge Boeing 747 freighters which TWA has ordered.

In September, construction got under way for an $8,000,000 expansion of TWA's aircraft engine overhaul facilities at the airlines overhaul base at Mid-Continent International Airport, Kansas City.



TWA announced plans for construction of a series of fully automated air cargo terminals so advanced they can load or unload 100 tons in 30 minutes. Designed for the Boeing 747 jumbo freighter, the terminals will be built between 1968 and 1970.

In 1966 TWA established a facility at Rockleigh, New Jersey, which will become the nerve center for a fully automated centralized passenger reservations system and a total management information system. At the close of 1965 TWA announced the purchase of Burroughs D830 electronic computer equipment to provide for the system which represents a $25,000,000 initial capital investment. Activation of Phase I of the system was planned for mid-1967.

During 1966 TWA opened or renovated 17 more city ticket offices, renovated and expanded eight passenger terminals, and renovated and expanded facilities and offices at its Flight Training Center and Midtown Building offices in Kansas City to accommodate more personnel and equipment.

On May 3, 1966, the Hughes Tool Company sold to the public all 75 percent of outstanding common stock it had held in TWA. The action increased the number of TWA shareowners of record from 11,000 to some 24,000 toward the end of the year.

UNITED AIR LINES

United Air Lines' year was characterized by new traffic records in three categories despite the crippling 43-day strike against United and 4 other airlines.

Although figures for December were not available, estimates for the year indicated that United would top its previous records for revenue passengers carried, revenue passenger miles and mail ton miles, and there was also a possibility of a new record in the express category.

President G. E. Keck estimated that United would carry 18,400,000 passengers in 1966 as compared with 17,340,000 in 1965. Other estimates included: revenue passenger miles of 13.4 billion, up 8 percent; freight ton miles, 326,000,000, up 41 percent; mail ton miles, 84,000,000, up 15 percent; and express ton miles, 19,000,000. The latter figure represented a decrease of 5 percent, but a strong month of December could also swing this category into the record class.

On the basis of these estimates, Keck forecast another banner year for air transportation in general and United in specific in 1967. He predicted that industry trunkline passenger miles would increase from 13 to 18 percent over 1966. As for United's outlook, Keck anticipated an increase of 15 to 20 percent as measured in revenue miles flown. Cargo, particularly air freight ton-mile volume which might go up more than 40 percent, was expected to continue its brisk expansion.

Summing up the industry outlook, Keck said that factors favoring growth in 1967 include still wider acceptance of air travel by the public, additional traffic generated by military activity and the bargain status of airline fares.

"As for fares and tariffs, it seems obvious that no additional general reductions would be prudent until the record is clear as to the net effect of higher cost levels and declining yields resulting from the multiplicity of promotional fares instituted in the past few years. In the 5 years 1962-66, the yield of domestic trunklines has gone down 11.3 percent per passenger mile and 9 percent per freight ton mile.

"In our case the trend is even more pronounced. In the 5 years ending with 1966, United's yield per passenger mile flown in domestic operations declined 14.6 percent and freight yield was down 10 percent."

During the year United strengthened its equipment position with the addition of 15 Boeing 727-QC's, or Quick Change jets that convert from passenger to all-cargo configuration in 30 minutes. United planned to expand its capacity by 20-25 percent in 1967 with deliveries of 45 new planes including 2 new types of jets, the short-range Boeing 737 and the 200-passenger Super DC-8. Two of the latter craft were to be delivered in January and introduced to service on the California-Hawaii run in February. The 737's were scheduled for delivery late in the year. The anticipated delivery schedule for 1967 included 2 737's, 11 Super DC-8's, 2 DC-8F Jet Freighters, 15 more 727QC's and 17 standard Boeing 727's.

WEST COAST AIRLINES

New pure jets, new service, new records. That, in brief, summed up 1966 at West Coast Airlines. Even in a business characterized by growth and change, the results achieved during the year were little short of spectacular.

The month of November was particularly significant: West Coast marked the completion of its 20th year of operation with the beginning of new DC-9 Fanjet service to 7 of the 42 cities on its 4,000 mile, 6-state system.

The jet service was initiated in time to help the airline set an all-time record November passenger total of 50,635—a gain of 25 percent over the previous year and 93 percent over the same month in 1964. It was West Coast's 35th consecutive record-setting month in a string extending back to January of 1964. Moreover, cumulative boardings for 1966 (through November) were 585,540—26 percent ahead of the preceding 12-month total.

It was also a year of record earnings. For the first 9 months of 1966, passenger revenue was 38 percent ahead of 1965, and net income per share was 81 cents, compared with 55 cents for the same period of the previous year.

During the year, schedules were improved virtually throughout the entire West Coast system. A new, non-stop "Jetbus" service was initiated between Seattle and Portland, and existing Jetbus schedules between Seattle and Spokane were expanded. The Jetbus commuter concept eschews all passenger delays, providing specially simplified boarding and baggage-handling techniques.

In Oregon, West Coast inaugurated the first known regularly-scheduled "light-plane" service, utilizing twin-engined Aztecs to provide several small, low-volume airports with convenient connections with larger towns. Other innovations included a new fly-and-drive package plan, which permits West Coast passengers to reserve rental cars at the same time they make flight reservations. The plan also provides special rental-car rates, approximately 40 percent less than the average.

West Coast's optimistic outlook for the future appeared altogether justified. Its first DC-9 Fanjet already reduced many previous time barriers which restricted the swift and easy flow of passenger traffic within and beyond the Northern West. For example, where the flight between Portland and San Francisco formerly took 6 hours or more, a DC-9 makes the trip in 3 hours without the need for changing planes. But the airline has only begun to realize the effects of jet service. With the addition of 5 more Fanjets in 1967-68, the country's first regional-service airline expected to effectively reorient the travel habits of commuters throughout its entire system. The company planned on 2 additional 75-passenger models and 3 99-passenger, series 30 versions. When completed the jet conversion will represent a basic investment of $21,-500,000 exclusive of spare parts and engines.

In addition, West Coast planned to continue to operate 10 40-seat, F-27 turboprops, providing 922 passenger seats in all. During 1967, the airline was to phase out most of the 8 DC-3's remaining from the piston fleet with which the organization began operations in December 1946.

WESTERN AIR LINES

Western Air Lines' most significant event of the year came on October 27 when it was announced that Western and Pacific Northern Airlines planned to merge. Seattle-based PNA is the major Alaskan

Western Air Lines president Terrell C. Drinkwater (left) and Pacific Northern Airlines president Arthur G. Woodley announced the proposed merger of the 2 companies.

carrier and one result of such a merger would be the first single-plane service to the 49th state from California. Adding PNA as an Alaskan Division, Western would then serve the Pacific coast rim from Anchorage to Acapulco. The combination would total 13,075 route miles.

For WAL 1966 was a year of aggressive route development activity. Starting with the addition of Acapulco, Mexico, to its 12-state, 3-nation system in January, the company continued its drive to expand by filing for authority to serve a greater number of new cities and regions. Among these are routes between the Gulf States and the Mid-west, and California to Miami and Atlanta, non-stops.

Important route cases in which Western was a participant included the Transpacific, Northwest-Southwest, California-Vancouver, California-Toronto (the latter 3 should be settled by early 1967), California-Twin Cities (including filings to major eastern cities) and others.

Changes in Western Air Lines' board of directors included addition of Leonard K. Firestone, president of Firestone Tire and Rubber Company; Art Linkletter, noted as both a television personality and business entrepreneur; and Richard W. Wright, chief executive of Mountain States Employers Council, Denver. Resigning and appointed directors-emeriti were Dr. Donald McLaughlin and John M. Wallace.

Financially, Western netted $14,392,000, or $3.35 a share, during the first 10 months of 1966, representing a 36.6 percent increase over the net profit of $10,537,000, or $2.45 a share, for the like 1965 period. The figures reflected increased traffic in the summer during the strike against several other carriers.

Operating revenues for the 10 month period were $130,371,000, compared to $102,076,000 a year earlier. Expenses during that time increased 23.6 percent, from $82,258,000 a year before, to 1966's $101,696,000.

Seat mile production was up 19.2 percent, while seat miles sold during the 10 months increased 30 percent over 1965. Load factor for the period was 61.7 percent, compared to 56.5 percent. Breakeven point increased to 48.1 percent from 45.8 percent.

The company's personnel growth (up to some 5,200 employees) resulted in a great number of new staff assignments, including creation of an executive vice presidency in transportation and vice presidencies in the fields of economic planning, government and industry affairs, public relations and for the company's Mexico operation.

Western's fleet at year-end included 22 Boeing 720B fanjets (with 5 on order for delivery in mid-1967), 12 Lockheed Electra II's and 5 Douglas DC-6B's. Firm orders were also placed for 20 Boeing 737 Twinjets, to be delivered in 1968, with options for 10 more.

Western added a new Tokyo sales office in 1966 to handle greatly increased interline business emanating from the Far East. The company has other "offline" locations in New York City, Dallas, Chicago and Vancouver.

WAL continued its promotion of travel agencies as the place to buy the air travel product. This relationship resulted in 1966 agency sales amounting to about 40 percent of Western's total sales and establishment of an assistant vice presidency for direction of the agency and interline sales function.

Further solidifying their established reputation as passenger service innovators, WAL personnel developed such aids as electric "Commuter Catchers," whereon ride ticket agents with handy cash registers, to serve travelers waiting in line to board commuter flights between Los Angeles, San Francisco and Las Vegas. Also, special passenger boarding equipment, allowing Electra II jet-prop planes to use terminal "jet" loaders.

Celebrating its 40th anniversary on April 17, WAL became the oldest continuously operating air carrier in the nation.

VERTICAL LIFT AIRCRAFT

The output of vertical lift aircraft continued to grow at a faster rate than any other segment of the aerospace industry. For example, U. S. employment for the prime manufacturers of vertical lift aircraft by mid-1967 was expected to exceed 44,000. This would represent a 46 percent increase over the 1965 total.

Although production for some domestic and export markets was curtailed because of increased military requirements, unit production for 1966 totalled approximately 2,500 units, almost double the 1965 production.

During 1966, military helicopters in Viet Nam daily performed combat and life saving missions, while domestically civil helicopters continued to provide a myriad of services—air taxis, agricultural tools, construction cranes, forest fire fighters, traffic patrols, ambulances and executive transports. The Citizens and Southern National Bank in Atlanta, Georgia, developed a new use for the helicopter that was being adopted by other financial institutions in the country. The roof of the bank's main office serves as a heliport. Initially, regular flights were made from there to the 30 branches in the metropolitan area. The helicopter lands at some; at others a crew member uses a specially made pole to lift a mail pouch into the helicopter. Over 150,000 checks, drafts and pieces of mail were being flown by helicopter to the main office each day. Bank officials found that checks can be processed and cleared overnight. In addition, helicopter service results in an increase in the bank's level of lendable funds.

After the first 3 months of operation, the banks bought a second helicopter and expanded the service to a 75-mile radius of Atlanta.

Banks in Philadelphia and Boston later began using helicopters. The Philadelphia National Bank has a heliport atop its main office in downtown Philadelphia, the city's first licensed heliport.

The use of helicopters by law enforcement agencies increased notably in 1966. In 1965, 90 police and traffic control helicopters were operating in 36 cities in 16 states. By 1966, there were 115 helicopters in 44 cities in 22 states.

To the ever-expanding list of helicopter applications a new use was added in 1966—bank messenger, permitting overnight processing and clearance of checks. In photo, heliport at Philadelphia National Bank, one of the pioneers of the new service.

In Lakewood, California, the helicopter is used for police patrol. Known as Project Sky Knight, this crime control copter is never more than 2½ minutes away from any part of the city and is proving a deterrent to crime. Law enforcement officials say the crime control helicopter is the most dramatic support the police have had since the 1929 advent of radio-equipped patrol cars.

The 1966 Directory of Helicopter Operators—Commercial-Executive-Civil Government and Helicopter Flight Schools in the U.S. and Canada listed 933 operators operating 2,318 helicopters. The total represented an increase of 9 percent in the number of operators and 12 percent in the number of helicopters as compared with the 1965 totals.

The largest increase—18 percent—was in the number of companies and executives that own and operate helicopters. Many companies today use helicopters to transport personnel and priority mail between plants or to the airport, and executives are commuting by helicopter.

This continuing growth in the civil use of rotary-wing aircraft pointed to the need for the establishment of public use city-center and suburban heliports. For example, of the 1,118 helicopter landing facilities listed in the Vertical Lift Aircraft Council's Directory of Heliports/Helistops in the United States, Canada and Puerto Rico, more than half are privately owned.

As part of the Council's program to aid in the establishment of heliports, 12 prints of the public service film "When Minutes Really Count" which dramatizes the need for city-center, suburban and hospital heliports and demonstrates the rescue role the helicopter can perform on highway accidents, continued to be distributed for showings before civic groups and city planning officials. In the first

8 months, the film was shown in 24 states, the District of Columbia, Canada and Viet Nam. AIA/VLAC also published an illustrated Directory of Hospital Heliports. By year-end, the number of hospitals with landing facilities for helicopters had more than doubled since 1965.

A direct result of the Council's heliport program was the Montana Aeronautics Commission inauguration of a Hospital Heliport Program. Under this program, the Commission will construct hospital heliports at any location in Montana where hospital administrators are willing to set aside a usable ground level of rooftop area. The Commission will provide the surfacing, safety barriers and marking for the hospital heliport. The Commission Director predicted that hospital heliports would add substantially to the handling of emergency cases, would increase the use of helicopter ambulances and result in the saving of lives. Michigan and Wyoming announced plans for a similar program.

The Council, in 1966, named a committee to prepare an analysis of current and projected VTOL capabilities, in relation to the short haul intercity transportation problem for presentation to the Governmental Task Force on Interurban Air Transportation. The report generated interest in the proposal that VTOL offers one solution to the problem and awareness of industry's capability to provide safe, reliable, profit making equipment.

In the report, the Council specifically recommended the establishment of a national policy for VTOL development to identify the short-haul intercity transportation requirements and that a solution with VTOL aircraft be pursued as a national objective.

National attention was dramatically focused on other capabilities of VTOL aircraft during the Metro Air Support '66. This 2-day program was designed to show how VTOL helicopters and STOL airplanes could be used to re-supply and support a large metropolitan city in an emergency. It was sponsored by the Federal Aviation Agency with the active cooperation of members of the VLAC, STOL airplane manufacturers, the military and the New York and New Jersey State Governments.

More than 200 aircraft, fixed wing and helicopters converged on Manhattan as a part of Metro '66 to show that vital supplies and personnel could reach New York City quickly, even if ground transportation was halted during an emergency.

A 1-year study of a combined ground-air transportation system—the Sky Lounge—was initiated for the Los Angeles Department of Airports. The unique system plans to use a 40-passenger vehicle to pick up passengers and baggage at different downtown sites. The vehicle would then be driven to a central pick up station where a flying-crane helicopter would airlift the vehicle to Los Angeles International Airport. After landing, the vehicle would then be driven to the various airline terminals or aircraft. The flight from downtown Los Angeles to the airport is expected to be 8 minutes, compared to ground travel time of 1 hour or more. This $735,000 study is being funded by the U.S. Department of Housing and Urban Development, by the City of Los Angeles and by the project participants.

The 2 goals for the Skylounge study are to define a system adaptable for other metropolitan areas and to design a specific configuration for metropolitan Los Angeles.

Department of Commerce interest in a helicopter highway test program was first reported to the Vertical Lift Aircraft Council in December 1965. Discussions were held with department officials on the possible application of vertical lift aircraft for highway accident patrol and rescue operations. As a result, the new National Traffic Safety Agency has been delegated responsibilities which include emergency service and demonstration of Highway Safety Research and Development. The Agency's Administrator, Dr. William Haddon, Jr., was to name an Agency-Industry Task Force to assist in developing a proposed test and evaluation program. Members of the Vertical Lift Aircraft Council together with representatives of the helicopter operators and the military will serve on this Task Force.

The School of Medicine of the University of California at Los Angeles was engaged in a study of traffic accidents. The study will now include the use of helicopters both for traffic accidents investigation and for transportation of accident victims.

GENERAL AVIATION

The spectacular increases in general aviation which began earlier in the decade accelerated in 1966. Production of new equipment and utilization of the existing fleet leaped to new records during the year.

By September the industry had delivered more new airplanes than were delivered in the full 12 months of 1965, which had been a record year. Total production reached the 16,000 mark. While all categories of models showed substantial gains, the largest numerical increase came in the smaller single-engine models. This growth in numbers of aircraft in which most flight training is accomplished reflected both the industry's efforts at broadening the base of general aviation and the public's widening moves to use their own airplanes.

Supercharged engines appeared in greater numbers on single-engine as well as twin-engine airplanes. These pushed more airplanes into the environment of higher altitude operations. Jetprop and pure jet powered general aviation airplanes increased substantially in number. By mid-year there were about two-thirds as many jet powered airplanes in the general aviation fleet as in the scheduled airline fleet. Total general aviation airplanes outnumbered the airlines by more than 50 to 1.

Early in the year the Federal Aviation Agency issued the results of a study which showed that general aviation airplanes carry about half as many passengers on intercity flights as do the airlines. The report further stated that when other activities of general aviation are taken into account—patrol work, agricultural application, flight training, local pleasure flights and similar types of flying—as many people get into the air each year in general aviation airplanes as in all the domestic airlines combined.

Indicative of the utilization of general aviation airplanes is the traffic count made by the FAA at the 302 airports where traffic control towers are maintained. Two of the 3 busiest fields in total traffic are exclusive general aviation airports having no scheduled airline service. In September, 1 of these 2 general aviation airports moved into first place in total traffic, displacing Chicago's O'Hare as the busiest airport in the world.

Air taxi and commuter airline operations continued to lead as the fastest growing segments of general aviation. More than 5,000 airplanes were operated by 3,200 air taxi companies. Of these, more than 100 were operating over scheduled routes. In 1964 there were only 12 scheduled commuter airline operators.

At just the 302 airports where the FAA maintains air traffic control towers, takeoffs and landings averaged better than 1 a second every second of the day and night. These movements, representing only 3 percent of the nation's airports, showed a gain of 27 percent over the previous year. Three out of every 4 movements recorded at these airports were made by general aviation airplanes.

General aviation handled under IFR (Instrument Flight Rules) increased 44 percent over 1965. More than half as many landing approaches were performed under IFR by general aviation as by the scheduled airlines.

Flight training showed similar growth, boosted by both a public interest in general aviation and industry promotion. In the first 6 months of the year issuances of new student pilot certificates increased 54 percent over the same period of 1965. By year-end an estimated 130,000 new pilots had been licensed, raising the total pilot population to over the 500,000 mark.

Air cargo operations in general aviation airplanes began to burst at the seams during 1966. Airplanes designed with special, wide cargo doors and quickly removable seats appeared in greater numbers and varieties from the manufacturers. With past major emphasis placed on transportation of people, little attention had been paid to the looming cargo market. Now, however, manufacturers, operators and shippers are recognizing the potential of cargo transportation by air, with the future growth termed "fantastic."

Along with cargo, other "non-people" use of general aviation airplanes continued to advance. Aerial application, power and pipeline patrol, police traffic monitoring and fire fighting are a few of the workhorse jobs general aviation was performing.

Business twins expanded in both numbers delivered and models available. By year-end, deliveries of multi-engine airplanes totaled approximately 2,500, a 25 percent increase over 1965.

As an example of the trend by business to use their own air transportation, in one Midwest community 3 new twin-engine airplanes were purchased by local industry within 3 months after the local airport had been improved to accommodate the larger equipment. Airports were still one of the major problems facing full utilization of airplanes. This was becoming particularly acute in major metropolitan areas where travel is concentrated and where land values are at a premium. Manpower also loomed as a major concern. Shortages were felt in all areas, from designers and production workers to pilots and mechanics.

One of the most encouraging signs for the future of general aviation was the upsurge in interest by non-industry-related groups. General media—newspapers, magazines, TV and radio—"discovered" general aviation during 1966. The general aviation airplane showed up with increasing frequency in television commercials and printed advertising as background props. Security analysts probed the industry. Educators at all levels showed interest in including aviation-oriented curriculum as a requirement for preparing today's students for the air transportation society in which they will live.

CIV

QUALITY PRODUCTS FOR DEFENSE AND INDUSTRY

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An Aerospace
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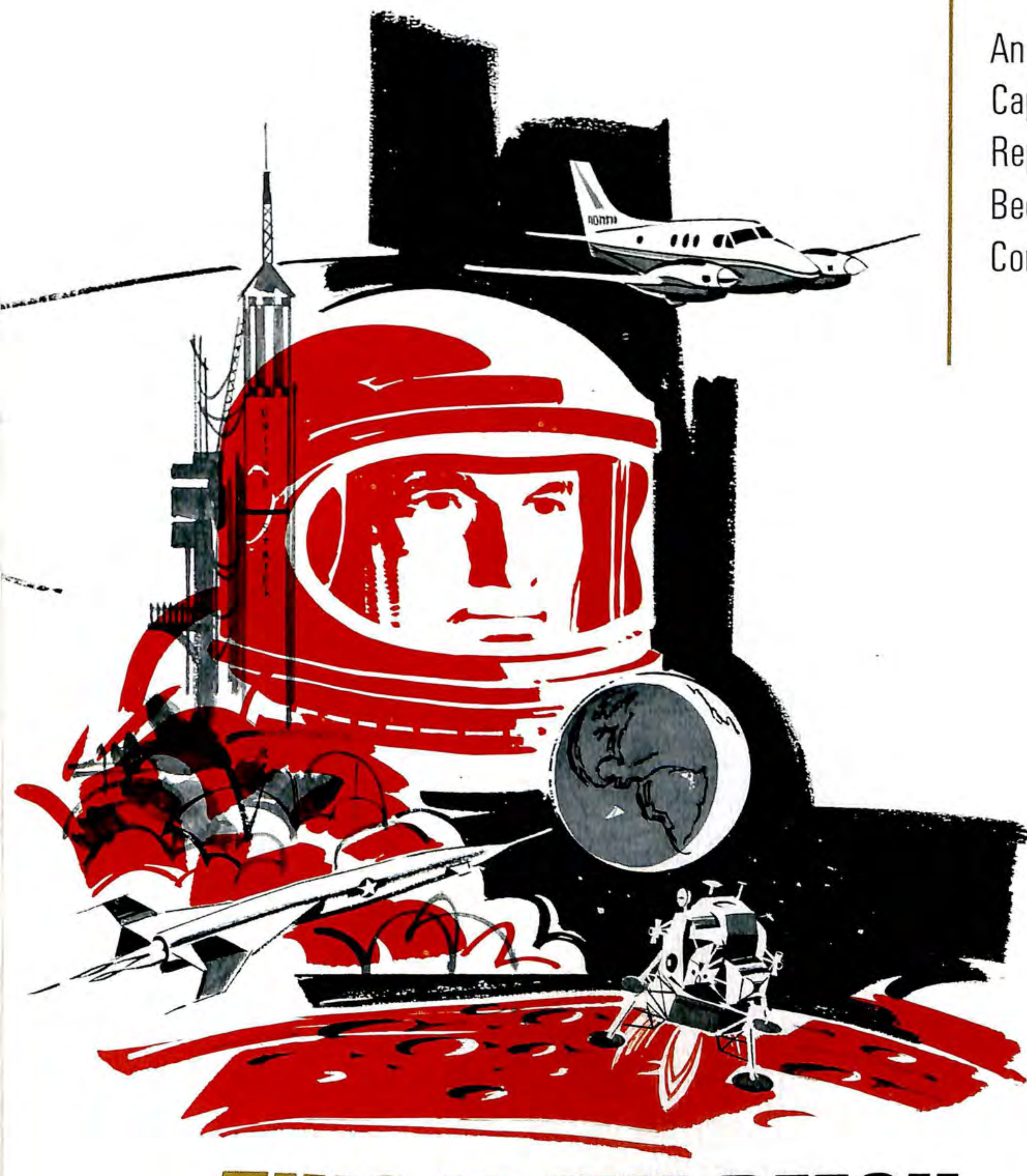


THIS IS THE BEECH CAPABILITY SPECTRUM:

The Beech History of Accomplishment

It all started with the first Beechcraft Model 17 "Staggerwing" biplane, designed and built from scratch in 1932. It was far advanced in aerodynamics and engineering for its day. It was *planned* that way...and it *succeeded.* By 1936, the Model 17 so dominated the many air races of the day that a familiar (and still true) phrase was coined: "It takes a Beechcraft to beat a Beechcraft."

When World War II struck, Beech was ready to expand and mold its facilities and leadership to meet the urgent needs

Beech is in Business Aircraft! Pilots around the world are still saying: "It takes a Beechcraft to beat a Beechcraft." Dealers and distributors in 50 countries throughout the world sell and service Beechcraft. The complete line extends from the 2-place single-engine Musketeer III to the twin-turboprop King Air.

Beech is in Subcontract Aircraft Assemblies! Beech builds flaps, ailerons, nose landing gear doors, emergency exit doors, wing spoilers, and provides tooling and engineering design services for Lockheed's great C-141A "StarLifter." Like services are performed for almost every prime contractor in the aviation and aerospace industries.

Beech is in Project Gemini! The entire Aerospace Ground Equipment systems for providing liquid oxygen and liquid hydrogen to the Gemini spacecraft tanks are Beech responsibilities. Performance is a matter of history, and has firmly established Beech capabilities in the field of cryogenics.

Beech is in Military Aircraft! Virtually every U. S. Navy and U. S. Air Force pilot, and pilots of eleven other nations receive their primary training in the T-34 Beechcraft Mentor. The versatile Beechcraft U-8 family of twin engined aircraft is the workhorse of the U. S. Army, Navy and Air Force Mission Support fleets.

Beech is in Target Missiles! Beech has designed **and produced** a complete family of target missile systems for a wide variety of defense training missions ranging from Mach .52 to Mach 3, ranging in altitudes from sea level to 90,000 ft. Beech is now conducting feasibility studies beyond Mach 7 and at orbital altitudes.

of America and its allies. As with so many companies, the years 1940 to 1945 were years of fantastic growth and accomplishment for Beech. Beech Aircraft Corporation came out of the war with a strong organization and leadership that used the war experience as fine tooling for the further development of its capabilities.

Beech capabilities now include nearly the entire spectrum of research, development and manufacture in aircraft, flight equipment, aerospace and related fields.

Beech is in Project Apollo! Beech is designing, building and testing cryogenics storage subsystems to supply breathing oxygen and electrical energy to the command module. In addition, Beech is designing, building and testing the storage and loading systems for filling the Lunar Excursion Module liquid helium tank. The entire bench maintenance systems for providing liquid oxygen and liquid hydrogen to the Apollo cryogenic storage system for ground checkouts and operations are Beech responsibilities.

Beech is in Flight-Weight Thermal Protection! A new Beech "breakthrough" in flight-weight thermal protection systems will be applied to the cryogenics storage subsystems of the Apollo spacecraft. The new system reduces heat leak by one-half and insulation weight by 75% of original project specifications.

Beech is in R&D and Testing! What Beech can research and develop, Beech can test and prove. Whether a project involves electronics, fluids or metallurgy; 100 G's of acceleration or the void of outer space; extreme cold of liquid helium (minus 452° F) or transient heat to 1500° F, Beech has the facilities and the capabilities.

Beech Plant Facilities are Extensive! A floor area of 1,999,700 square feet and a land area of 2,500 acres assures Beech of "elbow room" to perform its many and varied projects. Research, development, testing and manufacturing are performed by 7,000 skilled workmen in Wichita, Kansas; Boulder, Colorado; and Liberal, Kansas. In addition, Beech has 480 approved subcontractors that possess a wide variety of equipment and skills.

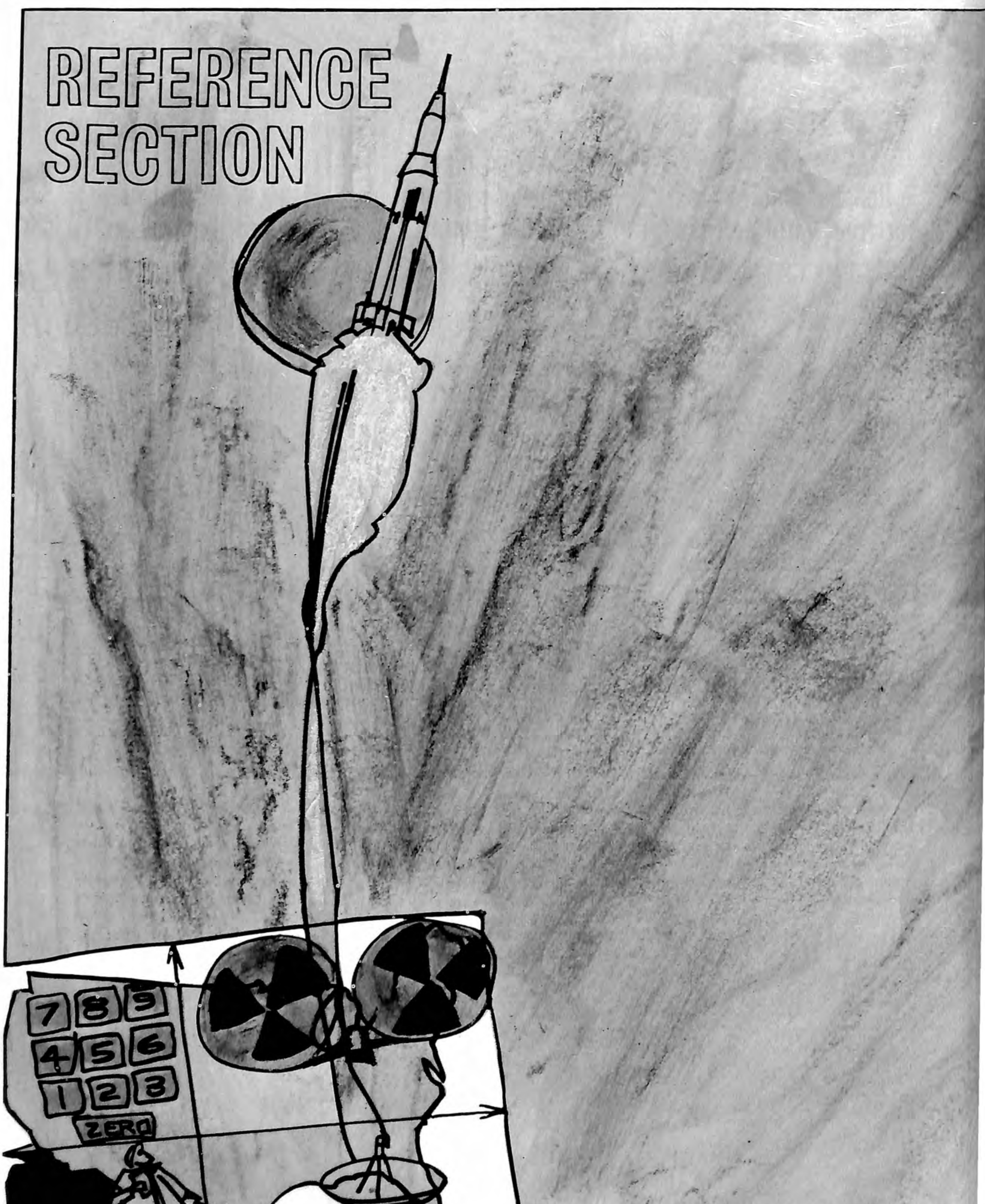
Beech offers complete Systems Management! Tested and proved through a wide variety of "total" assignments, Beech offers complete systems management capabilities in many diverse areas. Whatever field your project may involve, it will pay you to "take a look at Beech."

The best assurance Beech has of a great future . . .

The creative imagination to penetrate to the heart of a problem that didn't even exist yesterday—plus the knowledge, talent and ingenuity required for a satisfactory solution — combine to make Beech's greatest capability. We call it *Beech "Imaginuity."*

The facilities, personnel and experience of Beech are at *your* disposal. May we discuss with you how we may put them to work for you?

REFERENCE SECTION



The following pages, designed for reference use, contain specifications, performance and other data on well over 600 products of the aerospace industry. In addition to the primary products—aircraft, engines, missiles, targets and drones, sounding rockets, spacecraft and launch vehicles—the Aerospace Year Book now includes a section devoted to systems. The term system here denotes ground based and airborne aerospace equipment other than primary products, together with certain non-aerospace items produced by aerospace manufacturers. Although more than 100 systems are listed, they constitute only a fraction of the industry's extremely broad product line; the selection is intended only to be representative rather than all-inclusive. For easier reference, missiles and spacecraft are organized by functional groups, such as surface-to-surface missiles or meteorological satellites. All other products are arranged in alphabetical order by name of the parent manufacturing company. For specific listings consult the index. The term *prime contractor* used throughout this section refers to the builder of the product listed, regardless of whether it is a primary product or a subsystem, military or commercial.

AERO COMMANDER-100

Prime Contractor: Aero Commander-Albany 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-Albany 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 6-cylinder opposed 10-520-A, 285 horsepower Continental engine and a McCauley constant speed metal propeller. The Commander 200 has an 80-gallon fuel capacity including auxiliary fuel of 40 gallons in outer wing panel tanks.

Specifications

Span 30 feet 6 inches; length 24 feet 4 inches; height 7 feet 4 inches; empty weight 1,940 pounds; useful weight 1,060 pounds; gross weight 3,000 pounds; baggage capacity 200 pounds; wing loading 18.75 pounds per square foot; power loading 10.5 pounds horsepower.

Performance

Take-off distance over 50-foot obstacle 1,200 feet; landing distance over 50-foot obstacle 1,150 feet; rate of climb 1,450 feet per minute; optimum cruise speed 218 miles per hour; range 1,380 statute miles; landing speed 54 miles per hour (full flaps); service ceiling 18,500 feet.

JET COMMANDER

Prime Contractor: Aero Commander-Bethany Division, Rockwell Standard Corporation

Remarks

The Jet Commander is an executive jet capable of carrying 8 passengers and 735 pounds of baggage on a trip of 1,585 miles at speeds above 500 miles per hour.

Specifications

Wing span 43 feet 3.7 inches; length 50 feet 11 inches; height 15 feet 10 inches; empty weight 9,155 pounds; gross weight 16,800 pounds; wing loading 55.39 pounds square feet; power loading 2.9 pounds per pound of thrust; engines two GE CJ-610-1 rated at 2,850 pounds thrust at sea level; fuel capacity (JP-4) 926 gallons; cabin capacity 6–8; cabin pressure at sea level up to 20,000 feet, 7,000 feet at 30,000 feet; certified to operate to 45,000 feet with 9.0 pounds per square inch; at 45,000 feet cabin altitude is 8,000 feet. Useful load 7,240 pounds.

Performance

Maximum speed 568 miles per hour at 35,000 feet; cruise speed 503 miles per hour at 35,000 feet; approach speed at 14,000 pounds, 100 knots; rate of climb 5,000 feet per minute; operational ceiling 45,000 feet; range with 45 minute reserve 1,585 statute miles.

GRAND COMMANDER

Prime Contractor: Aero Commander-Bethany Division, Rockwell Standard Corporation

Specifications

Span 49 feet 6 inches; length 41 feet 3.25 inches; height 14 feet 9 inches; tread 12 feet 11 inches; maximum take-off weight 8,500 pounds; empty weight 5,200 pounds; useful load 3,300 pounds; maximum fuel capacity 223 gallons (285 with auxiliary tank).

Performance

Cruise speed, 70 percent power, 10,000 feet 244 miles per hour; take-off distance over 50-foot obstacle, 1,560 feet; landing distance over 50-foot obstacle, 1,360 feet; cruising range with 45 minute fuel reserve, 1,565 statute miles; service ceiling 26,500 feet.

Note: The airplane is also available as the Pressurized Grand Commander which has identical specifications and performance with these exceptions: Empty weight 5,700 pounds; useful load 2,800 pounds.

TURBO COMMANDER

Prime Contractor: Aero Commander-Bethany Division, Rockwell Standard Corporation

Specifications

Span 44 feet, length 41 feet 3.25 inches; height 14 feet 8 inches; tread 12 feet 11 inches; maximum take-off weight 8,950 pounds; empty weight 5,450 pounds; useful load 3,550 pounds; maximum fuel capacity 287 gallons.

Performance

Cruise speed at 16,500 feet, 285 miles per hour; take-off distance over 50-foot obstacle, 1,740 feet; landing distance over 50-foot obstacle, 2,340 feet (with propeller reversal 1,200 feet); cruising range with 45-minute reserve, 1,000 statute miles; operational ceiling 28,000 feet.

AERO COMMANDER 500U

Prime Contractor: Aero Commander-Bethany Division, Rockwell Standard Corporation

Specifications

Span 49 feet 6 inches; length 35 feet 1 1/4 inches; height 14 feet 9 1/2 inches; tread 12 feet 11 inches; take-off weight 6,750 pounds; empty weight 4,350 pounds; useful load 2,400 pounds; fuel capacity 156 gallons; engines 2 Lycoming IO-540 290 horsepower each.

Performance

Cruise speed 70 percent power, 10,000 feet, 218 miles per hour; take-off distance over 50-foot obstacle 1,375 feet; landing distance over 50-foot obstacle 1,235 feet; range with 45-minute reserve 1,305 statute miles; service ceiling 21,000 feet.

SNOW COMMANDER S-2D

Prime Contractor: Aero Commander-Olney Division, Rockwell Standard Corporation

Remarks

The Snow Commander is a highly maneuverable agricultural duster/sprayer with exceptional visibility and safety features. A monoplane with a full cantilever low wing, it is of all-metal construction with the exception of fabric empennage skin surfaces. The cockpit is stressed to over 40 G's and is completely sealed against chemical entry.

Specifications

Span 44 feet 6 inches; length 28 feet 4 inches; height 8 feet 10 inches; tread 8 feet 4 inches; take-off weight 6,000 pounds; empty weight 3,400 pounds; useful load 2,600 pounds; fuel capacity 109 gallons; hopper capacity 300 gallons; engine 1 Pratt & Whitney Aircraft R-1340AN-1 rated at 600 horsepower.

Performance

Cruise speed 140 miles per hour; stall speed (normal) 57 miles per hour; stall speed at gross weight 70 miles per hour; take-off distance 850 feet; landing distance 500 feet; service ceiling 15,000 feet; range with 45-minute reserve at 50 percent power 470 statute miles.

BEECHCRAFT MUSKETEER SPORT III, CUSTOM III AND SUPER III

Prime Contractor: 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. New options include six-place seating in the Super III and optional left-side cabin door and tinted glass on all models. In photo, 6-place Super III.

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) 138, (Super) 150 miles per hour at 75% power at 7,000 feet; cruise range, same conditions, (Sport) 767 miles, (Custom) 778 miles, (Super) 630 miles; rate of climb, (Sport) 900, (Custom) 725, (Super) 805 feet per minute; service ceiling (Sport) 14,900, (Custom) 11,870, (Super) 14,850 feet.

BEECHCRAFT C33 AND C33A DEBONAIR

Prime Contractor: 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 208 miles per hour, with 200 miles per hour cruise speed at 75 percent power at 6,500 feet. One-piece windshield becomes standard.

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

Prime Contractor: 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 is the compact light-weight AiResearch TEO 659 turbine in the turbocharged V35TC Bonanza, newest model in the Bonanza line. The V35TC has a top speed of 240 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 1,915 pounds; engine 285 horsepower Continental IO-520B.

Performance

Cruising speed 203 miles per hour; cruise range 599 miles standard, 1,111 miles with optional 80 gallon tanks; rate of climb 1,136 feet per minute; service ceiling 17,500 feet.

BEECHCRAFT D95A TRAVEL AIR

Prime Contractor: 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, a new fresh air system and avionics.

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

Prime Contractor: 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 TURBO BARON MODEL 56

Prime Contractor: Beech Aircraft Corporation

Remarks

Outstanding performance marks introduction in 1967 of the new Beechcraft Turbo Baron Model 56—fastest light twin in its class. With a top speed in excess of 300 miles an hour, the Turbo Baron is designed to carry up to six people high above the weather. Powered by 2,380 horsepower Lycoming TIO-541 engines, preliminary engineering data gives the Turbo Baron a single engine ceiling above 17,000 feet. In styling, the Turbo Baron generally retains the family resemblance to the popular B55 and C55 Beechcraft Barons, but it has a special paint scheme and large, tightly cowled turbocharged engines.

Specifications and Performance

Preliminary engineering estimates give the Turbo Baron a top speed of over 300 miles per hour; single-engine ceiling in excess of 17,000 feet; gross weight 5,990 pounds; useful load of approximately 2,400 pounds.

BEECHCRAFT QUEEN AIR A65

Prime Contractor: Beech Aircraft Corporation

Remarks

A swept vertical stabilizer distinguishes the newest model of Beechcraft's Queen Air series—the Queen Air A65. The A65 also features increased range through an optional fuel supply and capability of all-weather flight with de-icing and advanced avionics equipment. An Air-Stair door allows easy access to the three-compartment interior designed for optimum crew and passenger privacy and comfort. Center aisle cabin design permits freedom of movement about the cabin in flight.

Specifications

Span 45 feet 10.5 inches; length 35 feet 6 inches; height 14 feet 2 and 9/16 inches; gross weight approximately 7,700 pounds; useful load 2,850 pounds; engines 2 Lycoming IGSO-480-A1E6 rated at 320 horsepower.

Performance

Cruising speed 214 miles per hour; cruise range 800 miles with standard fuel, approximately 1,500 miles with optional fuel; rate of climb at gross weight, 1,300 feet per minute; service ceiling, 31,300 feet.

BEECHCRAFT QUEEN AIR 88

Prime Contractor: Beech Aircraft Corporation

Remarks

Offering a combination of pressurization, supercharged engines and all-weather instrumentation in a new market price category, the Beechcraft Queen Air 88 has cabin pressurization, offering sea level pressure to 8,200 feet. Rate is 3.8 pounds per square inch. It creates in the Model 88, 6,500-foot cabin comfort for passengers at a 16,500-foot altitude. Standard equipment on the Model 88 includes complete cabin pressurization, the required avionics and associated systems which give the Beechcraft transport all-weather capability, air conditioning, super soundproofing, de-icing and anti-icing equipment, and oxygen system.

Specifications

Span 50 feet 3 inches; length 35 feet 3 inches; height 14 feet 8 inches; gross weight 8,800 pounds; useful load 2,780 pounds; engines 2 380 horsepower Lycoming IGSO-540-A1D.

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

Prime Contractor: Beech Aircraft Corporation

Remarks

Since its introduction in 1937, the Beechcraft Model 18 has had an outstanding record as an executive, twin-engine airplane. Powered by reliable Pratt & Whitney 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 accumulators; bladder-type fuel tank arrangements; tricycle landing gear option; and automatic oil coolers. Super H18's performance has been boosted to 220 mile-per-hour cruise at 66 percent power, range boosted to 1,530 miles.

Specifications

Span 49 feet 8 inches; length 35 feet 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 Jr.

Performance

Cruising speed at 300 horsepower per engine 220 miles per hour; cruising range 1,530 miles; rate of climb 2 engines 9,900 pounds 1,400 feet per minute; service ceiling 2 engines 9,400 pounds 21,400 feet.

BEECHCRAFT KING AIR A90

Prime Contractor: Beech Aircraft Corporation

Remarks

The Beechcraft King Air A90 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 500 shaft horsepower each, the King Air cruises at 254 miles per hour, can fly to a service ceiling of 30,200 feet, and is capable of flying almost 1,500 nonstop miles at maximum cruise power. King Air A90 pressurization differential is 4.6 to allow a sea level cabin to 10,500 feet.

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 & Whitney PT6A-20 free turbines with reverse pitch propellers optional.

Performance

Cruising speed maximum cruise power 254 miles per hour; cruising range at 21,000 feet 1,478 miles; rate of climb 2 engines 9,300 pounds 1,900 feet per minute; service ceiling 2 engines 9,300 pounds 27,000 feet.

BEECHCRAFT QUEEN AIR B80

Prime Contractor: Beech Aircraft Corporation

Remarks

An established high-performance, medium twin-engine business aircraft, the Queen Air B80 offers such comfort features as 3 individual compartments to provide privacy for crew and passengers as well as restroom facilities; a center aisle and writing tables allowing passengers to work and move about in flight; optional 4-place couch interior and optional 11-place configuration with airline-style seating for commuter airline operation or high-density corporate use.

Specifications

Span 50 feet 3 inches; length 35 feet six inches; height 14 feet 2 1/2 inches; gross weight 8,800 pounds normal—8,832 as Queen Airliner; useful load 3,620 pounds—3,232 as Queen Airliner; engines 2 380 horsepower Lycoming IGSO-540 A1D.

Performance

Cruising speed 224 miles per hour; cruise range 1,200 miles standard, 1,560 with optional 264 gallon fuel tanks; rate of climb at gross weight, 1,275 feet per minute; service ceiling 28,900 feet.

BEECHCRAFT MODEL 45 MENTOR

Prime Contractor: Beech Aircraft Corporation

Remarks

Late in 1948, following a first flight on December 2, Beech Aircraft announced a new primary and basic-advanced trainer, the Beechcraft Model 45 Mentor, a single-engine, 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 and Debonair); tandem cockpits under continuous canopy.

Performance (T34A)

Maximum speed 189 miles per hour; maximum cruise speed 173 miles per hour; service ceiling, 20,000 feet; maximum cruising range 737 miles.

T-42A INSTRUMENT TRAINER

Prime Contractor: Beech Aircraft Corporation

Remarks

The T-42A is the military counterpart of the Beechcraft Model B55 Baron and is being utilized as a fixed-wing twin-engine instrument trainer by the Army Aviation School Instrument Training Division at Fort Rucker, Alabama. Secondary mission of the aircraft is the twin-engine transition of single-engine rated aviators.

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 the T-42A 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 antisubmarine warfare, landing and patrol operations, mine countermeasures, high-speed transport of personnel and cargo and rescue operations.

Specifications

Length 65 feet; width 27 feet; height 23.5 feet, plus four foot flexible trunks; engines 4 Solar Saturn marine gas turbines rated at 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 the British Hovercraft Corp. Bell Aerosystems delivered three SK-5s to the Navy which are being employed in Viet Nam, marking the first U.S. military application of this new means of transportation. In addition, two SK-5s proved effective and reliable during a one-year demonstration project on San Francisco Bay featuring the nation's first scheduled ACV passenger service. Bell Aerosystems, in a joint effort with Skimmers, Inc., also conducted a demonstration program in Alaska to introduce this new concept of transportation to potential users.

Specifications

Length 39.2 feet; width 22.9 feet; height 16.6 feet; gross weight 15,000 pounds; engine one General Electric LM100 marine gas turbine rated at 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. A unique variable stability and control system is combined with high control power levels and a three-engine hovering capability to provide an extremely versatile V/STOL research aircraft. The first X-22A was rolled out on May 25, 1965; it made its first flight on March 17, 1966, but subsequently was extensively damaged in an August 1966 hard landing. Bell was preparing the second X22A for flight testing.

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-3B-1 HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

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, 20,000 feet; service ceiling 20,000 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/E/540 IROQUOIS HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1B/E/540 is an 8–10 place military utility and armed helicopter. In service since March, 1961, it is still in production. UH-1B is the Army version, UH-1E the Marine Corps configuration.

Specifications

Overall length 53 feet; fuselage length 42.6 feet; height 12.6 feet; empty weight B 4,842 pounds, E 5,055 pounds; gross weight 9,500 pounds; engine Lycoming T53-L-11 turbine, 1,100 shaft horsepower.

Performance

Maximum speed 161 miles per hour; cruise speed 138 miles per hour; normal range 286 miles; rate of climb 1,849 feet per minute; service ceiling 21,000 feet; hover ceiling OGE 11,800 feet, IGE 15,800 feet.

UH-1D IROQUOIS HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The UH-1D is a utility helicopter with a capacity of 12–15 seats in service with the Army since June, 1963.

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 1100 shaft horsepower.

Performance

Maximum speed 138 miles per hour; cruise speed 135 miles per hour; normal range 355 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-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 1,272 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 250 miles per hour.

47G-5 HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The 47G-5, first delivered in January, 1966, comes in two versions. The agricultural model (Ag-5) features low empty weight (1,550 pounds) and high useful load capability (1,300 pounds) and has two seats. Equipped with Bell's new AgMASTER chemical application system, the Ag-5 will spray up to 14.4 acres per minute. The 47G-5 utility model, with three seats, also features low empty weight and high useful load and is described below. Both models are in production and in service.

Specifications

Fuselage length 31.6 feet; overall length 43.2 feet; main rotor diameter 37.1 feet; normal gross weight 2,850 pounds; empty weight 1,590 pounds; useful load 1,260 pounds; engine Lycoming VO-435, 220 horsepower.

Performance

Maximum speed 105 miles per hour; cruise speed 88 miles per hour; maximum range at 5,000 feet, 340 miles; rate of climb 1,070 feet per minute; hovering ceiling, IGE, 6,000 feet; service ceiling 10,200 feet.

47G-4A HELICOPTER

Prime Contractor: Bell Helicopter Company

Remarks

The 47G-4A is the latest version of Bell's Model 47 series, with first deliveries in January, 1966. It is in service and in production. This three-place model is Bell's standard utility aircraft.

Specifications

Fuselage length 31.6 feet; overall length 43.2 feet; main rotor diameter 37.1 feet; normal gross weight 2,950 pounds; empty weight 1,823 pounds; useful load 1,127 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 800 feet per minute; hovering ceiling, IGE, 6,810 feet; service ceiling, 17,500 feet.

206A JETRANGER

Prime Contractor: Bell Helicopter Company

Remarks

The Model 206A Jetranger is a 5-place, turbine-powered, light utility helicopter. It has a single 2-bladed main rotor with a diameter of 33 feet 4 inches and a 2-bladed tail rotor with a diameter of 5 feet 2 inches.

Specifications

Overall length 38 feet 9.5 inches; overall width 6 feet 3.5 inches; overall height 9 feet 6.5 inches; gross weight 2,900 pounds; empty weight 1,295 pounds; engine Allison Model 250-C18, 317 horsepower.

Performance

Maximum speed 150 miles per hour; cruise speed 140 miles per hour; range 451 statute miles; service ceiling 15,800 feet; hover ceiling OGE 7,900 feet, IGE 12,400 feet; rate of climb 1,860 feet per minute.

MODEL 209 HUEYCOBRA (ARMY AH-1G)

Prime Contractor: Bell Helicopter Company

Remarks

The HueyCobra, or AH-1G, is a 2-place high speed weapons helicopter which incorporates stub wings for ordnance stores and a nose mounted turret. It has a 2-bladed, "door hinge," 44-foot diameter main rotor and a 2-bladed tail rotor. The first helicopter of this type specifically designed for the armed helicopter role, it is scheduled for initial delivery in July, 1967.

Specifications

Length 42 feet 5.2 inches; wing span 10 feet 11.6 inches; height 10 feet 2.3 inches; gross weight 9,500 pounds; empty weight 5,288 pounds; engine Lycoming T53-L-13, 1,400 shaft horsepower.

Performance

Maximum dive speed 218 miles per hour; cruise speed without external stores up to 196 miles per hour; ferry range with external fuel 980 statute miles; range without external stores 478 statute miles; service ceiling 16,900 feet.

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 have been eclipsed by later-generation jetliners, but 147 have been sold to six airlines.

Specifications

Span 130 feet 10 inches; length 144 feet 6 inches; height 42 feet; wing sweepback 35 degrees; weight 258,000 pounds; engines 4 Pratt & Whitney JT3C-6 turbojets of 13,000 pounds thrust (-120 model), and JT3D-3 turbofans of 18,000 pounds thrust for -120B model; tricycle gear with four-wheel bogie-type truck main units and dual nose wheels; payload is up to 181 passengers.

Performance

Speed up to 600 miles per hour; range more than 3,000 miles; ceiling over 30,000 feet.

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 can carry 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 189 passengers for -320B and up to 202 for the -320C in all-economy, or 96,800 pounds of cargo in -320C.

Performance

Speed more than 600 miles per hour; range more than 6,000 miles; ceiling 42,000 feet.

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. More than 150 of the series have been ordered by 16 airlines.

Specifications

Span 130 feet 10 inches; length 136 feet 2 inches; height 41 feet 6 inches; sweepback 35 degrees; weight 230,000 pounds (720), 235,000 pounds (720B); engines 4 Pratt & Whitney JT3C-7 turbojets of 12,000 pounds thrust for the 720, JT3D-1 turbofans 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 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 medium range routes, and it has a take-off 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 179 passengers economy class, QC payload up to 46,440 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 up to 108,000 pounds, compared to 161,000 pounds for the three-engined 727. Contrary to the trend in twin-jet airliners toward aft-mounted engines, Boeing placed the engines under the wings on the 737 for the advantages of: easier maintainability, reduction in structure weight, additional passenger space in the cabin, better balance characteristics, simplified systems, more loading flexibility and better aerodynamic efficiency. Two versions of the 737 went into production during late 1965, the 737-100 and the six-foot-longer 737-200. More than 100 have been sold including cargo and quick-change versions.

Specifications

Span 93 feet; length 94 feet (-200 is 100 feet); height 37 feet; wing sweepback 25 degrees; weight 97,800 pounds (-100), 108,000 pounds (-200); engines 2 Pratt & Whitney JT8D-7 turbofans of 14,000 pounds thrust each; gear tricycle, dual-wheel units; payload 29,093 pounds (structural limit) or up to 101 passengers for -100, 31,931 pounds or up to 117 passengers for -200.

Performance

Speed 575 miles per hour; normal operating range up to 1,500 miles; ceiling 35,000 feet.

BOEING 747 JETLINER

Prime Contractor: The Boeing Company

Remarks

When the first 747 rolls from the factory in late 1968, it will be the largest commercial jetliner in history. Designed to carry up to 490 passengers in all-economy seating or 360 in mixed-class configuration over long ranges, this 625 mile-per-hour aircraft offers the opportunity for a combination of new standards in low-priced air travel and luxury. Its 185-foot long, 20-foot wide cabin will permit spacious seating as well as such innovations as nurseries, lounges or theater areas. In addition, a stateroom area will be available on an upper level behind the crew. Its size may lead to new concepts in ticketing, baggage checking and terminal arrangements. As a cargo carrier, it will have straight-in nose loading and powered loading devices in the floor. Convertible and all-freighter versions are offered.

Specifications

Span 195 feet 8 inches; length 231 feet 10 inches; height 63 feet 5 inches; wing sweepback 37.5 degrees; max ramp weight 683,000 pounds; engines 4 Pratt & Whitney JT9D turbofans of 41,000 pounds thrust each; dual nose wheels, 4 4-wheel bogie type main trucks; payload up to 490 passengers in all-economy or 222,000 pounds in all-cargo version.

Performance

Speed up to 640 miles per hour, range nearly 8,000 miles, ceiling 45,000 feet.

KC/C-135 TANKER/TRANSPORT SERIES

Prime Contractor: The Boeing Company

Remarks

Shortly after Boeing's privately-financed 707 prototype flew in July 1954, the USAF ordered a derivative into limited production as the KC-135A jet tanker. The tanker, incorporating a highly streamlined flying boom developed by Boeing, for the first time allowed refueling of the USAF's jet bombers and fighters at jet speeds and altitudes. By the time the military production line phased out at Boeing at the beginning of 1965, the company had delivered 732 tankers plus 88 transports, flying command posts or reconnaissance aircraft. A total of 820 KC/C-135s were built. The tankers and some transports all used water injection turbojet engines, while a "B" model using turbofans was developed and put into transport service by the USAF in 1961.

Specifications

Span 130 feet 10 inches; length 136 feet 6 inches; height 38 feet 5 inches (KC-135), 41 feet 8 inches (C-135B); wing sweepback 35 degrees; weight 297,000 pounds (KC-135), 275,000 pounds (C-135B); engines 4 Pratt & Whitney 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); 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. The tandem-rotor helicopter, with all-weather and shipboard capabilities, features a power blade folding system which enables the blades to be folded automatically in winds up to 45 knots in less than 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

Maximum 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.

MODEL D-10B COMMERCIAL UTILITY HELICOPTER

Prime Contractor: Caribe Doman Helicopters, Inc.

Remarks

The Caribe Doman D-10B is a 400 horsepower, 8–10 place helicopter, which emphasizes high lift capacity and high altitude performance. Commercial appeal is enhanced by the simplified hingeless, lightweight rotor systems which are sealed and self-lubricated. Quiet operation is derived from the silenced ejector cooling system and faired tips of the tapered rotor blades. Versatility and convertibility of fuselage design permit quick change from deluxe passenger version to cargo, or stripping to an open structure for spraying and dusting.

Specifications

Fuselage length 38 feet; width 5 feet; cargo doors 4 feet by 7 feet on each side; rotor diameter 48 feet; gross weight, 5,500 pounds; minimum empty weight 3,127 pounds; normal fuel capacity, 119 gallons; maximum seating, pilot and 9 passengers; engine, Lycoming HIO-720-A1A derated to 400 horsepower with AiResearch turbo supercharging.

Performance

Maximum speed, 107 miles per hour at full gross; range normal tanks, 322 miles at 100 miles per hour; service ceiling, 19,900 feet at full gross.

CESSNA MODEL 150

Prime Contractor: Cessna Aircraft Company

Specifications (Standard and trainer Versions)

Gross weight 1,600 pounds; empty weight 975–1,005 pounds; baggage 120 pounds; wing loading 10.2 pounds per square foot; power loading 16 pounds per horsepower; fuel capacity 26 gallons, with long range tanks 38 gallons; wing span 32 feet 8 1/2 inches; length 23 feet; height 8 feet 7 1/2 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) 1,260 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) 1,515 pounds; baggage capacity 350 pounds; wing loading 16.1 pounds per square foot; power loading 12.2 pounds per horsepower; fuel capacity 65 gallons; engine 230 rated horsepower; propeller constant speed 82 inches diameter.

Performance

Maximum speed at sea level 170 miles per hour; cruise speed 75 percent power at 6,500 feet 162 miles per hour; cruise range 75 percent power at 6,500 feet 695 miles per hour; optimum range at 10,000 feet 1,215 miles; rate of climb at sea level 1,090 feet per minute; service ceiling 19,600 feet; take-off run over 50-foot obstacle 1,205 feet; landing roll over 50 foot obstacle 1,365 feet.

Note: Model 180 also available as float plane and amphibian.

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 3,300 pounds; empty weight (approximate) 1,560 pounds; baggage capacity 350 pounds; wing loading 18.9 pounds per square foot; power loading 12.7 pounds per horsepower; fuel capacity 65 gallons; engine 6-cylinder fuel-injection; propeller constant speed diameter 88 inches.

Performance

Maximum speed at sea level 172 miles per hour; cruise speed 75 per cent power at 7,000 feet 164 miles per hour; cruise range 75 percent power at 7,000 feet 715 miles; optimum range at 10,000 feet 875 miles; rate of climb at sea level 950 feet per minute; service ceiling 16,600 feet; take-off run over 50 foot obstacle 1,605 feet; landing roll over 50 foot obstacle 1,400 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 3,300 pounds; empty weight 1,865 pounds; useful load 1,435 pounds; wing loading 18.8 pounds per square foot; power loading 11.6 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 198 miles per hour; cruise speed 75 percent power at 6,500 feet 190 miles per hour; range at cruise speed 755 miles; maximum range with maximum fuel 1,270 miles; rate of climb at sea level 1,115 feet per minute; service ceiling 19,900 feet.

CESSNA 310K

Prime Contractor: Cessna Aircraft Company

Specifications

Gross weight 5,200 pounds; empty weight 3,110 pounds; baggage capacity 600 pounds; wing loading 29.1 pounds per square foot; power loading 10.0 pounds per horsepower; fuel capacity 102 gallons; engines 2 6-cylinder fuel-injection IO-470-U's; propeller constant-speed full-feathering diameter 81 inches.

Performance

Maximum speed at sea level 237 miles per hour; maximum recommended cruise speed 75 percent power at 6,500 feet 222 miles per hour; cruise range 777 miles; maximum range at 10,000 feet 966 miles; rate of climb at sea level 1,540 feet per minute (twin engine), 330 feet per minute (single engine); service ceiling 19,900 feet (twin), 6,850 feet (single); take-off run at sea level over 50-foot obstacle 1,716 feet; landing roll at sea level over 50-foot obstacle 1,582 feet.

CESSNA SKYNIGHT

Prime Contractor: Cessna Aircraft Company

Specifications (5,300 pound Skynight)

Wing span 36.9 feet; wing area 179 square feet; length 29.5 feet; height 10.3 feet; weight 5,300 pounds; empty weight 3,266 pounds; baggage capacity 600 pounds; wing loading 29.6 pounds per square foot; power loading 9.3 pounds per horsepower; fuel capacity 102 gallons; engines 2 Continental 6-cylinder fuel injection TSIO-470-D; propeller constant-speed full-feathering.

Performance

Maximum speed at 16,000 feet 275 miles per hour; cruise speed 75 percent power at 10,000 feet 233 miles per hour; maximum recommended cruise range 75 percent power at 20,000 feet 845 miles, 75 percent power at 10,000 feet 763 miles; rate of climb at sea level 1,924 feet per minute (twin engine), 475 feet per minute (single engine); service ceiling 29,000 feet (twin), 18,800 feet (single); take-off run (maximum performance), over 50-foot obstacle 1,513 feet, landing roll over 50-foot obstacle 1,734 feet.

CESSNA EXECUTIVE 411

Prime Contractor: Cessna Aircraft Company

Specifications

Wing span 39.86 feet; length 33.46 feet; height 11.55 feet; gross weight 6,500 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 at 5,200 pounds gross weight at 16,000 feet 274 miles per hour; cruise speed 75 percent power at 20,000 feet 254 miles per hour, at 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 10 inches; height 9 feet; gross weight 2,800 pounds; empty weight (approximate) 1,560 pounds; baggage capacity 120 pounds; wing loading 16.1 pounds per square foot; power loading 12.2 pounds per horsepower; fuel capacity 65 gallons; engine 6-cylinder 230 rated horsepower; propeller constant speed 82-inch diameter.

Performance (182)

Top speed at sea level 167 miles per hour; cruise speed 75 percent power at 6,500 feet 159 miles per hour; cruise range 75 percent power at 6,500 feet 685 miles; optimum cruise range at 10,000 feet 905 miles; rate of climb at sea level 980 feet per minute; service ceiling 18,900 feet; take-off distance over 50-foot obstacle 1,205 feet; landing distance over 50-foot obstacle 1,350 feet.

Note: Skylane version also has gross weight of 2,800 pounds, but empty weight is 1,620 pounds; other specifications identical. Performance slightly higher than above for Skylane.

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 3,600 pounds; empty weight (approximate) 1,785 pounds; fuel capacity standard 65 gallons optional 84 gallons; oil capacity 12 quarts; wing loading 20.5 pounds per square foot; power loading 12.6 pounds per horsepower; engine, 6-cylinder fuel injection 285 horsepower; propeller constant speed diameter 82 inches.

Performance

Top speed at sea level 174 miles per hour; cruise speed 75 percent power at 6,000 feet 163 miles per hour; cruise range 63 gallons-no reserve 4 hours at 162 miles per hour; optimum range at 10,000 feet 810 miles; rate of climb at sea level 920 feet per minute; take-off run over a 50-foot obstacle 910 feet, total distance 1,810 feet; landing run over 50-foot obstacle 735 feet, total distance 1,395 feet.

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 (3,600-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 3,600 pounds; configuration 6-place; empty weight (approximate) 1,760 pounds; baggage capacity 88 pounds; wing loading 20.5 pounds per square foot; power loading 12.6 pounds per horsepower; fuel capacity 65 gallons; engine 6-cylinder fuel injection; propeller constant-speed 82-inch diameter.

Performance

Maximum speed at sea level 174 miles per hour; cruise speed 75 percent power at 6,000 feet 163 miles per hour; cruise range 75 percent power at 6,000 feet 650 miles (optimum at 10,000 feet 810 miles); rate of climb at sea level 920 feet per minute; service ceiling 14,800 feet; take-off run over 50-foot obstacle 1,810 feet; landing run over 50-foot obstacle 1,395 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 900 were built for the USAF and for air forces of other nations. The T-37C with tip tanks and armament provisions is being delivered to foreign countries under the Military Assistance Program.

Specifications

Span 33 feet 8 inches; length 29 feet 2 inches; height 9 feet 1 inch; empty weight 4,076 pounds; wing loading 35.7 pounds per square foot; power loading 3.2 pounds per pound thrust; engines 2 Continental J69-T25.

Performance

Maximum speed 408 miles per hour; cruise speed at normal rated power 368 miles per hour; gross weight landing speed 85 miles per hour; rate of climb at sea level 3,200 feet per minute; service ceiling 35,000 feet; range with maximum fuel 796 miles.

AT-37D STRIKE AIRCRAFT

Prime Contractor: Cessna Aircraft Company

Remarks

Cessna is under contract to modify the T-37B as a strike aircraft for Air Force counter-insurgency (COIN) operations. Designated AT-37D, this strike aircraft has twice the power and twice the weight of the parent jet trainer. Although similar in appearance to the trainer, alterations include installation of eight wing pylons, self-sealing fuel cells, and 90-gallon fuel tanks on each wing tip; larger wheels, tires, and brakes; and a rapid fire GE Minigun in the nose. There are provisions for an access door for aerial cameras under the fuselage, a fire-control and electrical system to accommodate all weapons for close support missions, and long-range fuel drop tanks. As a counter-insurgency aircraft, the AT-37D has great survival potential because of its excellent maneuverability and small silhouette.

Specifications

Gross weight 12,000 pounds; length 29.3 feet; wingspan 35.8 feet; engines 2 General Electric J85/J2, total thrust 4,800 pounds.

Performance

Maximum speed 415 knots; gross weight take-off distance over a 50-foot barrier 2,650 feet; landing distance over 50-foot barrier 2,350 feet; rate of climb 6,500 feet per minute; single engine performance after lift-off at gross weights up to 11,700 pounds.

T-41A MILITARY TRAINER

Prime Contractor: Cessna Aircraft Company

Remarks

Cessna is producing T-41A trainers in which Air Force student pilots will receive first flight instruction. The T-41A is a version of the Cessna commercial Model 172, which holds the world's flight endurance record by remaining in flight continuously for 64 days and 22 hours. The company is also under contract to the Army to produce a similar version of this aircraft for use in training student aviators and for installation support roles.

Specifications

Wing span 36 feet 2 inches; wing area 174 square feet; length 26 feet 6 inches; height (with depressed nose strut) 8 feet 11 inches; gross weight 2,300 pounds; empty weight (approximate) 1,260 pounds; wing loading 13.2 pounds per square foot; power loading 15.9 pounds per horsepower; fuel capacity 42 gallons; engine Continental 0-300-C; propeller all-metal, fixed pitch 76-inch diameter.

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 230 AND 300 AGWAGON

Prime Contractor: Cessna Aircraft Company

Remarks

The Agwagon aerial application aircraft is being produced by Cessna in two models, the Agwagon 230 with a 230-horsepower engine and standard fixed-pitch prop or optional constant-speed prop, and the Agwagon 300 with a 300-horsepower engine and standard constant-speed prop.

Specifications

Gross weight 3,300 pounds (without dispersal equipment); length 25 feet 3 inches, height 7 feet 4 1/2 inches; wing span 40 feet 4 1/2 inches; hopper capacity 200 gallons, 757 liters; wing loading 16.3 pounds per square foot; power loading 14.3 pounds per horsepower (Model 230) and 11 pounds per horsepower (Model 300); engine Continental 0-470-R (Model 230) and Continental I0-520-D (Model 300).

Performance

Top speed at sea level: (230-horsepower fixed-pitch) 119 miles per hour, (230-horsepower constant-speed) 138 miles per hour, (300-horsepower constant-speed) 151 miles per hour; normal range: (230 fixed-pitch 70 percent power at 5,000 feet) 325 miles, (230 constant-speed 75 percent power at 6,500 feet) 335 miles, and (300 constant-speed 75 percent power at 6,500 feet) 320 miles; rate of climb at sea level for the three versions: 710, 755, and 940 feet per minute; service ceiling: 13,000 feet, 13,700 feet, and 15,700 feet.

A-3 SKYWARRIOR

Prime Contractor: Douglas Aircraft 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 inflight refueling system converts it to a high-speed jet tanker. First A-3 flight was on October 28, 1952. It is now the largest of the Navy's carrier-based aircraft. Wings and vertical tail surface fold for convenience in carrier handling. The A-3 was phased out of production in 1961.

Specifications

Wing span 72 feet 6 inches; length 74 feet 8 inches; height 22 feet 9 inches. Normal gross weight 70,000 pounds; engines 2 Pratt & Whitney J57; basic crew of 3.

Performance

Range more than 2,500 nautical miles. Other data classified.

A-4F AND TA-4F SKYHAWK TRAINER-ATTACK BOMBER

Prime Contractor: Douglas Aircraft Group, Long Beach

Remarks

Newest versions of the versatile A-4 Skyhawk series of Navy attack bombers are the A-4F and TA-4F, the latter a jet trainer. The TA-4F modification includes the addition of a 28-inch section for a second seat and dual controls. New safety features include the Navy-Douglas ESCAPAC zero-level, zero-speed ejection seat system for both instructor and student. The A-4F incorporates the advanced avionics and Pratt & Whitney J52-P-8A engine of the trainer into an improved attack bomber. Nosewheel steering and landing spoilers also have been added to the original Skyhawk. Both are produced at Long Beach with final assembly at Palmdale, California. In photo, A-4F.

Specifications (TA-4F)

Wing span 27 feet 6 inches; length 42 feet 10 inches; height 15 feet; empty weight 9,300 pounds; loaded weight 24,500 pounds; weapons weight 8,200 pounds; engine Pratt & Whitney J52-P-8A.

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 Super Sixty Series 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. Super 61, first of the Super Sixty Series versions, has a fuselage extension of 440 inches to a total of 187.4 feet and carries up to 251 passengers. Super 62, an ultra-long range transport, seats up to 189 passengers in a fuselage extended 80 inches to 157.4 feet and has a six-foot increase in wing span, increased fuel capacity and redesigned engine pylons and ducted fan nacelles. Super 63 is a combination of the full fuselage extension of Super 61 with pylon and engine pod modifications of the Super 62. First flight of the Super 61 was March 14, 1966; and of Super 62, August 29, 1966.

Specifications—(basic DC-8)

Span 142 feet 5 inches; length 150 feet 6 inches; height 42 feet 4 inches; wing area 2,773 square feet; crew 3-5 plus cabin attendants; engines 4 Pratt & Whitney 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 Series 10 with a fuselage 104.4 feet in length to accommodate up to 90 passengers, and Series 30 with an extension of 15 feet, seating as many as 115. Convertible passenger-cargo and executive models also are in production. All have Pratt & Whitney Aircraft JT8D ducted fanjet power plants, mounted on the aft fuselage. All versions are designed to operate from relatively short airfields. Wings of the larger Series 30 have leading edge slats to increase lift on takeoff. Features such as a self-contained boarding ramp and chest-level baggage compartment are of special value for service at airports of limited facilities. First flight of Series 10 February 25, 1965; first delivery September, 1965; certification, November, 1965. First flight Series 30, Aug. 1, 1966; certification, Nov. 1966.

Specifications

Span 87.4 feet; length 104.4 feet; height 27.4 feet; wing area 925 square feet; crew 2 plus cabin attendants; engines 2 Pratt & Whitney 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.

EC-135N APOLLO RANGE INSTRUMENTED AIRCRAFT

Program Direction: Electronics Systems Division, Air Force Systems Command
Contractors: Douglas Aircraft Modification Division (prime contractor for Apollo Range Instrumented Aircraft Program); Bendix Corporation (major subcontractor for electronics); The Boeing Company (basic airframe).

Remarks

The EC-135N is an Air Force jet transport modified to play an important role in the Apollo lunar landing program. A fleet of 8 Apollo Range Instrumented Aircraft will provide a highly mobile communications network which can be quickly shifted to allow coverage in areas where ground or sea stations cannot afford maximum radio and telemetry contact with Apollo astronauts. Most prominent addition to the transport is a huge protruding radome attached at the nose. The 10-foot-long bulb houses a 7-foot VHF and S-band parabolic dish antenna which will scan for a spacecraft, lock onto it and then transmit and receive voice and telemetry communications. Four of the aircraft will also be equipped with optical tracking and photographic equipment. The first EC-135N made its initial flight on September 19, 1966.

F-27J PROPJET TRANSPORT

Prime Contractor: Aircraft Division, Fairchild Hiller Corporation

Remarks

Fairchild Hiller has built 120 F-27 airplanes that are flown by 11 airlines and many corporations. This aircraft, one of the most efficient and economical twin-propjets in service, is now available in a new more powerful version—the F-27J. It is pressurized and completely air-conditioned on the ground as well as in flight. Important features of the F-27 are a highly reliable completely pneumatic retractable landing gear and braking system and fuel-carrying wings that have never experienced algae corrosion. The F-27 meets medium and short range requirements of regional airlines; offers 36, 40 or 44 passenger seating; operates from short runways and unimproved fields.

Specifications

Wing span 95 feet 2 inches; length 77 feet 6 inches; empty weight 21,961 pounds; operational weights: 42,000 take-off, 40,000 landing; engine Rolls-Royce Dart RDa 7/Mark 532-7 2,050 maximum horsepower; fuel capacity 1,364 or 2,063 gallons; propeller Rotol 4-blade constant speed; wing area 754 square feet.

Performance

Cruise speed 300 miles per hour at 20,000 feet; rate of climb 2,200 feet per minute at sea level; service ceiling 32,700 feet.

FH-227B PROPJET TRANSPORT

Prime Contractor: Aircraft Division, Fairchild Hiller Corporation

Remarks

Fairchild Hiller has introduced the FH-227B, an enlarged and improved version of the F-27. With a 6-foot longer fuselage, the FH-227B was designed to meet the requirements of short haul airlines for additional capacity for both passengers and cargo. A second new freight area is offered in the aft section.

Specifications

Wing span 95 feet 2 inches; length 83 feet; operational weights: 45,500 take-off, 45,000 landing; engine Rolls Royce Dart RDa 7/Mark 532-7 2,050 maximum horsepower, fuel capacity 1,364 or 2,063 gallons; propeller Rotol 4-blade constant speed; wing area 754 square feet; aileron area 37.6 square feet; total flap area 136.9 square feet; vertical tail including dorsal 190 square feet; rudder area (aft of hinge line) 33 square feet; horizontal tail surfaces 172 square feet; elevator area (aft of hinge line) 34 square feet.

Performance

Cruise speed 300 miles per hour at 20,000 feet; rate of climb 2,200 feet per minute at sea level; service ceiling 35,000 feet.

HELI-PORTER

Prime Contractor: Aircraft Division, Fairchild Hiller Corporation

Remarks

Fairchild Hiller has started production of 100 units of the Heli-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 Heli-Porter is an all-purpose aircraft capable of operating from extremely small unprepared fields. It features large double doors installed on either or both sides, depending on customer requirements. Interior configuration can be changed by one man in a matter of seconds without tools because of 4 "T" rails built into the floor to receive passenger seats, cargo tie-down rings, or stretchers. Arranged as a passenger aircraft, it can transport 8 people including the pilot.

Specifications

Wing span 50 feet; length 36 feet; empty weight 2,270 pounds; gross weight 4,850 pounds; useful load 2,500 pounds; wing area 310 square feet; 2 integral wing tanks have total capacity of 130 gallons.

Performance

Cruise speed 140 knots; range 550 nautical miles plus 30-minute fuel reserve; take-off run 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.

12E HELICOPTER

Prime Contractor: Aircraft Division, 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: Aircraft Division, Fairchild Hiller Corporation

Remarks

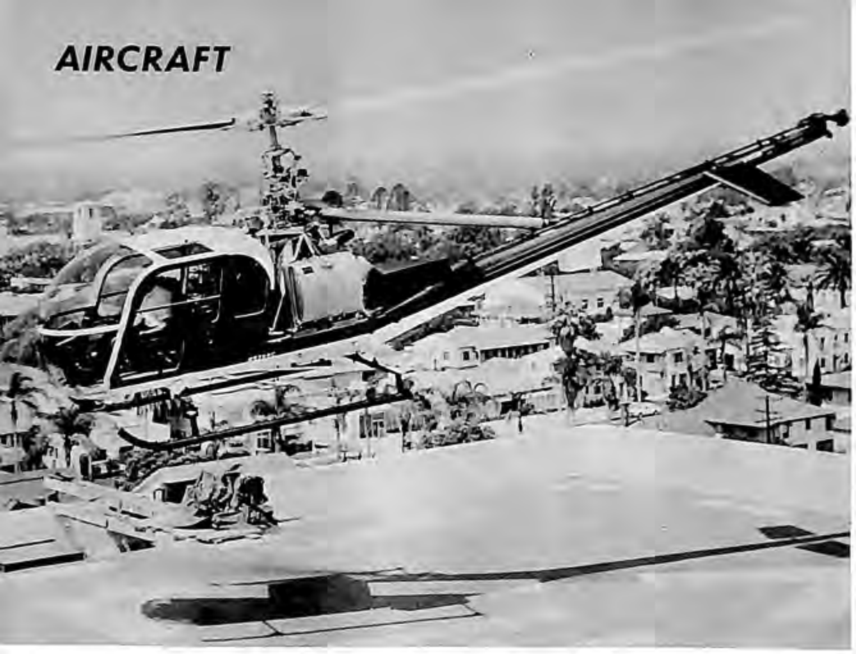
Built to meet the Army's high-altitude, rugged terrain requirements, the OH-23F is a four-place utility helicopter. As a civilian craft, the E4, it is in wide service in forestry work, missile site construction support, executive transportation and off-shore oil rig supply.

Specifications

Main rotor diameter 35.4 feet; tail rotor diameter 5.5 feet; length 29.8 feet; height 9.8 feet; empty weight 1,813 pounds; engine 1 Lycoming VO-540 305 horsepower.

Performance

Maximum speed 96 miles per hour at sea level; cruise speed 92 miles per hour; maximum rate of climb 1,920 feet per minute; service ceiling 19,300 feet; range with maximum load 225 miles.



SL4 HELICOPTER

Prime Contractor: Aircraft Division, Fairchild Hiller Corporation

Remarks

Powered by a 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.

F-84F THUNDERSTREAK FIGHTER BOMBER

Prime Contractor: Republic Aviation Division, Fairchild Hiller 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: Republic Aviation Division, Fairchild Hiller 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 the tactical Air Force 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.

CONVAIR 600/640

Prime Contractor: Convair Division of General Dynamics Corporation

Remarks

Convair 600 is the general designation for a Convair-Liner 240 airframe modernized with Rolls-Royce Dart turboprop engines. The Convair Liner 340 or 440 airframe with Dart engines is designated Convair 640. Among improved performance features of the 600's are a payload increase of up to 2,850 pounds and a cruising speed increase of 50 miles an hour.

Specifications

600: Wing span 91 feet 9 inches; length 76 feet 11 inches; height 26 feet 11 inches; passengers 40; 2 Rolls-Royce MK 542-4 turboprops with 3,025 shaft horsepower each; 2 Dowty Rotol 4-bladed 156-inch propellers; empty weight 28,250 pounds; gross weight 46,200 pounds.

640: Wing span 105 feet 4 inches; length 81 feet 5 inches; height 18 feet 2 inches; passengers 44; 2 Rolls-Royce MK 542-4 turboprops with 3,025 shaft horsepower each; 2 Dowty Rotol 4-bladed 156-inch propellers; empty weight 30,540 pounds; gross weight 55,000 pounds.

Performance

600: cruise speed 312 miles per hour at altitude of 10,000 feet at maximum cruise power; rate of climb 1,600 feet per minute; service ceiling 24,000 feet; maximum range 2,280 miles.

640: cruise speed 300 miles per hour at altitude of 10,000 feet at maximum cruise power; rate of climb 1,400 feet per minute; service ceiling 22,500 feet; maximum range 3,225 miles.

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.

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-111As for the U. S. Air Force and five aircraft designated F-111Bs 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 scheduled for first deliveries in 1967. The F-111B, which operates from aircraft carrier decks, is a Navy air superiority fighter. The same basic design is being used for four other F-111 airplanes that will be built by General Dynamics: RF-111A reconnaissance fighter, FB-111 strategic bomber, F-111A fighter/bomber for the Royal Australian Air Force, and F-111K fighter/bomber for the Royal Air Force. 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.

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.

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.

S-2E TRACKER

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

Grumman's S-2E tracker, built for the Navy, was designed to perform the complete antisubmarine warfare mission: detection, localization, classification and destruction of hostile submarines. The plane is equipped with a variety of electronic sensory and search devices coordinated with a tactical navigation system that features memory, display and automatic computation for solving tactical or navigational problems. Armament includes nuclear depth charges, depth bombs, rockets and homing torpedos.

Specifications

Span 72 feet 7 inches; length 43 feet 6 inches; height 17 feet 6 inches; power plants 2 Wright R-1820 1,525 horsepower engines.

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.

EA-6A ELECTRONIC COUNTERMEASURES AIRCRAFT

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

The EA-6A is the progenitor of a line of aircraft specifically created to monitor electronic emissions and interfere with automatically controlled weaponry. Twelve of these aircraft are in service with the Marine Corps, first service to fly this type of weapon system. The 2-place EA-6A will detect, locate, classify, record and jam radiations from enemy weaponry. Its main mission is to support strike aircraft and ground troops by suppressing air-to-air, air-to-ground and ground-to-air electronically controlled weapons. The EA-6A, which has the same airframe as the A-6A Intruder, can function in all weather conditions. Development of a second generation EA-6B electronic countermeasures craft with much greater capabilities is already under way at Grumman.

Specifications

Span 53 feet; length 55 feet; power plants 2 Pratt & Whitney Aircraft J52-P-6 turbojets 8,500 pounds thrust each.

C-2A GREYHOUND

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

A new carrier-on-board delivery system for the Navy, the C-2A Greyhound is designed to keep fleet units supplied with high priority items like jet engines and in addition to serve as a personnel transport for carrier groups. The C-2A permits the Navy to fly directly from land bases to operating forces at sea without disruption of battle efficiency. The aircraft has a fully-pressurized fuselage and a tail ramp loading device which allows ease of loading operations; it is readily convertible into a personnel carrier.

Specifications

Span 80 feet 7 inches; length 56 feet 6 inches; power plants 2 Allison T56A8 engines rated at 4,050 shaft horsepower each.

Performance

Range 1,300 nautical miles with a 10,000 pound payload.

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.

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.

GULFSTREAM I

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

The Grumman Gulfstream I is a twin-engine corporate transport with transcontinental range. The plane carries a 2-man crew and is designed for 10–14 passengers in the executive version or up to 24 passengers in a high-density configuration. The plane has short field flexibility. More than 180 Gulfstream I's have been sold to the nation's leading corporations.

Specifications

Span 78 feet 4 inches; length 64 feet; height 22 feet 9 inches; power plants 2 Rolls Royce Dart Mark 529-8H turboprops rated at 2,190 equivalent shaft horsepower.

Performance

Cruise speed 357 miles per hour; range more than 2,500 miles; service ceiling 39,000 feet.

GULFSTREAM II

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

A fast, long range corporate jet transport, Gulfstream II is a twin turbofan, T-tail aircraft which can fly from New York to Los Angeles against a continuous 90-knot headwind. Powered by 2 aft-mounted Rolls Royce Spey fanjets, the 10–19 passenger aircraft grosses 54,000 pounds. Gulfstream II also retains the short field flexibility of its predecessor, the turboprop Gulfstream I. By September, 1966, even before Gulfstream II had made its first flight, 55 customers had placed orders with Grumman for the plane.

Specifications

Span 68 feet 10 inches; length 79 feet 11 inches; cabin interior 34 feet long, head room 6 feet 1 inch; seating 10–19 normal, up to 30 in high density version; engine 2 Rolls Royce Spey RB-163-25 turbofans rated at 11,400 pounds thrust each.

Performance

Speed up to 585 miles per hour; range 3,010 nautical miles; rate of climb 4,000 feet per minute; cruise altitude 40,000 feet.

AG-CAT

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

The Grumman Ag-Cat is a biplane built specifically for crop dusting and spraying operations. It features high performance, safety characteristics and easy maintenance. Extremely safe, the Ag-Cat has gentle stall characteristics, excellent handling and control qualities and low maintenance costs. The plane is powered by a variety of engines; a new Super model has a Pratt & Whitney Aircraft 450 horsepower engine together with stronger construction, increased fuel capacity and higher gross weight.

Specifications (standard)

Span 35 feet 8 inches; length 24 feet 4 inches; height 10 feet 9 inches; gross weight 3,750 pounds; hopper load 220 gallons; engines 220 horsepower Continental, 240 horsepower Gulf Coast or 300 horsepower Jacobs.

Performance

Normal dusting speed 75-95 miles per hour; maximum speed 103 miles per hour; rate of climb 700 feet per minute.

XRON-1 ROTORCYCLE

Prime Contractor: Gyrodyne Company of America, Inc.

Remarks

The Rotorcycle is a single place coaxial helicopter originally developed under a Navy contract for possible field use with the Marine Corps. It won the "Grand Prix International de Giraviation" of the Aero Club de France at Le Bourget on June 1, 1961.

Specifications

Rotor system coaxial; fuselage length, including stabilizer empennage, 11 feet 6 inches; rotor diameter 20 feet, maximum gross weight 906 pounds; empty weight 550 pounds; powerplant, 1 Gyrodyne-Porsche YO-95-6 72 shaft horsepower.

Performance

Maximum speed sea level 66 knots; endurance 1.86 hours with 10 gallon fuel tank; maximum rate of climb with normal loading 1,140 feet per minute, service ceiling 12,400 feet; hovering ceiling IGE 7,300 feet.

MODELS 280U, 300

Prime Contractor: Hughes Tool Company, Aircraft Division

Remarks

The Model 300 (in photo) is a three-place aircraft designed for personal transportation and general utility operations such as traffic and power line patrol, aerial photography and offshore oil supply. Optional equipment includes floats, litters, cargo racks and external load sling. The Model 300 has a maximum speed of 87 miles per hour. Newest addition to the Hughes line of helicopters, the 280U is especially designed for operators who seek in a helicopter maximum utility at low cost. Light in weight, just 920 pounds empty, the 280U is powered by the same engine that has made the Model 300 famous. From its specially designed interior to its quiet tail rotor, the 280U is equipped to handle a variety of jobs including personal transportation, crop spraying and aerial observation. At design gross weight of 1,670 pounds, the Model 280U has a cruise speed of 80 miles per hour and a maximum cruise speed of 88 miles per hour.

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. Hughes will deliver a total of 351 TH-55A helicopters to the Army. The helicopter features low maintenance, low operating cost and low initial purchase price.

Specifications

Crew 1; main rotor diameter 25 feet 3 1/2 inches; length 28 feet 5 inches; height 8 feet 3 inches; design gross weight 1,600 pounds; useful load 590 pounds; engine Lycoming H10-360-B1A 180 horsepower.

Performance

Maximum speed 75 knots; endurance 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. Deliveries are now being made to the Army. 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.

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.

MODELS 500, 500U

Prime Contractor: Hughes Tool Company, Aircraft Division

Remarks

The Hughes 500 executive transport, luxurious commercial version of the U. S. Army's OH-6A, carries 5 people and their luggage. It is a helicopter designed to rival fixed-winged aircraft in executive transportation providing faster point-to-point travel up to 450 miles. Exceptional performance, luxurious appointments and low maintenance requirements make the Hughes 500 today's most advanced helicopter for the discerning executive. The companion Model 500U (in photo) provides maximum utility with its 40 cubic foot cargo compartment which eliminates cargo balance problems due to the compartment's position at the center of gravity of the aircraft. Extremely versatile, the 500U may carry up to 950 pounds of internal cargo in the aft compartment; total personnel carrying capability is seven including pilot. Speed, performance, low maintenance, exceptional external and internal cargo lifting capabilities enable the 500U to fulfill many roles in the fields of agriculture, forestry, construction, oil exploration and offshore supply.

HH-43B, HH-43F RESCUE/UTILITY HELICOPTER

Prime Contractor: Kaman Aircraft Corporation

Remarks

The Kaman Huskie has a unique intermeshing rotor system and servo-flap control system. In service with the Air Rescue Service of the Air Force and foreign governments around the world the Huskie has demonstrated an ability to perform in the jungles, mountains and remote corners of the world previously inaccessible to aircraft. The Huskie has established a record of safety and reliability far exceeding that of any military aircraft ever in service.

Specifications

HH-43B powered by Lycoming T53-L-1B and HH-43F by T53-L-11A. Two intermeshing, counter-rotating two-bladed rotors, diameter 47 feet; height 12.6 feet; empty weight 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.

UH-2C RESCUE/UTILITY HELICOPTER

Prime Contractor: Kaman Aircraft Corporation

Remarks

The UH-2C is a conversion to twin-turbine configuration of a number of UH-2A/B's under a Navy contract awarded Kaman. Retrofitting the craft with 2 General Electric T58-8 engines provides the Seasprite with twin-engine reliability for nighttime overwater rescue missions. Compact and able to operate from fleet vessels as small as destroyers, the UH-2C has completely self-contained navigation capability.

Specifications

Length 52.5 feet; height 13.6 feet; empty weight 7,440 pounds; gross weight 9,951 pounds; overload gross weight 11,614 pounds; main rotor, single, 4-bladed, 44 feet diameter; tail rotor, 3-bladed, 9.3 feet diameter; engines 2 General Electric T58-8, 1,250 shaft horsepower each.

Performance

Maximum speed 162 miles per hour; cruise speed 152 miles per hour; normal range 466 miles; ferry range 570 miles; rate of climb, sea level, 1,890 feet per minute; hover ceiling, OGE, 15,900 feet; service ceiling 18,300 feet.

LA-4 AMPHIBIAN

Prime Contractor: Lake Aircraft Corporation

Remarks

The Lake LA-4 is an all-metal mid-wing 4-passenger amphibian aircraft. It has retractable tricycle gear and large flaps, both actuated by an engine-driven hydraulic system. This system is backed up for emergency use by a manually-operated hand pump. The aircraft is powered by the Lycoming 180 horsepower 0-360A1A used in pusher configuration and it utilizes a Hartzell forged dural controllable constant-speed metal propeller. The aircraft is unusually rugged and is capable of operating from short fields and in extremely rough water conditions. This high-performance amphibian is enjoying a wide acceptance on the world market, several having been flown to Europe and to Australia.

Specifications

Wing span 38 feet; wing area 170 square feet; wing load 14.1 pounds per square foot; length 24 feet 11 inches; height 9 feet 4 inches; gross weight 2,400 pounds; empty weight 1,555 pounds; useful load 845 pounds.

Performance

Speed 132 miles per hour; stall speed 50 miles per hour; take-off run 650 feet (land), 1,125 feet (water); landing roll 475 feet (land), 600 feet (water); rate of climb 800 feet per minute.

LEAR JET MODEL 24

Prime Contractor: Lear Jet Industries, Inc.

Remarks

A growth version of the Lear Jet Model 23, the Lear Jet Model 24 was certified in March, 1966, under part 25 of the new Federal Air Regulations. In May, 1966, a standard, production Lear Jet Model 24, with no auxiliary fuel, circled the globe in 50 hours 21 minutes flying time. Total elapsed time, including 17 stops, was 65 hours and 40 minutes. The officially-sanctioned flight established 18 world speed records in the business jet category, but more importantly, demonstrated the performance, reliability, and flexibility available via modern business jet aircraft. More than 140 Lear Jet 23/24 aircraft were delivered by end of 1966 to corporate firms in the United States and abroad.

Specifications

Span 35 feet 7 inches; length 43 feet 3 inches; height 12 feet 7 inches; wing sweepback 13 degrees; take-off gross weight 13,000 pounds; pressure differential 8.78 pounds per square inch; engines 2 General Electric CJ610-4.

Performance

Speed 565 miles per hour; stall speed, normal landing weight 104 miles per hour; maximum range with 45-minute reserve 1,780 statute miles; cruising altitude 41,000 feet; 1 engine service ceiling 26,000 feet; rate of climb at sea level 6,300 feet per minute; 2 engine take-off over 35-foot obstacle 3,017 feet; 2 engine landing over 50-foot obstacle 3,307 feet.

LEAR JET MODEL 25

Prime Contractor: Lear Jet Industries, Inc.

Remarks

First flown August 12, 1966, the Lear Jet Model 25 was scheduled for initial delivery in the spring of 1967. Measuring 4 1/2 feet longer than the Lear Jet Model 24, the new Model 25 Transporter carries a total of 8 passengers plus 2 pilots, 2 passengers more than the Model 24. The aircraft's program flight test indicated availability of essentially the same high performance as the Model 24, with certain advances in range, load-carrying ability, cruising altitude, and other criteria. Single point refueling is standard.

Specifications

Span 35 feet 7 inches; length 47 feet 7 inches; height 12 feet 7 inches; wing sweepback 13 degrees; take-off gross weight 15,000 pounds; pressure differential 8.94 pounds per square inch; engines 2 General Electric CJ610-6.

Performance

Speed 565 miles per hour; stall speed, normal landing weight, 105 miles per hour; maximum range with 45-minute reserve 1,950 statute miles; cruising altitude 45,000 feet; 1 engine service ceiling 25,000 feet; rate of climb at sea level 5,600 feet per minute; 2 engine take-off over 35-foot obstacle 3,750 feet; 2 engine landing over 50-foot obstacle 3,307 feet.

LEAR LINER MODEL 40

Prime Contractor: Lear Jet Industries, Inc.

Remarks

The Lear Liner Model 40 is designed to fill existing gaps of available equipment in two categories: scheduled and non-scheduled airline, and the corporate market. In the former, the airplane will seat 40 passengers, crew of two and a stewardess. In its business aircraft configuration, the Lear Liner will seat up to 16 in plush, customized comfort. Scheduled for first flight in the fall of 1967, the Model 40 will be available for deliveries following planned Federal Aviation Agency certification by mid-year 1968.

Specifications

Span 70.67 feet; length 95.66 feet; height 24.42 feet; wing sweepback 25 degrees; take-off gross weight 51,808 pounds; pressure differential 8.94 pounds per square inch; engines 2 Rolls-Royce Spey turbofans.

Performance

Speed 580 miles per hour; stall speed, normal landing weight, 106 miles per hour; maximum range with 45-minute reserve 3,350 statute miles; cruising altitude 45,000 feet; 1 engine service ceiling 26,500 feet; rate of climb at sea level 5,000 feet per minute; 2 engine take-off over 35-foot obstacle 3,530 feet; 2 engine landing over 50-foot obstacle 3,430 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. 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 misssions. 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.

RF-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 Aerospace Corporation 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, 1965 and a fifth delivered in August, 1966. Designed to operate from landing areas as small as 350-feet square, the XC-142A will carry 32 fully-equipped combat troops or 8,000 pounds of cargo. With its wing tilted straight up, its four T64 turboprop engines permit it to make vertical take-offs, transition to level flight and fly up to 430 miles an hour. The XC-142A made its first flight September 29, 1964; its first hover flight December 29, 1964, and first full transition flight 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 2,200 Super Starfighters for the air arms of 14 free world nations—Germany, Canada, Belgium, The Netherlands, Italy, Japan, Norway, Turkey, Greece, Nationalist China, Pakistan, Denmark, Spain and the United States.

Specifications

Span 21 feet 11 inches; length 54 feet 9 inches; height 13 feet 6 inches; gross weight 28,800 pounds; engine General Electric J79 16,000 pounds thrust with afterburner.

Performance

Speed Mach 2 plus; altitude above 100,000 feet.

P-2 NEPTUNE

Prime Contractor: Lockheed-California Company

Remarks

The P-2 Neptune made its first flight in May, 1945 and today—more than 20 years later—it is ably performing its antisubmarine patrol mission for the U.S. Navy and for other free world nations. Steady refinements and new additions kept the P-2 modern and up-to-date through seven models. Although the P-2 is gradually being replaced in the Navy by Lockheed's P-3A Orion, it still bears the insignia of seven other nations, including The Netherlands, France, Canada, Australia, Brazil, Japan and Argentina.

Specifications

Span 103 feet; length 91 feet 5 inches; height 29 feet 4 inches; gross weight 72,000 pounds; engines 2 Wright R3350-32 turbo compounds.

Performance

Speed 300 miles per hour; altitude 22,000 feet.

P-3 ORION

Prime Contractor: Lockheed-California Company

Remarks

The P-3 Orion is an advanced, long-range, anti-submarine patrol aircraft which has been in service with the Navy since August, 1962. The Orion carries the latest, most efficient ASW equipment and has sufficient space, weight and power reserve to incorporate ASW systems of the future. Orions have also been purchased by New Zealand, and Australia has announced plans to purchase the P-3.

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. 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 8 feet 2 inches; 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 8 feet 2 inches; 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 3500 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. Exactly a year later the Model 286 received its Federal Aviation Agency type certificate. It was the first rigid-rotor helicopter to be certificated by the FAA. It has a wide range potential for transport, rescue, and various military missions. As a light anti-submraine 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.

ADVANCED AERIAL FIRE SUPPORT SYSTEM (AAFSS)

Prime Contractor: Lockheed-California Company

Remarks

A U.S. Army contract for the engineering development of the Advanced Aerial Fire Support System was awarded in March, 1966, to Lockheed, whose winning design was chosen from open competition in the AAFSS. This winged rotorcraft is designed to replace armed helicopters now used by the Army. AAFSS will escort troop-carrying helicopters enroute to objective areas and provide suppressive fire in the landing zones during air mobile operations. The AAFSS compound helicopter will have a two-man crew and will mount various combinations of weapons. It will have all-weather day and night operational capability. AAFSS will have the Lockheed rigid-rotor system. First helicopters conceived and designed exclusively as weapons ships, the AAFSS aircraft are being developed on an expedited basis.

Specifications

Fuselage length 55 feet; height 14 feet; rotor blade diameter 50 feet; engine General Electric T64-16 gas turbine.

Performance

Maximum speed 250-plus miles per hour; cruising speed 230-plus miles per hour.

XV-4B HUMMINGBIRD

Prime Contractor: Lockheed-Georgia Company

Remarks

The XV-4B Hummingbird is a vertical take-off and landing (VTOL) mid-wing monoplane, with provisions for a crew of 2 in a side-by-side seating arrangement. Uniquely, this aircraft is a 6-engine direct and diverted thrust V/STOL configuration which resembles most closely a compact, twin-engine jet observation aircraft. Four of the engines are vertically mounted in the fuselage and are used for lift only, while 2 cruise engines are mounted horizontally in the nacelles, providing normal thrust for conventional flight and lift thrust for hover and transitional flight through thrust diversion by means of diverter valves. Vertical flight, hover, transition, and horizontal flight take place in this manner: With the diverter valves positioned to cause the dual-cruise engine exhaust to flow out the bottom of the airplane, accompanying the thrust from the four direct-lift engines, the throttles are advanced and the plane rises vertically. Small jets in the wing tips, nose, and tail are used to direct roll, pitch and yaw, deriving their power from a common engine compressor bleed air system. After obtaining the desired height over adjacent obstacles, the transition to forward flight is accomplished by tilting the nose downward to obtain a horizontal thrust component from the lift and diverted cruise engines.

Specifications

Overall length 33 feet, 9.4 inches; wing span 27 feet, 1 inch; 6 modified General Electric J85 turbojet engines provide a total of 18,000 pounds thrust.

C-140 JETSTAR EXECUTIVE AND MILITARY JET TRANSPORT

Prime Contractor: Lockheed-Georgia Company

Remarks

The JetStar is a 575-mile per hour, 4-engine, multi-mission transport, stressing reliability and safety with double and triple backup systems; it is the only 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 60 of the world's top corporations. Because of this proven experience and reliability, it has been selected for use in the Presidential jet fleet. Air Force Communications Service and Military Airlift Command operate C-140A and VC-140B JetStars. The compact jetliner seats 10 passengers and a crew of two. It is also available in a 19-place military version, which can be quickly transformed to a cargo-personnel transport with a 3,500-pound combined payload, or to a hospital plane. A new breed, the "Dash 8" was scheduled for 1967.

Specifications ("Dash 8")

Span 54 feet 5 inches; length 60 feet 5 inches; height 20 feet 5 inches; wing sweepback 30 degrees at 25 percent chord; maximum take-off weight 41,-900 pounds; engines 4 Pratt & Whitney JT 12A-8s, 3,300 pounds thrust each.

Performance

Maximum speed 575 miles per hour; unrefueled range 2,250 statute miles with 8 passengers; certificated altitude 43,000 feet.

C-130E HERCULES TRANSPORT

Prime Contractor: Lockheed-Georgia Company

Remarks

The C-130E is an advanced version of the C-130A and C-130B, embodying various structural and system modifications. Maximum payload has been increased to 45,000 pounds and this weight can be carried over 2,100 nautical miles. Using an overload take-off weight, the payload can be carried over 3,100 nautical miles. The C-130E is designed for the optional use of externally mounted wing fuel tanks. The use of these external tanks gives this model Hercules true trans-ocean capability. More than 435 of the C-130E models are being produced for the Air Force, the Navy, and foreign countries.

Specifications

Wing span, 132.6 feet; overall length, 97.7 feet; height, 38 feet; cargo floor height above ground, 41 inches; maximum payload, 45,000 pounds; maximum overload take-off weight, 175,000 pounds; maximum take-off weight, 155,000 pounds; fuel capacity, 9,680 gallons; Engines 4 Allison T56-A-7 propjet, 4,050 shaft horsepower each.

Performance

Range with maximum payload, approximately 2,100 nautical miles; high speed cruise, 315 knots; take-off run at 155,000-pound gross weight, 3,800 feet; landing ground run at design weight, 2,120 feet; propellers, Hamilton Standard, 4 blades, 13.5 feet diameter, full reversing capability.

HC-130H 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. The HC-130H entered operation with the Air Rescue Service in late 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 is 10.

Specifications

Wing span 132.6 feet; overall length 101.6 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 318 knots; take-off run at 155,000 pounds gross take-off weight 4,140 feet; take-off run at 175,000 pounds gross take-off weight, 6,000.

HC-130P AERIAL REFUELER FOR HELICOPTERS

Prime Contractor: Lockheed-Georgia Company

Remarks

The HC-130P Hercules of Aerospace Rescue and Recovery Service (ARRS) with an in-flight refueling system for helicopters can refuel two CH-3C/HH-3E helicopters simultaneously. It is the first production aircraft of this type in the world. The system includes a hose reel pod on a pylon under each outer wing. This version has beefed-up outer-wing tank areas, back-up fuel pumps, and special electronic equipment. Fuel for the in-flight refueling system may be carried in the main, auxiliary, external, and fuselage tanks as required. The system is capable of delivering 150 gallons of fuel per minute to each helicopter. Fuel is delivered through approximately 85 feet of hose reeled out from the under-wing pods. Helicopters lock into the drogues at speeds from 105 to 120 knots air speed at altitudes up to 5,000 feet.

Specifications

Wing span, 132.6 feet; length, 101.6 feet; height, 38 feet; power plants, 4 Allison T56A-15 propjets of 4,200 shaft horsepower each, driving 4-bladed Hamilton Standard 13.5 foot diameter hydromatic propellers; maximum fuel capacity, 13,280 gallons.

Performance

In a typical mission, the HC-130P, with a maximum 155,000 pounds gross take-off weight, can fly 1,800 nautical miles, then off-load 9,000 pounds of fuel at 5,000-foot altitude and return to its original departure point with its required military fuel reserve.

EC-130E HERCULES

Prime Contractor: Lockheed-Georgia Company

Remarks

This new version of the military C-130E Hercules provides the U. S. Coast Guard with a multiple-duty, long-range aircraft. It is an electronics mission aircraft designed specifically for use in calibrating LORAN A and C chains around the world operated by the Coast Guard. It will also test new airborne electronic equipment. Other missions include air search and rescue and logistics cargo-personnel transport. The EC-130E contains a specially-designed Staff-Pak to provide a relatively noise-free environment for electronic evaluation/calibration missions. The Staff-Pak consists of 4 7 1/2-foot cube compartments, or modules, which interlock into a single unit to provide work space, lavatory and galley facilities for 12 persons.

Specifications

Wing span 132.6 feet; overall length 97.7 feet; height 38 feet; maximum payload with maximum fuel 35,926 pounds; maximum gross take-off weight 151,522 pounds; fuel capacity 6,960 gallons; power plants 4 Allison T56A-7 propjet engines.

Performance

The EC-130E has a cruising speed of 300 knots true air speed with normal power, at 148,000 pounds gross take-off weight and 20,000-foot altitude; maximum range is 2,800 nautical miles at long-range cruise, with maximum fuel, 35,926 pounds payload, and 4,260 pounds of reserve fuel.

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 12 nations. Powered by 4 propjet engines, the L382B will carry a 49,000 pound payload nonstop over 2,000 nautical miles. At maximum landing weight of 130,000 pounds, normal landing distance is 4,760 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.

Specifications

Wing span 132.6 feet; length 97.7 feet; height 38 feet; cargo floor above ground 3.4 feet; maximum payload 49,000 pounds; engines 4 Allison 501-D22 turboprop, 4,050 shaft horsepower each; maximum take-off weight 155,000 pounds; maximum landing weight 130,000 pounds; normal crew 3; clear cube volume 4,300 cubic feet; bulk loaded volume 5,000 cubic feet.

Performance

Range with maximum payload 1,920 nautical miles; range with 30,000 pounds payload 3,250 nautical miles; high speed cruise 300 knots.

LOCKHEED-100 HERCULES

Prime Contractor: Lockheed-Georgia Company

Remarks

The Lockheed-100 started service Sept. 15, 1966, serving Delta Air Lines. The Hercules, a propjet cargo carrier, is capable of payloads of up to 45,747 pounds, exclusive of the weight of loading system, pallets, nets, and container. The aircraft carries, as a standard, five pallets plus a ramp container. The pallets are made of plywood and have a capacity of 10,000 pounds each. They measure 88 inches by 118 inches and can be stacked with cargo to a height of 102 inches. The cargo compartment features straight-in-and-out loading at the rear of the fuselage. The compartment measures 38 feet from the forward barrier net to the ramp hinge, plus 10.3 feet on the ramp. It is 10.1 feet wide and 9 feet high.

Specifications

Length 97.7 feet; height 38 feet; wing span 132.6 feet; maximum take-off weight 155,000 pounds; maximum net payload 45,747 pounds; crew 3; 4 Allison 501-D22 turboprop engines, driving 4-blade Hamilton Standard hydromatic propellers; fuel 50,-926 pounds.

Performance

Maximum cruise speed 300 knots; range with maximum payload 1,920 nautical miles take-off distance at 155,000 pounds gross weight 6,910 feet; landing at 130,000 pounds gross weight 4,760 feet; actual landing roll 2,120 feet.

C-141A STARLIFTER CARGO-TROOP CARRIER

Prime Contractor: Lockheed-Georgia Company

Remarks

The C-141 StarLifter, fanjet cargo-troop carrier which can cross any ocean nonstop, is in service with the Air Force's Military Airlift Command. It will airlift a 70,847 pound payload 3,975 miles nonstop, or 31,000 pounds 6,040 miles nonstop. Ferry range is 6,840 miles. The C-141 will transport the Minuteman missile or it will transport 154 troops or 123 paratroopers or 80 litters with 16 ambulatory patients and/or attendants. The StarLifter began squadron duty in 1965, and received its FAA certificate as a commercial freighter in January, 1965. It is flying supplies to Viet Nam, and is the first fanjet from which troops have jumped.

Specifications

Wing span 159.9 feet; length 145.0 feet; height 39.3 feet; wing sweepback 25 degrees; take-off weight 316,100 pounds; engines four Pratt & Whitney TF33-P-7 fanjets, 21,000 pounds thrust each; dual wheel nose landing gear; 4-wheel bogie main landing gear; cargo compartment 81 feet long (including ramp), 9.1 feet high, 10.25 feet wide.

Performance

Speed 550 miles per hour; ferry range 6,840 miles; maximum payload range 3,975 miles; cargo compartment and flight station pressurized for 8,000-foot cabin altitude at 40,000 feet, or sea level cabin up to 21,000 feet.

LOCKHEED-200 COMMERCIAL STARLIFTER

Prime Contractor: Lockheed-Georgia Company

Remarks

The Lockheed commercial StarLifter has essentially the same capabilities as the C-141As in Military Airlift Command service. First aircraft developed from inception as both a military airlifter and commercial airfreighter, the StarLifter will carry up to 72,000 pounds of cargo across the Atlantic. Lockheed-Georgia and major subcontractors sponsored the transport's demonstration tours in 1966 to show its truckbed-level, straight-in rear loading, and mechanized loading systems. In August, 1966, it delivered German and French stages of the Europa I space vehicle from LeBourget Field, Paris to Woomera, Australia in 20 1/2 hours flying time.

Specifications

Wing span 159.9 feet; length 145.0 feet; height 39.3 feet; wing sweep 25 degrees; take-off weight 316,100 pounds; engines 4 Pratt & Whitney JT3D-8A fanjets of 21,000 pounds thrust each; dual-wheel nose landing gear; 4-wheel bogie main landing gear; cargo compartment 81 feet long, including ramp; 9.1 feet high; 10.25 feet wide.

Performance

Speed 550 miles per hour; ferry range 7,040 miles; maximum payload range 3,660 miles; cargo compartment and flight station pressurized for cabin altitude of 8,000 feet at 40,000 feet, or sea level up to 21,000 feet.

C-5A CARGO/PERSONNEL CARRIER

Prime Contractor: Lockheed-Georgia Company

Remarks

Primary mission of the C-5A, which will be the world's largest aircraft, is to provide a significant increase in the Military Airlift Command's ability to airlift all types of combat and support forces. Basic requirements are for very high payload and cargo volume, intercontinental range, support area airfield operations, and air-dropping of troops and equipment. Double-deck design provides cargo compartment 121 feet long between ramps, 19 feet wide, and 13 1/2 feet high. Flight or relief crews, and support personnel for vehicles carried below, ride on upper deck. Prototype roll-out is due in February, 1968; first flight in June, 1968. Operational deliveries will begin a year later.

Specifications

Wing span 222.7 feet; length 245.9 feet; height 64.7 feet; wing sweep 25 degrees; gross take-off weight (2.5 g) 728,000 pounds; engines 4 General Electric TF-39 turbofans of 41,100 pounds thrust each; 4-wheel nose landing gear; 4 6-wheel-bogie main landing gears.

Performance

Maximum cruise speed 470 knots; long-range cruise speed 440 knots; range with 220,000 pounds design payload 3,050 nautical miles; range with 112,600 pounds payload 5,500 nautical miles.

LOCKHEED-500

Prime Contractor: Lockheed-Georgia Company

Remarks

Proposed as a commercial derivative of the military C-5A, the Lockheed-500 has three basic configurations: all-passenger, combination passenger and cargo, and all-cargo. The all-passenger version can carry 844 persons in tourist-class appointments, or 667 luxury-class. The combination interior will carry 231 passengers on the upper deck and 257,321 pounds cargo on the main deck. The all-cargo model will carry 330,000 pounds of freight including loading provisions. Fuselage volume is sufficient to accommodate three decks for the all-passenger airplane. Direct operating costs and passenger-mile and ton-mile costs are expected to set new lows for a commercial transport.

Specifications

Wing span 222.7 feet; length 245.9 feet; height 65.1 feet; wing sweep 25 degrees; gross take-off weight 845,000 pounds; engines 4 Rolls-Royce RB-207 turbofans in the 50,000-pound thrust class each.

Performance

Maximum cruise speed 470 knots; long-range cruise 440 knots; range with maximum payload 2,350 nautical miles; range with maximum fuel 4,900 nautical miles; take-off field length, maximum gross weight 9,050 feet; landing field length, 702,360 pounds, 6,900 feet.

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

Remarks

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-4C PHANTOM FIGHTER-BOMBER

Prime Contractor: McDonnell Company

Remarks

The F-4C Phantom is an Air Force fighter-bomber aircraft, a 2-engine, 2-man, all-weather weapon system employed for the close support and attack mission of Tactical Air Command, PACAF and USAFE. Basic armament of the F-4C is 4 radar-guided Sparrow III air-to-air missiles carried semi-submerged under the fuselage; 2 additional Sparrow III's or 4 infrared-guided Sidewinders may be carried on wing stations. First flight of the F-4C was made on May 27, 1963, less than 14 months after McDonnell received contractual go-ahead from the USAF. The first two aircraft were delivered on November 20, 1963, and the last of 583 F-4C's was delivered on May 4, 1966. The F-4D Phantom is augmenting the F-4C in the USAF inventory.

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 2,300 miles; airborne in less than 3,000 feet, lands in even less distance.

F-4B PHANTOM AIR SUPERIORITY FIGHTER

Prime Contractor: McDonnell Company

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.

RF-4B PHANTOM RECONNAISSANCE FIGHTER

Prime Contractor: McDonnell Company

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 Company

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-4D PHANTOM

Prime Contractor: McDonnell Company

Remarks

The Air Force's newest, fastest and highest-flying fighter bomber, the F-4D is the second version of the Phantom to enter USAF service. The plane has essentially the same airframe and engines as its predecessor, the F-4C, but it carries major systems improvements which increase its capability to deliver accurate air-to-ground weapons. The F-4D is equipped with a new APQ-109 fire control radar system. First flight of the F-4D took place at Lambert-St. Louis Municipal Airport on December 8, 1965. On March 10, 1966, the first F-4D was delivered to the USAF at Warner-Robbins AFB, Georgia, later flown to Bitburg, Germany as the forerunner of several squadrons of F-4D's that are replacing F-105 aircraft stationed there.

F-4J PHANTOM

Prime Contractor: McDonnell Company

Remarks

An advanced version of the Phantom II series, the F-4J was the 6th model to reach production status. It made its first public flight on May 27, 1966, the 8th anniversary of the initial flight of the first airplane of the Phantom II series. Being delivered to both the Navy and the Marine Corps, the F-4J has a higher maximum speed, greater range, higher combat ceiling, shorter take-off distance, lower approach speeds and better air-to-air and air-to-ground combat capabilities than any predecessor Phantom model. Major improvements include a new radar system, a new bombing system, new electronics systems, improved control surfaces and new engines. The 2 General Electric J79-10 engines each produce 17,900 pounds thrust at take-off, provide additional acceleration at supersonic speeds and operate with reduced fuel consumption at cruise speeds. Above Mach 2 each engine produces 2,000 pounds more thrust than the J79-8/15 engines that power the earlier B and C models.

F-4K PHANTOM

Prime Contractor: McDonnell Company

Remarks

The F-4K, which made its initial flight on June 28, 1966, is the 8th production model of the Phantom II series and the first to be purchased outside the United States; it is a specially designed version for use by the United Kingdom's Royal Navy. In many respects the plane is similar to the U.S. Navy's F-4J. Among the major differences are an extendible nose landing gear and provisions for folding the radome and radar antenna to permit use of the 54-foot elevators on the British carriers (folding reduces the overall length to just under 52 feet). Prime difference is the substitution of Rolls-Royce Spey engines for the J79's in the American versions; the larger Speys give the F-4K an increase in performance capability over U.S. versions in virtually every area of flight. The United Kingdom also ordered a Royal Air Force version, designated F-4M; first flight was scheduled for 1967.

F-101B VOODOO INTERCEPTOR

Prime Contractor: McDonnell Company

Remarks

The F-101B has the greatest combination of speed and long-range of any operational interceptor in the Air Defense Command. It is equipped with Genie rockets possessing a nuclear capability. In addition, it carries conventional rockets and Falcon missiles. The F-101B is a 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 Company

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 800 feet per minute at gross weight; 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 1,575 pounds; useful load 1,000 pounds; baggage 120 pounds; wing loading 15.4 pounds per square foot; power loading 12.9 pounds per horse-power; 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 1,110 feet per minute; normal range 1,024 miles; service ceiling 18,800 feet.

MOONEY MUSTANG

Prime Contractor: Mooney Aircraft, Inc.

Remarks

The Mustang is an advanced single engine business aircraft with pressurized cabin seating 4–5. It was designed as a high performance airplane capable of going anywhere, anytime, at a practical price. With a self-imposed operational ceiling of 24,000 feet, the Mustang will fly above virtually any en route weather. The 310 horsepower engine is turbo-charged. The Mustang will fly at speeds up to 250 miles per hour.

Specifications

Span 35 feet; length 26 feet 11 inches; height 9 feet 11 inches; gross weight 3,680 pounds; useful load 1,300 pounds; engine 1 Lycoming T10-541-AIA; usable fuel 92 gallons.

Performance

Maximum level speed 253 miles per hour; maximum recommended cruise 230 miles per hour; stall speed 69 miles per hour; gross weight rate of climb at sea level 1,120 feet per minute; take-off over 50-foot obstacle 2,079 feet; maximum certificated operational ceiling 24,000 feet; maximum range over 1,100 statute miles.

MOONEY MU-2

Prime Contractor: (U.S., Mexico & Canada) Mooney Aircraft, Inc.

Remarks

The Mooney MU-2 is a new 7-place, twin turboprop, executive transport featuring exceptionally high speeds with good short-field capabilities at a practical investment and operating cost. It can cruise at 310 mph and has a 26,500 feet ceiling. Passengers enjoy air conditioned and pressurized comfort. Its two 605 shaft horsepower engines, full-span double slotted flaps, and reversible propellers allow the Mooney MU-2 to get in and out of short airstrips.

Specifications

Span 38 feet 9 inches; length 33 feet 3 inches; height 13 feet; gross weight 8,930 pounds; useful load 3,600 pounds; engines 2 AiResearch TPE-331; fuel 295 gallons.

Performance

Maximum level speed 325 miles per hour; maximum cruising speed at 10,000 feet 310 miles per hour; stall speed 74 miles per hour; rate of climb 2,000 feet per minute; maximum range 1,200 miles.

MOONEY EXECUTIVE 21

Prime Contractor: Mooney Aircraft, Inc.

Remarks

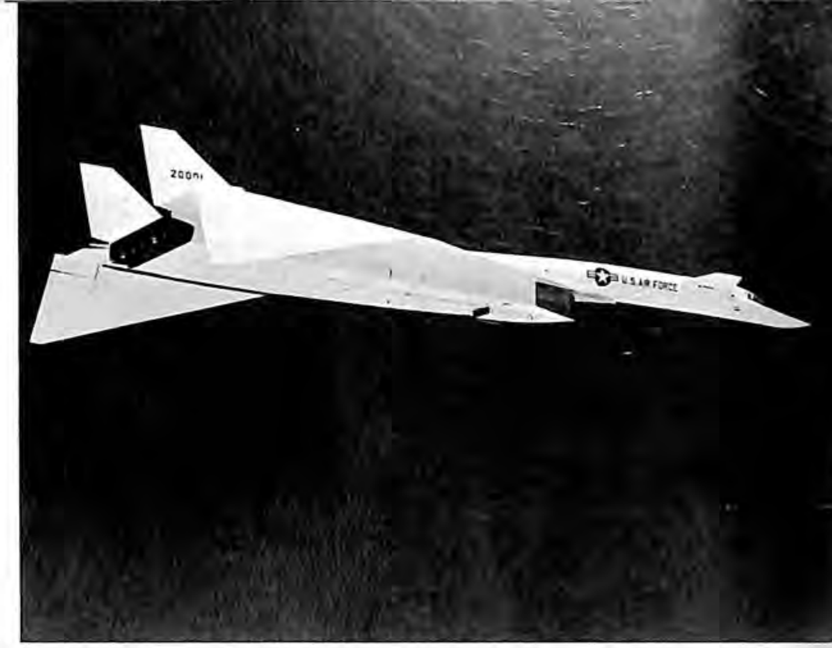
The Mooney Executive 21 combines all the high performance features of the Mark 21 and Super 21 with a longer fuselage allowing more leg room for both front and back seat passengers. It has individually reclining seats and a longer range. The Executive 21 features three windows on each side and a full-length rudder. It has modified wing tips which reduce aileron pressures to provide easier control response.

Specifications

Span 35 feet; length 24 feet 3.1 inches; height 8 feet 4.5 inches; gross weight 2,740 pounds; empty weight 1,622 pounds; useful load 1,118 pounds; baggage 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 inch; engine 1 Lycoming IO-360-200 horsepower; propeller 74-inch constant speed; fuel capacity 64 gallons.

Performance

Maximum level speed 197 miles per hour; maximum cruise speed at 75 percent power 187 miles per hour; stall speed 64 miles per hour; rate of climb 1,080 feet per minute; maximum range 1,432 miles at 10,000 feet; service ceiling 17,900 feet.



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 2,500 pounds, empty weight 1,475 pounds; useful load 1,025 pounds; baggage 120 pounds; wing loading 15.4 pounds per square foot; power loading 14.3 pounds per horsepower; wing area 167 square feet; engine 1 Lycoming 0-360-180 horsepower; fuel capacity 52 gallons.

Performance

Maximum level speed 146 miles per hour at sea level; cruise speed at 75 percent power 138 miles per hour at 10,000 feet; stall speed 57 miles per hour; rate of climb 740 feet per minute; maximum range, 750 miles; service ceiling 13,600 feet.

XB-70A RESEARCH AIRCRAFT

Prime Contractor: 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. The No. 2 aircraft flew sustained Mach 3 for 32 minutes on May 19, 1966. On June 8, 1966, it crashed after a mid-air collision with one of its chase planes. At that time the two XB-70 airplanes had accumulated 95 flights totaling more than 185 hours. Its design features include a canard on the forward fuselage, wing tips that fold downward during high speed flight to increase directional stability, and use of the "compression lift" principle which enables the aircraft to "ride" its own shock waves at high Mach numbers.

Specifications

Span 105 feet; length 185 feet; height 30 feet; weight over 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 90 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 560 miles per hour plus; range 2,005 miles; altitude 40,000 feet, certified to 45,000 feet (business version).

X-15 RESEARCH AIRCRAFT

Prime Contractor: 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. Vehicle No. 2 has been fitted with twin droppable external fuel tanks which are needed to extend burning time in program to achieve Mach 8.

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-100 SUPER SABRE

Prime Contractor: North American Aviation, Inc.

Remarks

The F-100 Super Sabre was the first supersonic fighter in the U.S. Air Force Tactical Air Command. The first production model, the F-100A was delivered in October 1953. It was produced in four models, the A, C, D, and F. The F-100A, an air superiority fighter, is flown by the Air National Guard. The F-100C, with in-flight refueling and bombing capabilities, is assigned to the Air Force's tactical fighter wings. The D and F fighter-bomber models are providing the Tactical Air Command with a long range nuclear striking power and supersonic air-to-air combat ability. In addition to its bomb armament and four 20 millimeter cannon, the Super Sabre can be equipped to fire rockets and missiles, including the heat-seeking Sidewinder. The world-famous Thunderbird aerial demonstration team marked its tenth anniversary of flying in F-100 aircraft in June, 1966.

Specifications

Span 38 feet; length 47 feet; height 16 feet; weight 18,239 to 22,337 pounds according to model; engine J57, 10,000 pounds thrust class; crew, pilot, except F model, pilot and observer or student.

Performance

Speed more than 800 miles per hour; range more than 1000 miles; altitude more than 50,000 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. By September 1966 10 Free World nations had received quantities of F-5's. Canada and Spain are planning to build F-5's under licensing agreements. 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.

Specifications

Span 26 feet 7 inches with wing tip armament; length 45 feet; height 13 feet 2 inches; weight 13,000 pounds with full internal fuel; external lead 6,200 pounds of air-to-air and air-to-ground weapons, reconnaissance and surveillance equipment and extra fuel; engines two General Electric J85-13 turbojets 4,080 pounds thrust each.

Performance

Speed Mach 1.4-plus; combat ceiling more than 50,000 feet; sea-level rate of climb more than 29,000 feet per minute; range more than 1,500 nautical miles with external tanks dropped, tactical mission radius up to 760 nautical miles.

T-38 TALON TRAINER

Prime Contractor: Northrop 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. More than 800 have been delivered to the USAF. A quantity of T-38s has also been ordered by the German Air Force.

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 990 nautical miles; rate of climb over 30,000 feet per minute; ceiling 54,000 feet.

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 B

Prime Contractor: Piper Aircraft Corporation

Remarks

The Cherokee 235 B can carry 4 passengers, 200 pounds of luggage, 84 gallons of fuel and still have weight left over. With its Lycoming 0-540- B2B5 235 horsepower engine and its modern low wing design, the Cherokee 235 B can operate out of even the shortest fields, and then cruise at 156 miles per hour for a range of over 900 miles. The new Cherokee 235B incorporates many new improvements, such as "shock-mounted" cowling, dynafocal engine mounting, increased soundproofing and a new, larger instrument panel that will accommodate even the most professional type of equipment.

Specifications

Wing span 32 feet; length 23.5 feet; height 7.1 feet; gross weight 2,900 pounds; empty weight 1,465 pounds; wing area 170 square feet, wing loading 17 pounds per square foot; power loading 12.4 pounds per horsepower, fuel capacity 84 gallons; propeller either McCauley metal fixed-pitch or Hartzell constant speed, both with 80-inch diameter.

Performance

Top speed 166 miles per hour; cruise speed at 75 percent power, 156 miles per hour at 2,900 pounds gross; stall speed 60 miles per hour; take-off run 800 feet; landing roll 680 feet; rate of climb at sea level 825 feet per minute; service ceiling 14,500 feet; cruising range at 75 percent power 935 miles.

PIPER CHEROKEE SIX

Prime Contractor: Piper Aircraft Corporation

Remarks

The Piper Cherokee Six is unique in its class. Ideal for business, pleasure, ranch or utility and air taxi, it is offered with a choice of horsepower, 6 or 7 place seating and also in seaplane configuration. The 260 horsepower version uses a Lycoming 0-540-E4B5 and the 300 horsepower version uses the IO-540-K with Bendix fuel injection. Cruising speed of 160 miles per hour in the 260 horsepower model is increased to 168 miles per hour at full 3,400 pound gross in the 300 horsepower version. Both models carry 6 passengers, 200 pounds of luggage and full fuel of 84 gallons, with a 7th seat optional.

Specifications

Wing span 32.8 feet; length 27.7 feet; height 7.9 feet; gross weight 3,400 pounds; empty weight 1,655 pounds; wing area 174.5 square feet; wing loading 19.5 pounds per square foot; power loading 13.1 pounds per horsepower; fuel capacity 84 gallons; propeller either fixed-pitch metal McCauley or Hartzell constant speed with 82-inch diameter.

Performance

Top speed, 260 and 300 horsepower versions respectively, 166 and 174 miles per hour; cruise speed at 75 percent power 160 and 168 miles per hour; stall speed, either version, 63 miles per hour; take-off run 740 and 700 feet; landing roll 630 feet; rate of climb at sea level 850 and 1,050 feet per minute; service ceiling 14,500 feet; cruise range at 75 percent power 960 and 880 miles.

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 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's entry into the medium twin field is marked by two models of the Navajo, the Turbo Navajo with 310 horsepower turbocharged Lycoming T10-540-A engines and the Navajo 300 with IO-540-K engines. At full gross of 6,200 pounds, the Turbo Navajo will cruise at 247 miles per hour at 23,500 feet and the Navajo 300 210 miles per hour at 6,400 feet. Accelerate-stop distance is just over 2,000 feet for both models and short field characteristics are similar to the Aztec.

Specifications

Wing span 40.67 feet; length 32.63 feet; height 13 feet; gross weight 6,200 pounds; empty weight 3,603 pounds for Navajo 300 and 3,759 pounds for Turbo Navajo; wing area 229 square feet; fuel capacity 190 gallons; propellers full-feathering constant speed Hartzells.

Performance

Top speed 224 and 260 miles per hour; cruise speed at 75 percent power 210 miles per hour at 6,400 and 247 at 23,500; stall speed 71 miles per hour; take-off run 1,080 feet and 1,066 feet; landing roll 1,725 feet; rate of climb at sea level, Navajo 300 1,440 feet per minute, Turbo Navajo 1,395 feet per minute; service ceiling 20,500 feet and 26,300 feet (absolute ceiling for Turbo Navajo 30,000 feet plus); cruise range at 75 percent power, 1,240 miles for Navajo 300, 1,305 miles for Turbo Navajo; single engine ceiling 5,750 feet and 15,800 feet.

XV-5A V/STOL VERTIFAN

Prime Contractors: Ryan Aeronautical Company and General Electric Company

Remarks

The Ryan XV-5A V/STOL research aircraft, utilizing 5-foot diameter fans submerged in its wings for vertical flight, is powered by 2 General Electric J85 engines. Its speed range includes capabilities of zero speed in hover to more than 400 knots in conventional jet mode. The XV-5A made its first fllight on May 25, 1964 and the first complete transition from vertical to forward flight and vertical landing on November 17, 1964. It successfully completed extensive soil erosion hover, landing and takeoff tests in early 1966 at Edwards Air Force Base, and later engaged in tests to demonstrate jet strike escort and rescue capabilities.

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 1966.

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 123 miles per hour; service ceiling 9,500 feet; range 280 miles.

SH-3A/D ANTISUBMARINE HELICOPTER

Prime Contractor: Sikorsky Aircraft

Remarks

The SH-3A/D 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/D is in the weight class of 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 (SH-3D)

Empty weight 11,711 pounds; normal gross weight 18,568 pounds; useful load 6,857 pounds; engines 2 General Electric T58-10, 1,400 shaft horsepower each.

Performance

Maximum speed 167 miles per hour; service ceiling 14,700 feet; range 625 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-3D helicopter, which is produced by Sikorsky as an antisubmarine warfare weapons system for the U.S. Navy.

Specifications

Empty weight 12,256 pounds; normal gross weight 19,000 pounds; useful load 6,744 pounds; engines 2 General Electric CT58-140-1 1,500 horsepower each.

Performance

Maximum speed 150 miles per hour; service ceiling 12,200 feet; range 265 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/E 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/E 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 (CH-3E and HH-3E)

Empty weight 12,423 pounds; normal gross weight 19,500 pounds; useful load 7,077 pounds; engines 2 General Electric T58-5 1,500 horsepower each.

Performance

Maximum speed 150 miles per hour; service ceiling 12,200 feet; range 450 miles.

S-62 SEARCH & RESCUE HELICOPTER

Prime Contractor: Sikorsky Aircraft

Remarks

The single-turbine S-62, the first amphibious helicopter built with a flying boat-type hull, is used by the Coast Guard as its search and rescue helicopter. The S-62 was the first American turbine-powered helicopter to be certified by the Federal Aviation Agency for commercial operations. The FAA certificate permits it to carry a pilot, a co-pilot, and 11 passengers. It can operate from land, water, ice, snow, swamp, mud or almost any other surface. The first flight took place May 22, 1958. Besides its Coast Guard application, the S-62 is used in airline and industrial operations. It is especially useful to the oil industry in supplying offshore drilling platforms.

Specifications

Empty weight 5,083 pounds; normal gross weight 8,100 pounds; useful load 3,017 pounds; engine General Electric T58-8 1,250 horsepower.

Performance

Maximum speed 110 miles per hour; service ceiling 11,200 feet; range 463 miles.

S-64 SKYCRANE

Prime Contractor: Sikorsky Aircraft

Remarks

The first flight of the twin-turbine-powered Sikorsky S-64 Skycrane, a universal transport vehicle with both military and industrial potential, took place May 9, 1962. The S-64 carries a 10-ton payload. First deliveries of the S-64 were made to the West German Ministry of Defense. 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 18,969 pounds; normal gross weight 38,000 pounds; useful load 19,031 pounds; alternate gross weight 42,000 pounds, useful load 23,031 pounds; engines 2 Pratt & Whitney JFTD-12A 4,500 horsepower each.

Performance

Maximum speed 126 miles per hour; service ceiling 13,000 feet; range 253 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 35,000 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. The aircraft is also being procured by the U.S. Air Force as the HH-53B for the A.R.R.S. mission.

Specifications

Empty weight 22,221 pounds; normal gross weight 35,000 pounds; useful load 12,779 pounds; engines U.S.M.C. 2 General Electric T64-6 turboshaft and for U.S.A.F. 2 General Electric T64-3 turboshaft.

Performance

Cruising speed 172 miles per hour; service ceiling with T64-6 engines 16,700 feet, with T64-3 engines 18,550 feet; range 259 miles.

MINUTEMAN ICBM

Weapon System Integrator: The Boeing Company; technical direction by TRW Systems Group of TRW Inc.
Associate Contractors: Thiokol Chemical Corporation, first stage engine; Aerojet-General Corporation, second-stage engine; Hercules Incorporated, third-stage engine; Autonetics Division 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

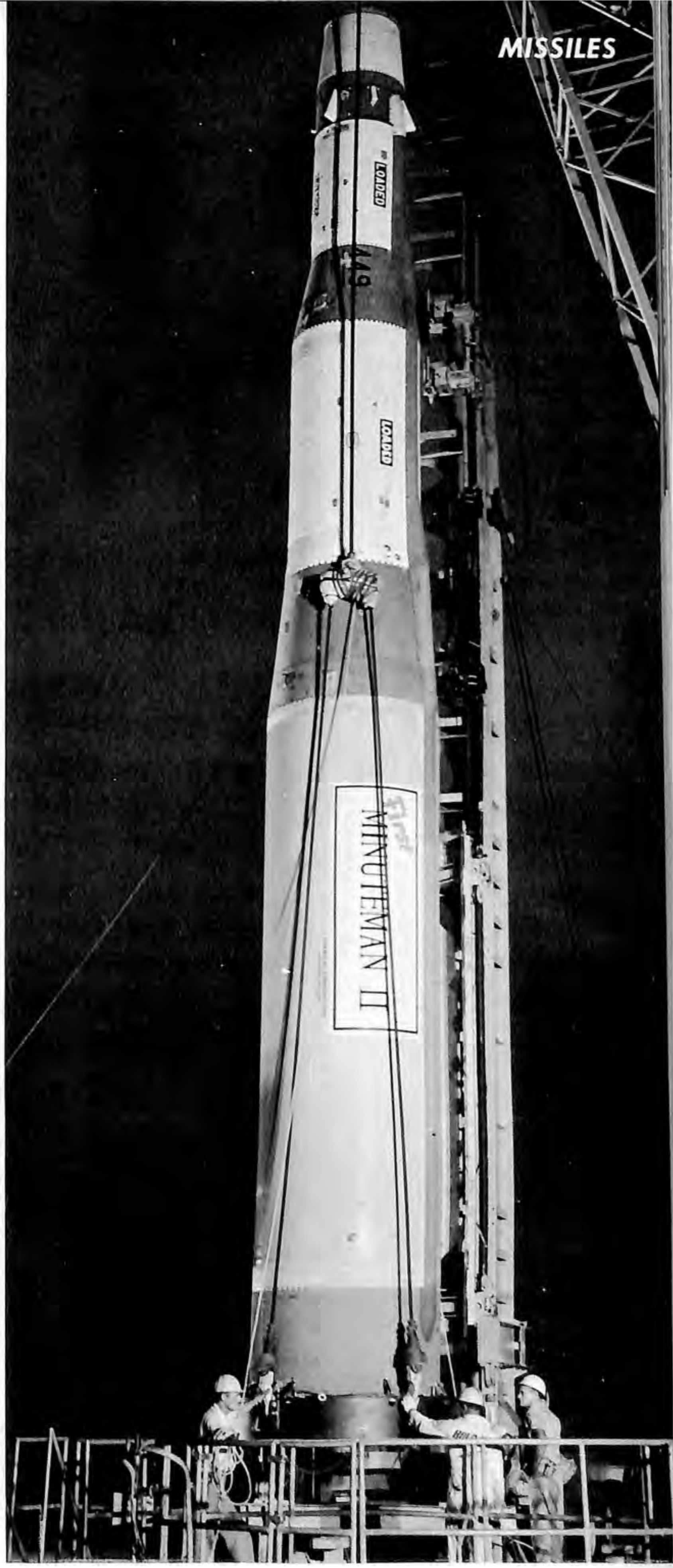
Minuteman I (WS-133A)
Model LGM-30A 54 feet, Model LGM-30B 55.9 feet; weight approximately 65,000 pounds; diameter, approximately 6 feet at first stage interstage.

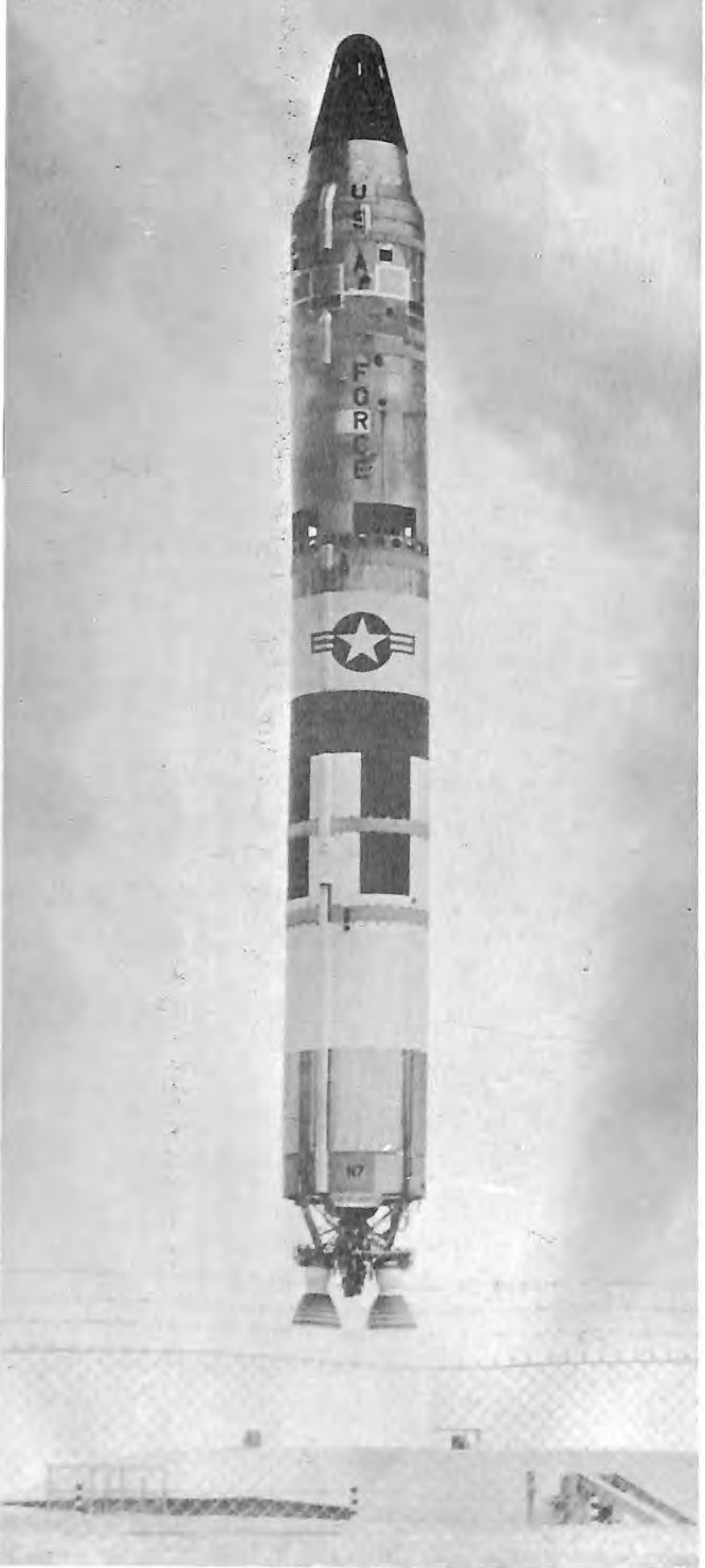
Minuteman II (WS-133B)
Length, 59.8 feet; weight approximately 70,000 pounds.

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, Denver, 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 Systems Group of TRW Inc., (technical direction).

Remarks

Titan II is an intercontinental ballistic missile operated by the USAF's Strategic Air Command. In 1966 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 used for flights in the Air Force ABRES (Advanced Ballistic Re-Entry Systems) program, the Nike-Target program and the OV1 satellite program.

POLARIS/POSEIDON FLEET BALLISTIC MISSILES

Prime Contractor: Lockheed Missiles & Space Company
Associate Contractors: Aerojet-General Corporation and Hercules Incorporated (power plants); General Electric Company and Hughes Aircraft Company (guidance and fire control); Nortronics Division of Northrop Corporation (nose cone).

Remarks

Now in production at Lockheed, the third generation Polaris A3 became operational with the Navy in September, 1964. It was preceded into service by the A1 version, which had a range of 1,200 nautical miles, and the A2, with 1,500 nautical miles range. While A2 was an outgrowth of A1, the A3 is a 90 percent new missile. Among many innovations was a switch from the "champagne bottle" shape of the earlier missiles to a simple, bullet-shaped configuration. The A3, with a range of 2,500 nautical miles, 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 3 versions of the Polaris are 2-stage, solid propellant, inertially guided ballistic missiles which can be fired from submerged or surfaced submarines, from surface ships or from land bases. In early development is a new, follow-on fleet ballistic missile designated Poseidon C3 and designed to be "8 times as effective as the A3." Poseidon will have range comparable to that of the A3 but twice the payload and twice the accuracy.

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 and is also in the hands of Federal Republic of Germany Air Force units, within the framework of NATO. Pershing has the longest range and greatest firepower of all weapons in the Army's arsenal. Four tracked vehicles carry the firing equipment to the firing position in the ground-mobile mode. The system can also be air-lifted. The missile is transported in a horizontal position on its unique erector-launcher, which contains its own launch pad and leveling jacks and raises the missile to vertical firing position. Under a $41 million contract awarded by the Army to Martin in early 1966, improved ground support equipment is under development. The Pershing Ia system, using the new equipment, will be adapted to wheeled vehicles. Rate of fire and system reliability will be increased, with major system improvements centered in a new programmer-test station and a new erector-launcher. Improved missile components are also being developed, under a $14 million contract awarded in April, 1966.

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 with U. S. and Federal Republic of Germany 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 weapons system but it has research utility. Chrysler Missile Division, as a major subcontractor to TRW Systems, is making major modifications to a number of Redstones for use in the SPARTA (Special Anti-Missile Research Tests in Australia) program. SPARTA is part of Project Defender, sponsored by the Defense Department's Advanced Research Projects Agency. Equipped with solid propellant upper stages and Reentry Payloads, the Redstones will be assembled and launched at Woomera, Australia. Chrysler will also build the payloads and provide launch support. Other Redstones have been reactivated for Project Defender. One was launched from the Pacific Missile Range in November 1965. Other programs utilizing Redstone for new missions are under consideration.

Specifications

Length 69 feet; diameter 70 inches; weight 60,970 pounds.

Performance

Range 200 nautical miles; 75,000 pounds thrust.

MACE SURFACE-TO-SURFACE MISSILE

Prime Contractor: Martin Company, Baltimore
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, (inertial guidance) (B version).

Remarks

An improved version of Matador first launched in 1959, Mace is an all-weather guided missile incorporating enough innovations to justify its classification as an entirely new weapon system. Mace TM-76A is fired from a truck-drawn zero-length launcher; Mace TM-76B, from hardened underground bases.

Specifications

Swept-wing missile; length 44 feet; span 23 feet; diameter 54 inches; guidance Mace A self-contained ATRAN (Automatic Terrain Radar and Navigator) map-matching system; guidance Mace B all-inertial; warhead nuclear or conventional; power Allison J33 jet engine, booster Thiokol motor.

Performance

Speed over 650 miles per hour, supersonic in terminal dives; range over 650 miles (Mace A), over 1,200 nautical miles (Mace B); thrust 5,200 pounds (engine), 100,000 pounds (booster).

LANCE SURFACE-TO-SURFACE MISSILE

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.
Associate Contractors: American Bosch Arma Corporation, (gyroscope); Systron-Donner Corporation, (guidance components); 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 field weapons such as Honest John and 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 ANTI-ARMOR GUIDED MISSILE SYSTEM

Prime Contractor: Aeronutronic Division, Defense, Space and Industrial Electronics Group, Philco-Ford Corporation

Remarks

Shillelagh is a tank fired surface-to-surface anti-armor guided missile system which is standard armament on Army's General Sheridan Armored Reconnaissance Vehicle. A lightweight guided missile system, Shillelagh is designed to give U. S. armor field superiority over enemy armored vehicles and tanks, troops and field fortifications. Shillelagh utilizes a command guidance system, giving it extreme high accuracy against either stationary or moving targets and a high first round "kill" probability. The system includes both the guided missile system and conventional ammunition, both fired from a 152 millimeter combination gun/launcher. Now in production by Aeronutronic at the Army's Lawndale, California, Missile Plant, Shillelagh is also being adapted to the compact turret version of the Army's M60 Main Battle Tank. It will also be standard armament on the U.S.-Federal Republic of Germany Main Battle Tank, to be operational in the 1970's. The Army awarded Shillelagh a type standard "A" Classification, the classification given to any Army material item determined to be the most advanced and satisfactory item to fill a given Army need. Shillelagh, which is handled in the field with the ease of a conventional round of ammunition, has been tested under extreme environmental conditions ranging from desert heat to arctic cold and high tropical humidity.

DAVY CROCKETT CLOSE SUPPORT MISSILE

Prime Contractor: Army Weapons Command (In-House)

Remarks

A small Army battlefield missile, Davy Crockett is a short range weapon for support of ground troops. It is fired from a bazooka-type launcher carried by two men or mounted on a vehicle.

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. 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 ANTI-TANK ASSAULT WEAPON)

Prime Contractor: McDonnell Company

Remarks

In engineering development status, MAW is a medium anti-tank assault weapon designed for use by the infantryman. Light enough to be carried by 1 man and shoulder-fired, MAW has a warhead big enough to knock out most armor and other infantry targets. It will be far superior in range, accuracy and hit probability to the 90-millimeter recoilless rifle it will replace. Weighing about 27 pounds, the system employs command-to-line-of-sight guidance and consists of 3 main items: a tracker, a recoilless launcher and a missile. In operation, the gunner sights the target through a telescopic sight, then launches the missile. While he holds his sight on the target, the tracker senses missile position relative to the gunner's line of sight and sends command signals over wire to the missile. This causes rocket "side thrusters" to fire, applying corrective control forces. The thrusters are fired at appropriate roll angles so that the missile is automatically guided throughout flight. In photo, sight and launcher (missile is enclosed within the launcher and is never seen by the gunner).

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 MOD 1 ANTISUBMARINE TORPEDO

Prime Contractor: Honeywell Incorporated
Associate Contractor: TRW Incorporated

Remarks

The Mark 46 Mod 1 antisubmarine warfare torpedo is a liquid-propelled version of the Mark 46. It is in production at Honeywell Ordnance Division, Minneapolis, Minnesota.

MARK 46 ANTISUBMARINE TORPEDO

Prime Contractor: Aerojet-General Corporation
Subcontractors: Bendix Corporation (guidance and control system); Clevite Corporation and National Waterlift Company (engine).

Remarks

The Navy's Mark 46 is a rocket propellant driven, high speed, deep running, passive/active acoustic homing antisubmarine torpedo. It is designed to seek, acquire, pursue and destroy conventional and nuclear submarines. The Mark 46 can be launched from aircraft, the torpedo tubes of antisubmarine vessels, from conventional or drone helicopters or by ASROC (antisubmarine rocket). The Mark 46 is now in production at Aerojet's Von Karman Center, Azusa, California.

Specifications

Approximate dimensions: Length 101 inches; diameter 12 3/4 inches; weight 570 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 (antisubmarine rocket) and Terrier supersonic guided missile weapons system in an advanced ASROC/Terrier combination aboard a new class of ship. The ASROC has been modified so that it can be fired from a Terrier launcher on the forward deck of the ship. Two Terrier or two ASROC missiles can be alternately mounted on the launcher and fired in rapid succession, although one cannot be on the launcher with the other at the same time. Combining the systems leads to several advantages, including reduced manpower requirements, greater missile storage capacity and less topside weight and deck area. The first of the new class of ships to be equipped with the system is the USS Belknap (DLG-26).

SPRINT 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.

ZEUS ANTIMISSILE MISSILE

Prime Contractors: Western Electric Company (for complete Nike-X ground and flight system); Douglas Aircraft Company (Zeus Airframe).

Remarks

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. An advanced version is under development.

Specifications

Three stages, all solid propelled; overall length about 50 feet; basic stage thrust 450,000 pounds.

Performance

Has successfully intercepted target 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 which can be packaged on wheels (mobile HIPAR), a target tracking radar, a missile tracking radar, electronic and data processing equipment, and remote controlled launchers. The system is continually being modified to meet new threats and to incorporate advances in missile technology.

Specifications

Length 41 feet; diameter 31 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 NATO nations for their own use. Hawk employs a radar homing system. It is effective against targets ranging from tree-top level to about 50,000 feet. Hawk is now employed in South 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 more reliable and capable defense against attacking aircraft, Raytheon is developing an improved Hawk.

Specifications

Weight 1,275 pounds; length 198 inches; span 47.4 inches; solid propellant; high explosive warheads.

Performance

Speed supersonic.

TARTAR SHIPBOARD ANTIAIRCRAFT MISSILE

Prime Contractor: Pomona Division of General Dynamics Corporation
Associate Contractor: Aerojet-General Corporation (propulsion).

Remarks

Tartar is a high-performance guided missile that arms 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 Incorporated/Allegany (propulsion).

Remarks

The Advanced Terrier guided missile is fulfilling its design role as a major element in the Navy's missile arsenal. This surface-to-air antiaircraft weapon already arms 35 of the 40 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 Company (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 USS Chicago, USS Galveston, USS Little Rock, USS Oklahoma City, USS Albany, USS Columbus and the first nuclear-powered cruiser, USS Long Beach.

Specifications

Length 20 feet; diameter 30 inches; weight over 3000 pounds; booster 10 feet long.

Performance

Range over 65 nautical miles; speed classified.

REDEYE SURFACE-TO-AIR MISSILE

Prime Contractor: Pomona Division of General Dynamics
Associate Contractor: Atlantic Research Corporation (propulsion).

Remarks

Redeye, the world's smallest guided missile, is designed to be carried into combat on a soldier's back and fired from his shoulder. Its infrared sensor is mounted in the nose of the solid propelled missile, which is fin stabilized and aerodynamically controlled in flight. Redeye, now in production, will for the first time give the infantryman effective antiaircraft defense against low-flying enemy aircraft. Target detection and tracking are accomplished visually by the gunner. When the aircraft is within the range of the missile and the infrared seeker has locked on the target, a simple squeeze of the trigger fires the missile.

Specifications

Length 4 feet; diameter 3 inches; weight 28 pounds.

Performance

Classified.

BOMARC B INTERCEPTOR

Prime Contractor: The Boeing Company
Subcontractors: The Marquardt Corporation (ramjet engines); Thiokol Chemical Corporation (booster rocket); Westinghouse Electric Corporation (guidance).

Remarks

Bomarc B is a surface-to-air interceptor missile operated by the USAF's Air Defense Command and the Royal Canadian Air Force. 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.

CHAPARRAL AIR DEFENSE GUIDED MISSILE SYSTEM

Prime Contractor: Aeronutronic Division, Defense, Space and Industrial Electronics Group, Philco-Ford Corporation

Remarks

Chaparral is an adaptation of the Sidewinder IC air-to-air missile system to a ground-to-air configuration to provide maximum air defense against low and medium flying aircraft in forward battle areas. In production by Aeronutronic at Anaheim, California, Chaparral utilizes the Sidewinder IC in a multiple mount, mounted on a highly mobile M730 vehicle to insure rapid deployment for defense of forward battle areas. Production began in April, 1966, with awarding of a $6.4 million initial tooling and production contract to Aeronutronic by the Army. Chaparral can be fired from various types of existing Army vehicles including railroad flat cars, flat bed trucks, flat bed trailers or can be ground mounted. The missiles are aimed by a gunner in a turret mount and automatically guide on the target's heat source after launch. Chaparral, which has completed successful test firings and guided launchers at White Sands Missile Range, New Mexico, and Naval Ordnance Test Station, China Lake, California, has been selected by the Army as one of two major weapon systems to be included in new air battalions being organized to provide field commanders with low altitude air defense. The M730 is a lightweight, fully tracked vehicle capable of extended cross-country travel over rough terrain and of high speed travel over improved roads.

STANDARD SHIPBOARD MISSILE

Prime Contractors: Pomona Division of General Dynamics Corporation (guidance, control and airframe); The Johns Hopkins University Applied Physics Laboratory (consultant to Ordnance System Command).

Remarks

The Standard Missile program implements the Navy's concept of a standardized shipboard missile system for defense of the fleet against surface and aerial threats. Primary objectives in attaining the performance improvements are maximum reliability and overall economy, all to be achieved with simplified logistics and compatibility with existing Terrier/Tartar handling and shipboard weapon systems. There are 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.

SEA SPARROW SURFACE-TO-AIR MISSILE

Prime Contractor: Raytheon Company

Remarks

Sea Sparrow (AIM 7E) is under development for use by the Navy and the armed forces of NATO nations as a basic point defense missile system.

Specifications

Length 12 feet; maximum diameter .67 feet; span over fins 3.3 feet; launch weight 400 pounds; guidance semi-active homing radar.

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 Company
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 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: Columbus Division, North American Aviation

Remarks

Condor, designated AGM-53A, is a rocket powered, conventional warhead guided missile designed for use with current and future Navy aircraft. The Condor system relies upon closed-circuit television and command link between missile and airplane for guidance. The air launched missile is adaptable to the armament system in the Navy's A6A all weather attack aircraft.

HORNET AIR-TO-SURFACE MISSILE

Prime Contractor: Columbus Division, North American Aviation

Remarks

Hornet is a rocket powered air-to-surface missile system designed for use on tactical aircraft. The missile depends upon a television guidance system which locks on and automatically guides it to previously identified mobile or stationary targets.

WALLEYE TELEVISION GUIDED GLIDE BOMB

Prime Contractor: Martin Company, Orlando. (Walleye was developed by the U. S. Naval Ordnance Test Station, China Lake, California).

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 missiles, 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.

SPARROW III AIR-TO-AIR MISSILE

Prime Contractor: Raytheon Company

Remarks

Developed and produced by Raytheon's Missile System Division, Sparrow III is a supersonic, radar homing weapon which can be launched from aircraft flying at subsonic or supersonic speeds. The original model became operational with Navy squadrons in 1956; the missile is now being used as primary defensive armament on USAF, Navy and Marine Corps fighters and current models have greater performance capabilities than the original, due to a series of engineering and design changes. Sparrow III has an advanced fire control system which consists essentially of a radar in the nose of the aircraft, a fire control computer and cockpit displays and controls. The radar searches for, acquires and tracks the target. This information is supplied to the computer to generate signals that will enable the pilot to attack targets successfully.

Specifications

Weight 400 pounds; length 12 feet; diameter 8 inches.

Performance

Speed supersonic; all-weather, all-aspect, all-altitude capability.

SIDEWINDER IC AIR-TO-AIR MISSILE

Prime Contractors: Philco-Ford Corporation and Raytheon Company
Associate Contractors: Rocketdyne, A Division of North American Aviation (propulsion) and General Electric Company (guidance).

Remarks

Sidewinder IC (AIM9D) is a second generation version of the Navy's air-to-air missile. A simple aluminum tube powered by a Rocketdyne Mark 18 Mod 1 solid propellant rocket, Sidewinder IC is a rugged, inexpensive weapon used on fighter aircraft. The first missile to destroy enemy aircraft in combat, it has interchangeable infrared and radar heads. AIM9D is operational with the Navy, in production, and scheduled for service in the United Kingdom.

Specifications

Overall length 9.5 feet; maximum diameter .42 feet; span over fins 2.1 feet; launch weight 185 pounds.

Performance

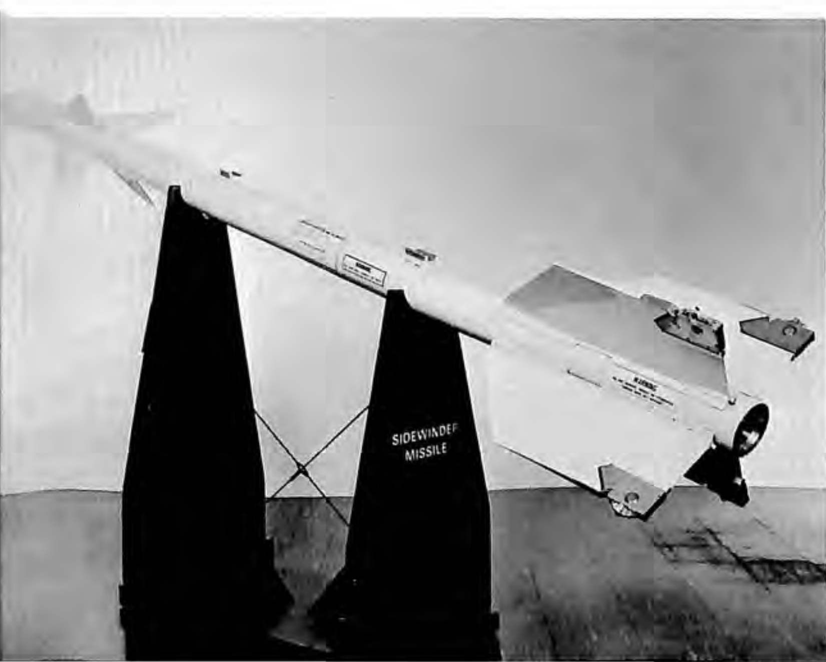
Speed Mach 2.5

FALCON AIR-TO-AIR MISSILES

Prime Contractor: Hughes Aircraft Company
Associate Contractors: Thiokol Chemical Corporation and Lockheed Propulsion Company (propulsion).

Remarks

Among the smallest missiles in service, the Air Force's Falcon family consists of several different types of air-to-air missiles which are guided either by radar or by a heat-seeking (infrared) homing device. Among the later versions are the AIM-26, which has a nuclear warhead, 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: Control Data Corporation (computer); Rocketdyne, A Division of North American Aviation (propulsion).

Remarks

The Navy's Phoenix missile system is designed for capabilities exceeding those of any operational air-to-air weapon. The system consists of the missile itself, designated XAIM-54A; an advanced AN/AWG-9 radar and missile control system; and the MAU-48A missile/bomb launcher. Under development for use in the F-111B aircraft, the missile is a long range, high performance, solid propelled weapon.

GENIE AIR-TO-AIR ROCKET

Prime Contractor: Douglas Missile & Space Systems Division
Major Subcontractor: Aerojet General Corporation

Remarks

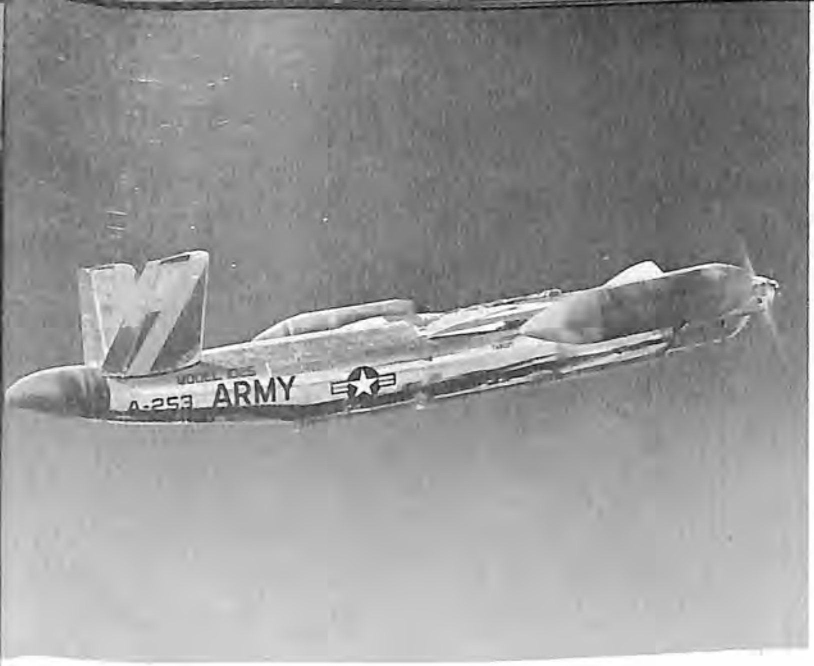
The AIR-2A Genie is an air-to-air rocket with a solid-propellant motor capable of carrying a nuclear warhead. Douglas builds the Genie weapon system for the USAF's Air Defense Command. It is carried on the F-101B Voodoo and the F-106 Delta Dart.

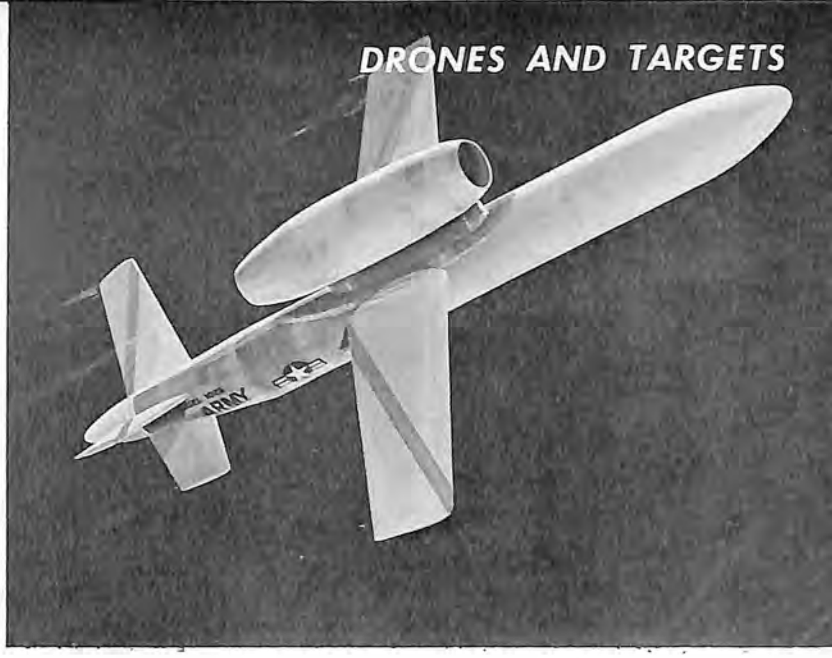
Specifications

Length 9 feet; width 1 foot 5 inches; weight 830 pounds.

Performance

Classified.





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 bi-propellant 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 3; service ceiling, 90,000 feet.

QH-50A TARGET DRONE HELICOPTER

Prime Contractor: Gyrodyne Company of America, Inc.

Remarks

The QH-50A drone helicopter was the original evaluation prototype for the DASH Weapon System. One QH-50A made the world's first free flight of an unmanned drone helicopter on August 12, 1960. In 1965, several QH-50A helicopters were re-conditioned and equipped with new avionic systems for use as air to air missile targets. These drones were shipped to the Pacific Missile Range at Point Mugu, California and performed extremely reliable and effective service as aerial targets for 4 months during the period November 1965 through February 1966.

Specifications

Rotor system coaxial, fuselage length 8 feet 10 inches, height 8 feet 3 inches; rotor diameter 20 feet; maximum gross weight 906 pounds; empty weight 578 pounds; disc loading 2.88 pounds per square foot; power plant 1 Gyrodyne-Porsche YO-95-6 72 shaft horsepower.

Performance

Maximum speed at sea level 68 knots; combat radius 29 nautical miles; maximum rate of climb at sea level 956 feet per minute; hovering ceiling OGE 3,200 feet.

QH-50B DRONE HELICOPTER

Prime Contractor: Gyrodyne Company of America, Inc.

Remarks

The QH-50B is a single place twin engine drone helicopter. It was bujlt strictly as a development aircraft to test the digital data link, autopilot and avionic components of the anticipated turbine powered QH-50C slated as the operational drone helicopter for the DASH Weapons System. This piggy-back drone allowed complete flight testing development of combinations of components in a drone system with the safety pilot able to monitor performance and take control of the aircraft instantly in case of malfunction. The QH-50B was never converted to a pure drone but only flown in the man carrying configuration.

Specifications

Rotor system coaxial; fuselage length 7 feet; rotor diameter 20 feet; height 8 feet 3 inches; maximum gross weight 1,450 pounds; empty weight 819 pounds; powerplant 2 Gyrodyne-Porsche YO-95-6, 72 shaft horsepower each.

Performance

Maximum speed sea level 76.8 knots; endurance 1.08 hours with 11 gallon fuel tank; maximum rate of climb 1,162 feet per minute; vertical rate of climb 640 feet per minute; service ceiling 8, 600 feet.

QH-50C DASH DRONE HELICOPTER

Prime Contractor: Gyrodyne Company · of America, Inc.

Remarks

The DASH (Drone Anti-Submarine Helicopter) Weapon System provides destroyers with a flexible, deliberate long range attack capability against submarines. DASH not only provides the range to fully exploit the recent advances in sonar detection capability but also provides a means for the destroyer to drive home an attack against a nuclear submarine without itself coming within lethal range. The QH-50C drone helicopter was the first operational drone as the airborne portion of the DASH System. The QH-50C was introduced into the Fleet in quantity beginning in November of 1962. Production of this model was terminated in December, 1965.

Specifications

Rotor system coaxial; fuselage length with tail stabilizer empennage 12 feet 11 inches; height 9 feet 8.5 inches; rotor diameter 20 feet; empty weight 1,166 pounds; normal gross weight 2,296 pounds; powerplant 1 Boeing T50-BO-8 turboshaft normal rated power 270 horsepower; armament normally 2 MK44 homing torpedoes.

Performance

Maximum speed sea level 80–103 knots; hovering ceiling 11,100 feet; service ceiling 16,200 feet; vertical rate of climb at sea level 1,350 feet per minute; operational radius 30 nautical miles.

QH-50D DASH DRONE HELICOPTER

Prime Contractor: Gyrodyne Company of America, Inc.

Remarks

The model QH-50D drone helicopter is an advanced version of the unmanned aerial vehicle for the DASH Weapon System. It has simplified avionics, greatly increased range capability and load carrying capacity as compared to the QH-50C. Fleet deliveries of the D model commenced in January, 1966.

Specifications

Rotor system coaxial; fuselage length 7 feet 3 inches; height 9 feet 8.5 inches; rotor diameter 20 feet; rotor blades molded fiberglass; weight 1,093 pounds; normal gross weight 2,350 pounds; powerplant 1 T50 BO-12 turboshaft, normal rated power 300 horsepower.

Performance

Maximum speed sea level 80–103 knots; hovering ceiling 10,200 feet; service ceiling 15,700 feet; vertical rate of climb at sea level 1,230 feet per minute; operational radius over 30 nautical miles.

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.

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.

NV-105 TARGET DRONE

Prime Contractor: Northrop Ventura, a Division of 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 is capable of flying both visual and out-of-sight missions. The Luneberg lens passive radar augmenter providing radar cross-section of an actual aircraft increases the realism of training for gun and missile crews.

Specifications

Wing span 66.7 inches; weight 218 pounds empty, 335 pounds fully fueled for flight; launch standard zero-length from ground or shipboard; guidance radio control; power plant 32-pound-weight 121 pound-thrust turbojet Williams engine.

Performance

Speed to 400 knots; service ceiling 40,000 feet; endurance 0.5–1.5 hours. Recovery by parachute.

MQM-57A SURVEILLANCE DRONE

Prime Contractor: Northrop Ventura, a Division of 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 Ventura, a Division of 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 Ventura, a Division of 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 Ventura, a Division of 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.

BMTS (BALLISTIC MISSILE TARGET SYSTEM)

Prime Contractor: Raytheon Company
Subcontractor: Aerolab Development Company

Remarks

The Ballistic Missile Target System was developed for the Army as an effective, low cost target system for ballistic missile defense studies. The system consists of a modified mobile Terrier launcher, a control center and a target vehicle. The vehicle is composed of 3 stages, the first a Nike M-5 booster, the second either a Cajun or an Apache rocket motor, depending on desired range. Third stage is the payload, which includes augmentation, telemetry, tracking aids, electronic countermeasures equipment, miss distance indicators or other devices. Range, apogee and velocity can be adjusted to produce a variety of targets.

Specifications

Length 13.5 feet; length with booster 25 feet; maximum diameter 16 inches; span of wings, 1st stage 5 feet, 2nd stage 2 1/2 feet; launch weight 2,000 pounds; guidance spin stabilized.

Performance

Speed at burn-out 2,000–6,000 feet per second; range 12 to 175 nautical miles.

BIKINI SURVEILLANCE SYSTEM

Prime Contractor: Republic Aviation Division, Fairchild Hiller Corporation

Remarks

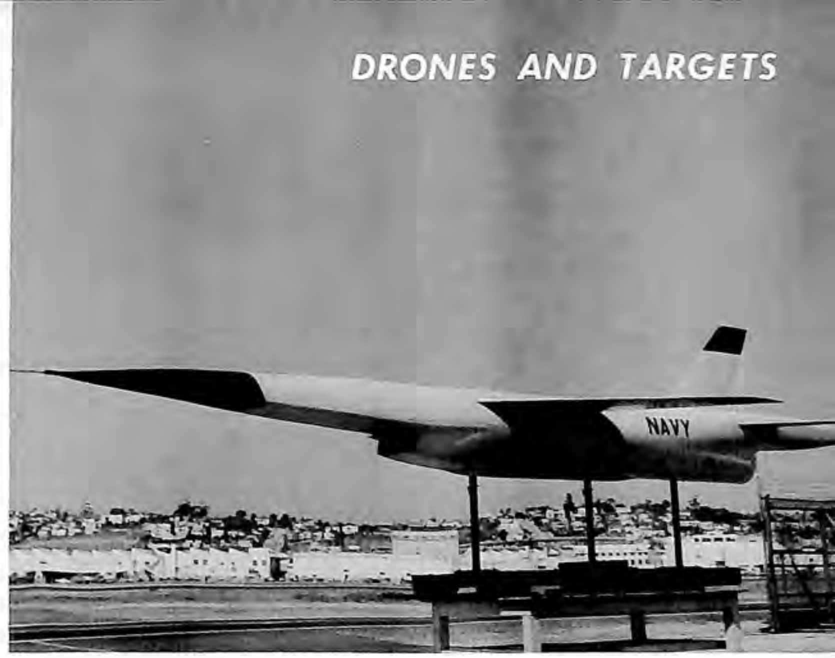
The Bikini aerial drone surveillance system was developed for the Marine Corps to provide combat units with quick-response, short-range reconnaissance. Designed to be operated from unprepared advanced positions by battalion or brigade personnel with only a minimum of special training, the highly mobile system can supply intelligence on enemy vehicles, emplacements, troops, and terrain. A Bikini system consists of a small radio-controlled reconnaissance aircraft and supporting launch and control ground equipment. An entire system, including 2 drones, fits into the jeep-drawn M100 trailer. A 2-man team can put the system in operation within 10 minutes from arrival at the launch site and provide finished 9 by 9 reconnaissance photographs 20 minutes later. The drone is a conventional high-wing propeller-driven aircraft. Lightweight yet rugged, it is launched by a trailer-mounted pneumatic catapult to flying speed in a distance of 6 feet.

Specifications

Wing span 96 inches; length 76 inches; weight 50 pounds (normal), 60 pounds (maximum); engine 4.5 horsepower, 2-cycle, 7,000–9,000 revolutions per minute, pull cord starter.

Performance

Rate of climb 1,000 feet per minute; speed 80–100 miles per hour; service ceiling 10,000 feet; flight duration 30 minutes.



RYAN FIREBEE JET TARGET DRONE (MQM-34D ARMY) — (BQM-34A NAVY, AIR FORCE).

Prime Contractor: Ryan Aeronautical Company

Remarks

Ryan Firebee jet target drone has been modified for 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.

RYAN SUPERSONIC FIREBEE II JET DRONE (XBQM-34E NAVY)

Prime Contractor: Ryan Aeronautical Company

Remarks

The Ryan supersonic Firebee II, XBQM-34E, under development for the Naval Air Systems Command, was scheduled to start its flight test program in mid-1967 at Point Mugu, California. The new generation Firebee II will perform missions in excess of 60,000 feet at speeds exceeding Mach 1.5 and will have 5 'g' maneuverability capabilities. The Continental YJ69-T-6 turbojet engine, a modification of the power plant used in the BQM-34A Firebee, will develop 1,840 pounds of static sea level thrust to power the XBQM-34E. Firebee II is designed to carry an external fuel pod under its fuselage. After completion of subsonic missions, the pod is jettisoned for higher performance, supersonic flight. Firebee II will carry active and passive augmentation as employed in the subsonic Firebee.

Specifications

Supersonic configuration: empty weight 1,257 pounds, gross weight 1,696 pounds, useful load includes 160 pounds augmentation equipment and 278 pounds internal fuel and oil. Subsonic configuration: empty weight 1,287 pounds, gross weight 2,126 pounds, useful load includes 160.8 pounds augmentation equipment and 678.2 pounds internal and external fuel and oil.

Performance

Sea level speed, Mach 1.1; at 50,000 feet, Mach 1.8; above 60,000 feet, Mach 1.5. 5g capability at altitudes up to 20,000 feet.

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

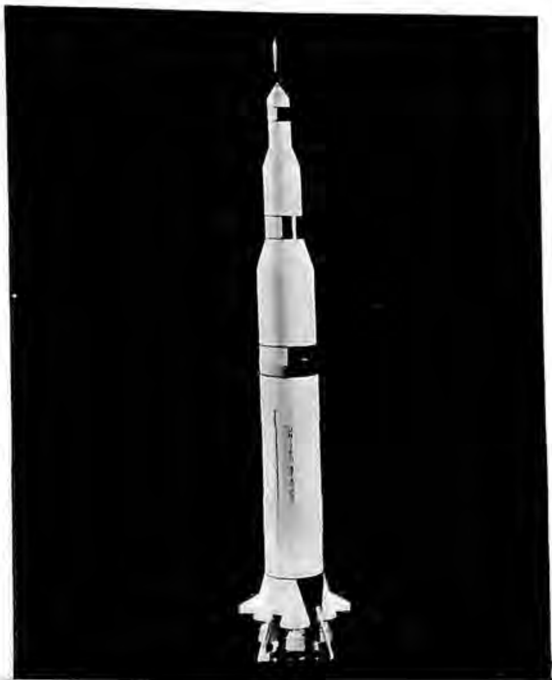
The S-IC is the first stage booster for the Saturn V launch vehicle. More than 10,000 Boeing employes are working on this largest and most powerful booster stage in the free world at six sites in the United States. Most of the major subassembly and vertical assembly tasks are accomplished at NASA's Michoud 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.

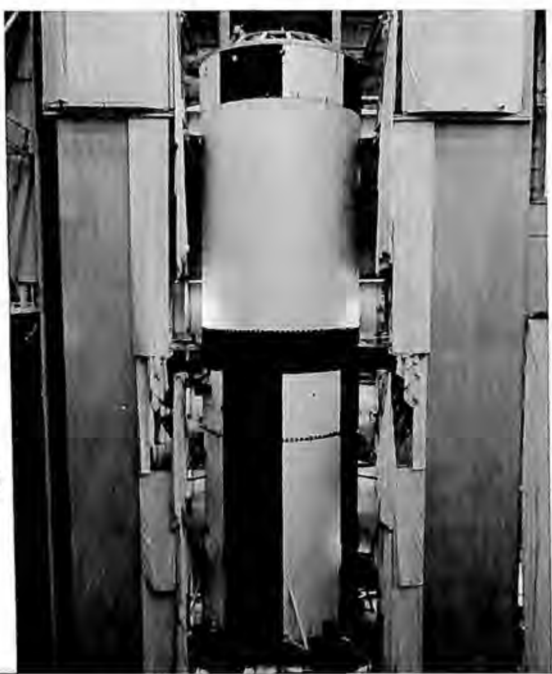
Specifications

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

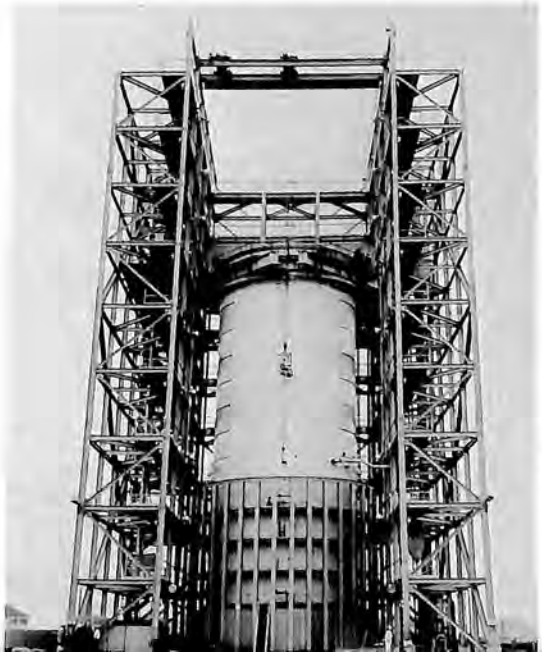
The upper stage of the Saturn V launch vehicle, the S-IVB fires on a lunar voyage after the S-II stage has burned for about 10 minutes. It sends the Apollo spacecraft into earth orbit, but, unlike the two lower stages, does not fall back to earth; it remains with the spacecraft for a later assignment, provision of thrust for the final kick into lunar trajectory. The 12-ton stage is fabricated of lightweight aluminum except for "battleship" or ground test versions which were made of heavy stainless steel. In addition to its use as topmost stage of the Saturn V "stack," the S-IVB is also used as the upper stage of the Uprated Saturn I vehicle. Propellant capacity is the same for both versions. The earlier S-IV stage, powered by six Pratt & Whitney RL10 engines producing 90,000 pounds thrust, was used on Saturn I.

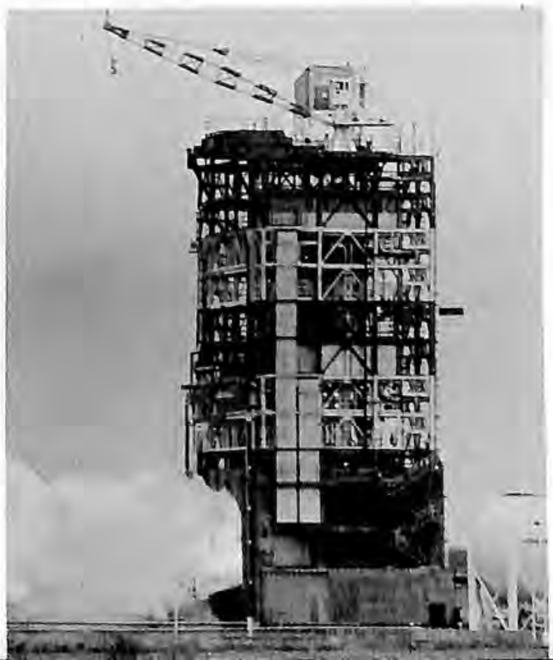
Specifications

Length 58 feet; diameter 21.7 feet; engine Rocketdyne J-2; propellants liquid oxygen/liquid hydrogen; propellant capacity 230,000 pounds.

Performance

Thrust 200,000 pounds.





UPRATED SATURN I

Contractors: Marshall Space Flight Center, NASA, engineering and systems assembly: first stage (S-IB), Chrysler Corporation Space Division; second stage (S-IVB), Douglas Missile & Space Division; Apollo spacecraft, Space & Information Systems Division, North American Aviation, Inc.; propulsion first and second stages, Rocketdyne, A Division of North American Aviation, Inc.

Remarks

The primary mission of the Uprated Saturn I is to launch the Apollo spacecraft into earth orbit for spacecraft testing and development and astronaut training. The 2 stage Uprated Saturn I is larger and more powerful than Saturn I. Major changes are in the first stage (S-IB) which has been redesigned by Chrysler to eliminate 10 tons of weight and in the use of the Douglas SIVB as top stage, in place of the earlier SIV stage. The first of 12 Uprated Saturn I's was launched February 26, 1966.

Specifications

Length 224 feet, with Apollo payload and escape tower; weight, approximately 1,300,000 pounds; first stage (S-IB) 80.3 feet long, 21.4 feet in diameter; second stage (S-IVB) 58.4 feet long, 21.7 feet in diameter.

Performance

The Uprated Saturn I first stage (S-IB) is powered by eight Rocketdyne H-1 engines, each of which produces 200,000 pounds of thrust or a total of 1,600,000 pounds. The second stage (S-IVB) is powered by a single Rocketdyne J-2 engine which generates 200,000 pounds of thrust at altitude. Uprated Saturn I is capable of placing approximately 18 tons in earth orbit and 2.5 tons in lunar orbit.

GEMINI–TITAN II LAUNCH VEHICLE

Program Management: Space Systems Division, Air Force Systems Command.
Major Contractors: Martin Company, Baltimore (systems integration, airframe, flight test); Aerojet-General Corporation (propulsion); General Electric Company and Burroughs Corporation (guidance)

Remarks

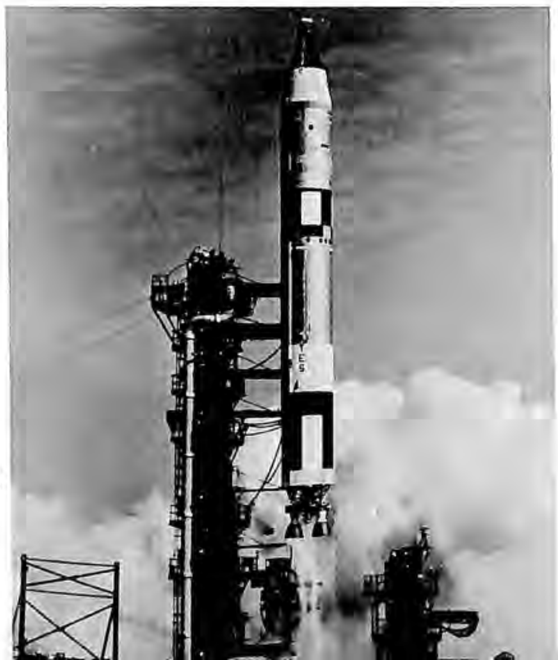
The Gemini-Titan II launch vehicle, a modified Titan II ICBM, is a two-stage, liquid fueled rocket powered by storable, hypergolic propellants. Fire-in-the-hole staging is employed, whereby the second stage engine ignites before separation from the first stage is complete. A number of modifications were 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.

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, (technical direction).

Remarks

Titan III is the nation's heavy-duty military space booster. All propellants are storable for long hold and quick reaction capabilities. Because it utilizes the building-block principle, its weight-lifting capabilities vary from 5,000 to 27,000 pounds into earth orbit, and up to 5,000 on a lunar trajectory. The largest version which has flown to date, Titan III-C (photo), 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 170 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 "taxicab," delivering multiple payloads to multiple destinations as needed. Among its initial missions was deployment of 8 satellites in near-synchronous, equatorial orbit as the vanguard of a worldwide military communications network.

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-3A AND SLV-3C

Prime Contractor: Convair Division of General Dynamics.
Associate Contractors: Rocketdyne, a Division of North American Aviation, Inc.; General Electric Company; Acoustica Corporation

Remarks

The SLV-3A is an uprated version of the dependable SLV-3 vehicle. The tapered forward tank has standardized interface equipment so that almost any current upper stage can be used with only minor booster modifications. Increased performance is achieved by modifying existing systems, thereby retaining the inherent, flight-proven reliability of the SLV-3. The new tank is 117 inches longer, holding about 48,000 pounds more of useable propellants than formerly. The intermediate bulkhead is relocated to retain the existing propellant ration. The MA-5 engine system is uprated by changing the settings of the engine reference regulators, causing an increased operating pressure in the gas generators. Also, lube oil tankage is increased to permit longer engine burn time. These modifications increase booster engine thrust to 168,000 pounds each; sustainer engine thrust is 58,000 pounds. The SLV-3A with an Agena second stage can inject a 7,950-pound payload into a 100-nautical mile orbit due east from the Eastern Test Range. The SLV-3C is an uprated version of the constant 10-foot-diameter LV-3C used to launch Centaur upper stages. The SLV-3C with a Centaur upper stage can launch a 2,900-pound payload to escape or a 2,200-pound payload to Venus or Mars from the Eastern Test Range.

R-134

SLV-3X(167)/CENTAUR AND SLV-3X(237)/AGENA D

Prime Contractor: Convair Division of General Dynamics.
Associate Contractors: Rocketdyne, a Division of North American Aviation, Inc.; General Electric Company; Acoustica Corporation

Remarks

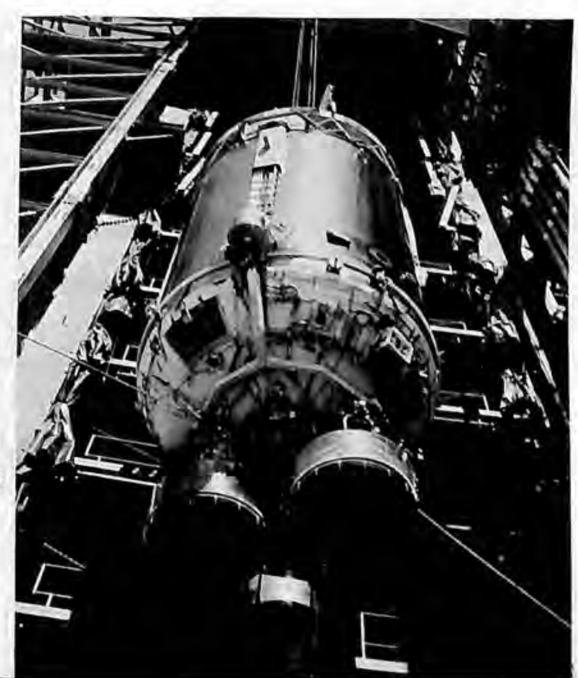
The SLV-3X(167) is, like the SLV-3C, an uprated, standardized version of the LV-3C. The standard operational two-burn Centaur liquid hydrogen/liquid oxygen upper stage will be used with this configuration. Techniques similar to those used to standardize and uprate the SLV-3C are used for this further uprating. The tank section is lengthened an additional 116 inches from the SLV-3C configuration (a total of 167 inches longer than the LV-3C, hence the designation). Booster engines are further uprated to a total thrust of 400,000 pounds. The 58,000-pound-thrust sustainer engine of the SLV-3C is retained. The SLV-3X(237) is, like the SLV-3A, an uprated version of SLV-3. The standard Agena D is used as the upper stage for this configuration. Techniques similar to those used to uprate the SLV-3A are used for this further uprating. The tank section is lengthened an additional 120 inches from the SLV-3A configuration (a total of 237 inches longer than SLV-3, hence the designation). Booster engines are further uprated to a total thrust of 400,000 pounds. The 58,000-pound-thrust sustainer engine of the SLV-3A is retained. Sufficient quantities of propellants are accommodated in the lengthened tanks to yield maximum performance within the constraint of a 1.2 thrust-to-weight ratio at liftoff.

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.



THOR, LONG TANK THOR

Prime Contractor: Douglas Missile and Space Systems Division
Associate Contractors: Rocketdyne, A Division of North American Aviation (liquid propulsion); Thiokol Chemical Corporation (solid propulsion); Western Electric (guidance).

Remarks

The Thor family of launch vehicles has included more than 2 dozen configurations and the vehicle has earned the title "Workhorse of the Space Age" with demonstrated reliability and versatility in more than 200 firings. Newest version is the Long Tank Thor, which is expected to boost the majority of USAF space programs. Long Tank Thor offers added payload capability by increasing the volume of the liquid propellant tanks. The new vehicle is a constant diameter (8 feet) where the predecessor was conical; total thrust is essentially the same as that for the Thrust Augmented Thor but Long Tank Thor gets its increased payload from a burn time of 216 seconds compared with 146 for the earlier Thor. In photo, Long Tank Thor at right, standard model left.

Specifications (Long Tank Thor)

Length 70 1/2 feet (compared with 56 in standard version); diameter 8 feet constant (compared with 8 feet maximum).

Performance

Thrust 330,000 pounds; payload varies with upper stage; Long Tank Thor has 3,000 pound low altitude orbit capability.

DELTA

Prime Contractor: 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 on space-probe and earth-orbital missions. Its first stage is a modified Thor rocket. Its first two stages are liquid propellants; a solid propellant is used in the third. With a reliability record of more than 90 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.

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 3 "strap-on" solid propellant rocket motors that bring TAD's first-stage lift-off thrust to 330,000 pounds—almost double the 172,000-pound-thrust capability of the standard Delta. Addition of the solids enables TAD to boost heavier payloads higher and farther. TAD has launched the Syncom C satellite that relayed on-the-spot television pictures of the Olympic Games from Japan to the U.S. and the Communication Satellite Corporation's history-making Early Bird, first link in a proposed worldwide communications network.

Specifications

Length 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.

IMPROVED 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).
Subcontractor: United Technology Center, Division of United Aircraft Corporation (third stage propulsion).

Remarks

The Improved Delta, introduced in 1965, is an advanced version of earlier Delta models, incorporating features and performance that meet the demand of current and future space progress requirements. Adaptable either as a two-stage or three-stage vehicle, the Improved Delta can carry a wide range of spacecraft, including communications satellites, specialized scientific capsules, navigation, meteorological, experimental and other types of payloads into near earth orbits, moon orbits or on into deep space. The Improved Delta, both as a 2-stage or a 3-stage vehicle, can be used with or without strap-on thrust augmentation boosters.

Specifications

Length 94 feet 10 inches; diameter (maximum including solid boosters) 14 feet 2 inches; liftoff weight (with solid boosters), 149,641 pounds; thrust 350,000 pounds (first stage), 7,900 pounds (second stage), 5,650 pounds (third stage).

Performance

1,120-pound payload in a 500-nautical-mile circular orbit.

SCOUT

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.
Associate Contractors: Aerojet General (first stage); Thiokol Chemical (second stage); Hercules Powder Company (third and fourth stages); Honeywell Inc. (guidance).

Remarks

The Scout research rocket is a four-stage, solid-fueled rocket developed by the National Aeronautics 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

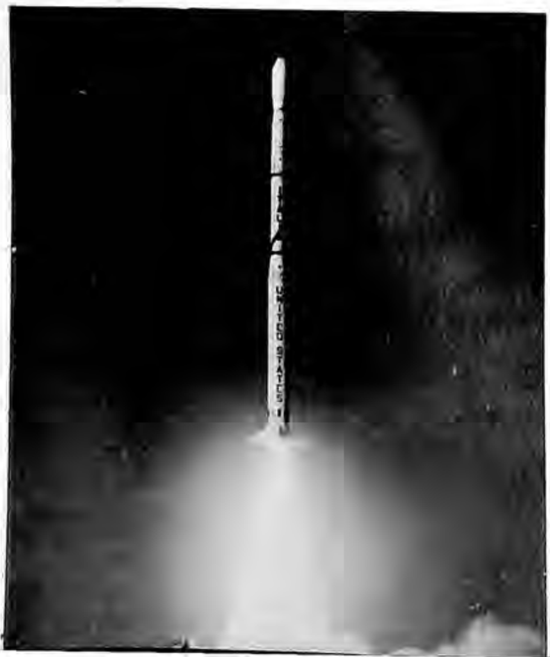
One of the real workhorses of U. S. space exploration, Agena is an upper stage which is also employed as a spacecraft, the whole vehicle going into orbit. Agena plays a key role in manned space flight; it is the target vehicle for rendezvous and docking maneuvers in NASA's Gemini project. Agena has a 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 Orbiting Astronomical Observatory. In photo, Gemini Standard Agena with astronauts Schirra and Stafford.

Specifications

Length 19–40 feet depending on version; Gemini version 25 feet; diameter 5 feet; all-inertial guidance.

Performance

Thor/Agena, 1,500-plus pounds in earth orbit; Atlas/Agena, 5,000 pounds in 300-mile orbit.



BURNER II

Prime Contractor: The Boeing Company
Major Subcontractors: Thiokol (solid rocket motor); Honeywell (preprogrammed inertial guidance system); Walter Kidde (reaction control system)

Remarks

Burner II is a new launch vehicle upper stage developed by Boeing for the Air Force Space Systems Division. It is the first solid-fuel upper stage with full control and guidance capability developed for general space applications. Burner II was designed for use with the Thor booster, but is readily adapted for use on the complete range of standard launch vehicles. Its general assignment will be to place small and medium-size payloads into orbit. The Burner II motor, guidance system and reaction control system are integrated to provide attitude stability and precise control of flight rate and burnout velocity for orbital injection and earth-escape missions. Boeing has delivered 3 flight vehicles and, under terms of a follow-on contract, is building 5 additional flight models. The first launch of a Thor/Burner II was scheduled for late 1966.

ATHENA RE-ENTRY TEST VEHICLE

Prime Contractor: Atlantic Research Missile Systems Division
Associate Contractors: Propulsion: Thiokol, 1st stage; Thiokol & Hercules Incorporated, 2nd stage; Aerojet-General Corporation, 3rd stage; Hercules Incorporated, 4th stage; Atlantic Research, spin rockets; Hercules, boost-assist motors and retro motors.

Remarks

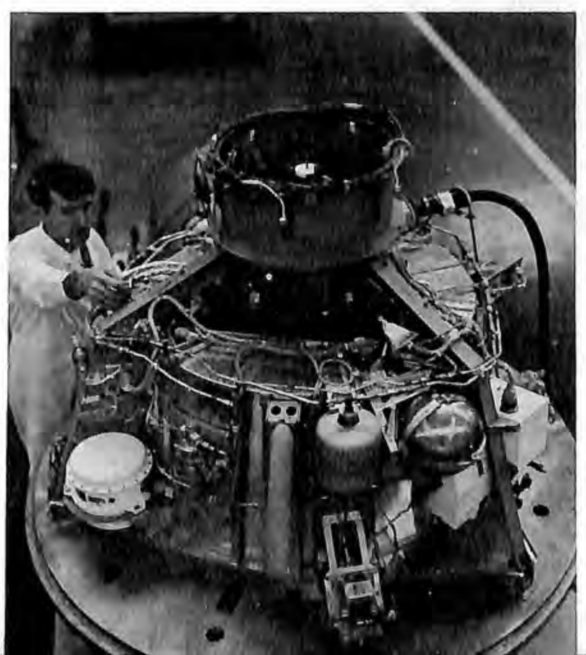
The Athena re-entry vehicle conceived to simulate the re-entry evironment of intercontinental ballistic missiles has proved to be one of the Air Force's most important research and development programs. Begun in February 1964, the Athena program christened what was to become this country's first inland range for the overland test of multi-stage vehicles. Athena is launched from Green River, Utah, along the Army's White Sands Missile Range, reaching altitudes of over 1,000,000 feet before descending on White Sands, New Mexico, some 470 miles downrange. The Army's highly instrumented range had monitored 49 flights by the end of August 1966 in a program of 113 launchings scheduled through early 1968. The program is under the direction of the Ballistic Systems Division, Air Force Systems Command.

Specifications

Four stages, all solid propelled; overall length 50 feet; diameter 31 inches; weight 16,000 pounds at launch; unguided boost, mid-course correction.

Performance

Speed in excess of 15,000 miles per hour at re-entry; range more than 470 miles; ceiling in excess of 1,000,000 feet. Is successfully yielding high degree of re-entry space physics data and sub-scale systems test data.



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); 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 the Apollo Spacecraft is under NASA's Manned Spacecraft Center, Houston, Texas. The Apollo spacecraft comprises 3 separable major parts called "modules" which are fastened together in tandem. North American's Space Division is producing the Apollo spacecraft Command and Service Modules. The Lunar Module is being built by Grumman Aircraft Engineering Corporation. The Command Module is the Apollo spacecraft's control center for the moon flight. It provides combination living, working and leisure time quarters for the 3-man crew. The Command Module consists of 2-shells—an inner crew compartment and an outer heat shield. Ablative materials are applied to the outer structure after it has been assembled and fit-checked to the crew compartment.

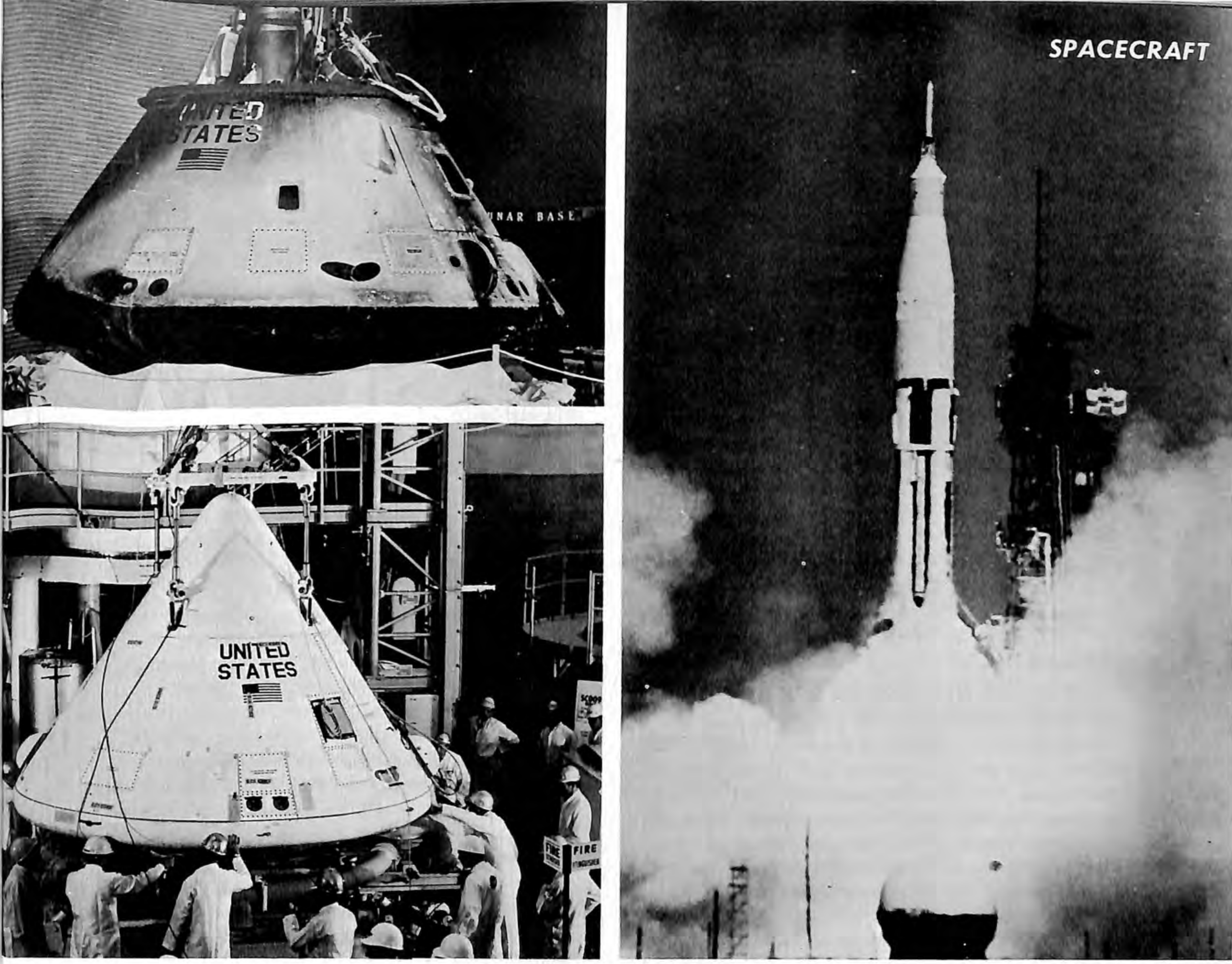
The Service Module houses the main propulsion motor and its propellants for return from the moon and for midcourse corrections. It contains the electrical system, reaction control engines and part of the environmental control system. Propellants and various systems are housed in pie-shaped sections surrounding the main engine. Attached to the Command Module during the flight to the moon, the Service Module is jettisoned prior to earth re-entry.

Command Module Specifications

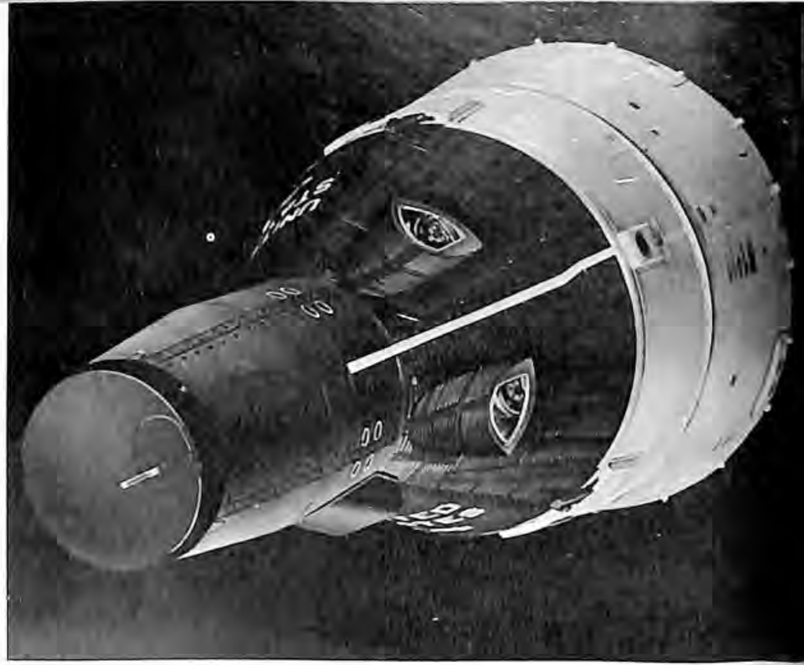
Shape, conical; height 12 feet; diameter (at the base), 13 feet; launch weight 11,000 pounds (approx.); outer structure: stainless steel honeycomb bonded between aluminum alloy sheets; inner compartment: primarily aluminum honeycomb bonded between aluminum alloy sheets; insulation: a two-layer microquartz 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.

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.).



START OF THE PROGRAM. The Apollo program got under way on February 26, 1966, when the first production spacecraft was launched by the first Uprated Saturn booster. Spacecraft 009 was sent 5,000 miles down the Eastern Test Range in a test to determine the capsule's ability to withstand re-entry temperatures and to check out the Service Module propulsion system, which drove the Command Module back into the atmosphere at about 18,000 miles per hour. In photos, lower left, 009 Command Module after acceptance by NASA; upper left, the same module after recovery and return to North American Aviation's Space and Information Systems Division for evaluation; at right, the launch of 009.



LUNAR MODULE

Prime Contractor: Grumman Aircraft Engineering Corporation

Remarks

The Lunar Module is a 2-stage vehicle to be used by Project Apollo astronauts for the descent from lunar orbit to the surface of the moon, and for the ascent from the lunar surface back to the orbiting Command Module. Unsymmetrical, and without any aerodynamic considerations imposed upon its structural design, LM lands by use of a main descent engine which is throttleable and capable of developing 10,600 pounds of thrust. Vehicle orientation is provided by 16 100-pound thrust rocket engines located in quads at 4 locations on the ascent stage. The LM can land either in the automated mode, utilizing a landing radar as the sensing device and a computer to update engine thrust, or can be controlled by the astronauts completely, or in conjunction with the vehicle's automated devices. Its landing gear consists of 4 padded legs. The lower portion of the legs telescope into the upper portion, crushing a honeycomb structure designed to absorb the energy of the landing impact. When LM is ready to return to the Command Module its 3,500 pound thrust ascent engine carries the ascent stage into lunar orbit, leaving the descent stage parked on the lunar surface.

Specifications

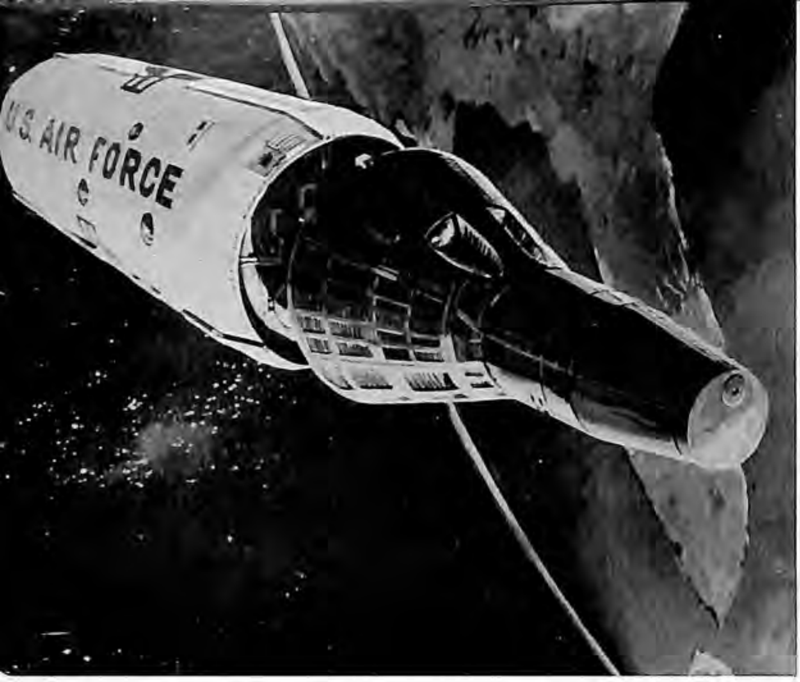
Height 21 feet; width 19 feet; weight more than 15 earth tons.

GEMINI

Prime Contractor: McDonnell Company
Associate Contractors: Honeywell Incorporated (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 2-man spacecraft designed for long-duration space physiological studies and development of rendezvous and docking techniques. Gemini's environmental control system is capable of sustaining 2 astronauts for 2 weeks. The spacecraft has 2 sections, a re-entry module housing the astronauts and an adapter section for equipment. The re-entry module is 11 feet tall, the adapter unit 7 1/2 feet tall. Spacecraft launch weight is approximately 7,000 pounds. On-board thrusters permit maneuvering for rendezvous and docking missions. McDonnell built 13 flight-rated spacecraft; 12 of them were used (10 manned) in NASA's 1964–66 Project Gemini. The spacecraft was scheduled for further use, in a modified version, in the USAF's Manned Orbiting Laboratory project.



MANNED ORBITING LABORATORY

Major Contractors: Douglas Missile & Space Systems Division (spacecraft); General Electric Company (experiments integration); McDonnell Company (Gemini spacecraft).

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 5 manned flights starting in 1969. 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.

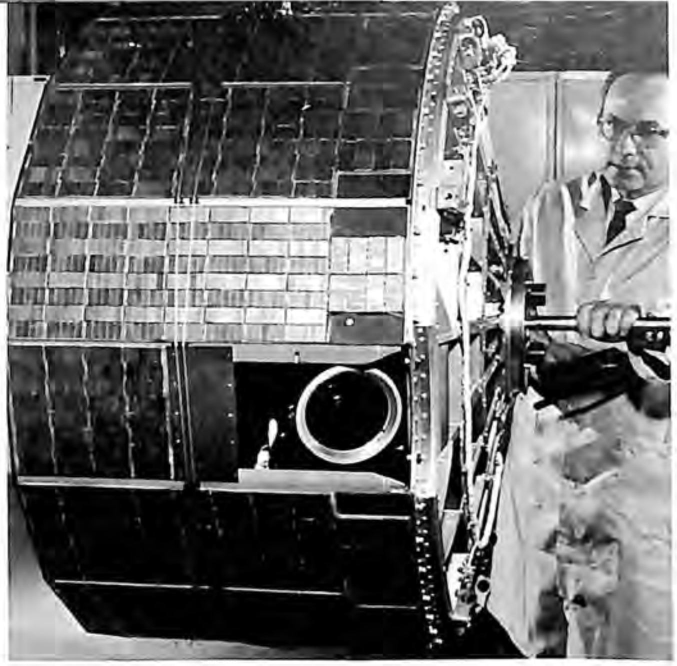
BIOSATELLITE

Prime Contractor: General Electric Company, Re-Entry Systems Department

Associate Contractors: Garrett AiResearch (cryogenics system); Hamilton-Standard (gas management); GE Direct Energy Conversion Operation (fuel cells).

Remarks

Biosatellite is the first U.S. spacecraft designed to demonstrate the effects of prolonged space travel on terrestrial life. The National Aeronautics and Space Administration's Ames Research Center has selected General Electric to develop and build the 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 3, 21 and 30 days are planned. 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 3 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.



NIMBUS

Prime Contractor: General Electric Company's Missile & Space Division, 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 meteoroligical 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 912 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, launched May 15, 1966, took first measurements of Earth's albedo. 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 3 axes. A Thor Agena B was the launch vehicle for Nimbus I, which was placed in polar orbit August 28, 1964. Nimbus II was boosted into a 700 mile-high polar orbit by a thrust-augmented Thor Agena B. Nimbus II's 4 camera systems transmitted more than 280,000 day and night photos of the earth.

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. 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. There were 10 successful developmental launches through 1965.

Specifications

Diameter 42 inches; weight approximately 300 pounds.

ESSA

Prime Contractor: Radio Corporation of America, Astro-Electronics Division.

Remarks

ESSA (Environmental Science Services Administration), the world's first global operational weather satellite, was designed and built by RCA under the technical direction of NASA's Goddard Space Flight Center for the Environmental Science Services Administration of which the U. S. Weather Bureau is a division. The first ESSA satellite was launched successfully on February 3, 1966. It carried 2 conventional TIROS-type television cameras in a rolling wheel configuration. ESSA 2 was successfully launched February 28, 1966, using 2 Automatic Picture Transmission (APT) cameras which enabled it to broadcast weather pictures to local stations around the world. It also rolled like a wheel in its orbital path. ESSA 3, launched October 2, 1966, replaced ESSA 1 and featured an Advanced Vidicon Camera System; it also operates in a wheel mode.

Specifications

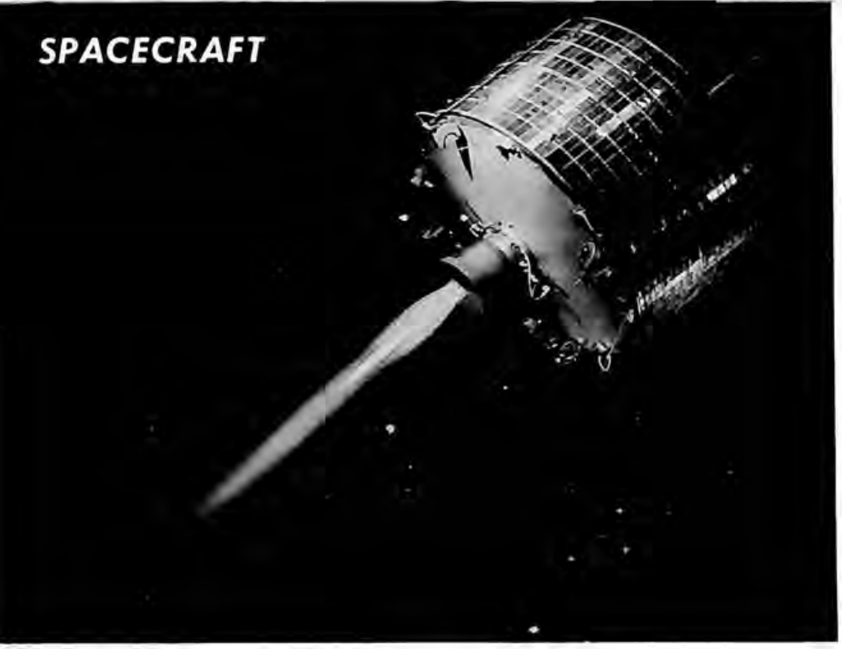
Right circular cylinder 42 inches diameter, 22.5 inches high; weight 325 pounds.

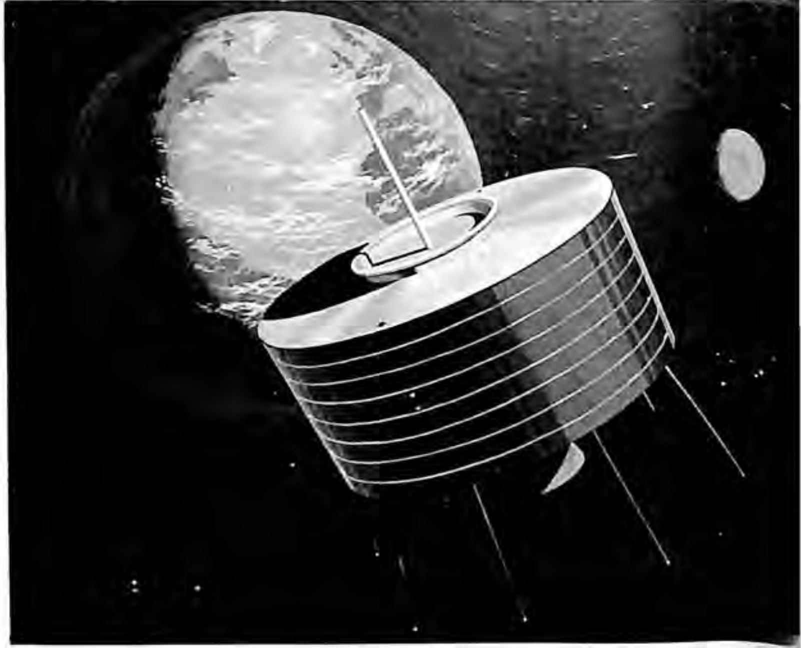
EARLY BIRD

Prime Contractor: Hughes Aircraft Company

Remarks

A synchronous communications satellite, Early Bird was launched April 6, 1965 by the U.S. Communications Satellite Corporation as agent for a world consortium of more than 40 participating nations. The satellite was injected into a synchronous orbit 22,300 miles above the equator over the Atlantic Ocean. The 85-pound spacecraft has capacity for 240 two-way telephone channels or simultaneous two-way television between Europe and North America on a 24-hour basis. It can also handle teletype and facsimile at the same time it carries telephone conversations. Power is supplied by some 6,000 solar cells. The satellite is a later version of the NASA-Hughes Syncom.





SYNCOM

Prime Contractor: Hughes Aircraft Company

Remarks

A second-generation active-repeater communications satellite, Syncom is a synchronous orbiting spacecraft, one whose orbital speed just matches that of the earth's rotation, so that the satellite remains in a fixed position with respect to a point on earth. To achieve the proper velocity, the satellite is sent into orbit at an altitude of 22,300 miles. From that altitude, more than a third of the earth can be "seen," so three such spacecraft can form a TV-telephone network providing 24-hour service. Syncom I, launched February 14, 1963, was unsuccessful. Syncom II, launched July 26, 1963, was completely successful and was the first spacecraft to achieve synchronous orbit. Syncom III, launched August 19, 1964, was placed in stationary orbit over the International Date Line and it relayed the Olympic Games to the U.S. from Japan.

INTELSAT II (Bluebird or LaniBird)

Prime Contractor: Hughes Aircraft Company

Remarks

Intelsat II is a new communications satellite designed to provide the first regular transpacific communications by satellite and at the same time to provide communications support for the Apollo program. Hughes is building 4 spacecraft under an $11,700,000 contract awarded by Communications Satellite Corporation, which acts as manager for the 54-nation International Telecommunications Satellite Consortium. Intelsat II is twice the size and weight of Hughes' Early Bird and it has 3 times the power. Where Early Bird's antenna concentrated its beam in a narrow band between Europe and the United States, Intelsat II offers broader antenna coverage over a wider global area and the ability to carry multiple conversations among ground stations simultaneously. First spacecraft of the series was launched October 26, later positioned so that it was simultaneously visible to earth stations at Brewster Flat, Washington, and Paumalu, Hawaii, although it did not achieve the planned synchronous orbit over the International Date Line. A second launch was scheduled for early 1967.

Specifications

Diameter 56 inches; height 26 inches.

INITIAL DEFENSE COMMUNICATIONS SATELLITE PROGRAM (IDCSP)

Prime Contractor: Space and Re-Entry Systems Division, Philco-Ford Corporation

Remarks

In late October, 1964, Philco-Ford Corporation was assigned prime contractor responsibilities to design, develop and assemble both the satellites and the multiple-launch dispensers for the Initial Defense Communications Satellite Program (IDCSP). Under the overall direction of the Defense Communications Agency, the space hardware portion of the program is the responsibility of the Air Force Space Systems Division, assisted by the Aerospace Corporation. On June 16, 1966, an Air Force Titan III-C rocket launched 7 IDCSP satellites (plus a gravity-gradient experimental satellite) into near-synchronous equatorial orbit at an altitude of approximately 21,000 statute miles to initiate the network—19 months from the start of hardware design. Later launches will augment the system's capability. The contract is being carried out by Philco-Ford's Space and Re-Entry Systems Division, Palo Alto, California. IDCSP is a tri-service program, with the Army and Navy handling ground and naval terminal development and operation. In photo, unique Philco-Ford dispenser system ejects satellites one at a time from Titan III-C Transtage.

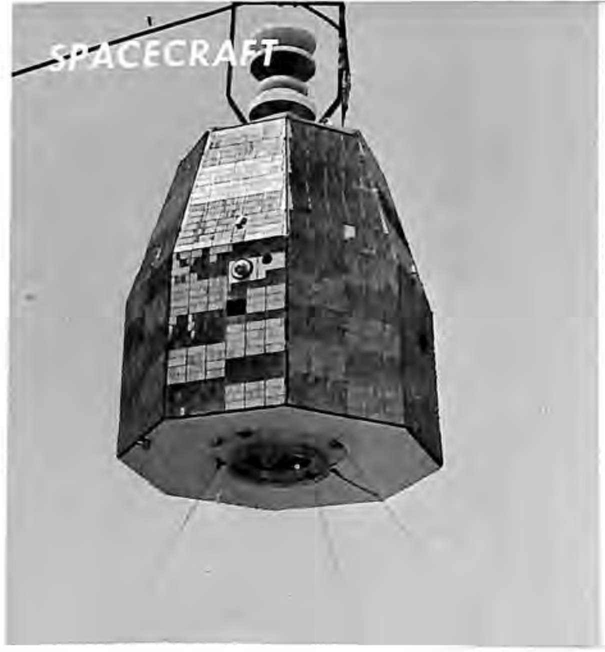
COMMUNICATIONS SATELLITE (INTELSAT III)

Prime Contractor: TRW Systems Group of TRW Inc. for Communications Satellite Corporation (COMSAT)

International Participants: Contraves AG, Switzerland; Engins MATRA SA, France; Entwicklungsring Nord (ERNO), West Germany; Hawker Siddeley Dynamics, Ltd. (HSD); ITT Federal Laboratories, United States; Mitsubishi Electric Corporation (MEC), Japan; Société Anonyme de Telecommunications (SAT), France; Sylvania Electronic Systems, United States; Lockheed Aircraft Corporation, United States.

Remarks

Intelsat III will be the first wholly commercial communications satellite to operate on a global scale. TRW Systems will build 6 flight spacecraft for initial operational use in 1968. Each satellite will handle a minimum of 1200, 2-way voice channels or 4, high-quality television channels. The spin-stabilized spacecraft will be positioned at synchronous orbit (22,300 miles) over the Pacific, Atlantic and Indian Oceans. A fourth satellite will be in orbit and act as a spare. They will be 56 inches in diameter, 37 inches high and weigh about 250 pounds.



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.

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.

TELSTAR

Prime Contractor: American Telephone and Telegraph Company, management by Bell Telephone Laboratories

Remarks

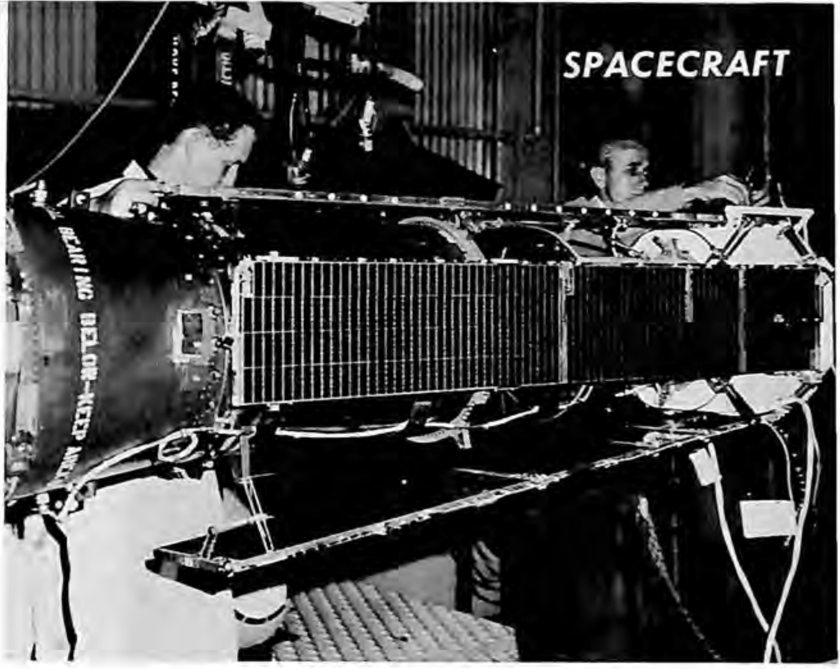
The first active-repeater communications satellite, Telstar demonstrated the feasibility of transmitting television images, telephone, telegraph and radio messages on a global basis. Launched by a Delta booster, Telstar first went into orbit on July 10, 1962. Telstar II was orbited on May 7, 1963. Both satellites were highly successful. NASA provided launch vehicles and tracking facilities on a reimbursable basis.

EROS (EARTH RESOURCES OBSERVATION SATELLITE)

Program Direction: Department of the Interior

Remarks

The Department of the Interior has announced Project EROS aimed at gathering facts about the earth's natural resources by means of instrumented spacecraft. Late in 1966 the project had not been approved for hardware status. Radio Corporation of America reported that it was feasible to build an EROS satellite that could be operational by 1969 for launch into a 300-mile, near-polar, synchronous orbit to permit continuous observation of the United States (or the world) under constantly favorable illumination conditions.



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.

SYNCHRONOUS METEOROLOGICAL SATELLITE

Prime Contractors: Republic Aviation Division, Fairchild Hiller Corporation; Hughes Aircraft Company; Radio Corporation of America, Astro-Electronics Division

Remarks

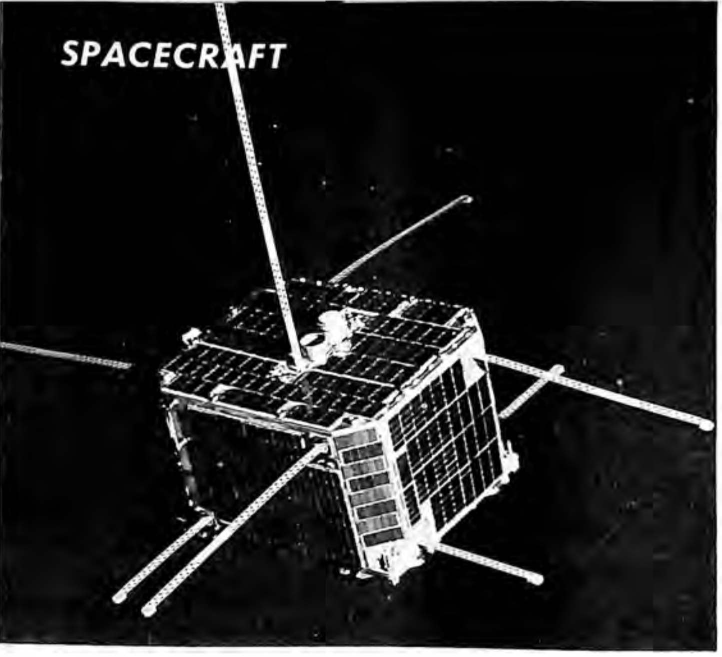
An synchronous or 24-hour satellite, the SMS is an advanced type of weather satellite, a follow-on to Tiros and Nimbus. In 1965 the program was still on a study basis; when hardware development is approved NASA will select one of the three study contractors. SMS booster will be either Atlas-Agena or Atlas-Centaur.

OSCAR

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

A number of Oscar satellites have been launched to enhance the Navy's world-wide all-weather navigation system being used operationally by the fleet (in photo, Oscar 09, launched by a 4-stage Scout May 19, 1966). The satellite is an octagonal prism, 18 inches across and 10 inches high with 4 blades of solar cells, 66 inches long and 10 inches wide. The 144-pound satellite carries 2 transmitters for telemetering, doppler signals and memory read-out. All of the Oscar spacecraft employ electromagnetic and gravity gradient stabilization systems. Each also has a memory system for storing advance orbital data. Pulse signals in the memory system provide the satellites with a digital clock. Launched into polar orbits, at a general inclination of 90 degrees to the equator, the Oscar satellites circle the earth at altitudes from 450 to 600 miles.



GEODETIC SECOR (SEQUENTIAL COLLATION OF RANGE) SATELLITE SURVEYOR

Prime Contractor: Cubic Corporation

Remarks

Geodetic SECOR is an operational 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 4 ground stations, 3 at geographical points whose coordinates have been surveyed accurately and the fourth at an unknown location. Radio waves are flashed from the ground stations to the satellite and returned. The position of the satellite at any time is fixed by the measured ranges from the 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 allows 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 52-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. In late 1966, GEOS A was still operational and returning useful data.

NUCLEAR DETECTION SATELLITES (VELA)

Prime Contractors: TRW Systems Group of TRW Inc. and Space Systems Division, Air Force Systems Command

Remarks

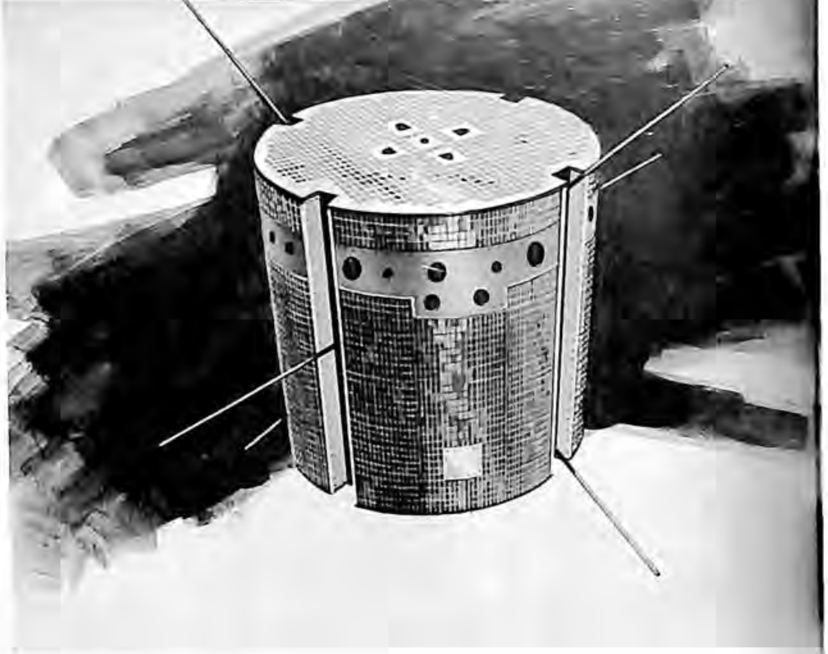
The Nuclear Detection Satellites, also known as Vela, are launched in pairs into high altitude orbits to detect nuclear explosions in space. The project is directed by the Advanced Research Projects Agency of the Department of Defense; Aerospace Corporation has system engineering responsibility. The first pair of satellites was launched in October, 1963, the second in July, 1964, and a third pair in July, 1965. A single satellite weighs slightly less than 500 pounds and has 20 sides, or detection faces; orbital altitudes range upward from 50,000 miles. A new series of Vela satellites has been funded and will be launched for the first time in 1967. These spacecraft are 26-sided and are heavier and larger than the first 6. Their mission has also been enlarged.

APPLICATIONS TECHNOLOGY SATELLITE

Prime Contractor: Hughes Aircraft Company

Remarks

The Applications Technology Satellite is a spacecraft whose mission is to improve other satellites, specifically to enhance the ability of existing and future satellites to provide weather, and communications data and air/sea navigation aids. Three types of missions are planned for ATS: a 6,000-mile earth orbit to experiment with the gravity gradient stabilization system; 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

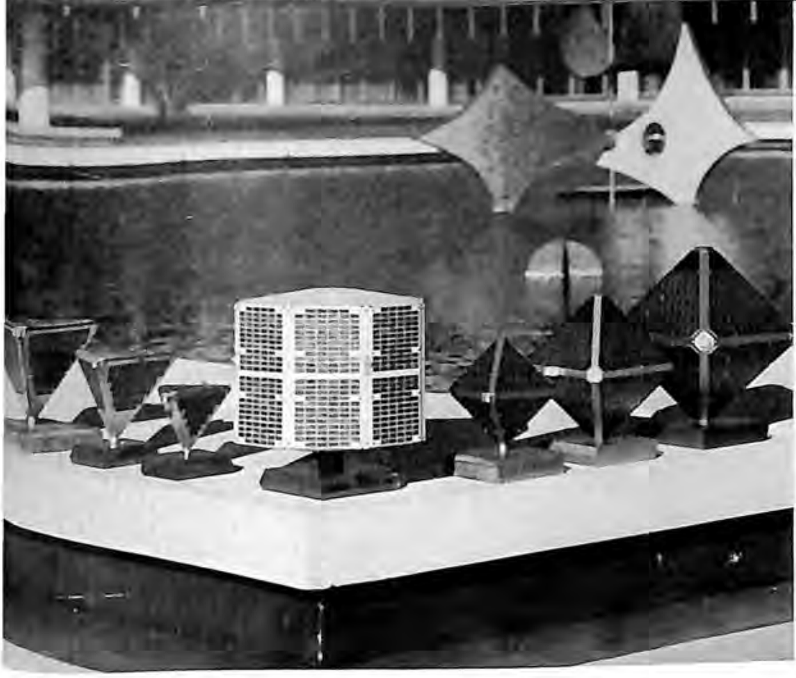
Explorer is not a specific spacecraft but a code name given a series of satellites of different configurations and with varying payloads and assignments. In photo is Explorer XXXI, Direct Measurement Explorer, launched with Canadian Alouette II on November 28, 1965, on Thor-Agena rocket from Vandenberg Air Force Base, California. The double-launch project known as ISIS-X was the first in a new co-operative NASA-Canadian Defense Research Board program for International Satellites for Ionospheric Studies. Explorer XXXI is in orbit with an apogee less than a mile more than Alouette's and with a perigee of less than a mile lower. The orbits are some 1,850 miles high at apogee and 310 at perigee. Explorer XXXI was built for the NASA Goddard Space Flight Center, Greenbelt, Maryland by the Applied Physics Laboratory of The Johns Hopkins University, Howard County, Maryland. Eight ionospheric measurement experiments sample the environment both forward and after the satellite's path. Explorer XXXI is 30 inches across the top and is 25 inches high. A spherical mass spectrometer protrudes 21 inches above the top surface, making the total height 46 inches. The satellite is powered by solar cells which cover about 15 percent of the spacecraft's surface.

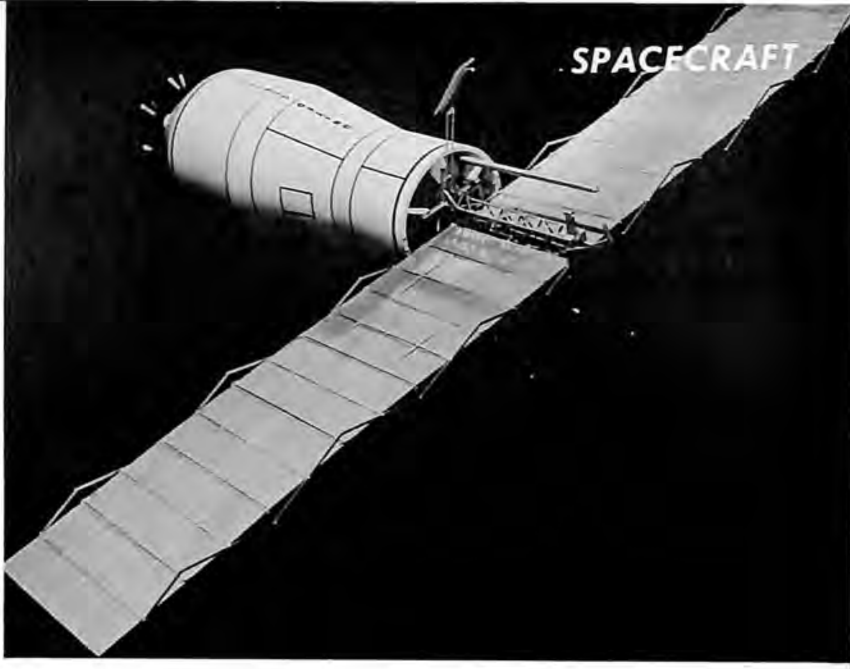
OWL

Prime Contractor: Rice University

Remarks

Latest addition to the Explorer series, Owl is designed to investigate a variety of low and high latitude phenomena and to make particularly powerful studies of auroral phenomena. Rice University is building 2 spacecraft, scheduled for late 1967 launch by Scout boosters. The satellites will be put into similar but not identical orbits at a high inclination with nominal altitudes of 500 and 600 nautical miles and with coincident but antiparallel lines of nodes. The 2 flight units (Rice is also building a flightworthy spare and prototypes of selected subsystems) are identical except that a large permanent magnet is in opposite directions. Each satellite has a flight weight of about 155 pounds; cylindrical, it has a height of 33 inches and a diameter of about 30 inches. Power is obtained by 9,000 solar cells distributed on all sides.





ENVIRONMENTAL RESEARCH SATELLITES

Prime Contractor: TRW Systems Group of TRW Inc.

Remarks

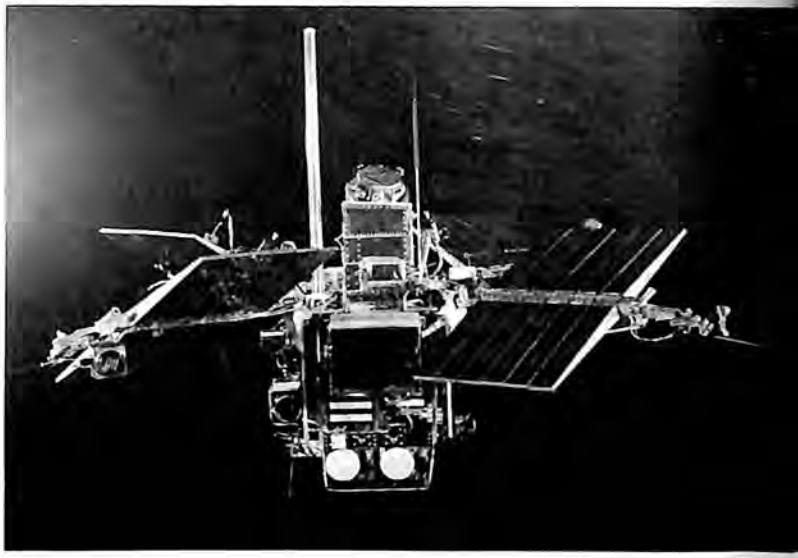
The Environmental Research Satellites were especially designed for piggyback launching from large primary mission vehicles. Ranging in weight from 1.5 to 65 pounds, and carrying from 5 to 14 experiments, these ERS "hitch-hiker" spacecraft provide an inexpensive, flexible vehicle capable of making scientific 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; the larger version weighs 65 pounds and is 17 inches on a side. Some 12 satellites have been launched since 1962 for a variety of missions and sponsors. The 8-sided version will be identified as the OV-5 and will become a part of a program conducted by the Air Force Office of Aerospace Research.

PEGASUS

Prime Contractor: Space Systems Division, Fairchild Hiller Corporation

Remarks

The mission of Pegasus, the Meteoroid Technology Satellite, was to define the magnitude and direction of medium size meteoroids in the near earth space environment. Three Pegasus spacecraft were sent into varying orbits, 300 to 500 miles high, transmitting meteoroid detection information on a daily basis to the FHC operated Satellite Control Center at Cape Kennedy. The spacecraft weighed 3,200 pounds, with a deployed wing 96 feet long and 14 feet high. Its 416 capacitor detectors of varying thickness provided over 2,000 square feet of area designed to count meteoroid hits for at least one year in space. It contained a solar cell powered battery power system, detection system, data processing and storage, real time and stored data transmission system, and temperature sensing and control and attitude sensing systems. Program was concluded in 1965.



OV1 (AEROSPACE RESEARCH SATELLITE)

Prime Contractor: Convair Division of General Dynamics Corporation
Associate Contractor: Allegany Ballistics Laboratory (propulsion system)

Remarks

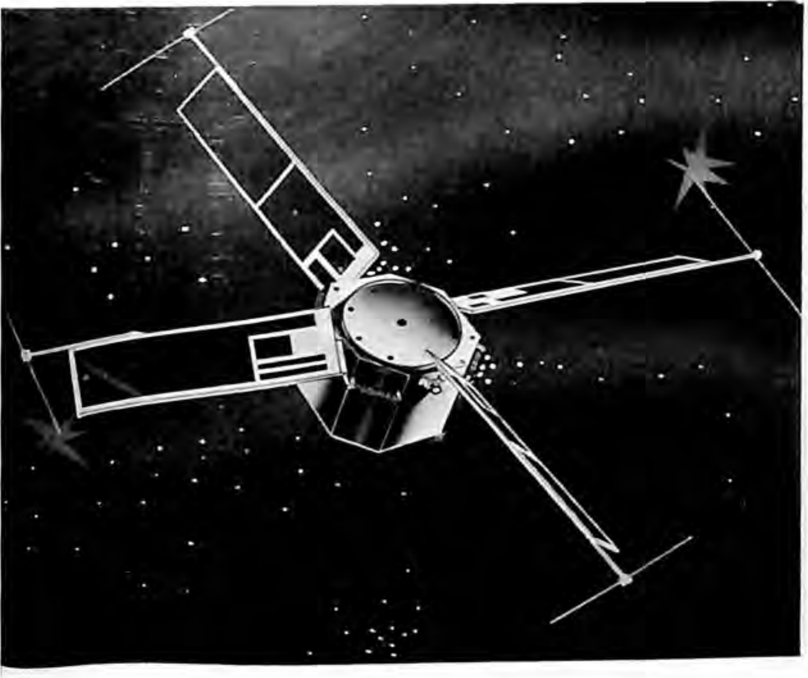
The OV1, formerly called SATAR, was designed to carry a variety of scientific experiments into orbit in a special pod on the Atlas booster when the lift capability of the Atlas is not fully utilized by other experiments, thus providing an economical satellite with "bonus" experiments. The OV1 has its own propulsion system which is fired after the satellite is ejected from the booster vehicle. The OV1 remains inside the Atlas-retained structure during the Atlas flight to protect it from aerodynamics loading and heating. The space vehicle coasts for about 8 minutes in space as preprogrammed attitude control maneuvers are performed on command of the propulsion module guidance system to position it for firing of its solid-fueled motor. OV1 can be launched singly on the side of Atlas or in dual pods on the booster nose. Once in space, it can perform near-circular or highly elliptical earth orbits, high altitude probes or high velocity re-entry missions. Each OV1 can carry an 80-pound payload. Total weight on the Atlas is 2,455 pounds for the dual pod load. The satellite is 54.6 inches long and 27 inches in diameter. Contracting agency is the USAF's Office of Aerospace Research.

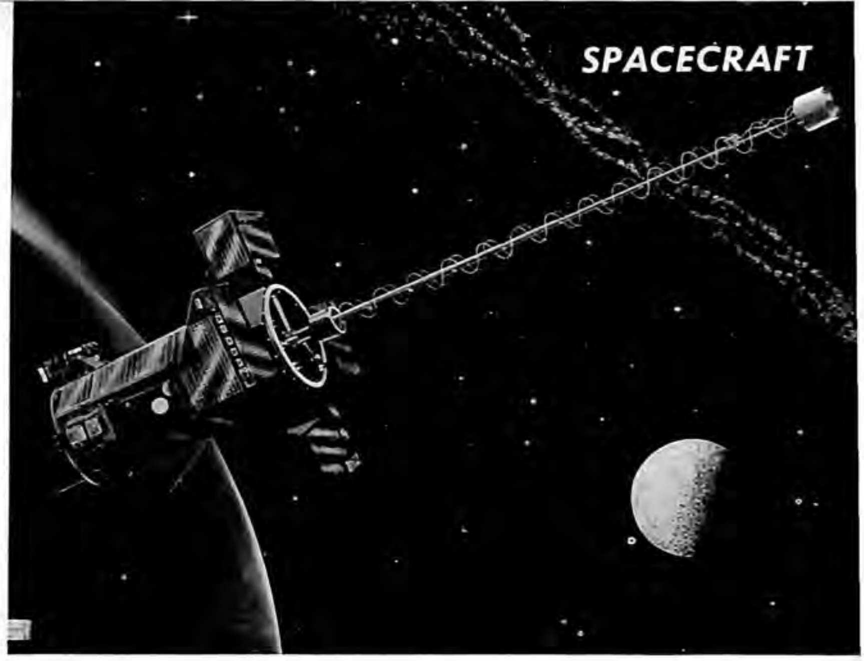
OV2 SATELLITE

Prime Contractor: Northrop Space Laboratories, Norair Division of Northrop Corporation.

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 due to Titan transtage malfunction. The OV2-2 was defined but subsequently cancelled as a result of changes in the Titan III flight test schedule. The OV2-3 was launched in December 1965 but did not achieve orbit similar to the first vehicle. An OV2-5 satellite built by Northrop is scheduled for launch late in 1967. 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 series is powered by solar energy collected by four paddles which extend when the vehicle is in orbit. Span of the basic satellite with paddles extended is approximately 12 feet.





SATELLITE 1963 38C

Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

Remarks

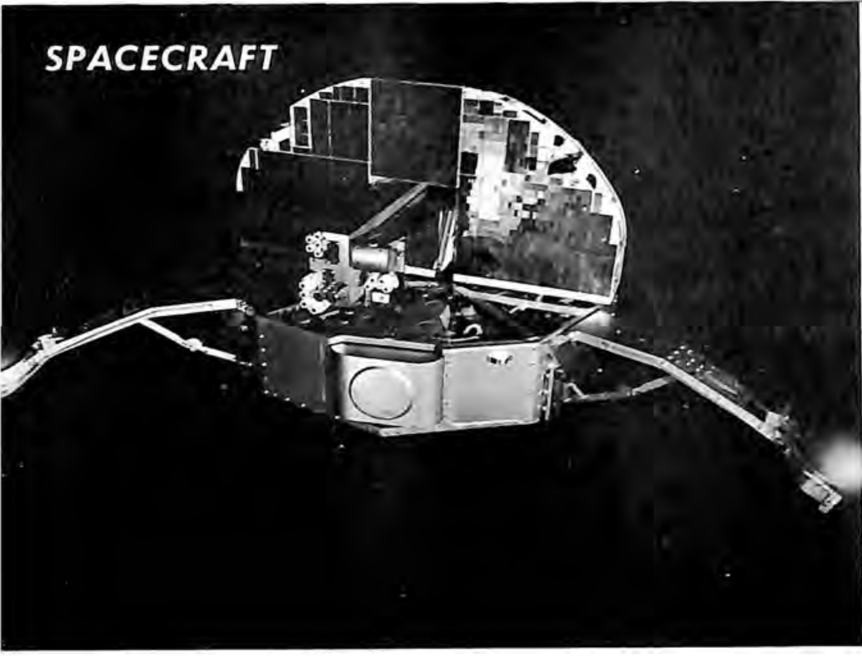
The missions of Satellite 1963 38C are to measure omnidirectional flux of protons and electrons at various energy levels, radiation effects on transistors, and the effectiveness of thermal coatings. The satellite was launched together with a classified Department of Defense spacecraft on September 28, 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. In 1966 it was still sending usable data from all systems.

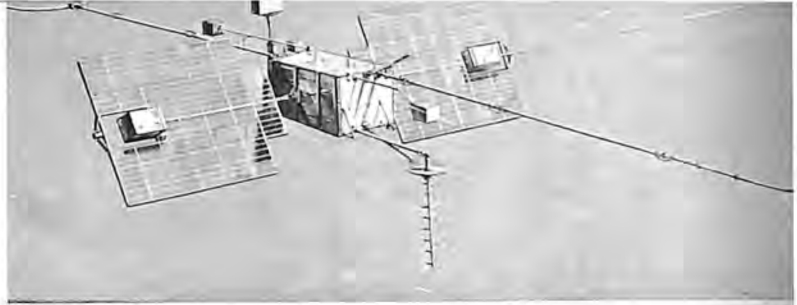
SATELLITE 1964 83C

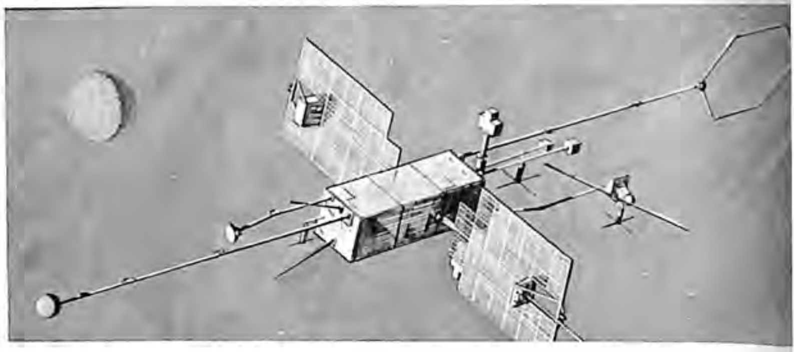
Prime Contractor: The Johns Hopkins University Applied Physics Laboratory

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. In 1966 it was still on a partially-operational basis.







ORBITING SOLAR OBSERVATORIES

Prime Contractor: Ball Brothers Research Corporation

Remarks

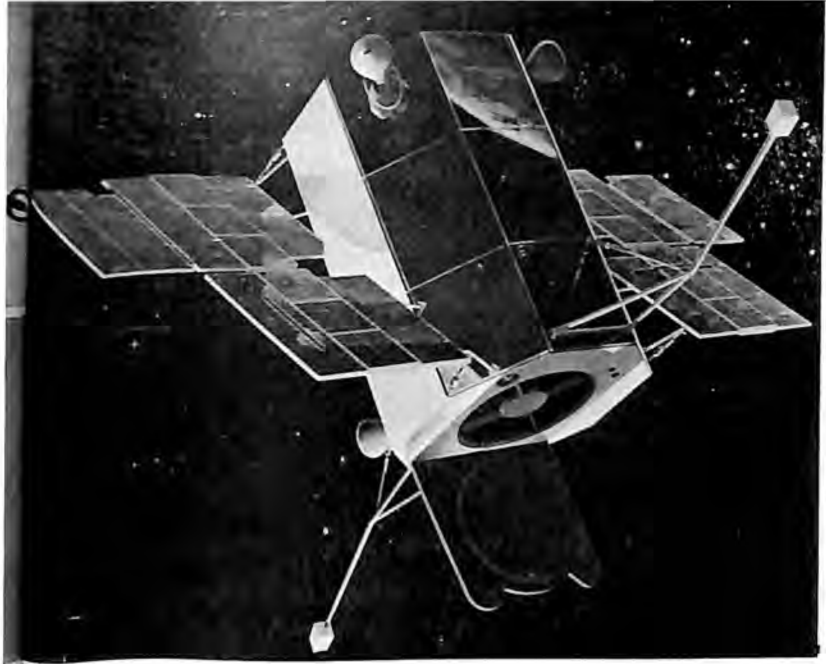
The Orbiting Solar Observatories, developed for NASA's Goddard Space Flight Center, are designed primarily as stabilized platforms for solar-oriented scientific instruments. OSO's use the gyroscopic properties of a spinning body for stability. The satellites are made up of two main parts–the lower "wheel" section which spins at an almost constant rate of 30 revolutions per minute, and the upper "sail" section, mounted on top of the wheel by a connecting shaft. Instruments housed in the wheel scan the sun every 2 seconds. The sail contains continuously pointed, solar-oriented experiments. Photoelectric solar sensors provide signals to orient the wheel and the pointed experiments in the sail. Placed 300-350 nautical miles above the earth by Thor-Delta boosters, the spacecraft orbit the earth every 96 minutes. Gross weight of each observatory (including experiments) is from 450-620 pounds. Their mission is to map the solar system and investigate various solar, coronal, and radiation activities. OSO's are designed for a six-month lifetime; however, OSO-I, launched March 7, 1962, lasted nearly 18 months. OSO-II, launched February 3, 1965, was shut off after nine months. In June, 1966, it was turned on again and operated satisfactorily. It will be turned on intermittently until the nitrogen gas supply is eventually depleted. OSO-E1 was scheduled for late 1966 launch and contracts have been received by Ball Brothers for OSO's D, F, G, and H.

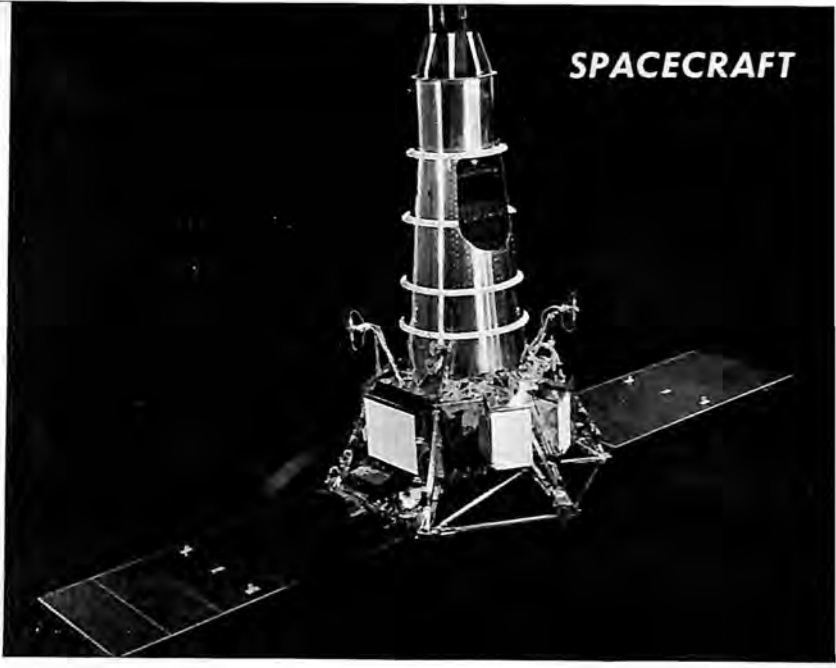
ORBITING GEOPHYSICAL OBSERVATORY

Prime Contractor: TRW Systems Group of TRW Inc.

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. Three OGO's have been launched and 4 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

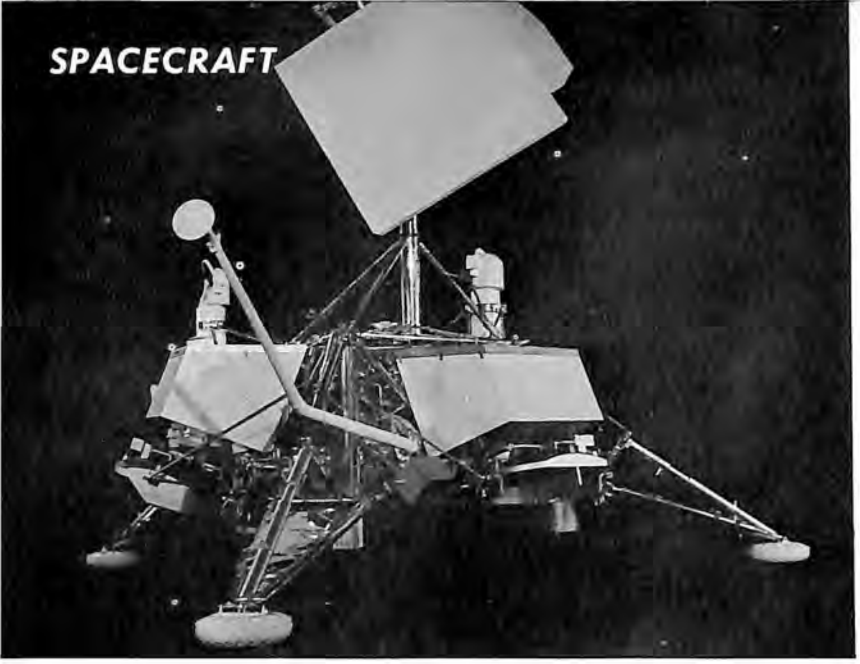
NASA's Orbiting Astronomical Observatory is a large (3,900 pounds) earth-orbiting satellite capable of lifting a number of telescopes above the earth's atmosphere, which obscures cosmic radiations of interest to astronomers. Solar paddles provide 350 watts of power for experiments and for stabilization. Launch vehicle is the Atlas-Agena D; three flights are planned, the first of which took place in April, 1966.

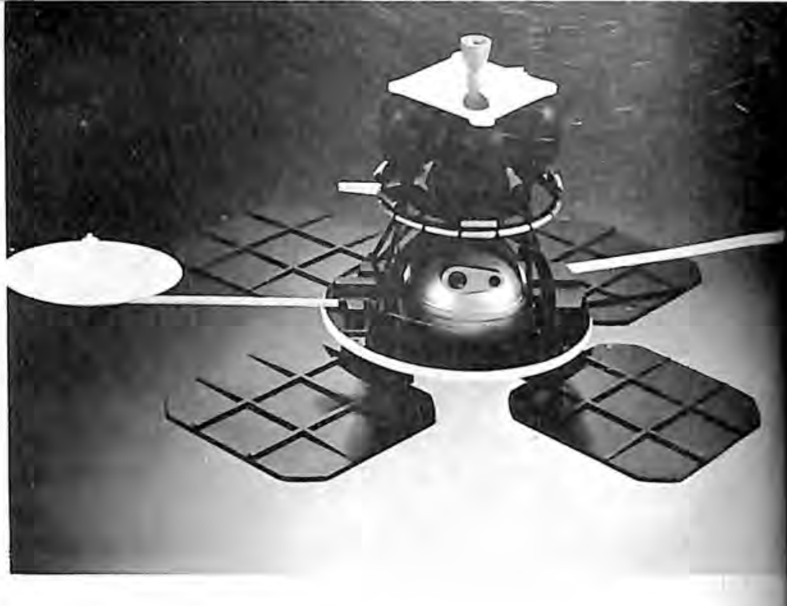
RANGER

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 was 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 of benefit both to the scientific program and the manned lunar flight program. The spacecraft weighed 809 pounds, and in its flight deployed configuration extended 15 feet across the solar panels and 10 1/4 feet from base to antenna top. On-board equipment included 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 2 wide-angle and 4 narrow-angle cameras, camera sequencers, vidio combiners, telemetry, transmitters and power supplies. Ranger program, concluded in 1965, consisted of 9 flights, the last 3 producing more than 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

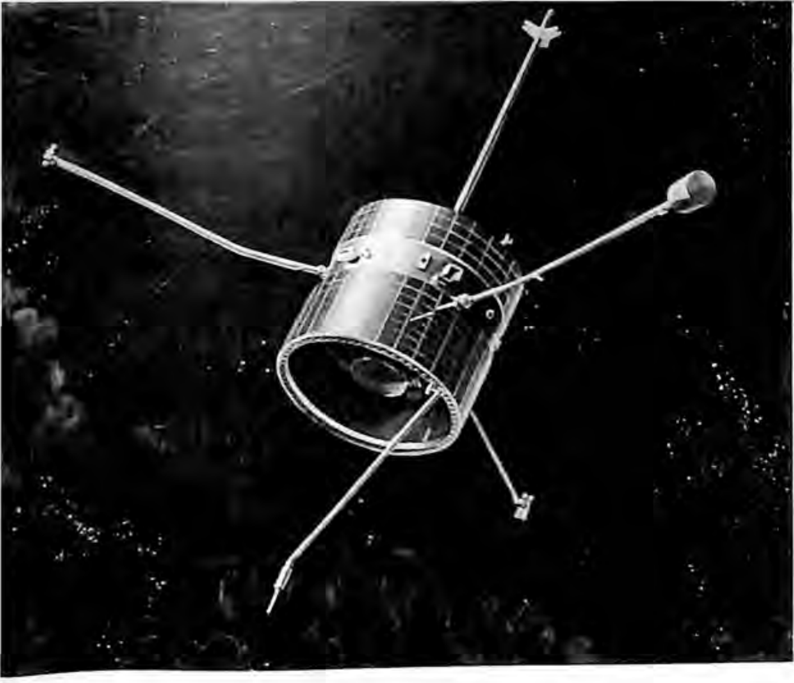
Surveyor is an unmanned, instrumented spacecraft for use in the National Aeronautics and Space Administration program for conducting scientific exploration of the moon and for developing equipment and techniques for soft landing of scientific payloads on the lunar surface. The initial test flights include 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. Surveyor I, launched May 30, 1966, successfully soft-landed and returned 11,150 pictures of the lunar surface. Surveyor II, launched later in the year, was unsuccessful. Later versions will weigh 2,500 pounds.

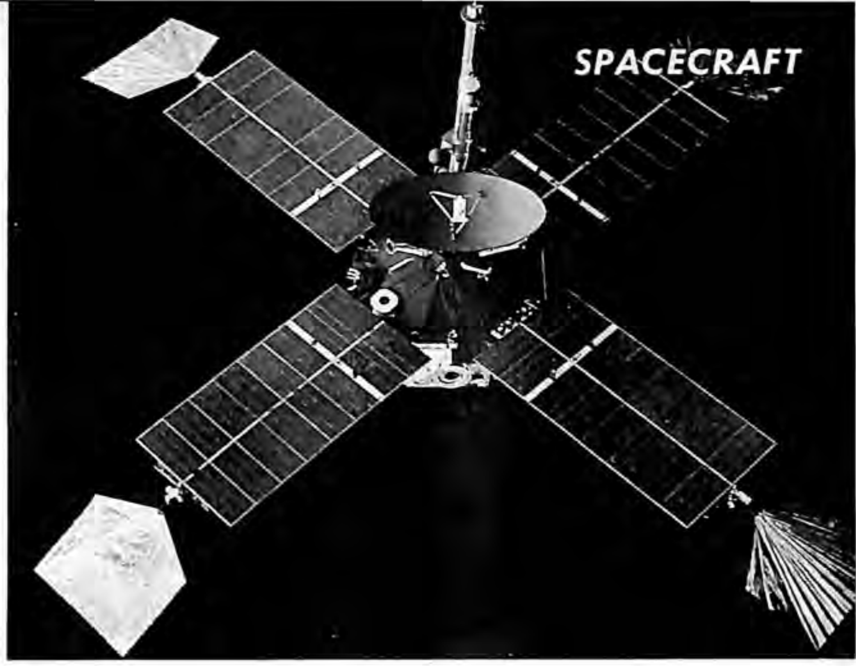
LUNAR ORBITER

Prime Contractor: The Boeing Company
Major Subcontractors: Eastman Kodak (photographic system); Radio Corporation of America (electrical power and communications equipment).

Remarks

Lunar Orbiter I, the first flight spacecraft, was launched August 10, 1966, and successfully achieved lunar orbit on August 14. During the 35-day picture-taking mission more than 40,000 square miles of the moon were photographed with overlapping exposures to provide stereoscopic mapping of the lunar surface. The spacecraft also took the first high-resolution pictures of the far side of the moon and the first picture of the earth taken from the moon. Four additional Lunar Orbiters will be launched on similar moon mapping missions, although the particular objectives will vary for each flight. The Orbiters will take sharp, close-up pictures of potential landing sites for Project Apollo astronauts. Negatives are processed on-board the vehicle and are read out with a scanning system for transmission as electronic signals back to stations of the Deep Space Network at Goldstone, California; Woomera, Australia; and Madrid, Spain. Each spacecraft also carries instruments to measure radiation near the moon and to detect the presence of micrometeoroids. Boeing contracted to build 8 Lunar Orbiters (3 of them ground test vehicles) for NASA's Langley Research Center, responsible for systems management. The Lunar Orbiter program is under the overall direction of NASA's Office of Space Science and Applications.





PIONEER

Prime Contractor: TRW Systems Group of TRW Inc.

Remarks

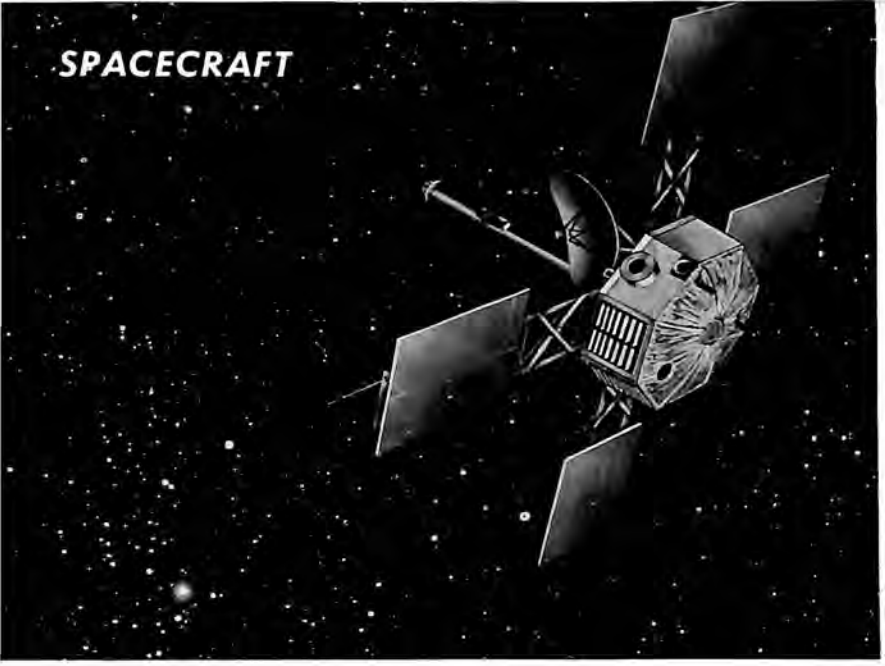
Pioneer is an interplanetary spacecraft designed to operate in solar orbit and send data on interplanetary magnetic fields, radio propagation effects of the "quiet sun," plasma spectrometry, ionization levels and solar, high-energy and medium-energy particles. Pioneer is cylindrical, 35 inches long and 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. Pioneer 6, launched Dec. 16, 1965, went into a solar orbit some 20 million miles closer to the sun than Earth. Pioneer 7, launched Aug. 17, 1966, will attain an orbit more than 13 million miles further from the sun than Earth. Both spacecraft are performing exceptionally well and returning vast amounts of valuable data on the solar environment. Three more Pioneers remain on the launch schedule.

MARINER-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 was an unmanned, instrumented spacecraft for use in the National Aeronautics and Space Administration program in conducting scientific observations of the planet Mars, for developing equipment and techniques for carrying out planetary explorations, and for making scientific measurements of the interplanetary environment. The spacecraft weighed 575 pounds and in its flight-deployed configuration extended 22 feet across the solar panels and stood 9 feet high from base to antenna tip. Onboard equipment included 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.



MARINER-VENUS

Prime Contractor: Jet Propulsion Laboratory, California Institute of Technology

Remarks

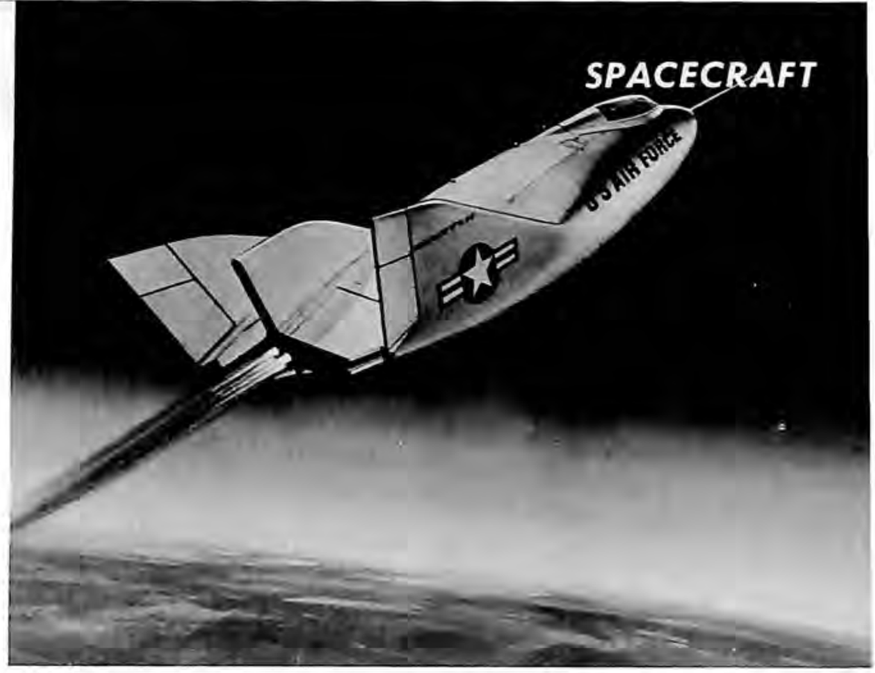
Mariner-Venus is an unmanned instrumented spacecraft for use in NASA's planetary exploration program. The spacecraft will weigh approximately 575 pounds and in its flight—deployed configuration extends 22 feet across the solar panels and stands 9 feet high from base to the tip of the omni-antenna mast. On-board equipment includes a mid-course propulsion guidance system, a central control and sequencer system, solar panels and battery, attitude control system utilizing sun and star sensors and instruments for making planetary and interplanetary measurements of fields and particles and for studies of the Venusian atmosphere. The spacecraft is a modified flight spare from the Mars mission in 1964–65. The launch vehicle will be an Atlas-Agena. A single spacecraft will be launched in 1967.

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 in 1973 and at 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 1973 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, of conventional aluminum aircraft structure, are covered with a Martin-developed, ablative heat shield material which is mounted in a special honeycomb base. Two movable flaps on the underside of the tail provide control in pitch and roll axes during atmospheric flight, and reaction jets are used in space. The vehicles were built for the Air Force Space Systems Division for hypersonic, maneuvering flight tests following launch from Vanderberg AFB by Atlas SLV-3 standard launch vehicles. Parachute recovery of the PRIME spacecraft begins once it slows to approximately Mach 2. The spacecraft is "snatched" in the air by a plane near Kwajalein. PRIME is one portion of the broader USAF program START (Spacecraft Recovery and Advanced Reentry Tests).

SV-5P PILOT (PILOTED LOWSPEED TEST)

Prime Contractor: Martin Company, Baltimore

Remarks

Pilot is a one man version of the SV-5 configuration. Rocket powered, it will explore flight characteristics of lifting bodies at supersonic speeds of Mach 2 down to normal jet landing speeds. Flight plans call for it to be carried aloft to 45,000 feet under the wing of a B-52 where it will be released to rocket up to 100,000 feet before maneuvering to a landing at Edwards AFB, California. Power will be supplied by the Thiokol XLR-11 engine. SV-5P has 8 aerodynamic control surfaces—2 upper and 2 lower flaps and 4 rudders, or 2 split rudders on each of the 2 outside vertical fins. The vehicle is 24 feet long, 13 feet wide and weighs about 5,000 pounds unfueled. The SV-5P flights will begin where PRIME ends, completing the technology necessary to develop manned maneuvering re-entry spacecraft. A Martin-funded manned SV-5J (for jet) is being built to provide additional flight experience. A Pratt and Whitney J60 engine will power the SV-5J

HL-10 LIFTING BODY VEHICLE

Prime Contractor: Northrop Norair Division of Northrop Corporation

Remarks

The HL-10 was built under contract to NASA and was configured at the Langley Research Center at Hampton, Virginia. It is an experimental wingless lifting body designed for high altitude flights within the earth's atmosphere. The HL-10 varies from the first Northrop-built M2-F2 lifting body vehicle in that it is flat on the bottom, whereas the M2-F2 vehicle is flat on the top. The modified half-cone shape of the HL-10 lifting body provides a useful volume-to-surface area and achieves aerodynamic stability and lift from the body alone, eliminating the need for wings. The HL-10 was scheduled for flight late 1966 or early 1967.

Specifications

Length 22 feet 2 inches; width 15 feet 1 inch; height 11 feet 5 inches; minimum weight 5,265 pounds; maximum weight 8,000 pounds; controls—a thick elevon between each outer fin and the center fin for pitch and roll control; a split rudder on center fin for yaw and speed brake control. All surfaces are used in the 3-axis stability augmenter system. Each elevon has a flap on the upper surface, each outer fin has 2 trailing edge surfaces, and 2 rudder surfaces can be controlled to vary the base drag.

Performance

Glide to landing approximately 3.5 minutes; flare for landing performed at an altitude of 1,000 feet, speed 200–300 knots; landing speed 140 to 210 knots; landing rockets (optional use) 1,000 pounds thrust for 12 seconds.

M2-F2 LIFTING BODY VEHICLE

Prime Contractor: Northrop Norair Division of Northrop Corporation

Remarks

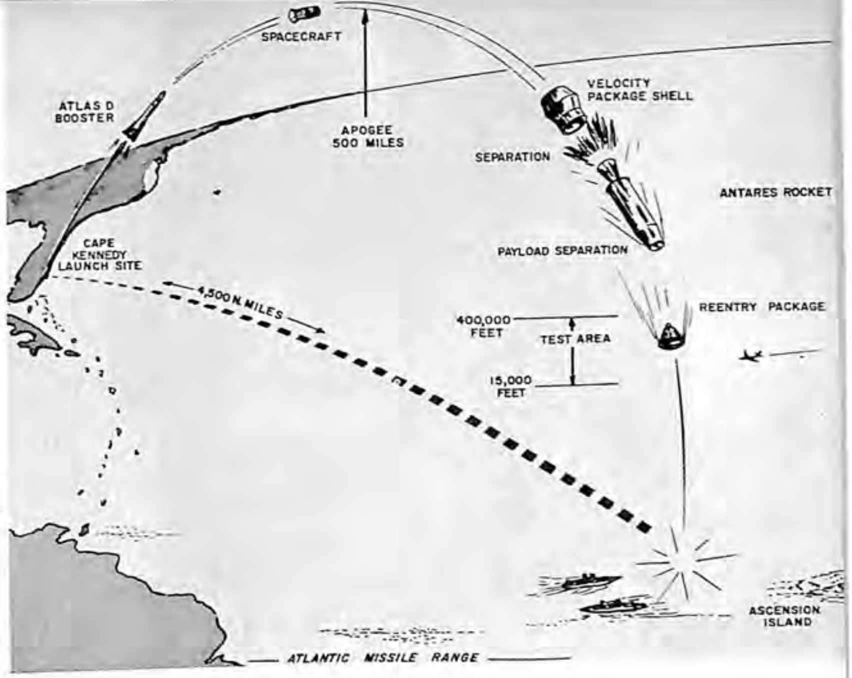
The M2-F2 is an experimental wingless lifting body designed for high altitude flights within the earth's atmosphere. It was produced by Northrop under contract to NASA to accomplish flight research in the art of controlling future manned space flights in the earth's atmosphere during the critical terminal approach and landing phase. The original M2 configuration design was created by NASA at the Ames Research Center at California. The basic lifting body is a half-cone altered by blunting the nose and adding tail fins. The M2-F2 was successfully dropped from a special pylon attachment on the wing of a B-52 bomber, flying at 45,000 feet, and piloted to a conventional airplane-type landing at Edwards, California on July 12, 1966. Several successful flights have been made since that date.

Specifications

Length 22 feet 2 inches; width 9 feet 7 inches; height 8 feet 10 inches; minimum weight 4,600 pounds; maximum weight 8,000 pounds; controls—1 pair thick rudders; 1 pair of flaps on upper surface of boat-tail; 1 full-span pitch flap on lower surface of boat-tail. Upper flaps aid in pitch control and are interconnected with rudders for roll control.

Performance

Average flight time approximately 4 minutes from 45,000 feet; first flight touchdown speed approximately 195 miles per hour.



ASSET

Prime Contractor: McDonnell Company

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

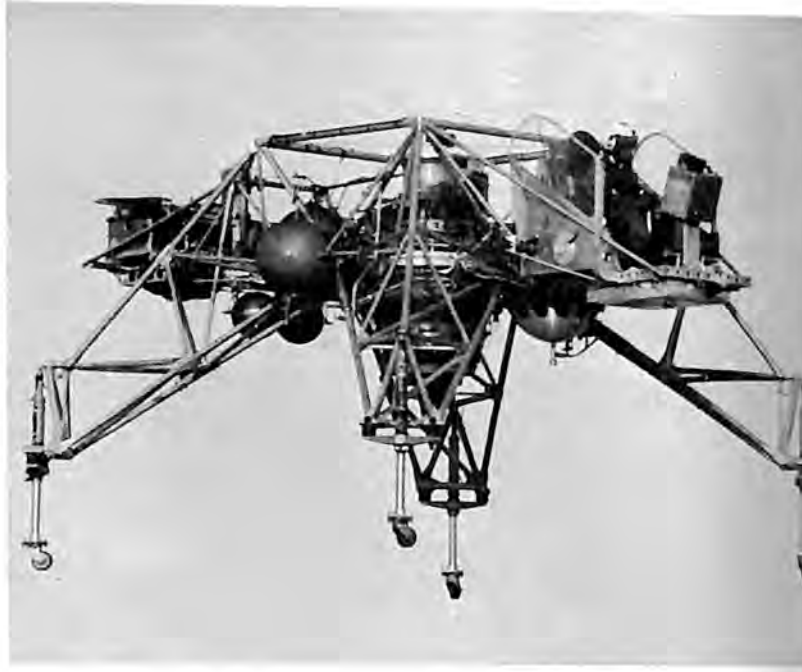
Prime Contractor: Republic Aviation Division, Fairchild Hiller Corporation

Remarks

Project FIRE was 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 2 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. The tests produced more than 100,000 telemetered data bits.

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 Incorporated

Remarks

Scanner is a spacecraft used in horizon definition experiments being directed by NASA's Office of Advanced Research and Technology. The spacecraft was 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. Horizon definition and measurement are being studied because of their importance to spacecraft stabilization and guidance techniques. First suborbital launch, to an altitude of 380 miles, was made from NASA's Wallops Station, Wallops Island, Virginia, on August 13, 1966.

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.

LUNAR LANDING RESEARCH VEHICLE (LLRV)

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

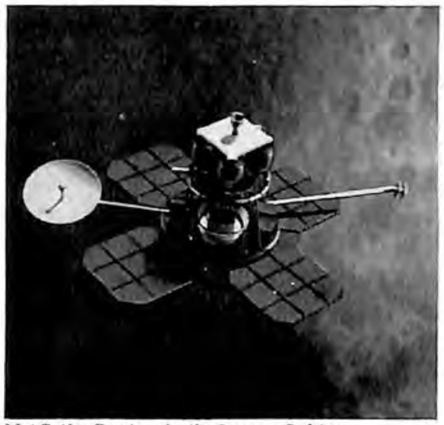
A space trainer rather than a flyable spacecraft, the Lunar Landing Research Vehicle was designed and built by Bell Aerosystems for the National Aeronautics and Space Administration. It is a non-aerodynamic VTOL craft being flown at the NASA Flight Research Center, Edwards, California, to train astronauts 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.

737, world's newest short-haul jet

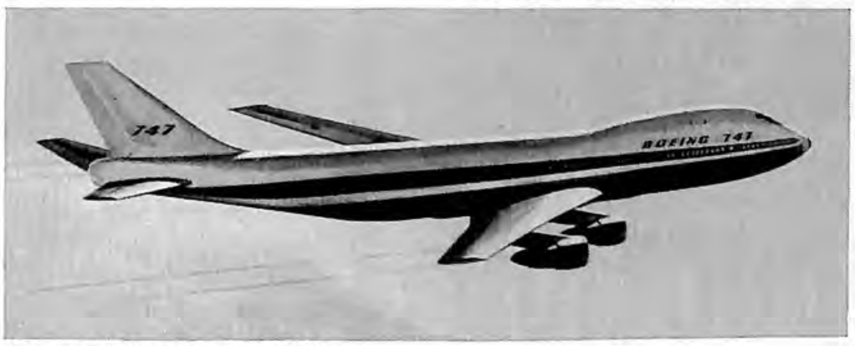
SRAM, Air Force short-range attack missile



NASA's Boeing-built Lunar Orbiter

U.S. Air Force Minuteman ICBM

Boeing helicopter



747, world's largest commercial jet

U.S. Navy Hydrofoil Gunboat

NASA's Apollo/Saturn V moon rocket

Capability has many faces at Boeing.

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

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

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

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

SRAM, a short-range attack missile with nuclear capability, is being designed and developed by Boeing for U.S. Air Force.

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

PGH (Patrol Gunboat-Hydrofoil), designed and being built by Boeing, will be first of its kind for U.S. Navy. Propulsion is by water-jet engine.

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

BOEING

SHILLELAGH

Anti-Tank Missile system now in its second year of volume production by Aeronutronic at Lawndale, Calif., for the U. S. Army Missile Command.

ARMOR

Light weight, low-maintenance, Ausform® steel armor in high volume production at Newport Beach and Santa Ana Calif., by Aeronutronic, for personnel and critical component protection of aircraft in Vietnam, for the U.S. Army Aviation Materiel Command.

IN

PRODUCTION

AT

AERONUTRONIC

IN THE LONG STANDING TRADITION OF FORD MOTOR COMPANY AND PHILCO-FORD CORPORATION, IN PROVIDING MILITARY HARDWARE FOR THE U. S. DEFENSE ARSENAL, AERONUTRONIC IS PRODUCING WEAPONS SYSTEMS FOR THE DEPARTMENT OF DEFENSE. WITH HEADQUARTERS AT NEWPORT BEACH, CALIFORNIA, AERONUTRONIC EMPLOYS OVER 5,500 PERSONNEL.

CHAPARRAL

Air Defense Missile System currently beginning production by Aeronutronic at Anaheim, Calif., for the U. S. Army Missile Command.

AUTOMATIC WEAPONS

Advanced Ground Combat and Airborne Weapons being developed and produced at Anaheim, Calif., by Aeronutronic, for the U. S. Army Weapons Command.

PHILCO Ford

PHILCO-FORD CORPORATION
Aeronutronic Division
Newport Beach, California

AP12V AIRBORNE HYDRAULIC PUMP

Prime Contractor: Aerospace Division, Abex Corporation

Remarks

Originally developed for the USAF/Navy F-111, the Abex AP12V series hydraulic pump is of simplified design, the axial piston arrangement eliminating universal joints. Direct oil entry permits longer periods of operation at low inlet pressure. All thrust loaded parts are pressure lubricated for reduced friction and increased life. With a maximum displacement of 2 cubic inches per revolution, the pump delivers 47 gallons per minute at 5,800 revolutions per minute. Growth potential of the series design is 65.5 gallons per minute at 8,000 revolutions per minute. The heart of the pump is a revolving cylinder barrel that holds 9 pistons. By means of a hold-down plate and hydraulically balanced shoes, the pistons are supported on an inclined cam plate which causes them to reciprocate as the barrel revolves. The hold-down plate insures positive stroking of the pistons during the suction stroke. Approximate weight of the unit is 17 pounds.

SNAP-8 NUCLEAR ELECTRICAL POWER GENERATING SYSTEM

Prime Contractor: Aerojet-General Corporation

Remarks

The SNAP-8 system, under development for NASA's Lewis Research Center, converts nuclear reactor heat into electrical power for large manned space stations, lunar bases and deep space probes of the future. The system is designed to generate 35 kilowatts and to operate for 10,000 hours (nearly 14 months). 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 electrical power for the spacecraft.

RESISTOJET SPACECRAFT CONTROL SYSTEM

Prime Contractor: Avco Corporation, Space Systems Division

Remarks

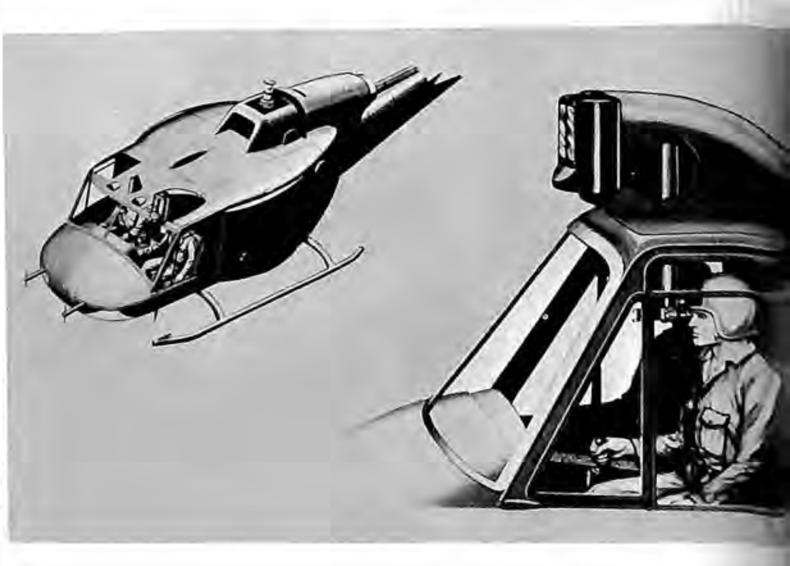
The Resistojet spacecraft control system was developed for the National Aeronautics and Space Administration for attitude and orbit control of stable-platform satellites weighing up to 1,000 pounds, using only 7½ watts of power to do so. Experimental models of slightly different configurations have been developed for NASA's Goddard Space Flight Center and Lewis Research Center. The hardware developed and delivered to Goddard was slated for experimental testing on the Applications Technology Satellite, scheduled for launch in December, 1966. On-board the ATS-B the Resistojet is used to change the spin-rate of the satellite in orbit. The Resistojet for the ATS-B measures 12 inches in length, 4½ inches in diameter and weighs 6 pounds when filled with 0.5 pounds of liquid ammonia. Each of the unit's 2, 1 and ¾ inch thrusters, powered by solar energy, can be operated independently to change spacecraft spin-rate. The propulsion unit has a total impulse capability of 100 pounds per second. Engines operate at a thrust level of about 500×10^{-6} pounds and a corresponding specific impulse of 150 seconds. The system's miniaturized components consist of 2 pressure switches, 2 supply valves and an electronics package. Fuel storage tanks hold a propellant supply designed for 3 years operation. The Resistojet system being developed for Lewis—essentially the same as that for Goddard—will be capable of 3-axis attitude control and multi-directional station keeping.

STABILIZED OPTICAL TRACKING DEVICE

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The Stabilized Optical Tracking Device (SOTD) is a new sighting device which will enable helicopter gunners to pinpoint and assess suspect targets quickly and easily. Bell Aerosystems is developing a demonstration model for the Army, designed for use in the Bell UH-1 Iroquois helicopter and scheduled for delivery early in 1967. The sight provides means for acquisition and tracking of targets by the co-pilot/gunner of a high-speed, highly maneuverable helicopter using manual control. The line of sight is inertially stabilized, virtually isolated from vibration and free from any detectable blurring of the target. This type of stabilization permits use of high magnification optics to aid in the tracking of distant and moving targets. Bell's design makes it possible to have an infrared tracking or laser range finder system, or both, added to the SOTD. In photo, SOTD as mounted on a helicopter.



DUAL PURPOSE MANEUVERING UNIT

Prime Contractor: Textron's Bell Aerosystems Company.

Remarks

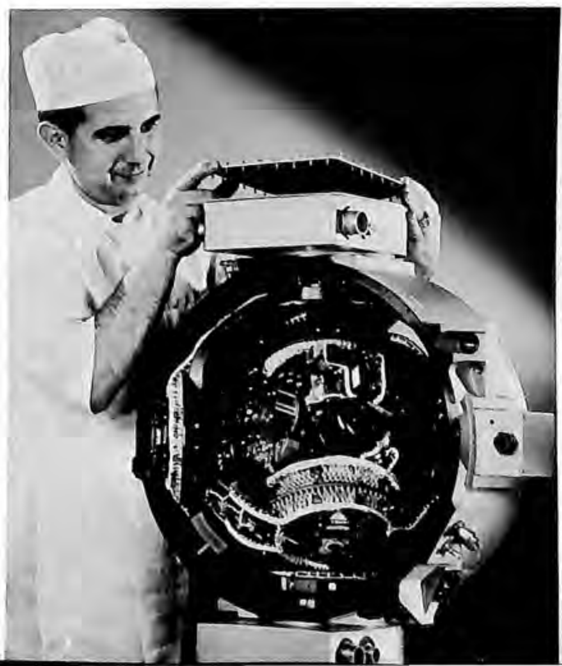
The Dual-purpose Maneuvering Unit (DMU) is a double-duty device which can be operated in space by an astronaut (as in photo, left) or remotely controlled from a parent vehicle (photo, right). Bell Aerosystems is developing the small, rocket-powered maneuvering spacecraft for the Research and Technology Division of Air Force Systems Command for possible use in support of future manned spacecraft operating in earth orbit. Incorporated in the DMU are a television camera, stabilization and control systems, propulsion systems, life support equipment, communications and radar as required by the operating mode. Should a mission call for it, a spaceman could don the DMU and help assemble a space station in space, repair a space vehicle or perform other tasks. For unmanned missions, the DMU could be guided remotely, by means of its TV camera and radio signals, for such tasks as inspection of satellites or assistance in docking and transfer of space equipment.

STABILIZED PLATFORM SYSTEM FOR SATURN ROCKET

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

The Saturn rocket's ST-124 stable platform provides guidance and second stage cutoff information, and velocity and attitude control signals. The platform operates in conjunction with 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. Mounted to the stable inner element, or inertial gimbal, are three single-degree-of-freedom gyros, three pendulous-gyro-accelerometers, and two preflight leveling pendulums. Gyros and accelerometers are gas floated. The gyro wheel is supported in the beryllium cylinder, which, in turn, is supported by the hydrostatic gas-bearing, with both radial and axial centering. All platform structural members and most of its components are made of beryllium, thereby affording considerable weight saving as well as greatly improved stability over a wide range of temperatures.



INERTIAL GUIDANCE SYSTEM FOR PERSHING MISSILE

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

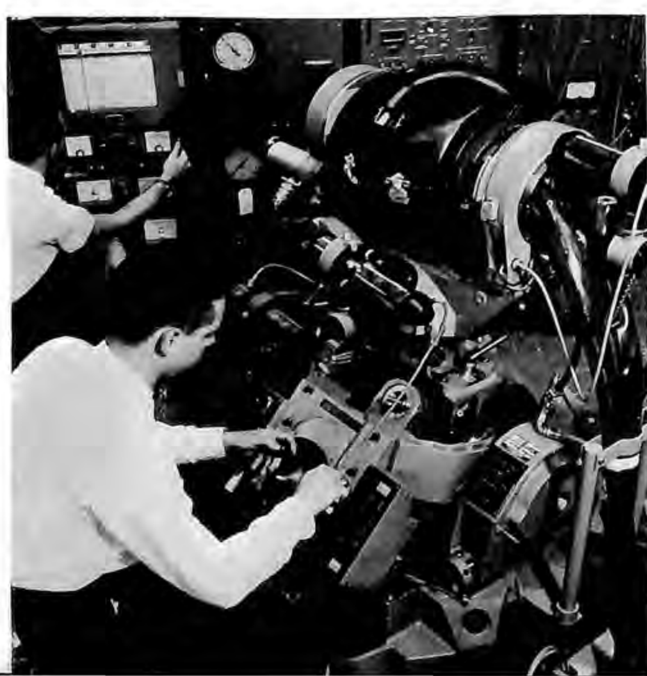
The inertial guidance system for the Army's Pershing selective range artillery missile contains three gryos and three accelerometers which provide directional references for hitting a target the size of a football field from a distance of several hundred miles. The actual spinning parts of the gyros are sealed-in miniature cylinders (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.

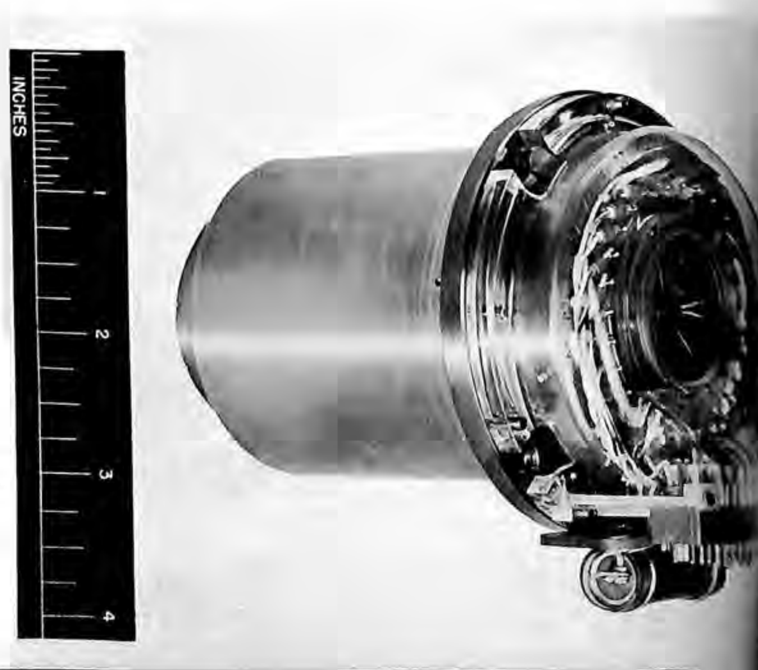
PENDULOUS INTEGRATING GYRO ACCELEROMETER FOR MINUTEMAN MISSILE

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 one of the most accurate velocity-measuring devices in production, precisely measuring accelerations in sensitivities as small as mill-minus g to as large as 30 g's. It is a sensitive, liquid-floated, single-degree-of-freedom gyro instrument rugged enough to operate in vibrational and thermal environments of any application where precise velocity information is required. An outstanding feature of the unit is the low threshold level of the gimbal rotation, resulting from floating the gryo 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. An advanced configuration, now in production, incorporates a gas, spin-axis bearing that greatly increases the predicted life.





RANGE INDICATOR FOR LUNAR MODULE

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

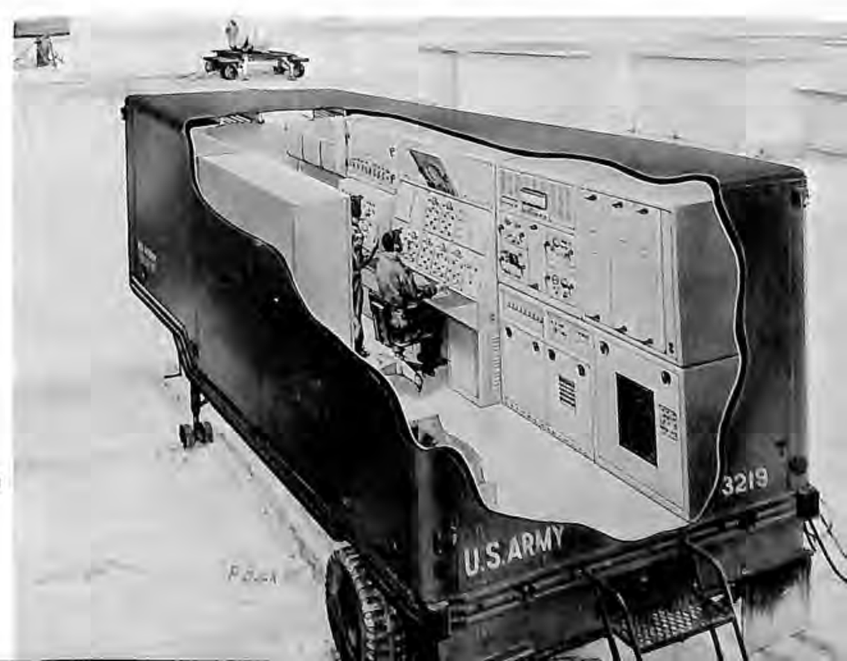
The Lunar Module (LM) range indicator will provide LM astronauts with altitude and rate-of-altitude change information during descent from NASA's Apollo Command and Service modules to the lunar surface. During the return ascent and rendezvous with Apollo spacecraft, it will display distance betwen the two lunar orbiting vehicles and the rate at which the distances closes. The indicator features a pair of specially developed digitized display tapes which cover a flight profile of 400 nautical miles. The front, or viewing side of the spool wound tapes, displays altitude, range and rate information to the astronauts in terms of miles, feet and feet per second. The reverse side contains corresponding information in the form of digital code by means of which the tapes are continuously programmed to the mission profile as the flight progresses. The 4-pound indicator incorporates the latest features of integrated micro-circuit design and has an accuracy of better than 1 mile at its maximum range and better than 5 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 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. 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; and Commercial Airplane Division, The Boeing Company

Remarks

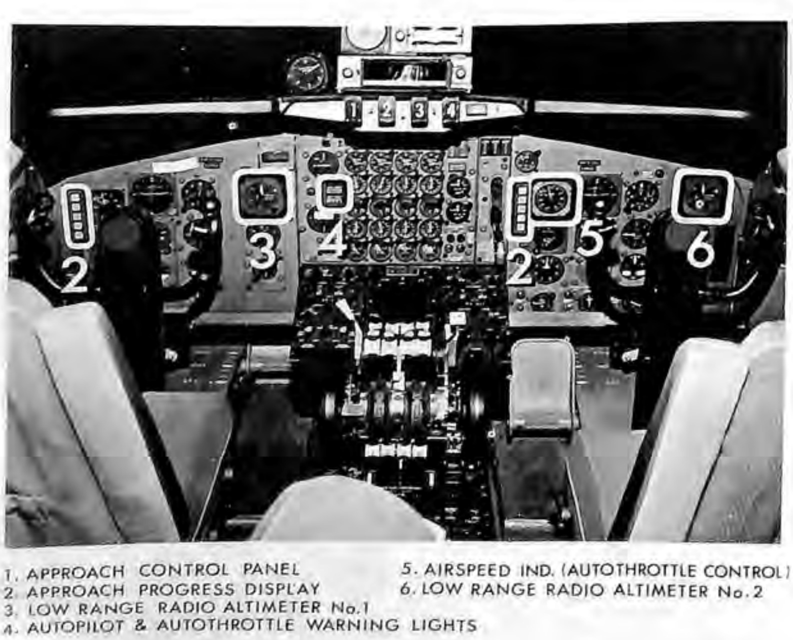
The Precision Approach and Landing System, which in 1965 won Federal Aviation Agency approval to permit large commercial jet aircraft to make fully automatic landing, and later, approval for use in Category II conditions, makes extensive use of transistorized equipment and microelectronics. A complete system for automatic landings is comprised of an improved autopilot coupler (which locks the aircraft's autopilot to the instrument landing system beam at the airport) and amplifier computer, two radio altimeters, 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. The sensitivity of the autopilot coupler permits a longitudinal dispersion of plus or minus 500 feet from intended touchdown point and a lateral dispersion of plus or minus 50 feet from the beam. Two radio altimeters provide height-above terrain signals for the autopilot and the indicator on the pilot's panel. At an altitude of 60 feet, the flare computer takes control of the airplane. Upon receiving the appropriate signals from the altimeters, it puts the airplane in the landing attitude and reduces its rate of descent to two feet per second for the touchdown. The yaw damper and automatic throttle system, tied into the autopilot, provide precise lateral and airspeed control. Operation of all components are constantly monitored during final approach, and should there be any error, the monitor disconnects the autopilot in trim, ready for pilot take-over.

MICROVISION

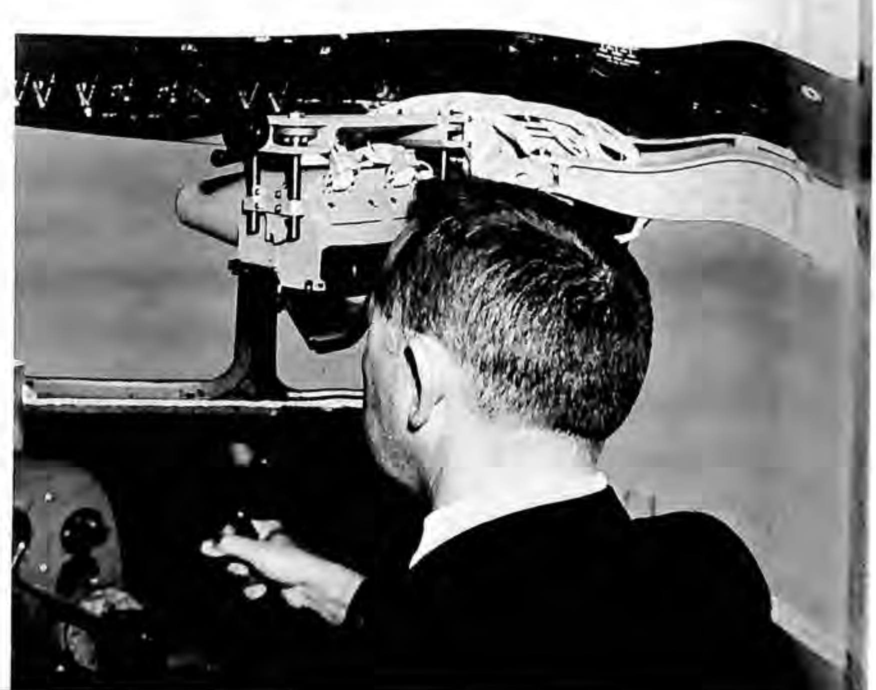
Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

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 installed by the Federal Aviation Agency at its research center in Atlantic City, New Jersey. Microwave radio signals—beamed to the plane from both sides of the landing strip—puts an electronic image or "picture" of the runway on a semi-transparent screen in the cockpit. The pilot "sees" the runway through his normal line of vision from a distance of about 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, on the aircraft's head-up display. The display consists of a cathode-ray tube, which presents the processed beacon pulses as coordinated images; an optical system, which collimates the images at infinity; and a combining mirror, which is positioned in the pilot's line of sight.



1. APPROACH CONTROL PANEL
2. APPROACH PROGRESS DISPLAY
3. LOW RANGE RADIO ALTIMETER No.1
4. AUTOPILOT & AUTOTHROTTLE WARNING LIGHTS
5. AIRSPEED IND. (AUTOTHROTTLE CONTROL)
6. LOW RANGE RADIO ALTIMETER No.2



VERTICAL SCALE FLIGHT INDICATORS 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

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

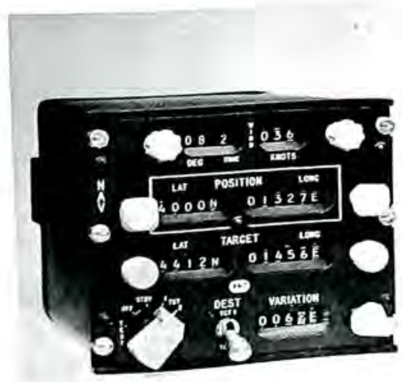
The Bendix PB-60 is one of the most advanced automatic flight control systems (AFCS) to meet fully the requirements for stability, precision, and accuracy for a variety of aircraft. It has been approved for use on aircraft ranging from USAF's C-141 transport to the Jet Commander and Fan Jet Falcon. It is equally applicable to private, business, and executive aircraft, as well as to jet and turbo prop transports in commercial and military operations. PB-60 engineering and design permits the installation of identical components in different aircraft through adjustment provisions for system gains and the function grouping of electronic units and modules. Convenient front connectors facilitate trouble shooting, while front panel adjustments enable shop calibration of black boxes that accommodate the differences among aircraft types. Such features as all-transistor circuitry, channelized design, and fail-safe control switching exemplify the latest state-of-the-art in the PB60 system.

BANC-660 NAVIGATION COMPUTER SYSTEM

Prime Contractor: 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.

RECORDER DATA PACKAGE

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

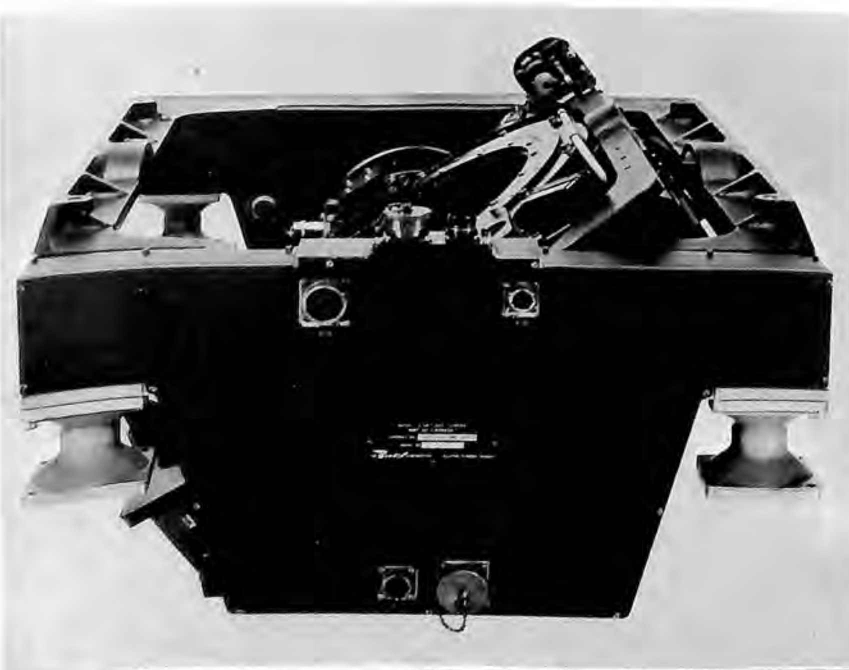
Designed for the Air Force, the recorder data package records the performance of subsystems in ballistic missile re-entry vehicles. The purpose of the package currently in production is to record data on the performance of arming and fusing systems under environmental stresses—launch, in-flight and reentry. Upon recovery from the landing area, the magnetic tape in the recorder data package is removed and the results analyzed. This recorder data package represents a significant step forward in the field of re-entry vehicle reliability analysis. Information received not only supplies factual operating data but also provides a means of verifying and improving techniques used in a variety of associated reliability analysis and testing programs.

BENDIX CAMERA MOUNT

Prime Contractor: Eclipse-Pioneer Division, The Bendix Corporation

Remarks

Designed and developed for aircraft applications, the Bendix camera mount supports and maintains aerial cameras in a vertical attitude under dynamic flight conditions. This highly stable platform isolates cameras from the aircraft's vibration and angular motions on all three axes. Electronically self-contained, the mount requires no electronic chassis while its solid state electronics assures trouble-free operation. Designed to accommodate a wide range of cameras, it has possible application to both military and commercial installations.



AN/GSM-133 PROGRAMMER COMPARATOR

Prime Contractor: 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 new radar facility, (original destroyed by fire January 1965) located at the Eglin Air Force Base, Florida, will become a major element of the United States aerospace surveillance and warning system. The building housing the space track radar is 13 stories high and more than a city block long. The radar system uses an electronic scanning technique called "phased array," a method of scanning large volumes of space with radar beams without any mechanical movement of the radar. Space track radar has thousands of small individual receivers and transmitters fixed in the face of the antenna structure. Through the high speeds available with electronic—rather than mechanical—beam steering, it is possible to track many satellites up to altitudes of several thousand miles in one "glance." Design, technical and contractual direction of the project is by the Air Force Systems Command's Rome Air Development Center. The development has been under the sponsorship of the Electronic Systems Division but will be operated by the Air Defense Command.

AN/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 multi-channel 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

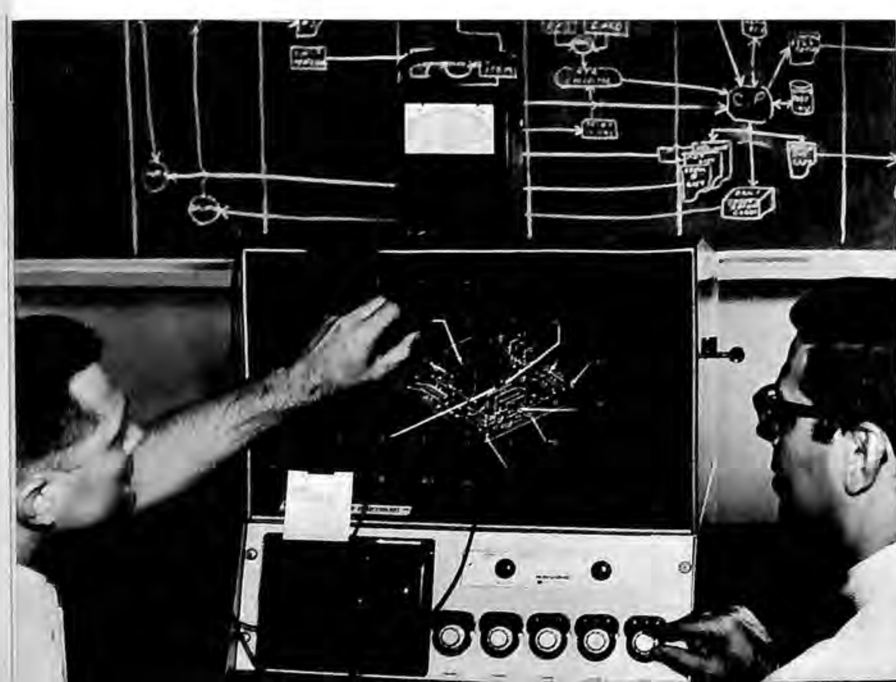
SAVAC is an electronic problem simulator being used by the Air Force to simplify training of technical personnel who man the complex electronic, electric or mechanical circuitry used in today's missile and fire control systems, radar equipment and automated devices. SAVAC stands for Simulates, Analyzes, 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.

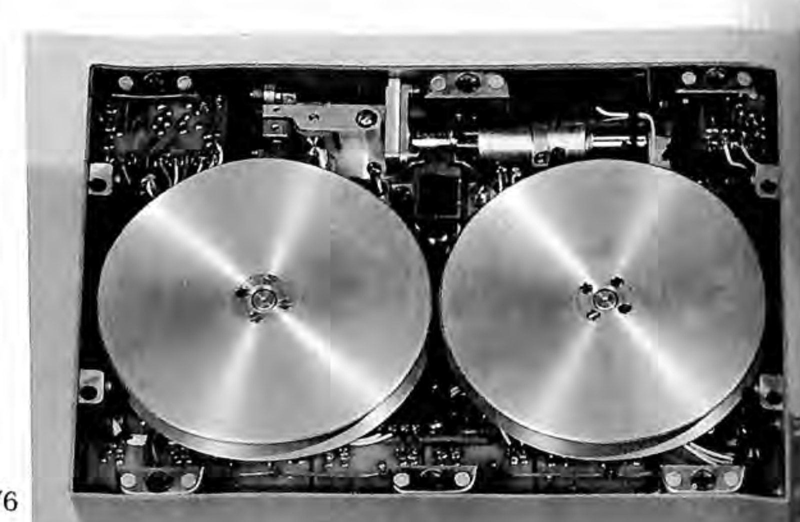
FM MINIATURE RECORDER

Prime Contractor: Cook Electric Company

Remarks

Cook Electric Company's Tech-Center Division has developed an FM version of a unique miniature magnetic recorder for industrial and military applications. The FM advance is a variation of the biomedical recorder developed by Cook for NASA's Gemini program (2 of the units were used successfully on each Gemini flight). The smallest ever developed for long operation, the FM recorder is 9 inches long, 6.8 inches wide, and 1.7 inches deep and weighs less than 5 pounds with a full tape load. The biomedical units receive and record on 7 channels simultaneously, 6 recording physiological data, the 7th a channel of time. Prior to the recorder advance, spot check telemetry to ground stations had been the only method for obtaining data on orbiting astronauts. Purpose of the FM variation is twofold. An FM recorder will facilitate higher accuracy data and easier transcription on standard data processing equipment, and better serve industrial applications. The FM version will feature 7 channels and record time of up to 140 hours, depending on signal frequency response requirements.





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 in production under USAF contract for depot maintenance of the F-111A avionics systems.

TACTICAL ARMAMENT TURRET (TAT) 102 ARMAMENT SYSTEM

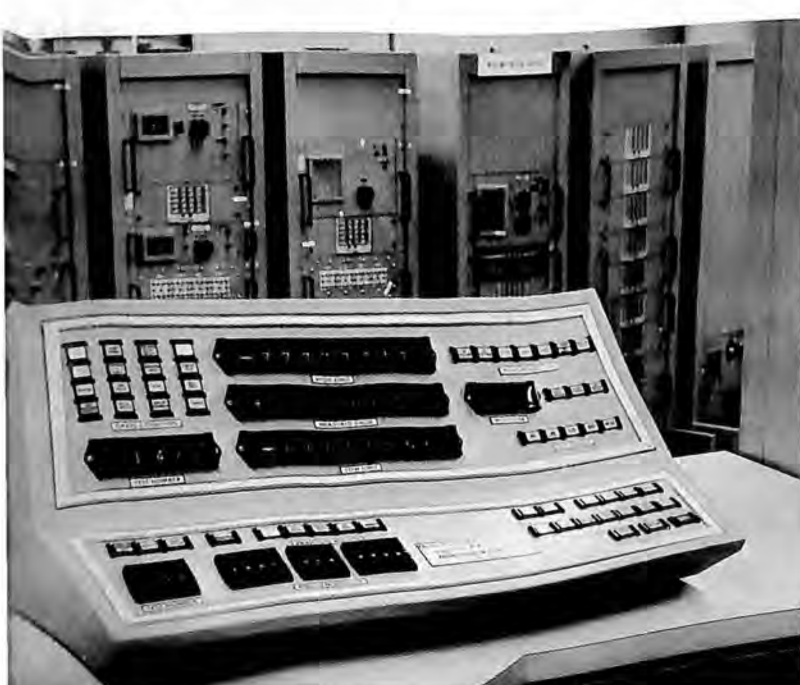
Prime Contractor: Emerson Electric Company

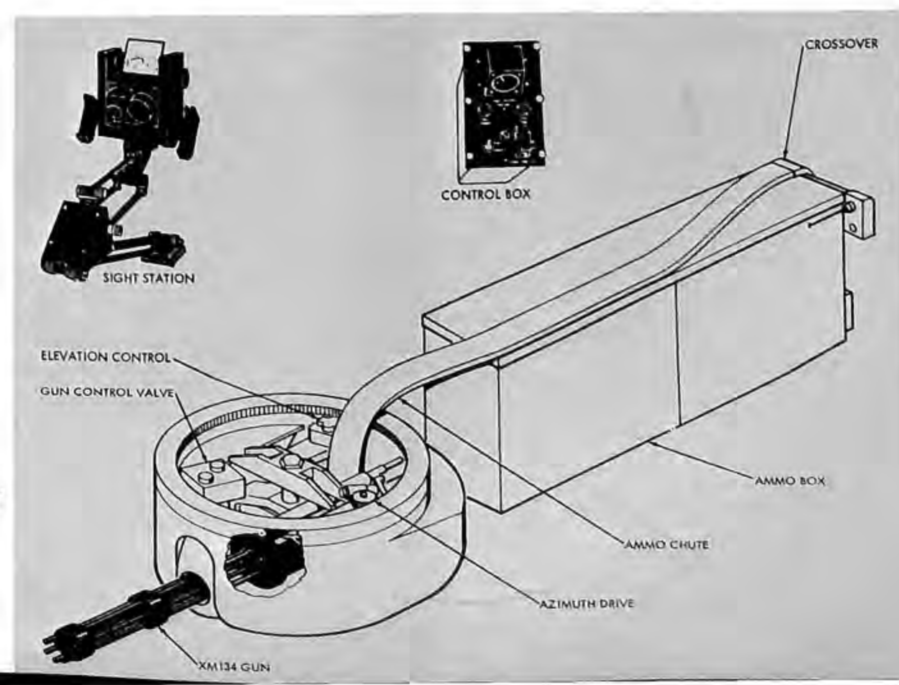
Remarks

The TAT 102 meets the need for an advanced weapons system for helicopter armament. It is an aerodynamically trim, high firepower system for use in support of limited warfare, counter-insurgency, and air assault missions. Light in weight and low in drag, the TAT 102 System is especially suited for the faster, trim silhouette helicopters under development. The TAT 102 System has been successfully demonstrated on the Bell Hueycobra and is in production for early models of this helicopter. The TAT 102 Armament System consists basically of a gunner's sighting station, power driven turret, fire control subsystem; linked ammunition storage; a synchronized ammunition feed system for 8,000 rounds of 7.62 millimeter ammunition; hydraulic and electrical interconnections, and the SM134 weapon and feeder. An Emerson Electric designed hydraulic motor gives the weapon a variable rate of fire from 800 to 4,000 rounds per minute.

Specifications

The TAT 102 turret weighs 72 pounds (less ammo and gun); the sighting station and controls weigh 17 pounds.





MAD (AN/ASQ-10A) MAGNETIC DETECTING SYSTEM

Prime Contractor: Emerson Electric Company

Remarks

The AN/ASQ-10A Magnetic Detecting System manufactured by Emerson Electric is a lightweight high-performance detecting-and-recording system which monitors submarine activity by detecting the presence of foreign magnetic fields. This system employs the use of a magnetometer detecting element which is located in an externally protruding boom from Navy reconnaissance and patrol planes. The input data is amplified and recorded by the use of a multi-pen drive type recorder.

Specifications

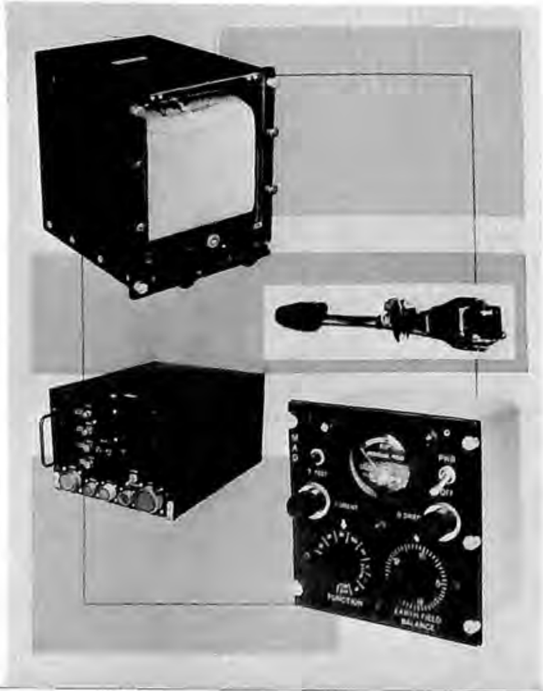
The total system weighs less than 75 pounds, a portion of which is built completely from lightweight non-magnetic or para-magnetic material.

AUTOMATIC PICTURE TRANSMISSION GROUND STATION—PHOTORECORDER

Prime Contractor: Fairchild Hiller Corporation, Electronics & Information 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 Nimbus and TOS satellites. A new Photorecorder that provides a photographic print instead of the electrolytic-type facsimile recording has been developed (in photo) for use with the APT Ground Stations and other applications. The Photorecorder provides high quality rapidly processed prints on 9-inch wide photographic paper. A high resolution cathode-ray tube is used to generate a line scan, which is imaged on the paper feed and rapid processor, and an 8-inch wide print is produced within 20 seconds after completion of the paper exposure. The rapid processor is integral with the printer and does not require dark-room operation. In addition to the APT mode, switch selected alternate operating modes provide printing of DRIR and WEFAX photographs in all commonly used scan rates and indices of cooperation.



AUXILIARY DATA ANNOTATION SYSTEM

Prime Contractor: Fairchild Hiller Corporation, Electronics & Information Systems Division

Remarks

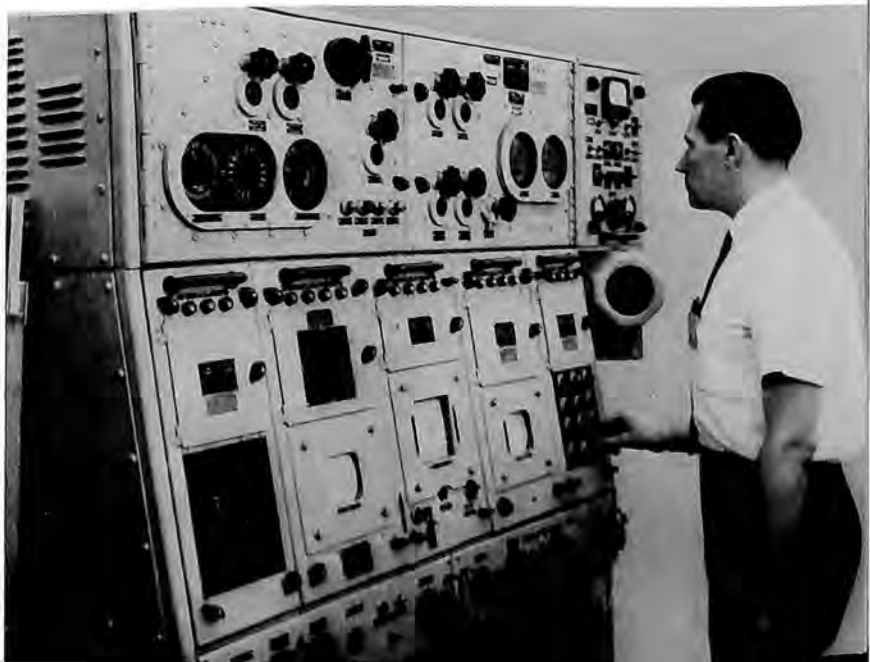
The Auxiliary Data Annotation System provides mission-pertinent data annotation capability to airborne reconnaissance photo cameras. Pertinent flight information, such as time, latitude, longitude, speed, barometric and radar altitude, heading, pitch, roll, drift, date, sortie number, detachment, radar 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 (in photo) consists of the Auxiliary Data Translator Unit, 6 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. The AN/ASQ-94 is used on the McDonnell RF-101 aircraft, and consists of the Auxiliary Data Translator Unit, and 4 Recording Head Assemblies. Information is recorded on film by means of a cathode ray tube contained in each Recording Head Assembly. Through the use of integrated circuits, miniature versions of the ADAS have been built which reduce the size, weight and power consumption to a minimum. A Fixed Programmer Card which provides a means of changing the fixed data (date, sortie number, etc), is inserted prior to flight. An earlier alphanumeric ADAS system was designed for the AN/USD-5 Reconnaissance Drone.

AN/SPQ-10 FIRE CONTROL METERORLOGICAL TRACKING SYSTEM

Prime Contractor: Fairchild Hiller Corporation, Electronics & Information Systems Division

Remarks

EISD is engaged in improving the AN/SPQ-10 Fire Control Meteorological Tracking System for the Coast Guard. These modifications will provide the system with the added capability of determining wind speed and direction as a function of altitude. Without degrading the fire control function of the system, the shipboard facility will be capable of automatic tracking of a meteorologicial balloon, providing wind velocity profiles with respect to the true horizontal place by correcting for roll, pitch and yaw influences on measurements. Modifications will include: replacement of the transmitter with that used in the AN/UMQ-7 Meterorological Data Sounding Set, addition of a new tunnel-diode-amplifier front end to the existing receiver, addition of the displays from the AN/TPS-41 Mobile Weather Radar modified to permit the range unit to operate over a 300,000 yard range, and addition of a digital computer (18 microsecond add time, 60 microsecond multiply time) which accepts ship's roll, pitch, heading and speed in addition to radar elevation angle, azimuth angle and slant range. The computer calculates absolute direction, velocity, azimuth, elevation and altitude of the target. Computer output includes a Nixie tube display and punched tape for direct printed readout and teletype transmission.



CODE MATRIX FILM READER

Prime Contractor: Fairchild Hiller Corporation, Electronics & Information Systems Division

Remarks

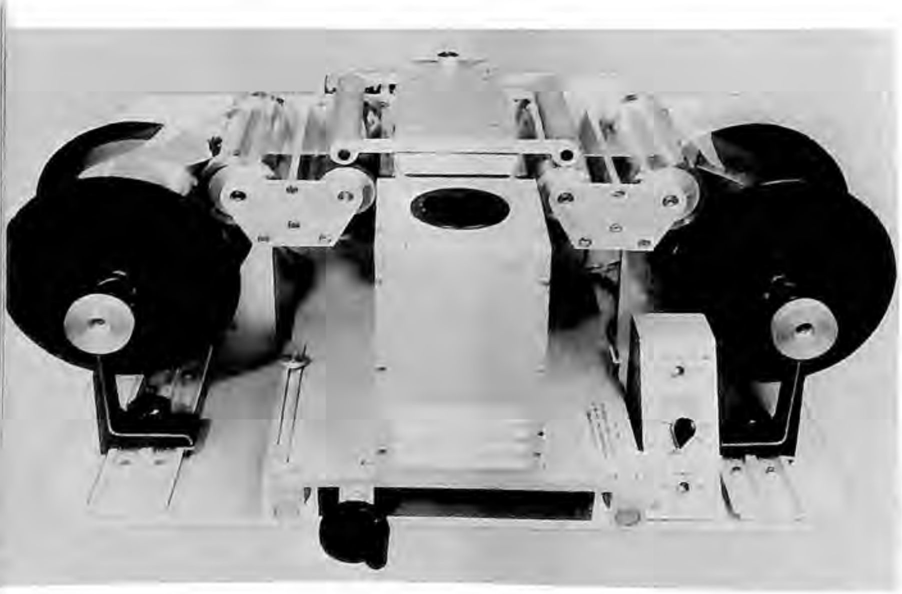
The advanced Code Matrix Film Reader developed by EISD will be employed with the existing viewing equipment in a photo-interpretation facility to retrieve automatically the desired frame by controlling reconnaissance film position. The "Tactical Intelligence Processing and Interpretation" system (TIPI) will also utilize this reader. The reader also will permit conversion of data into alpha-numeric form with a provision to direct outputs for hard-copy print-out, for on-line film titling, or for on-line general-purpose computation. The reader (in photo-reader without the electronics sub-system) uses a single line of photo-sensitive diodes to detect film images. Employed with ADAS-annotated film, the code blocks are read and the diode (analog) outputs are converted to digital form and stored. A sensing circuit, associated with the reader head, detects when a code block is being read. Sufficient time is allowed for the whole block to enter a memory section. It is then scanned and the digital expression reidentified as "dots" with each assigned to a proper location within a second memory carrying the code block format. From this second memory, the code block is transferred to numeric displays, printers or a computer buffer. With code block spacings of 5 inches or greater, the reader can handle film rates up to 40 inches per second in either direction; at minimum MIL-spec spacing of 0.7 inches edge to edge, a film rate up to 3 inches per second is possible.

METEOROLOGICAL DATA SYSTEM

Prime Contractor: Fairchild Hiller Corporation, Electronics & Information Systems Division

Remarks

The Meteorological Data System developed by the Electronics & Information Systems 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 system includes 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 (in photo) has the capability of accurately tracking and receiving data transmitted from airborne balloon and rocket probes. High accuracy and rapid data processing and reliability are the outstanding features of this system. The first system was delivered to the Army in September, 1965. It is 12 feet long, 7 feet wide and weighs 5,000 pounds including the mobile shelter in which it is housed.



AN/TPS-41 MOBILE RADAR WEATHER SYSTEM

Prime Contractor: Fairchild Hiller Corporation, Electronics and Information Systems Division

Remarks

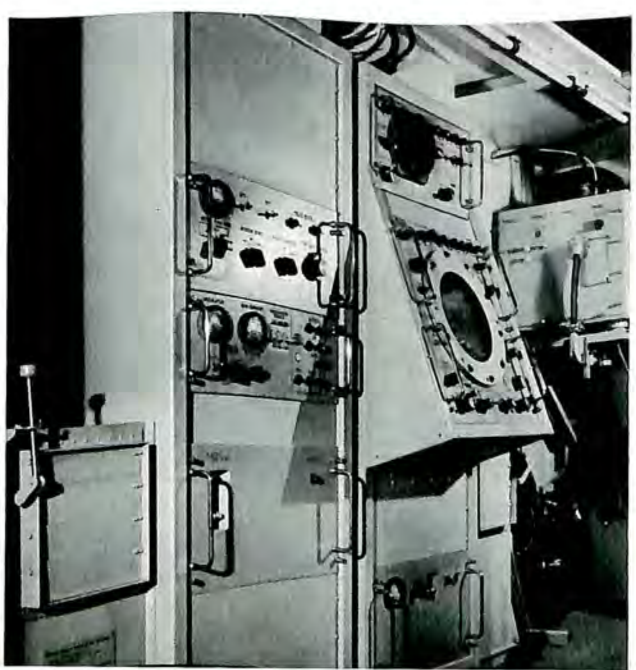
The Mobile Radar Weather System provides a completely automatic processing, reduction and display system for rapid presentation of fresh meteorological data from a mobile position. Battle commanders can locate and measure precipitation and natural or nuclear clouds for tactical purposes at ranges up to 150 miles. The MWR display system consists of three visual indicators—horizontal or vertical cross section area of precipitation and echo return to measure precipitation rate. First 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. A 40-foot high antenna support pedestal to be used with the AN/TPS-41 is being developed under a separate contract. The new antenna system can be erected or disassembled in less than 1 hour by a crew of 5 men. The erected structure is capable of withstanding 60-mile-per-hour winds, and will allow unobstructed operation in locations where the radar performance could otherwise be impaired by trees or other obstructions.

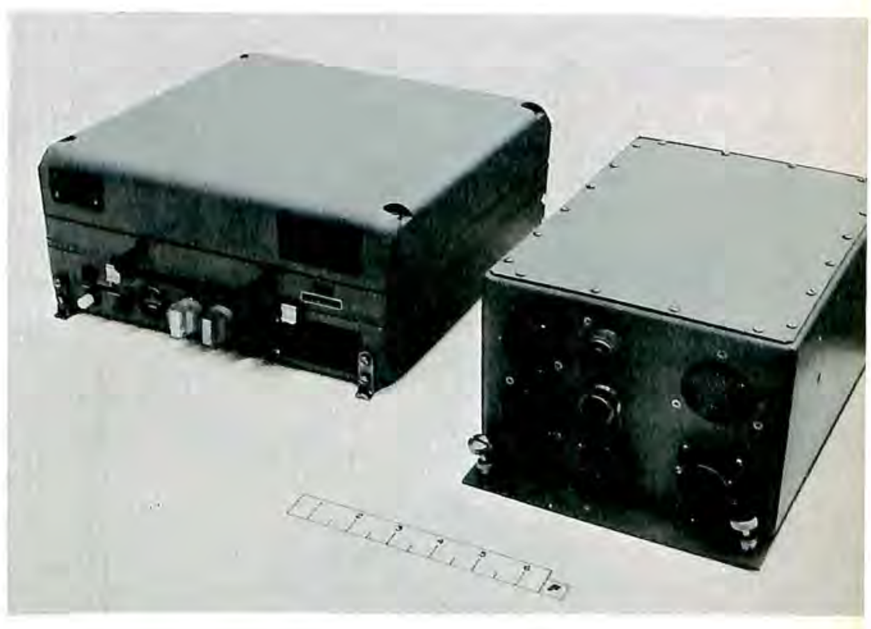
RECORDER, SIGNAL DATA

Prime Contractor: Fairchild Hiller Corporation, Electronics & Information Systems Division

Remarks

The Recorder, Signal Data RO 321/A, previously designated as the Airborne Central Data Tape Recorder (ACDTR), was developed for the Air Force by the Electronics and Information Systems Division, to work with the Auxiliary Data Annotation System for reduction of data interpretation time, automatically, following reconnaissance missions. The complete mission profile can be stored on a single half-inch, one-mil, 7-track magnetic tape to permit preliminary ground analysis while awaiting sensor film processing. The recorder permits photo interpreters to immediately program an updated plot of the missions as performed to identify deviations from the preflight planned observation path, to identify specific sensor coverage, and to compile detailed ELINT maps for the surveyed area. When employed with ADAS, the recorder is comprised of a synchronized magnetic-tape transport and a microelectronic special-purpose computer subsystem. At least 2 hours of continuous mission data can be recorded in a format compatible with an IBM-729 IV reader. Data are recorded ar 556 bits per inch on the 7-track, 1/2-inch tape. Four tracks carry mission data, 1 track ADAS parity, and 1 track tape parity. The 7th track serves as a spare. Recording of both system parities serves as a useful cross-check later in processing the stored data by digital computer.





MICRO-VUE

Prime Contractor: Fairchild Hiller Corporation, Republic Aviation Division

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, by indexing with a thumbwheel. With an optional slew switch, the operator can view a continuous strip, constituting a 99-page foldout of such data as wiring diagrams, logic flow diagrams, or wave form patterns. Transfer from one point on the matrix to another typically takes a tenth of a second. An optional Auto-Chip Loader can expand the stored data to approximately 200,000 frames.

MOBILAB

Prime Contractor: Fairchild Hiller Corporation, Space and Information Systems Group

Remarks

Mobilab, designed and built for the Air Force, is a mobile film processing laboratory which reduces time between acquisition and interpretation of aerial reconnaissance film. In operation, the Mobilab meets the reconnaissance aircraft upon return from its mission. The magazines or cassetts with exposed film are unloaded from the aircraft into the Mobilab darkroom, where technicians remove the film and put it in the EH-68 Bimat processors, returning the empty magazines to the aircraft immediately. Six EH-68 Processors, using the Eastman Kodak Bimat process, automatically develop and fix the film while the Mobilab is in transit. Both a positive and a negative are produced, exhibiting the high quality and definition required for reconnaissance purposes. For flash reporting, a roll of positive film can be produced with only 5 minutes of processing time. Mobilab is completely self-sufficient, i.e., fully mobile self-propelled, has air conditioning, heating, power, and two way radio. It is air transportable in a C-130 (2 per aircraft) and/or C-141 aircraft.

FILM TITLER

Prime Contractor: Fairchild Hiller Corporation, Space and Information Systems Group

Remarks

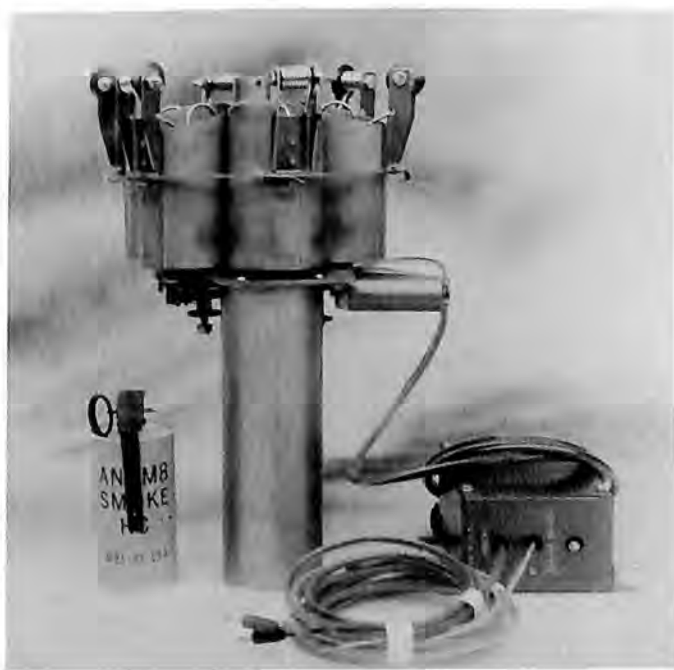
The Film Titler BS-8, developed for USAF, is considered a major breakthrough in the handling of large quantities of aerial survey and reconnaissance film. It will place repetitive or changing alphanumeric titles on successive, alternating, or randomly occurring photographic frames as programmed on punched paper tape at a rate of 100 characters per frame per second. The requirements in reconnaissance, intelligence, mapping, and cartographic photography for alphanumeric titles on individual frames are such that it is generally impossible to title the film optically, so that the title is developed with the photographic image. Even that data which can be recorded during flight often requires analysis, correction, interpretation, or alternation before being marked on film. Past methods of placing alphanumeric titles on processed film have created a bottleneck resulting, in some cases, in huge and unmanageable backlogs of unmarked film. The most common technique is the manual writing of titles with pen and India ink. Mechanical methods include gold leaf printing or printing with special image transfer materials. Both manual and mechanical methods were slow and inflexible and often damaging to the negative. The Fairchild Hiller Film Titler uses a Xerographic transfer technique. It rapidly produces repetitive or changing titles which are permanent but erasable. No damage occurs to the negative. It is the first significant improvement in film titling in over 50 years. Film identification is finally able to keep pace with new techniques in photography and processing.

AIRBORNE GRENADE LAUNCHER SYSTEM

Prime Contractor: Fairchild Hiller Corporation, Stratos—Western Division

Remarks

The Airborne Grenade Launcher is used in conjunction with a central fire control system for the purpose of marking ground targets. The unit retains and releases 6 standard ANM-8 and/or ANM-18 Smoke Grenades from aircraft in combat or rescue operations. A system consists of any number of launchers aboard an aircraft, all of which are remotely actuated. The launcher or launchers may be fired individually or simultaneously depending on the mission requirement. This system is specifically designed and readily adaptable to helicopters, cargo fighter, reconnaissance, observation, and bomber aircraft. Operation of a launcher is initiated by a remotely triggered 28 volt DC pulse. This pulse results in the solenoid latch release of the store and the reloading of the next store in firing position. The firing rate is 1 store every 2 seconds at an initial velocity of approximately 10 feet per second. A system consisting of 2 launchers and 1 control box has been successfully tested and is being used by the Army on the Bell Huey-Cobra.



CONSUMABLE FLARE—MLU-44/B

Prime Contractor: Fairchild Hiller Corporation, Stratos—Western Division

Remarks

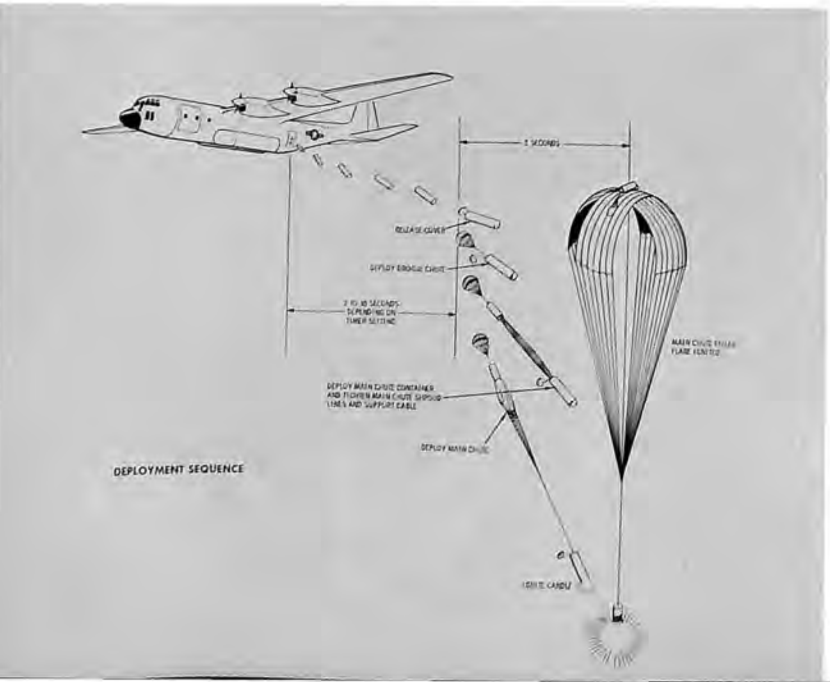
The MLU-44/B is a 5,000,000 candlepower Illumination Flare capable of emitting this intensity for three minutes. The flare has been designed to function as a total system with the LAU62/A Automatic Flare Launcher. The flare consists of a Candle Assembly, Parachute Assembly, Timer, and Outer Case. A direct series deployment system is utilized. The flare leaves the aircraft aerodynamically clean; a pre-set time interval elapses; simultaneously, the parachute deploys and the flare ignites; the flare then falls at 700 feet per minute average and burns for three minutes; at the conclusion of the illumination period, the flare descent rate increases to 1500 feet per minute, and the remainder of the assembly is destroyed. Reliability, plus operational and handling safety, were prime considerations in design of the flare system. The parachute system can be deployed only by timer sequence initiation; and opening force of the parachute is required to ignite the flare candle. A drogue chute is used to assure adequate force for stabilization and for deployment of the main parachute and ignition of the candle, in sequence; thus, no pyrotechnic type timers are employed. The MLU-44/B is designed (and environmentally sealed) to withstand 5 years storage.

HELIUM PRESSURE REGULATOR

Prime Contractor: Fairchild Hiller Corporation, Stratos—Western Division

Remarks

The Dual Series Helium Pressure Regulator is developed by Stratos-Western for the Apollo Prgram. The Apollo Regulator is fully space qualified and man rated and is the heart of the propellant tanks pressurization system for the 100 pound thrust, bipropellant reaction control systems. This regulator is used in the Apollo Command and Service Modules, the Lunar Module and the Saturn IVB stage. The dynamic characteristics of each section of the Dual Series Pressure Regulator are isolated by orifices, and even under operational and environmental extremes there is no interaction between the two regulator sections. This feature allows the primary and secondary regulators to perform individually in accordance with specification requirements and forms the basis for the successful performance of the primary regulator section. The regulator has integral sensing and inlet filtration and features a pilot poppet controlled by a large sensing area which works in parallel with a normally close main flow poppet. Under low flow demands only the pilot section operates and when the flow demand exceeds the capacity of the pilot, the main poppet begins modulating and augments the flow.



APOLLO ENVIRONMENTAL CONTROL SYSTEM

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Division

Remarks

The Apollo environmental control system (ECS) provides a controlled environment for 3 astronauts for up to 14 days. For normal conditions, this environment includes a pressurized cabin, a 100 per cent oxygen atmosphere, and a temperature of about 75 degrees. For emergency use the system includes a pressurized suit circuit. The ECS provides fresh oxygen and hot and cold potable water, removes carbon dioxide and odors, dissipates heat from the cabin and from operating electronic equipment, and removes waste water and solids from the gas stream. Primary oxygen for breathing, pressurization, and ventilation is stored cryogenically in the service module. Oxygen tanks in the command module serve crewmen after the separation of the 2 modules before re-entry. The system has provisions for supplying oxygen servicing to portable life support systems used by crewmen. Primary cooling is accomplished by means of an intermediate heat transport fluid which absorbs heat and dissipates this heat through a space radiator. A supplementary water boiler-type heat exchanger cooling system is used during launch, re-entry and emergency phases. The system is designed so that minimum amount of crew time is meeded for its normal operation.

ADVANCED RANKINE POWER SYSTEM

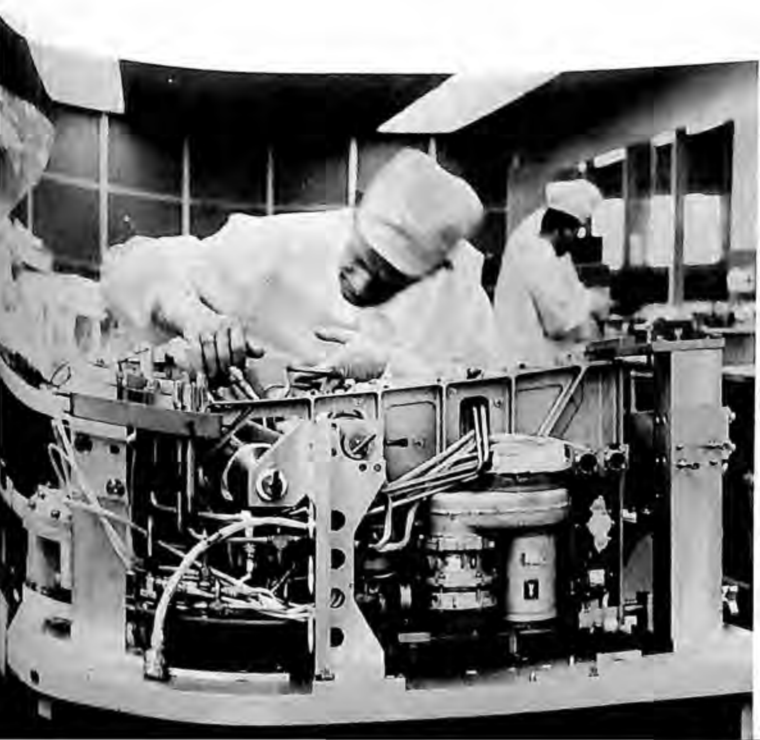
Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Company of Arizona

Remarks

In the component development stage at AiResearch is an advanced Rankine power system designed to satisfy the requirement for large (300–1000 KW_e) long duration (10,000 hours) electrical power that will exist in space missions, in the 1975–1985 time period, such as lunar bases, electrically propelled interplanetary probes and military satellite systems.

Specifications

Weight 20 pounds or less per KW_e (less shield); unattended lifetime 10,000 hours; operating temperatures 1,000 to 2,500 degrees Fahrenheit.



MUST (MEDICAL UNIT SELF-CONTAINED TRANSPORTABLE)

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Company of Arizona

Remarks

Under sponsorship of the U. S. Army Medical Service, The Garrett Corporation's AiResearch Manufacturing Company of Phoenix, Arizona, in 1963, undertook the development of a revolutionary military field hospital, designated MUST (Medical Unit Self-contained Transportable). The basic features of this new concept in military field hospital facilities include mobility, short setup time, high reliability and efficiency, controlled environment, and the capability of maintaining all-weather operation. The basic MUST system is made up of only 3 elements: an inflatable 20 X 52 feet ward-type unit; a 12 feet long, 7 feet wide, 8 feet high rigid panel expandable (12 X 18 feet) unit that serves a variety of shelter needs such as for surgery, laboratory, supply, and pharmacy; and a utility element that supplies all power requirements of the MUST complex. All are helicopter transportable. The MUST elements may be used together in combinations as small as 1 ward or surgery and utility element, up to a full 400-bed U. S. Army field hospital. One utility element provides power for the equivalent of 4 inflatable elements or 6 expandable elements, plus 1 additional expandable element having heavy power needs (such as for X-ray facilities) at the temperature extremes of minus 65 degrees or plus 140 degrees Fahrenheit. The utility element is a sound attenuated, weatherproof enclosure 72 inches wide, 108 inches long, and 86 inches high equipped with an AiResearch gas turbine which provides power for cooling, heating and electrical needs.

GRAVITY GRADIENT SYSTEMS

Prime Contractor: General Electric Company, Missile & Space Division, 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 2- and 3-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. One of 2 GE Gravity Gradient test satellites was launched June 16, 1966, from Cape Kennedy by a Titan III-C along with 7 communications satellites.

ADVANCED FIBROUS COMPOSITE MATERIALS

Prime Contractor: General Electric Company, Space Sciences Laboratory

Remarks

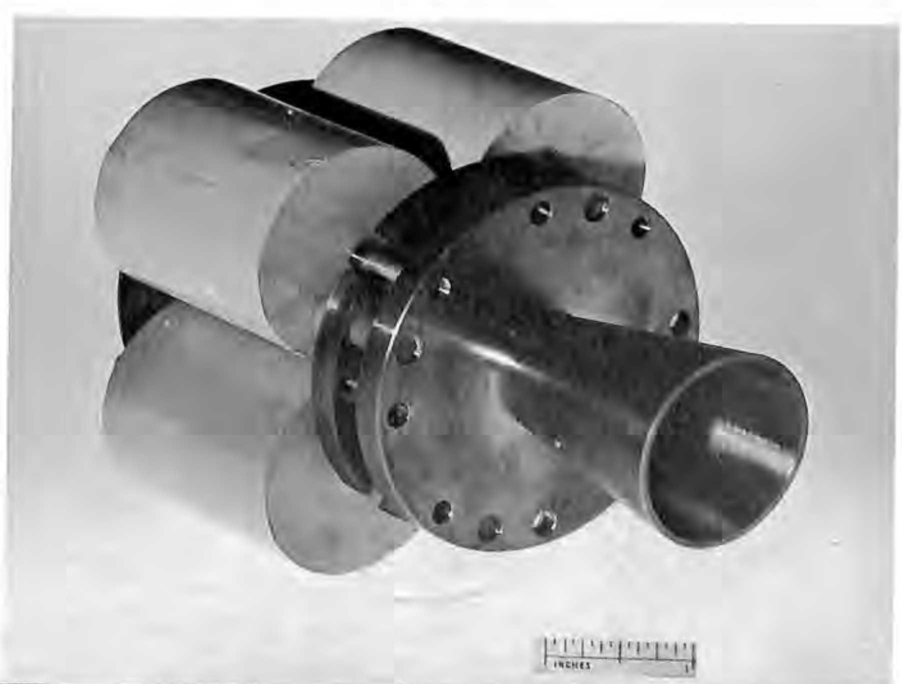
The GE Space Sciences Laboratory is engaged in a broad developmental program aimed at realizing the great potentials of the new generation of fiber-reinforced materials. The high strengths and stiffnesses of these advanced fibrous composites at both room and elevated temperatures, and their very low densities, give them outstanding advantages over conventional materials for aerospace structures, turbine engines, and innumerable other possible applications. The principle of fiber reinforcement has been well demonstrated by the glass-reinforced plastics, which are already in widespread use. The relatively low elastic modulus of the glass fibers, however, is a serious drawback. Under contract with the Air Force, the Laboratory has been conducting extensive investigations of continuous, vapor-deposited, multiphase filaments, such as boron and boron carbide, for use as superior, stiffer reinforcements in plastics. For the strengthening of metals at elevated temperatures, the Laboratory is developing composites reinforced by single-crystal "whisker" fibers of aluminum oxide (Al_2O_3) and boron carbide (B_4C). This work, funded by the Air Force Materials Laboratory, the Navy Air Systems Command, the Army Materials Research Agency, and the National Aeronautics and Space Administration, is seeking very high strength-to-weight ratios over wide temperature ranges. In photo, aluminum rod reinforced with Al_2O_3 whiskers, which are exposed at right end.

ELECTRIC PROPULSION SYSTEMS

Prime Contractor: General Electric Company, Space Sciences Laboratory

Remarks

The GE Space Sciences Laboratory is developing a new ELM device for application as a valveless propellant feed for highly efficient pulsed plasma engines and as a highly reliable, long-life microthruster for spacecraft and satellite attitude control, orbit adjustment, and station keeping. Work on the ELM, or exploded liquid metal, device is proceeding under contract with the Air Force Research and Technology Division. The technique involves confining a small amount of liquid metal behind a very fine stop hole by surface tension forces. Electric current pulsed through the liquid metal then vaporizes it. The vapor, unrestricted by the surface tension forces that held the liquid, explosively expands through the small hole, producing thrust. With mercury as the propellant, a specific impulse of about 30 seconds is achievable. Lighter metallic species should yield values up to 230 seconds. Other electric thrusters for similar applications and for deep-space propulsion are being investigated, primarily under contract with NASA's Lewis Research Center. One of these is REPPAC (Repetitively Pulsed Plasma Accelerator), a high specific impulse device which may be fed by ELM and which produces thrust by electromagnetically accelerating a low-density ionized gas. A continuously running plasma engine, CYCLOPS (Cyclotron-Resonance Plasma Accelerator), is being investigated for possible application on a satellite with a high-power microwave source that could be shared with intermittent communications use. In photo, the ELM microthruster.



HYPERSONIC AERODYNAMICS

Prime Contractor: General Electric Company, Space Sciences Laboratory.

Remarks

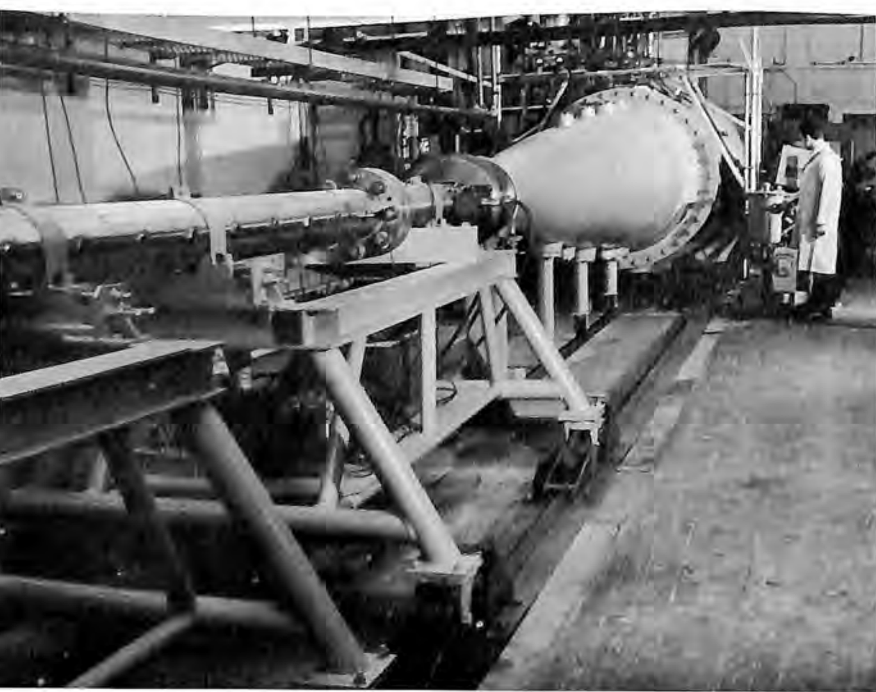
The GE Space Sciences Laboratory's largest shock tunnel has been modified to achieve a uniform parallel Mach 20 test flow. Added to the shock tunnel, under contract with the Air Force Ballistic Systems Division, was a 21½-foot-long contoured nozzle in which the test gas (usually air) is expanded to produce an inviscid core about 24 inches in diameter at the 54-inch-wide test section. At that point the cone of uniform, parallel hypersonic flow within this core is approximately 18 inches in diameter. The highly gradient-free quality (in pressure density, Mach number, etc.) of the flow and particularly its large size allow important studies to be made on long, slender, relatively sharp nose cone models. Models up to 12 feet long have been used—greater than some actual ballistic re-entry vehicles. Off-design operation of the tunnel is quite satisfactory down to Mach 10; by changing the throat, usable and almost parallel flow can be obtained over a range of conditions. The contoured nozzle facility is one member of the Laboratory's family of shock tubes and tunnels and electric-arc-heated plasma jets and wind tunnels devoted to experimental fluid dynamics studies in the simulated environments of earth and planetary entry. In photo, the Mach 20 Contoured Nozzle on the Large Shock Tunnel.

LOW COST INERTIAL SYSTEM

Prime Contractor: General Precision, Inc., Kearfott Systems Division, Aerospace Group

Remarks

The Kearfott K-70 system is the first generation of a series of Low Cost Inertial systems designed to provide the performance of current production inertial navigation systems at one-third their cost, size and weight. A General Precision system was flight tested at Holloman AFB during 1966. The testing consisted of long duration flights aboard a C-130 aircraft. Results of these Air Force flight tests and others conducted by the company indicate that the performance of production systems will exceed the Air Force goals for low cost inertial navigation (1 nautical mile per hour error). Applications for production versions of the basic low cost system component applications currently include Navy and commercial aircraft. In photo, the DDA Dydan computer (left) and the control indicator. The third unit of the system is a miniature 2-gyro, 4-gimbal platform.



GPK 33 DIGITAL COMPUTER

Prime Contractor: General Precision, Inc., Kearfott Products Division, Aerospace Group

Remarks

This is a special version of Kearfott's AN/ASN 24 digital computer used in the guidance system of the Centaur space booster. The Centaur's initial guidance system measures the vehicle's speed by the use of 3 accelerometers mounted on a gyro stabilized platform. The outputs of the accelerometers are transmitted to the computer in the form of electrical pulses representing vechicle velocity. From this data, the computer calculates the distance Centaur has traveled along its flight path. The computer is approximately the size of an office typewriter and weighs about 38 pounds. The guidance program is entered into the computer's memory well in advance of the Atlas/Centaur launch. The trajectory and position of Centaur is compared to the programmed flight path and suitable signals are transmitted to the autopilot which, in turn, sends correction signals to Centaur's engines, if a change is indicated. Within the system, pulse data is accumulated with the aid of electronic counters. The data accumulated and processed is used, in addition to generating steering correction signals, to generate control signals for engine cutoff, re-ignition and for steering the Centaur away from its payload after they have separated.

AN/ASN 24 (V) DIGITAL COMPUTER SET

Prime Contractor: General Precision, Inc., Kearfott Products Division, Aerospace Group

Remarks

Now in production for use in the USAF C-141A Turbofan logistics transport, the AN/ASN 24(V) represents the first airborne general purpose digital computer to go into Air Force inventory for MAC (Military Airlift Command) application. In this application, the AN/ASN 24(V) accurately computes and displays aircraft position based on true heading data from an automatic sextant and inputs from a central air data computer, Doppler radar, and a gyrocompass system. In addition, it uses the automatic sextant, TACAN, or LORAN, and navigation radar inputs to update aircraft position. The system provides steering commands to the pilot and autopilot in addition to furnishing the navigator with such flight information as range-to-go and true bearing to selected destinations, wind, ground speed and ground track, present position unrestricted in latitude and longitude, and a long track/cross track deviations from the selected flight path. The latest version also includes provision for air drop computations. An improved version of the computer is available which represents a 50 per cent improvement in the capacity and speed of the computer. This improvement has been made possible by increasing the density of the binary digits entered in the rotating memory drum.

GYROCOMPASSING ATTITUDE REFERENCE SYSTEM

Prime Contractor: General Precision, Inc., Kearfott Systems Division, Aerospace Group

Remarks

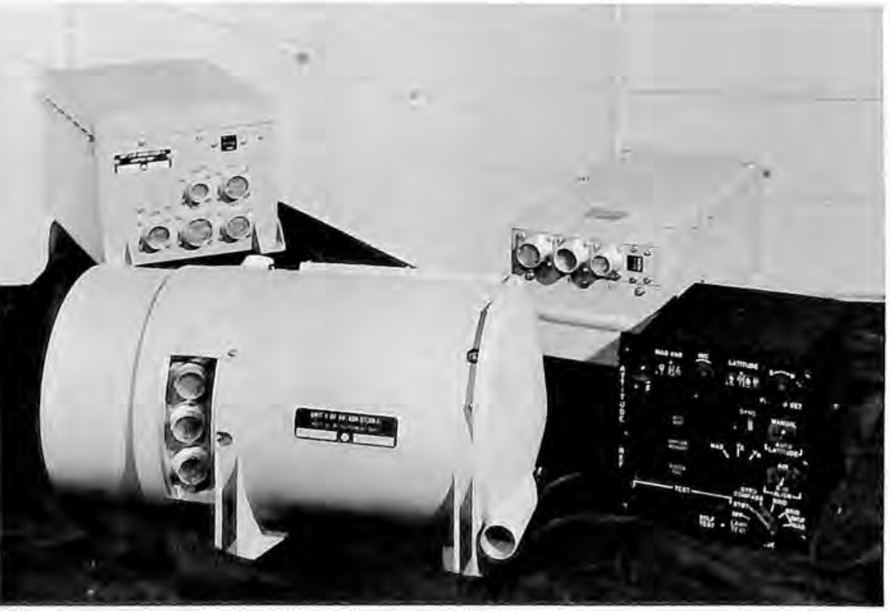
This system is based on General Precision's Low Cost Inertial System technology. It has been designed for Navy's Bureau of Weapons, Avionics Section. The system is designed to provide aircraft heading, attitude, and velocity information in conjucntion with an airborne Doppler radar set. By virtue of its airborne gyrocompassing capability, it provides precise heading and attitude data independent of time consuming, complex, pre-flight alignment procedures. There are two basic configurations. The AN/ASN 57 is a 3-gimbal version while the AN/ASN 58 is a 4-gimbal (unlimited attitude) version. Both systems are defined as Doppler-damped, Schuler tuned, local vertical systems with the capability of ground based or in-air gyrocompassing. These systems are in flight test status.

AN/ASN 41 HYBRID ANALOG DIGITAL NAVIGATION COMPUTER

Prime Contractor: General Precision, Inc., Kearfott Products Division, Aerospace Group

Remarks

This hybrid computer is being supplied to the Navy for use in the A-4E, TA-4E, A-7A, WC-121N. It uses a combination of state-of-the-art analog and digital computing techniques to provide high accuracy course-to-fly and distance-to-go data for two separate destinations. The computer is compatible with existing Doppler sensors and versions of it have been produced for use with an inertial platform input. Currently an advanced micro electronic version is under development which will provide a pin-to-pin replacement of the hybrid computer with an all digital version. The AN/ASN 41 consists of a control indicator and the computer proper. It computes and provides outputs of distance and bearing (relative to aircraft heading) to either of two selected targets. Great circle solution is employed for distances beyond 200 nautical miles while a planar solution is used for distances under 200 nautical miles. Present position of the aircraft is continuously computed for the 3 basic modes of operation: Doppler, memory, and air mass mode.



DATA ANNOTATION SYSTEM

Prime Contractor: General Precision, Inc., Kearfott Products Division, Aerospace Group

Remarks

Kearfott Products Division has designed and built signal converters to annotate position information for the radar (SLAR) pictorial data of the Army's OV-1B Mohawk and position and altitude data for the infrared equipped OV-1C version. The position (and altitude) information is provided as analog signals by the aircraft's navigational computer. The radar and infrared data are photographically recorded aboard the aircraft. The data annotation system converts to computer's outputs into digital form, and along with the pictorial data it is telemetered to the ground where it is reconverted to drive position counters in a display panel and for the data recording camera. Thus, this system permits real time annotation of a radar or IR image with the aircraft's coordinate position and altitude, providing the immediate presentation of surveillance data to a military commander on the ground.

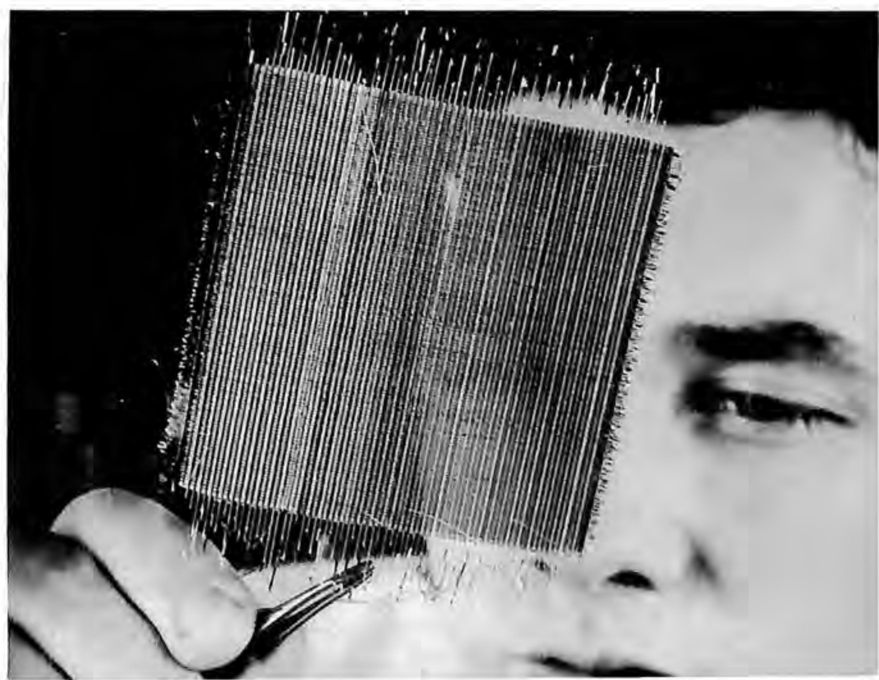
WOVEN PLATED WIRE MEMORY

Prime Contractor: General Precision, Inc., Librascope Group

Remarks

Librascope Woven Plated Wire Memory is a new-generation magnetic memory for aerospace computer, telemetry, and other applications. It is automatically woven on a loom. In aerospace computers, Woven Plated Wire Memory provides operational speeds in the low-nanosecond range, low-power consumption, nondestructive readout, and significant space savings. The memory, already ordered for many space programs, is available in four functional organizations: (1) linear select; (2) coincident select; (3) read-only, electrically alterable; and (4) read-only, permanently woven.

R-191



MOHAWK DUAL COCKPIT FLIGHT SIMULATOR

Prime Contractor: General Precision, Inc., Link Group

Remarks

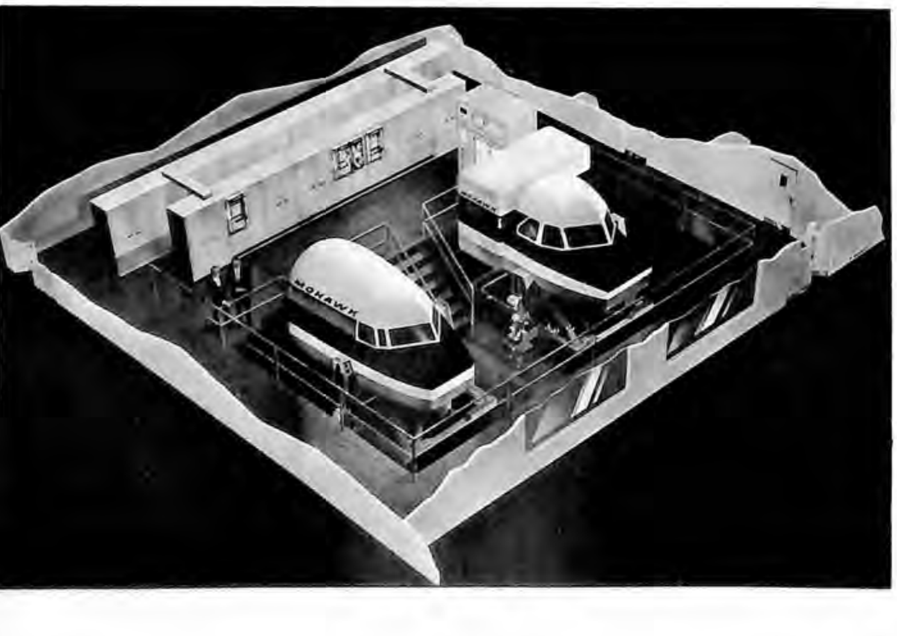
The Link-built flight simulator for Mohawk Airlines is the first training complex of its kind to be purchased by a regional carrier. It will consist of a flight simulator for 2 distinct aircraft. This new design approach to flight training equipment came into being with the development of the Link GP-4 digital computer, a large-scale, high-speed, all-solid-state, parallel process computer ideally suited to large-scale industrial process control and real-time simulation applications. The standard GP-4 consists of a high-speed central processor with parallel arithmetic and Boolean processing capabilities, a high-speed sequential access 122,880-word disc memory for instruction and constant data storage, a high-speed random access 8,192-word core memory for input/output and variable data storage, a high-speed disc loader and a Datamec D-2020 magnetic tape unit for program input-output, a buffered character channel, a Teletype Model 33 ASR and an NCR reader for instruction and data block modification and assembly under program control. The basic GP-4 computer occupies 2 standard double-bay cabinets, with the teletypewriter and card reader mounted on a separate stand, while the complete computing system has two additional double-bay cabinets for the linkage system. The GP-4 is constructed almost entirely of monolithic integrated microcircuits. Where microcircuits are not applicable, individual silicon solid-state components are used. Each of the simulators will be mounted on an individual 3-point motion system.

SPACECRAFT TELEVISION GROUND DATA HANDLING SYSTEM

Prime Contractor: General Precision, Inc., Link Group

Remarks

The Spacecraft Television Ground Data Handling System is used in NASA's Surveyor Program. During descent and after lunar landing, Surveyor telemeters a multitude of information, which, properly disseminated, will completely describe the surface structure. An integral part of this data will be in the form of video signals that will be processed in the Link-built system. The results of this processing will provide such pertinent facts about the moon as albido (Lunar surface reflection), contours, elevations, and other important structural details. Some of the more important features of the system include its capability of separating unwanted signals and noise, the synchronization of inputs for identification, the identification and preservation of details through high-resolution film recording techniques, human engineering to ensure optimum performance of personnel, an efficient and effective storage system, and the conversion of discontinuous slow-scan television from the spacecraft to a continuous conventional television rate presentation. During the Ranger IV moon probe this portion of the system was used to speed up the spacecraft signal rate to a rate that is compatible with commercial TV. Thus, home-viewers were able to witness this historic approach to the moon while it was actually happening. The complete spacecraft system contains a number of discrete subsystems including data acquisition and recording, data recovery, on-site film recording, media conversion, display and analysis, and storage retrieval and photoprocessing.



WAVEFORM DISPLAY ANALYZER

Prime Contractor: General Precision, Inc., Link Group

Remarks

The Waveform Display Analyzer is a computer input-output display device consisting of 2 units: a scanner and a display unit. It combines man's decision-making capability, self-programming flexibility and inductive reasoning potential with the extremely fast read-write capability of a flying spot scanner system. The Waveform Display Analyzer is used in analyzing and evaluating: Re-entry Phenomena, ELINT, ECM and ECCM, Wind Tunnel Data, Nuclear Radiation Patterns, Sonar and Oceanographic Returns, Propulsion Data, Upper Atmosphere Phenomena, Weather Radar, Bore Site Data, Missing Data in a Transmission (Telemetry) Contour Information (Mosaics), Linear Accelerator Data, and Medical Information. Input to the system is in the form of spectrographic, densitometric and waveform data recorded on 16-, 35- and 70-millimeter film. The Waveform Display Analyzer will perform the initial scanning operation, digitize the resultant data, and store it in a 1024-word (36 bits per word) buffer. The operator may, after viewing the recorded data on a 17 inch CRT, or when the buffer is full, introduce the data into the host digital computer for subsequent processing and numerical analysis. The Waveform Display Analyzer consists of an optical scanner cabinet (analyzer), and an operator's display/control console.

LIGHT WEIGHT PNEUMATIC DE-ICING SYSTEM, ELECTRICAL PROPELLER DE-ICING SYSTEM

Prime Contractor: B. F. Goodrich Aerospace and Defense Products

Remarks

The B. F. Goodrich Light Weight Pneumatic De-Icing System gives in-flight protection from the hazards of ice formations on wing and empennage leading edges. It can be put into operation instantly by "flip of the switch" convenience and will operate continuously, if necessary. Engine-driven air pumps give dependable source of energy for De-Icer operation. Spanwise tubes built into the light weight, reinforced rubber "boots" are automatically cycled for inflation and deflation, thus cracking the ice and shedding it into the air stream. Electrical Propeller De-Icers consist of heating elements sandwiched in rubber and bonded to propeller blades (photo). Electrical energy is cycled automatically through a slip-ring-brush assembly for an effective and efficient heat pattern on prop blades. BFG light weight Pneumatic and Electrical Propeller De-Icers are available for most popular twin-engine general aircraft. Total system weights depend upon make and model of aircraft. Ranges are approximately as follows: Pneumatic De-Icers, 40 to 45 pounds; Electrical Prop De-Icers, 11 to 13.5 pounds.

ASW HELICOPTER TACTICAL TEAM TRAINER

Prime Contractor: California Ordnance Center, Honeywell Inc.

Remarks

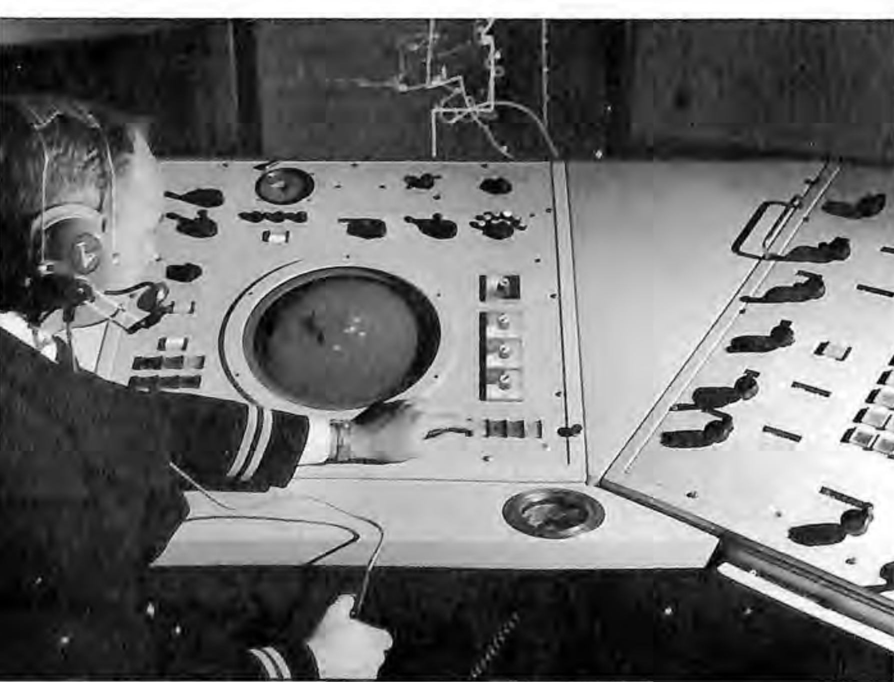
Navy helicopter pilots at Naval Auxiliary Air Station, San Diego, California, undergo realistic anti-submarine warfare exercises in the classroom with the aid of an ASW helicopter tactical team trainer built under contract from the Naval Training Device Center, Port Washington, New York. The trainer is designed to teach the most effective ASW tactics for detecting, tracking and attacking a submarine target without the time and cost of conducting actual sea exercises. Up to 3 2-man crews can be trained in simulated cockpits of SH-3A helicopters at one time. An instructor seated at an elevated console in the room can set up and control the entire ASW problem with the aid of a special analog computer. The problem is displayed on an 8-foot-square screen depicting movement of the helicopters, a simulated supporting surface ship and target submarines over a section of ocean 5 to 200 miles square. The computing system transforms inputs from the problem vehicles—such as position, course, speed and rate of turn—into calculated range and bearing. Up to 10 observers may monitor the action, wearing headphones to hear radio and instructor communications as the battle progresses. In photo, instructor's console, hub of the system.

QUARTZ LASER GYROSCOPE

Prime Contractor: Systems and Research Center, Honeywell Inc.

Remarks

First practical application of a laser gyroscope to measure angular motion of a moving vehicle was marked with the delivery of 3 helium-neon gas lasers housed in monolithic quartz blocks to the Naval Ordnance Test Station, China Lake, California. Three single-axis planar units are mounted to sense motion about each of 3 orthogonal axes—roll, pitch and yaw. Ruggedness of fused quartz block, made possible by Honeywell-developed precision machining and mirror fabrication techniques, overcomes inherent operating limitations of conventional glass-tube lasers in aerospace environment of shock, vibration and high-acceleration forces, and long life. Further advantages over conventional gyros are expected in cost, dynamic range of operation, power requirements, and by digital form of output. NOTS system, developed under contract from the Naval Air Systems and Ordnance Systems Commands, gave "excellent performance" during 7-hour flight test en route to California from Minnesota laboratory where it was built.



SIMPLIFIED TACTICAL APPROACH AND TERMINAL EQUIPMENT

Prime Contractor: Honeywell Radiation Center, Honeywell Inc.

Remarks

An all-weather tactical landing aid called STATE (Simplified Tactical Approach and Terminal Equipment) has been developed to visually inform pilot of his approach path range and range rate to touchdown. Requiring no voice radio contact for range information, the system is designed to meet military requirements for all-weather landings at remote, uninstrumented fields. The ground unit, weighing 55 pounds in prototype stage, can be carried onto field and aligned in 5 minutes by 1 man. Four foldable flat-plate antennae emit pulsed C-band localizer and glideslope guidance information to minimum range of 10 nautical miles. Range measuring equipment in aircraft furnishes omni-directional range (distance to landing system) and range rate (approximate ground speed to landing system), enabling pilot to remain in full command during approach and landing. Only leading edge of reflected pulse is tracked by aircraft, reducing multi-path effects. Coding system assures security for military operations, and use of same frequency by several aircraft using different codes. In photo, USAF T-39 makes approach over portable ground station.

NAVAL TACTICAL DATA SYSTEM

Prime Contractor: Hughes Aircraft Company

Remarks

The Naval Tactical Data System (NTDS) is an information display nerve center which exhibits instantaneous data about a tactical battle zone before the eyes of a Navy shipboard commander. In production at Hughes, NTDS consoles give tactical operations teams in the depths of a ship a comprehensive picture of ships, aircraft and submarines, friend or foe, within reach of a fleet's electronic eyes and ears. NTDS can detect, track and determine height, identity and composition of a raid. Within seconds, the system can evaluate the potential threat, assign and control countering weapons and perform other command functions for a single ship or for an entire fleet. NTDS replaces the conventional shipboard combat information center by virtually eliminating the possibility of human error and delays that often plagued the manual system of plotting. The NTDS display can be trimmed to 3 consoles for specific missions; other installations require up to 30 consoles. In addition to providing shipboard teams with specific information, NTDS can furnish display information throughout a data network linking several ships with each other and with shore stations.

MANPACK TRANSCEIVER

Prime Contractor: Hughes Aircraft Company

Remarks

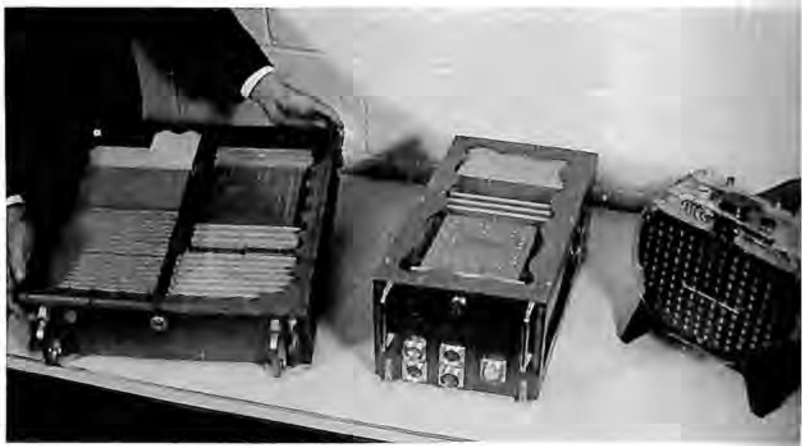
Hughes is producing for the Army a lightweight Manpack sending/receiving radio system that offers 10,000 individual voice channels and can operate effectively even in dense jungle. The solid state Manpack is a single sideband radio only 18 inches high, 12 inches wide and 3 3/4 inches thick. Its 2-12 megacycle range and 10,000 channels offer a wide, built-in frequency flexibility, making enemy jamming efforts more difficult. Manpack's high frequency signals reflect from the ionosphere, giving them a range beyond line-of-sight. Thus, the signals can traverse mountains and jungles where VHF and UHF signals often fail. The Manpack is designed to operate on ordinary flashlight-type dry cell batteries as well as wet cell batteries. Designed to be carried by one man wearing a standard Army shoulder harness, the system weighs about 29 pounds with wet cells. In field tests, the sets have operated efficiently between points more than 500 miles apart and on one occasion a Manpack clear transmission spanned 7,500 miles. Manpack uses a collapsible ship antenna, but for greater distances it can use a slant-wire antenna attached to a tree or a dipole antenna stretched between 2 vertical supports.

4PI COMPUTER

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

Special computers under development by IBM's Federal Systems Division apply the design principles of IBM System/360 commercial computers to military and space requirements. The new computer series is called "4Pi", reflecting its relationship to the company's System/360. Both use read-only storage to adapt a basic computer design to a "full circle" of applications. System/360 refers to the number of degrees in a circle, 4Pi to the number of steradians in a sphere—a 3-dimensional circle. IBM's 4Pi is the first application of read-only storage for computer logic control in military and space systems. Operating in billionths of a second, instructions in the read-only storage open and close electronic gates to set up circuit paths, enabling the computer to be tailored to specific requirements by changing the contents of its read-only storage rather than by physically changing circuits. This enables 4Pi to use standard mass-produced elements, and yet perform like a special-purpose computer. IBM is building 3 models of 4Pi at its Electronics Systems Center in Owego, New York. They are: TC (Tactical Computer) for satellites, tactical missiles, helicopters and other applications requiring the smallest and lightest computers; CP (Customized Processor) for avionics guidance and control and artillery fire control; and EP (Extended Performance) for aerospace applications that require high speed calculations of large amounts of data. All 3 use magnetic core main memory with up to 17,400 to a plane, and monolithic integrated logic circuits mounted on multilayer interconnecting boards.



AUTOMATIC COMPUTER-CONTROLLED FILM READER/RECORDER SYSTEM

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

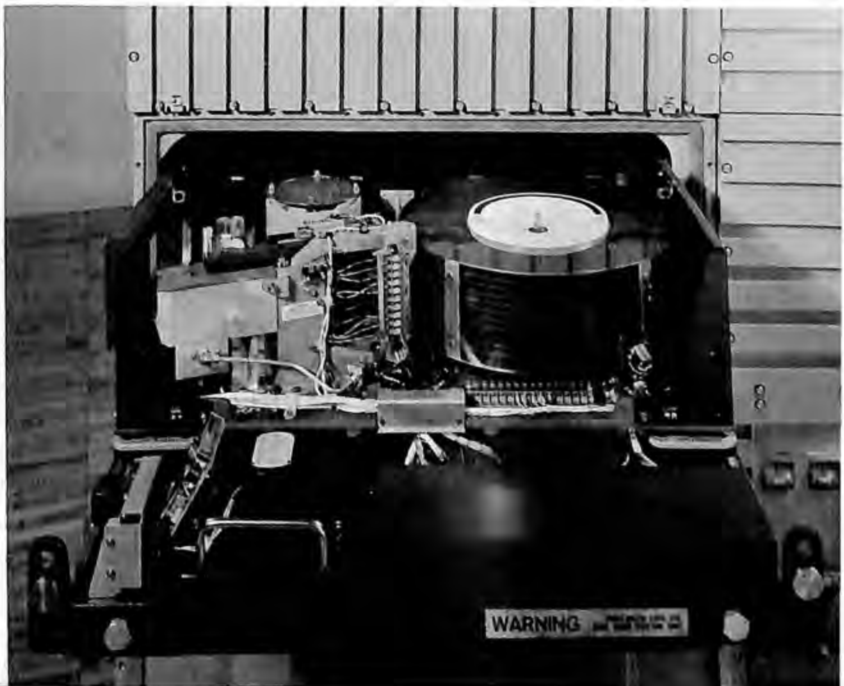
An automatic, computer-controlled Film Reader/Recorder has been developed by IBM Federal Systems Division for data handling, data compaction, and other applications involving large volumes of photographic information. The system utilizes a cathode ray tube scanner controlled directly by a digital computer. Rather than generating a normal TV type raster, the beam is directed to a particular spot on the film under computer program control. In this way, only areas of interest are digitized. A course scan can be generated to locate the areas of interest, if they are not known. In addition, the computer can control the intensity, for both reading and recording purposes. The reader has a full field of 4096×4096 positions and can encode 64 gray levels. This permits the program to look for changes in relative gray levels as significant events, rather than relying on a "black-white" decision imposed by a clipping level. Because of these features, the reader can digitize and re-create a 35 millimeter photograph, with little or no loss of information. The equipment can read a frame of cinetheodolite film in 2 or 3 seconds. IBM expects to add programmed Input/Output overlap and use improved reading algorithms to achieve a speed of better than 1 frame per second. In addition to data compaction, the Reader/Recorder can relieve human operators from the boring job of measurement or counting anything that is highly repetitive and requires accuracy. A great deal of imagery falls into this class.

RD-281 MILITARIZED DISK FILE

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

IBM's RD-281 is a militarized disk storage system capable of storing up to 200,000,000 bits of information. It can locate and retrieve specifically desired material within 185 milliseconds (.185 seconds) at random. The system is compact, highly reliable and extremely rugged. It is designed for use with tactical military computers in severe environments where highest reliability is essential, even under rigors of wide temperature ranges, shock, vibration, humidity, corrosion and radio frequency interference. The RD-281 is the first disk mass memory capable of being integrated with a wide range of military data processors without costly redesign or design-from-scratch efforts. It has proven itself in service for both the U. S. Navy and the Royal Canadian Navy. RD-281 is based on the commercial IBM 1311, which was militarized and altered using the corporation's new Military Solid Logic Technology (MSLT). Overall responsibility for marketing, engineering and construction of the Mil File rests with the Federal Systems Division's Federal Systems Center in Gaithersburg, Maryland. Power requirement for the basic Mil File is 1200 watts. Each additional disk drive requires 600 watts.



SATURN INSTRUMENT UNIT

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

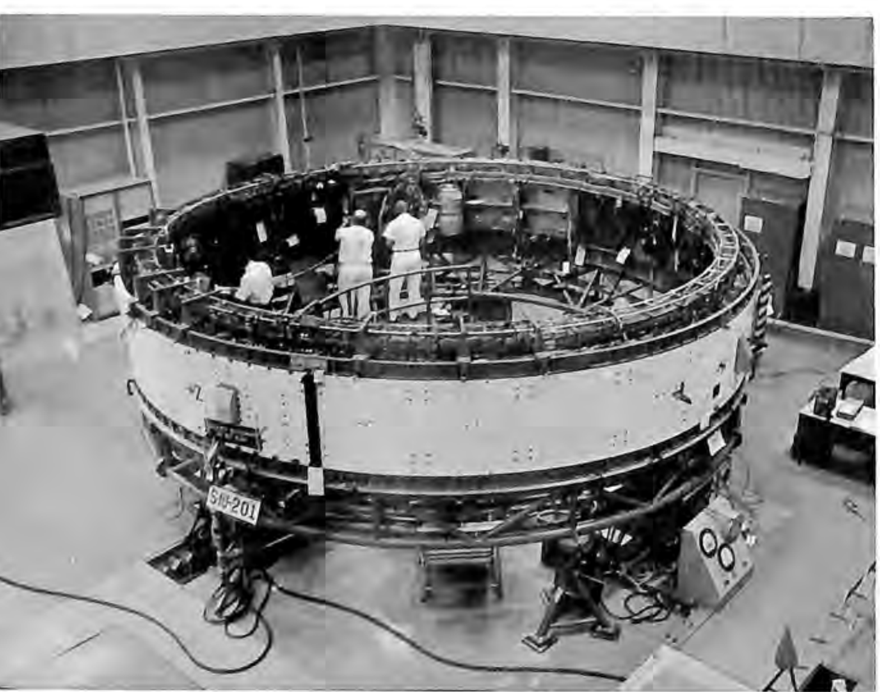
The Instrument Unit (IU)—the 3-foot high "nerve center" stage of Saturn—was designed at NASA's Marshall Space Flight Center and is assembled at Huntsville, Alabama, by IBM Federal Systems Division. Each Uprated Saturn I and Saturn V has one of these aluminum rings 21.7 feet in diameter. More than 60 electrical and electronic units are integrated within each IU to provide the vehicle with guidance, navigation, control and data handling systems. IBM has system integration responsibility for the Saturn IU's including fabrication, assembly, checkout and launch support. IBM also builds the on-board computer and the data adaptor. During a mission, the IU's sensitive instruments process millions of bits of data every few minutes, and its guidance system measures acceleration and vehicle attitude 25 times a second. It determines velocity and position every second, then calculates and issues steering commands to keep Saturn on course. The IU samples 200 sensors that measure environment and systems performance, tests sound levels, temperatures, pressures and vibration levels more than 7,000 times a minute, and records and relays flight information to ground stations. Before launch, the IU aids in countdown checkout. Under blockhouse control, the onboard IBM computer checks itself and the Saturn vehicle. It tests switch selectors in each stage, and orders first stage engines to gimbal for visual observation. Once in earth orbit, the IU commands engine ignition to put Apollo on a correct lunar trajectory. When on course, it stabilizes the stage.

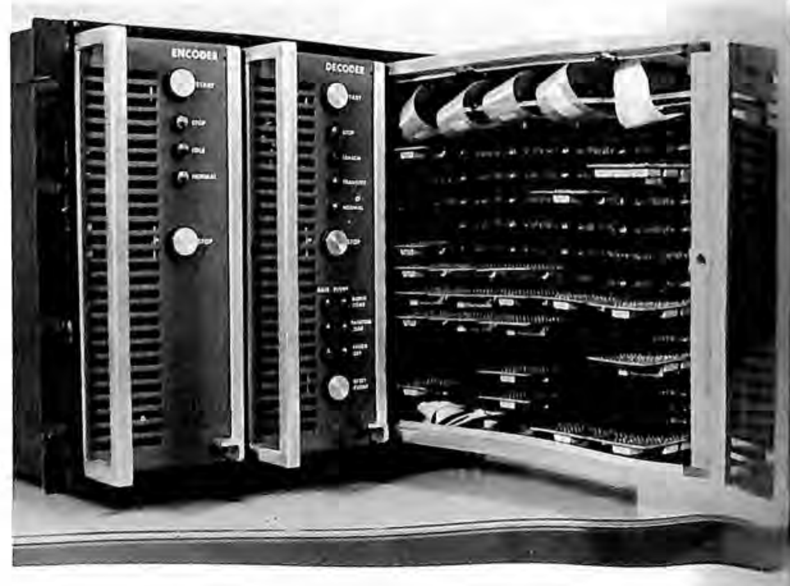
DACOR (DATA CORRECTION) FORWARD ERROR CONTROL SYSTEM

Prime Contractor: International Business Machines Corporation, Federal Systems Division

Remarks

IBM Federal Systems Division's Engineering Laboratory has developed a communications device called DACOR (DAta CORrection) that promises to greatly advance means of controlling errors in digital data transmissions. The device applies advanced polynominal coding techniques—complex algebraic formulas—for encoding and decoding to provide error correction capability. Information is encoded before transmission in a way that allows it to be decoded at the receiver into its proper form, even if errors have occurred during transmission. Thus, information sent by a data source which becomes garbled during transmission does not have to be retransmitted. The equipment has broad communications applications. While other methods of error control—error detection and error detection and re-transmission—provide no means for correcting transmission errors at reception, forward error correction provides for transmitting information with no delay in the data source, and with only a fixed, fraction-of-a second decoding delay. The DACOR system has a special decoding capability in its receiver called adaptive decoding which allows the decoder to determine whether clustered errors or random errors have occurred in an incorrect message and to adapt its correction process to the type of error pattern that is present. The type of error patterns to be corrected are decided beforehand and a code is chosen to distinguish these patterns. When a message is received without the proper code structure the decoder determines which error pattern has occurred.





DME RADIAL GROUND SPEED INDICATOR

Prime Contractor: ITT Federal Laboratories, a Division of International Telephone and Telegraph Corporation

Remarks

The AIN-150A DME Radial Ground Speed Indicator designed by ITT Federal Laboratories continuously displays a jet aircraft's ground speed, time and distance to destination. The instrument is being developed in accordance with specifications established by United Air Lines, which ordered the instrument for its fleet of Boeing 737 twin-jet aircraft, scheduled to be operational in 1968. The indicator reduces crew workload and requires no additional space on the instrument panel because it replaces the conventional DME (distance measuring equipment) indicator which displays nautical miles from a Vortac, Tacan or DME ground beacon. ITTFL's new instrument eliminates wind-computation errors and the need for slide-rule computation of the aircraft's estimated time of arrival. The indicator enables pilots to determine their best cruising altitude by monitoring the instrument for an increase or decrease in ground speed at different altitudes. The indicator can be installed in a few minutes on any aircraft equipped to accommodate an ARINC-type DME or military-type Tacan without changes in the aircraft wiring. The indicator presents no additional load to the DME or Tacan equipment over that required for a standard DME indicator.

SATELLITE COMMUNICATION EARTH TERMINAL

Prime Contractor: ITT Federal Laboratories, a Division of International Telephone and Telegraph Corporation

Remarks

Commercial satellite communication earth terminal designed and being fabricated by ITT Federal Laboratories is equipped with an 85-foot-diameter fully steerable parabolic antenna. Full steering capability allows the terminal to operate with satellites in orbits ranging from 5,000 nautical miles to synchronous orbits 22,300 miles high. The terminal is being built for the national telephone company of Spain, Compania Telefonica Nacional de España (CTNE) and will be located near Madrid. The earth terminal is designed for television transmission and reception as well as voice and data traffic. A microwave relay system will carry message traffic from the earth station to Madrid.

PRECISION DIGITAL TACAN TRANSCEIVER

Prime Contractor: ITT Federal Laboratories, a Division of International Telephone and Telegraph Corporation

Remarks

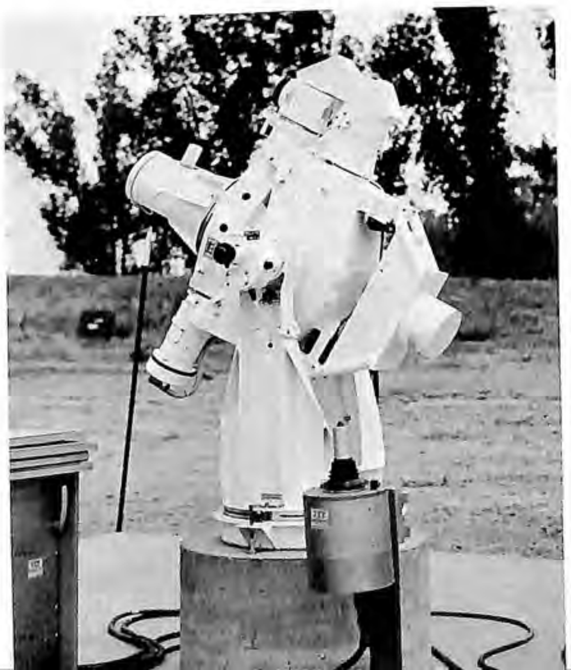
Microelectronic precision digital Tacan (tactical air navigation) transceiver AN/ARN-74(V) designed and developed by ITT Federal Laboratories uses solid-state digital circuitry wherever possible and is virtually free of moving mechanical parts. Distinct advantages ensuing from the design are increased destination-searching time, high accuracy, self-test and automatic fault detection. ITTFL has been awarded a multi-million dollar contract by the Air Force to build AN/ARN-74(V) Tacan sets for the F-111 aircraft.

PORTABLE AUTOMATIC CALIBRATION TRACKER

Prime Contractor: ITTFL-Aerospace, a Division of International Telephone and Telegraph Corporation

Remarks

The Portable Automatic Calibration Tracker (PACT) system was developed for the National Aeronautics and Space Administration's Goddard Space Flight Center to calibrate Space Tracking and Data Acquisition Network (STADAN) antennas. The system comprises an electro-optical sensor and X-Y mount assembly, and subsystems for mount control, data processing, display and printout. A 4,500-watt quartz iodine light source supplied with the system is mounted concentrically with a radar beacon antenna on a calibration aircraft. Simultaneous tracking of optical and radio-frequency targets by PACT and a STADAN antenna facilitates calibration of antenna pointing angles. Manual control is exercised during target acquistion; after the target has been acquired the system tracks automatically.



FLITE-PATH DISPLAY

Prime Contractor: Kaiser Aerospace & Electronics Corporation

Remarks

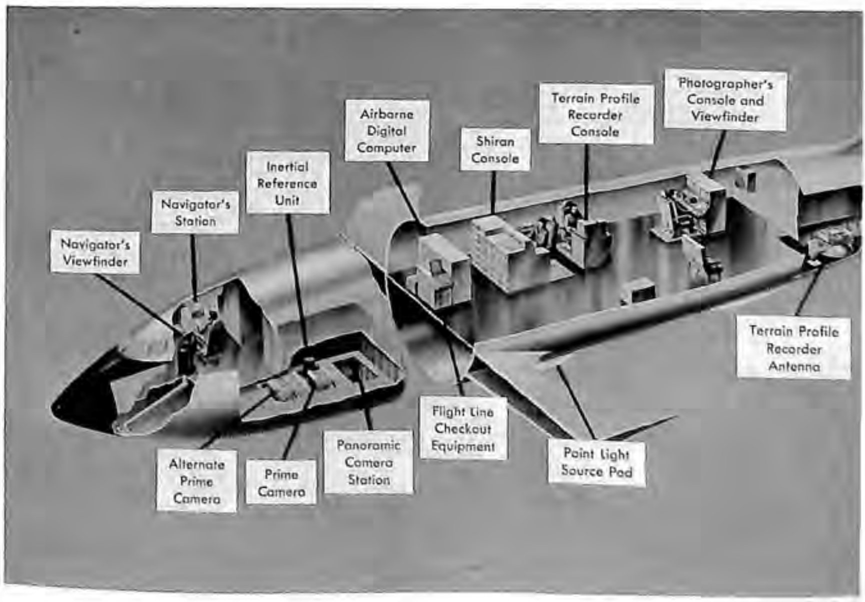
Kaiser Aerospace & Electronics Corporation has developed a revolutionary new aircraft instrumentation system for light aircraft named the Kaiser Flite-Path Display. It is an electronic system that integrates data from many of the currently-used standard instruments and converts it into a TV picture that can be scanned by the pilot as though he were flying in visual contact with the real world. Instead of the "black ball" artificial horizon in present use, the pilot sees in his TV-type picture a realistic portrayal of a light sky, dark ground with small symbols that represent earth features, and a highway that diminishes in perspective toward the horizon. The earth-feature symbols first appear as small fields on the horizon and increase in size as they move down the TV screen so the pilot feels he is moving over the earth below. In a turn, the symbols move sideways, giving the real-world impression that the landmarks remain stationary and the aircraft is turning away. The "highway in the sky," is superimposed over the basic display and directs the pilot to his destination. The path is positioned by information that has been processed from radios, gyro compass and an altitude sensor.

AN/USQ-28 AERIAL SURVEYING AND MAPPING SYSTEM

Prime Contractor: Kollsman Instrument Corporation

Remarks

The AN/USQ-28 is the first of a new class of advanced airborne electronic photography systems that completely integrates aerial surveying and photomapping techniques with computer control. The system includes mapping cameras of advanced design which, with their support equipment, are located in a pressurized compartment in the bottom of the forward section of the fuselage. Above this compartment is the Navigator's Station with an extremely accurate Navigator's Viewfinder and the controls for the Inertial Reference Unit. The other subsystems, which include the Photographer's Station with Console and Viewfinder, the Shiran Operator's Station and related equipment, the Terrain Profile Recorder Console and the Digital Computer are located amidships and aft in the aircraft. These subsystems are integrated to provide the fastest and most accurate means available to obtain raw geodetic and photomapping data. The AN/USQ-28 system is capable of mapping 30,000 to 40,000 square miles a day and will collect data on the location, altitude and angle at which the photographs were taken. The program is directed by the Aeronautical Systems Division, USAF, Wright-Patterson Air Force Base, and will be installed in Boeing RC-135A transport/reconnaissance aircraft. Kollsman has delivered a prototype system and 4 production models. Flight testing was completed at Boeing and the second phase got underway at Wright-Patterson Air Force Base in 1966.



CENTRAL AIR DATA COMPUTER SYSTEM

Prime Contractor: Kollsman Instrument Corporation

Remarks

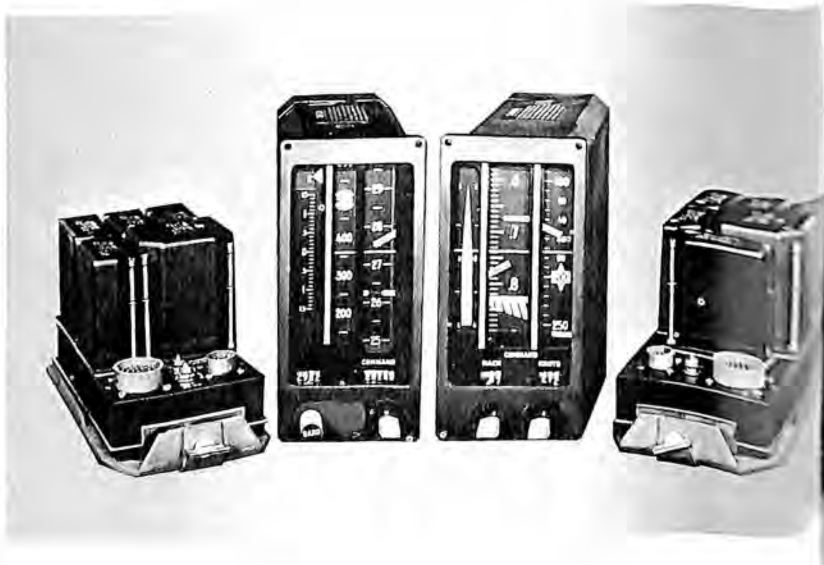
The Air Data Computer, in production for the Boeing 737, was developed to meet the requirements of commercial jet transports for an accurate, modular computing system. It operates with proven electromechanical and pneumatic computing elements. The design of the system is completely modular in construction to provide maximum configuration flexibility. The design of the basic computer is not affected by the configuration selected to meet the individual airline requirements. The basic computation provides the autopilot with altitude and airspeed from pneumatic inputs of static pressure and total pressure. Information modules can be converted to provide altitude, altitude hold and altitude rate outputs to panel indicators, autopilots, cabin pressurization systems and the automatic altitude reporting system. The computer can also be converted to provide airspeed and airspeed hold outputs. The addition of a Mach module and other conversions will provide Mach number outputs, static source error correction of altitude and airspeed, and the generation and transmission of true airspeed, saturated air temperature, Mach trim signals and other values. The computations are performed with Kollsman transducers that use basic altitude and airspeed mechanisms. The system is mechanically calibrated to eliminate any possibility of changes in accuracy or repeatability caused by aging or temperature changes.

VERTICAL SCALE FLIGHT INSTRUMENT SYSTEM

Prime Contractor: Kollsman Instrument Corporation

Remarks

The Vertical Scale Flight Instrument System, in long-term production for the Air Force C-141 Star-Lifter, includes altitude and vertical speed indicators, airspeed-mach number indicators, angle of attack indicators and related electronic components. These provide input information which is presented as direct readings on graduated moving tapes. The tapes are read relative to a common center reference line, instead of the conventional circular dial instrument presentation. The vertical scale design presents altitude, vertical speed, air speed, Mach number, angle of attack, command functions and barometric pressure on a single horizontal reference line, allowing the pilot to read them at a glance and make interpretations much more swiftly. Another advantageous feature of the new design is the use of larger numerals, which heretofore has been prohibited by the restricted area of dial-type indicators. Use of tape also allows more intermediate graduations and, in some instances, non-linear graduations for even higher accuracy. Command parameter functions can easily be displayed by vertical scale indicators, eliminating the need to retain such values mentally. The command marker is positioned to the desired value on the moving tape scale and "rides" the scale to the center reference line. For most aircraft parameters, this action allows the pilot to fly the command marker to the center reference line. Setting of a command parameter can be done either from a front panel slewing switch or automatically by an external command signal, depending upon the position of an internal mode relay.



GODDARD EXPERIMENT PACKAGE

Prime Contractor: Kollsman Instrument Corporation

Remarks

The Goddard Experiment Package is a scientific experiment for the second Orbiting Astronomical Observatory. The Experiment Package consists of a 38-inch spectrophotometric telescope and its associated electromechanical control and data handling equipment. The mission of the GEP is to measure the ultraviolet radiation intensity of many selected stars. Star data that is acquired is arranged by the GEP into a form acceptable to the OAO Spacecraft. The spacecraft stores the data and, upon interrogation from a ground station, transmits the data to the ground station. In addition to data transmission, the spacecraft provides a stable platform that can be commanded to orient the experiment as required, supplies power to the experiment, and provides a system for radio communication with the experiment. The telescope, the spectrometer, the mechanism, the detectors, the fine guidance and associated equipment are all contained on or within the optical structure. This assemblage is 40 inches in diameter and 112 inches in length and weighs 860 pounds. The data accumulators, the digital status-data circuits, and the control electronics are all contained within the Digital Bay Rack. This assembly is housed in Bay E4 of the spacecraft. Its volume is approximately 1 cubic foot and it weighs 40 pounds. A second external unit, the Analog Bay Rack, is housed in Bay E5 of the spacecraft. It is approximately 1 cubic foot in size and weighs 55 pounds.

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.

ATTITUDE REFERENCE AND BOMBING COMPUTER SET; MODEL 5103L

GEOCENTRIC VERTICAL REFERENCE SYSTEM

Prime Contractor: Lear Siegler, Inc., Instrument Division

Remarks

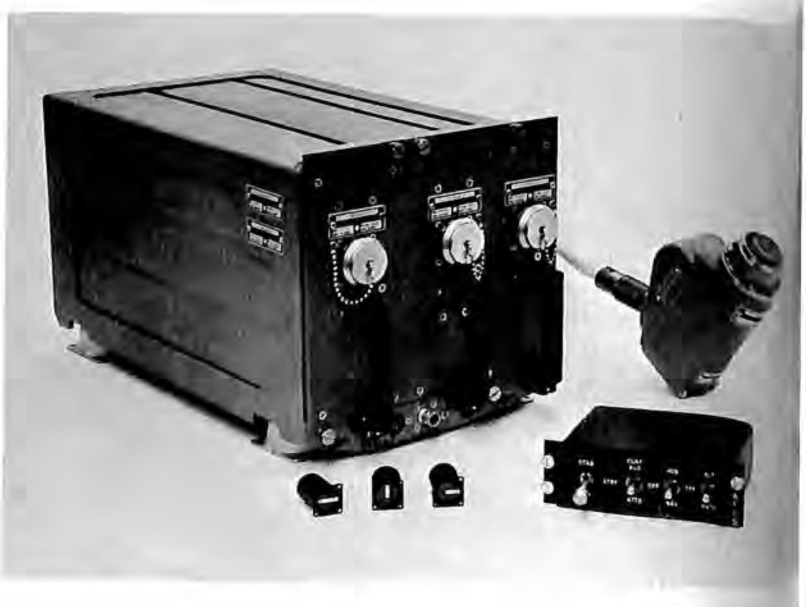
A Geocentric Vertical Reference System provides verticality data with less than 0.5 degrees of error under a wide range of flight conditions. Scheduled for use in the Navy's F-4J and F-4K fighter bombers, the system supplies accurate, gyro-stabilized roll and pitch synchro outputs during dynamic conditions 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.

DUAL AUTOMATIC FLIGHT CONTROL SYSTEM

Prime Contractor: Lear Siegler, Inc., Astronics Division

Remarks

Designed, developed and in production for LTV Aerospace Corporation's A-7A (Corsair II) light attack aircraft, the LSI dual channel, control system represents a considerable advancement in the state of the art. The normal operating modes of the AFCS include: stability augmentation, control augmentation, attitude hold, heading hold, heading select, altitude hold, TPQ-10 precision bombing, and automatic carrier landing. To meet the high reliability and safety requirements of today's high speed jets in such complicated maneuvers as automatic carrier landings, all 3 axes of the system are dual from sensors to actuators. The control augmentation, or all-attitude control stick steering, mode combines the advantages of a high damped stable platform for weapons delivery and extreme maneuverability with roll rates up to 180 degrees per second. Built-in-self-test circuitry allows the pilot to verify proper operation in a few seconds during the preflight checks. The rate and acceleration sensors employ built-in self-test torquers to produce system inputs and servo monitors are used to verify proper outputs. Maintainability aspects are of prime consideration during the design phase and the final product shows the results with the easily opened chassis and modular electronic construction. The ground test connectors allow the entire system to be ground checked in the aircraft with a relatively simple flight line analyzer in just a few minutes.



ARCADE (AUTOMATIC RADAR CONTROL AND DATA EQUIPMENT)

Prime Contractor: Lear Siegler, Inc., Data & Controls Division

Remarks

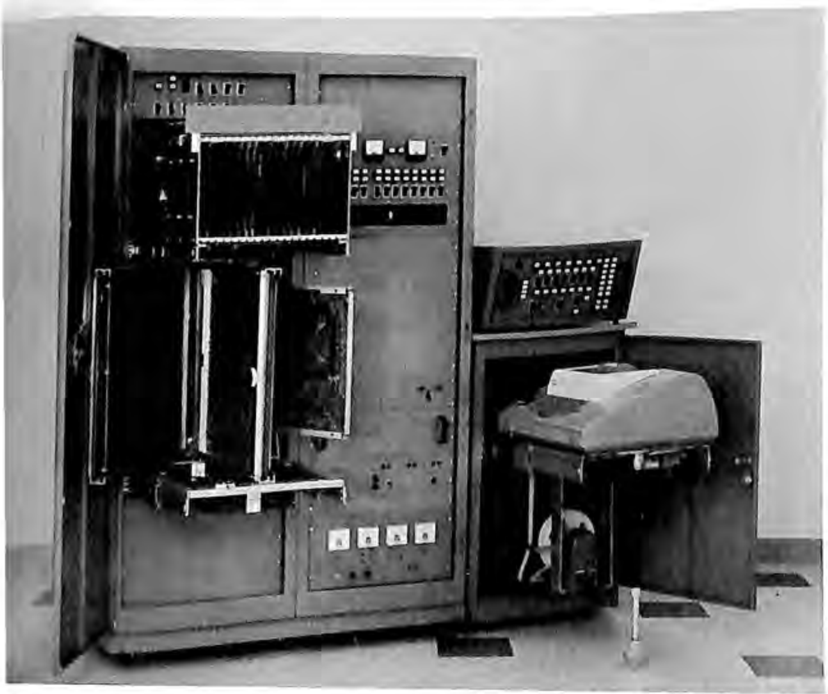
The ARCADE is a data processing system designed to operate with each radar set of a tracking chain. In the acquisition mode, the ARCADE accepts target positional data from a remote source and translates X, Y, and Z coordinates into local range, elevation, and azimuth. The system forms part of the radar servo loop, and after correcting the received data for local refraction, tilt, orthogonal vectors, and servo lag, it compares the local antenna position with the data and then drives the antenna to a position that permits target acquisition. In the tracking mode, the ARCADE receives target range, azimuth, and elevation coordinates from the local radar and corrects the data for refraction, tilt, orthogonal vectors, and servo lag. The corrected data is reformatted and transmitted to a remote site; in addition, if the destination is a remote radar ARCADE site, the corrected R, A, E, coordinates are translated into X, Y, Z coordinates before transmission. Comprehensive pre-flight calibration and system test facilities are provided. The heart of the ARCADE system is the LSI 8800 central processor, equipped with 8192-byte memory. The processor is fabricated entirely from monolithic silicon-integrated micrologic modules and is built on 2 printed circuit boards; the memory occupies a third board. The I/O devices include Kineplex modems, A/D and D/A converters, a real time clock, a typewriter, and a Wayne George recorder.

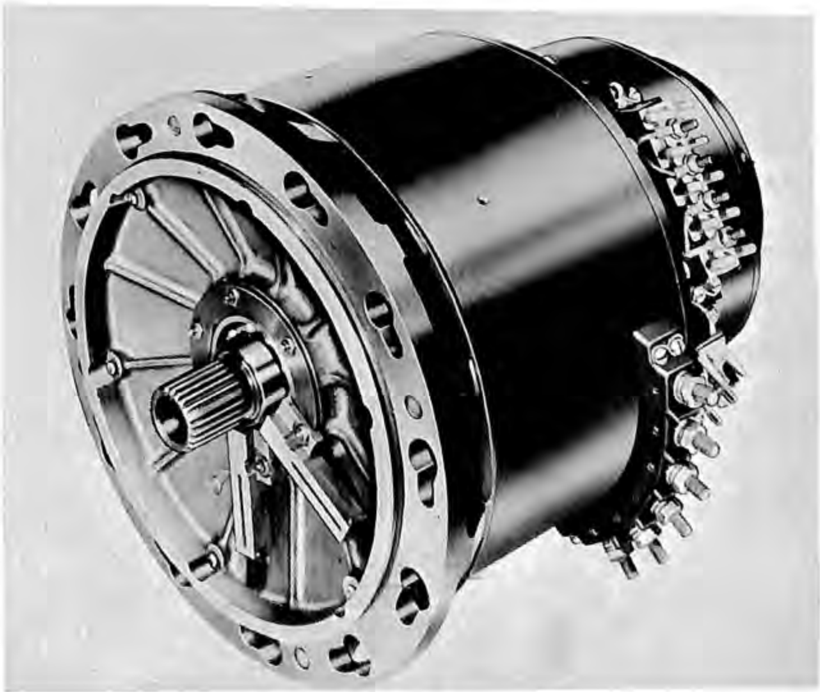
AC ELECTRIC POWER SYSTEM

Prime Contractor: Lear Siegler, Inc., Power Equipment Division

Remarks

This aircraft electric power generation system features a brushless AC generator and a solid state combination generator control pannel and voltage regulator. The 3-phase, 400 cycle, 120/208 volt generator is rated at 30 KVA for a continuous duty with class C cooling and 41.2 KVA with class B cooling. It is designed to the requirements of MIL-G-6099A-1. Use of oil lubricated bearing in the generator has extended Time-Between-Overhaul to in excess of 5,000 hours. The combination voltage regulator and generator control unit weighs only 8.6 pounds and will handle up to 60 KVA systems. Three additional items of equipment are required in multi-generator systems: a three pole electrically operated, mechaniclly latched power relay rated at 60 KVA; a current transformer and fuse box for load monitoring and sensing unbalanced current and real and reactive loads; a bus protection panel which protects the synchronizing bus of the system. The power relay meets the requirements of MIL-C-8379A (ASG). All units except the generator and power relay feature connector terminations. The system provides for parallel, unparallel or isolated operation. Initial application is on the Series 60 DC-8 aircraft.





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, 4 firing forward, 4 downward, 2 up and 2 down. The system has been tested under weightless conditions in flights on KC-135 aircraft flying ballistic trajectories to achieve up to 30 seconds of zero-gravity. LTV has built a number of test units and 3 flight models of the AMU for the Air Force.

SPACE ENVIRONMENT SIMULATOR

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.

Remarks

This cylindrical simulator, 12 feet in diameter and 11 feet deep, permits testing of space equipment and vehicles at extreme heat and cold to simulate actual space flight. It can simulate orbital altitude up to 200 miles, space thermal radiation levels, solar radiation, intensity and spectral distribution and orbital motion relative to the "sun". Gemini and Apollo astronauts' space suits have been tested in this simulator under heat and cold conditions. Liquid nitrogen flowed through coils permits tests at as low as minus 320 degrees Fahrenheit. Twenty xenon-mercury high pressure lamps of 2500 watts each permit solar simulation temperatures.

MANNED AEROSPACE FLIGHT SIMULATOR

Prime Contractor: LTV Aerospace Corporation, A Subsidiary of Ling-Temco-Vought, Inc.

Remarks

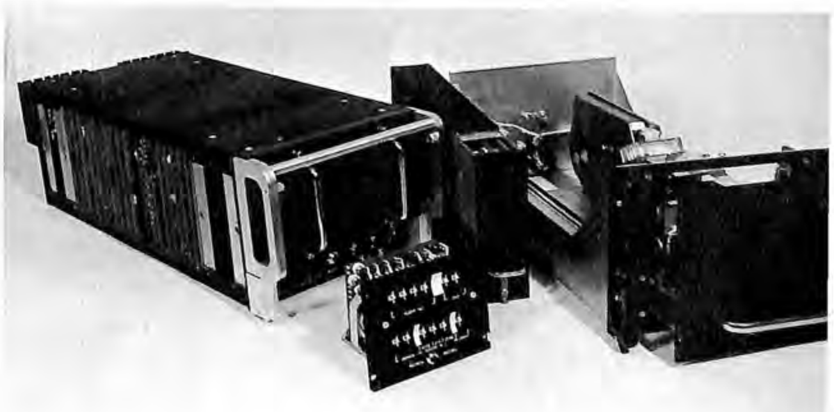
The manned aerospace flight simulator enables an astronaut to make realistic orbital, lunar and interplanetary "flights," view the movement of his vehicle in "space" and experience problems and stresses like those an actual space vehicle would encounter—all while remaining safely on earth. Developed 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.

AIRBORNE DATA ACQUISITION SYSTEM

Prime Contractor: Lockheed Aircraft Service Company

Remarks

The aerospace industry's first automatic airborne data acquisition system (ADAS) was developed and manufactured by Lockheed Aircraft Service Company in 1966. First units were delivered to Trans World Airlines for its fleet of DC-9 jet transports. The DC-9 installation, monitoring 50 separate parameters of engine information, marked the first fleet-wide application of automatic airborne data collection to provide a daily "health report" on aircraft engines and systems. ADAS is designed to reduce DC-9 cockpit paper work by automatically recording data reflecting the state of performance of all monitored components. Recorded on punched paper tape, data is transmitted by teletype to the airline's overhaul base at Kansas City, Missouri, where rapid computer analysis and printout permits quick and accurate diagnosis of maintenance requirements.



VISUAL APPROACH PATH INDICATOR

Prime Contractor: Lockheed Industrial Products

Remarks

Lockheed Industrial Products in Atlanta is the manufacturing facility for the Lockheed-Georgia Company in certain fields of ground support equipment for its aircraft and for cargo loading systems applicable to rail, air and sea transportaion. LIP has introduced the Visual Approach Path Indicator, an optical device which enables private and commercial pilots to make precision approaches and landings. Employing a tri-colored beam of amber, green and red, the pilot can tell his relative angle of approach to the air strip by straight-line sight. Amber means he is too high, red too low, and the green light is the safety zone for a smooth and safe landing.

Specifications

Weight 35 pounds, unit size 21 by 21 inches, 7-1/2 inches high, 3 power sources through a transformer, 110, 220 and 6 volts. Light is a 35-watt high intensity reflector bulb, which consumes 1/400 kilowatts per hour. Cast aluminum dome protects against ground equipment.

Performance

Visibility 3 miles in daylight, 12 miles at night.

EJECTABLE RECORDING SYSTEM

Prime Contractor: Lockheed Aircraft Service Company

Remarks

Lockheed Aircraft Service Company has installed the Lockheed Ejectable Recording System in the Military Airlift Command fleet of 42 C-133 aircraft. The system retains a 15-hour, continuous record of critical aircraft engine and system operations. A 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.

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. Martin has delivered to NASA several pairs 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.

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 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 fifth anniversary in space June 29, 1966, still functioning aboard the satellite, which Navy officials said was signalling 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, SNAP-29 RADIOISOTOPE THERMOELECTRIC GENERATORS

Prime Contractor: Martin Company, Baltimore

Remarks

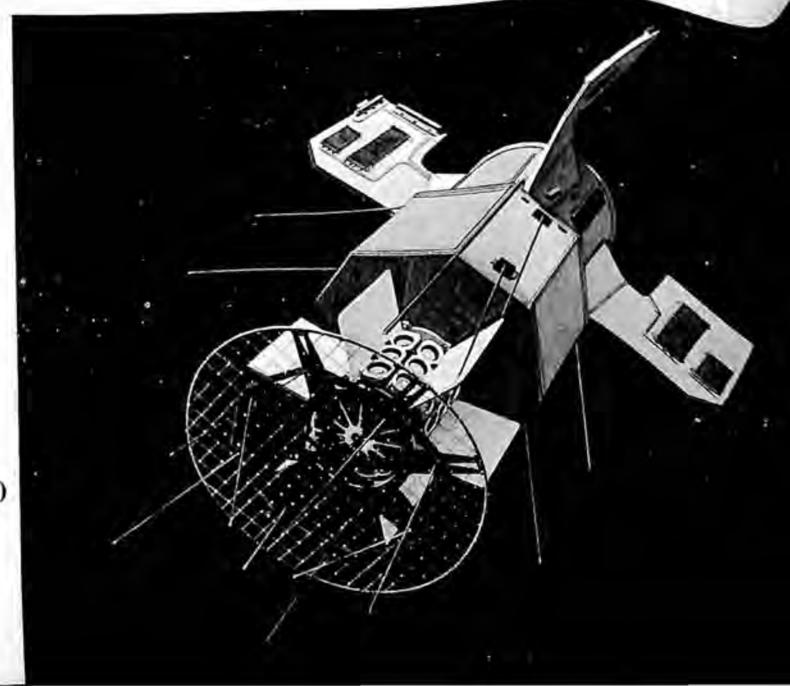
Two SNAP-9A radioisotope thermoelectric generators are in orbit aboard Navy navigation satellites (in photo, SNAP-9A is finned cylinder). The one launched in September, 1963, was the first all-nuclear power system to be used on a satellite. The second is part of a 3-satellite navigational system for fleet units. It is the only one in the system to be atom-powered. The others are powered by solar cells. Martin is also developing for AEC a SNAP-29 for use in short-term Earth orbit and lunar surface missions. It will be 10 times more powerful than any space isotopic power system now being developed.

Specifications

Finned cylinder shape, 20 inches in diameter, 9-1/2 inches high; SNAP-9A fueled with plutonium-238, SNAP-29 with plutonium-210; weight 27 pounds; electrical output 25 watts for 9A and 500 watts for 29; design life 5 years.

Method of Operation

The generator has no moving parts. The spontaneous decay of the plutonium generates heat in the containment block surrounding it. The heat is transformed directly into electrical energy by a series of thermoelectric elements.



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 were "flown" by 3-man crews from the Air Force's Aerospace Research Pilots School, Edwards AFB, California. Each crew spent 7 days on the simulated round trip to the moon following 5 weeks of classroom work, physical conditioning and simulator training. The Apollo mission was chosen for the studies because it represented a system already well defined and requiring a variety of tasks to be performed by the pilots. Major elements of the simulator include a full-scale Apollo spacecraft 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.

MINUTEMAN I (LGM-30B) GUIDANCE AND CONTROL SYSTEM (AN-DJW-16)

Prime Contractor: Autonetics Division, North American Aviation

Remarks

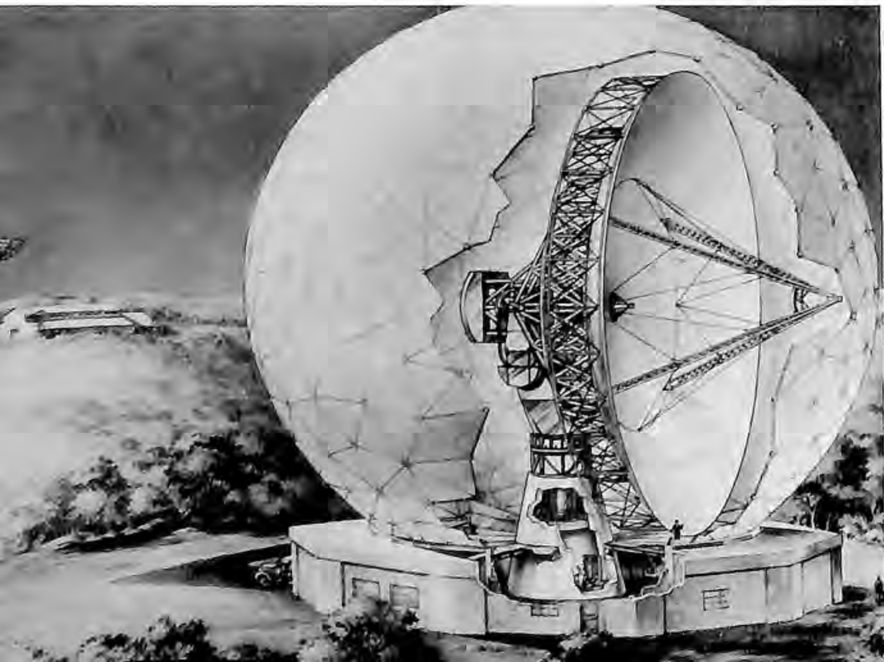
As associate prime contractor for guidance and control (G&C) equipment for the solid-fueled Minuteman I ICBM, Autonetics designed, developed and is producing virtually all this quick-reaction missile's avionics and its supporting ground checkout and alignment equipment. Minuteman I G&C features a degree 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 gyrostabilized 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. 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.

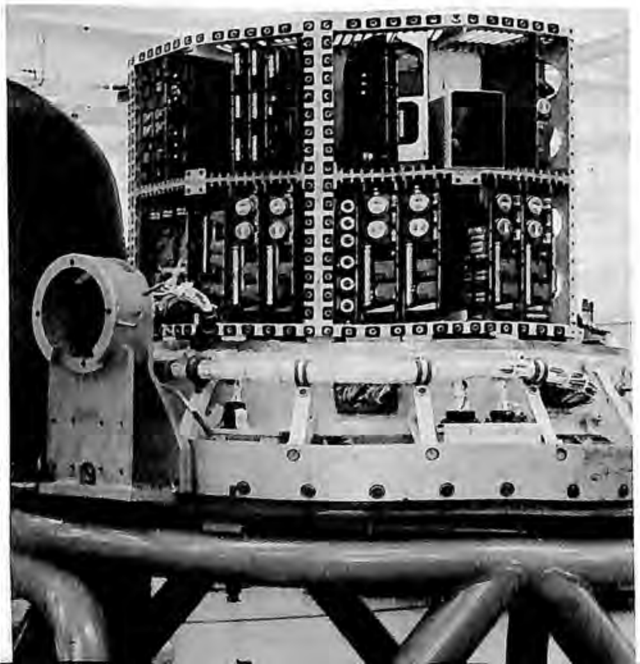
HAYSTACK 120-FOOT MICROWAVE ANTENNA SYSTEM

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 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.

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

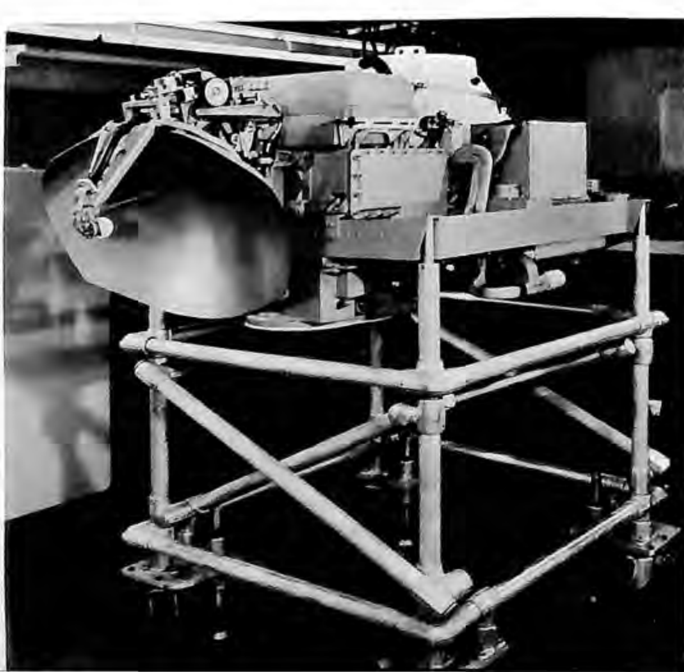
The AN-ASB-12 REINS provides the North American-built Navy Vigilante carrier-based attack bomber with precision guidance, all-weather terrain avoidance for low-altitude missions, air-to-ground ranging, and contour and ground mapping capabilities. REINS target identification and automatic navigation free 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.

ALOTS AIRBORNE LIGHTWEIGHT OPTICAL TRACKING SYSTEM

Prime Contractor: Northrop Nortronics, a Division of Northrop Corporation

Remarks

Operational at the Eastern Test Range, the Northrop Airborne Lightweight Optical Tracking System (ALOTS) was designed to provide precision photographic coverage of missiles during the early launch, stage separation and re-entry phases of flight. ALOTS is operated at an altitude of 40,000 feet to eliminate interference from cloud cover and other atmospheric conditions which frequently inhibit ground based camera systems. The Nortronics-developed ALOTS system can photograph and resolve a 12-foot target at a distance of 200 miles. The heart of ALOTS, an integrated automatic tracking and photographic system, was installed by Lockheed Aircraft Service in an external pod and mounted on the cargo door of a KC-135A (in photo).

MARINE STAR TRACKER

Prime Contractor: Northrop Nortronics' Marine Equipment Department

Remarks

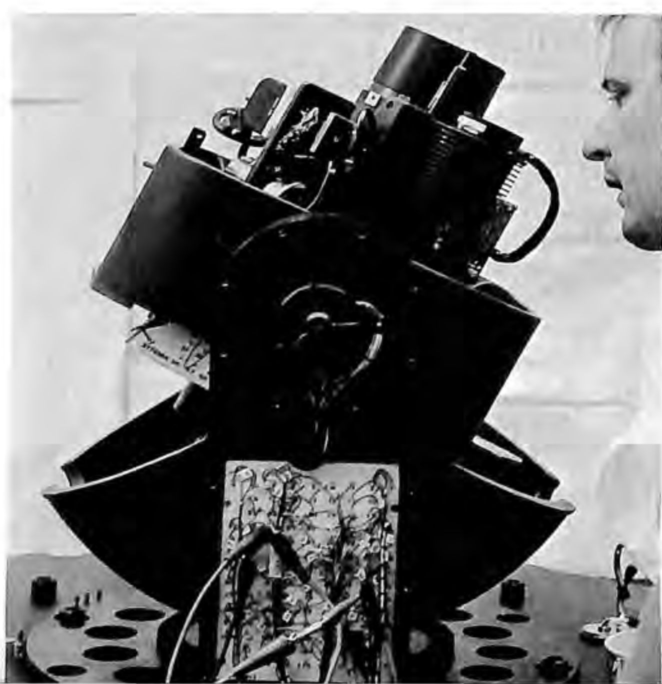
The Northrop Marine Star Tracker is a Vidicon type tracker that will be installed as a component of Sperry Ships Inertial Navigator/Star Tracker systems on Apollo range instrumentation surface ships. The tracker is designed to accept computer data on star position, automatically acquire the star, lock 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.)

TACTICAL EVALUATION AND MONITORING SYSTEM

Prime Contractor: Northrop Nortronics, a Division of Northrop Corporation

Remarks

The Navy's new Knox-class destroyer escorts, which will start putting to sea in early 1968, will have the fleet's fastest troubleshooter—an automatic checkout system that will continually monitor sonar gear, fire-control radar, and search radars, all crucial systems for combat. The Tactical Evaluation and Monitoring System (TEAMS), developed and produced by Northrop Corporation's Nortronics Division, will make a checkout of the four sonar and radar sets aboard the ASW ships in just 1-1/2 minutes. Northrop Nortronics has a contract to supply 26 TEAMS for the 26 destroyer escorts scheduled to join the fleet in the next three years. TEAMS is capable of monitoring up to 10 major systems on the 4,100-ton ships, but will be used for the AN/SPS-10 sonar; the AN/SPC-53 A fire-control radar, and the AN/SPS-10 and AN/SPS-40 search radars. Starting in January, 1967, Nortronics was scheduled to deliver a unit a month through December, 1968. TEAMS automatically prints out test data whenever it finds a fault in the set being tested. It is programmed to spot marginal performance so that preventive repairs can be made to keep the equipment on the air—ready to respond at all times.



C-5A INERTIAL NAVIGATION SYSTEM

Prime Contractor: Northrop Nortronics, a Division of Northrop Corporation

Remarks

Northrop Nortronics' unique "floated" inertial measurement unit will provide precise attitude information for navigation of the Air Force C-5A fan-jet cargo carrier. The Lockheed-Georgia Company selected Northrop to develop, test, and produce the new equipment, which will be the heart of the C-5A guidance system. The C-5A will be the first cargo plane to combine both doppler and inertial systems, each often used exclusively for guidance, for backup, and greater navigational accuracy. Called the FLIP for Floated Lightweight Inertial Platform, the ball is supported within a spherical platform by an extremely thin layer of fluid, allowing it to rotate freely to provide accurate pitch, roll and azimuth data regardless of aircraft movement. Conventional inertial platforms use mechanical instead of fluid support. Inertial accuracy of the system will be better than 1 nautical mile per hour. Total weight of the system is approximately 200 pounds, and it will have a reliability of at least 1,000 hours mean time between failures. Included in the Nortronics system will be 2 digital computers. Combined memory capacity will be 20,000 words. Add time will be 8 microseconds, with a word length of 28 bits. Doppler radar will be supplied by the GPL Division of General Precision, Inc.

50-TO-1 ZOOM LENS

Prime Contractor: Northrop Nortronics, a Division of Northrop Corporation

Remarks

A 50-to-1 dynamic range zoom lens, featuring only 1 moving part, has been produced by Northrop Corporation's Nortronics Division. It is the latest and most powerful in a series of zoom systems which are completely optically compensated, eliminating the need for many moving parts. Images are continually in focus throughout the zooming operation. The illumination system includes a 2,500-watt xenon light source and a movable condensor system which fills the entrance pupil of the zoom lens at all magnification ranges. Overall length of the system, including lens and illumination housing, is 81 inches.

APOLLO EARTH LANDING SYSTEM

Prime Contractor: Northrop Ventura, a Division of Northrop Corporation

Remarks

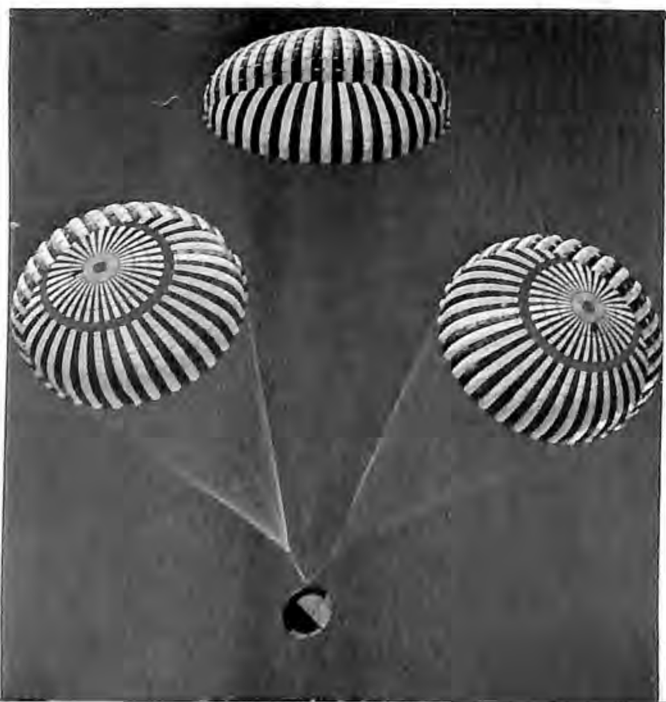
The Apollo landing system consists of several parachutes: 2 13-foot diameter drogue stabilization chutes; 3 Ringslot 7-foot diameter pilot parachutes; and 3 Ringsail-type main chutes each having a canopy diameter of 83.5 feet. Total weight of the system is approximately 540 pounds. An automatic system 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 2 drogue chutes are mortar deployed for stabilization and deceleration. At about 10,000 feet,. the 3 7-foot pilot chutes are deployed, also by mortar, and each pulls out 1 of the 3 main chutes. Landing speed is approximately 28 feet per second with 3 parachutes functioning; 33 feet per second with 2.

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

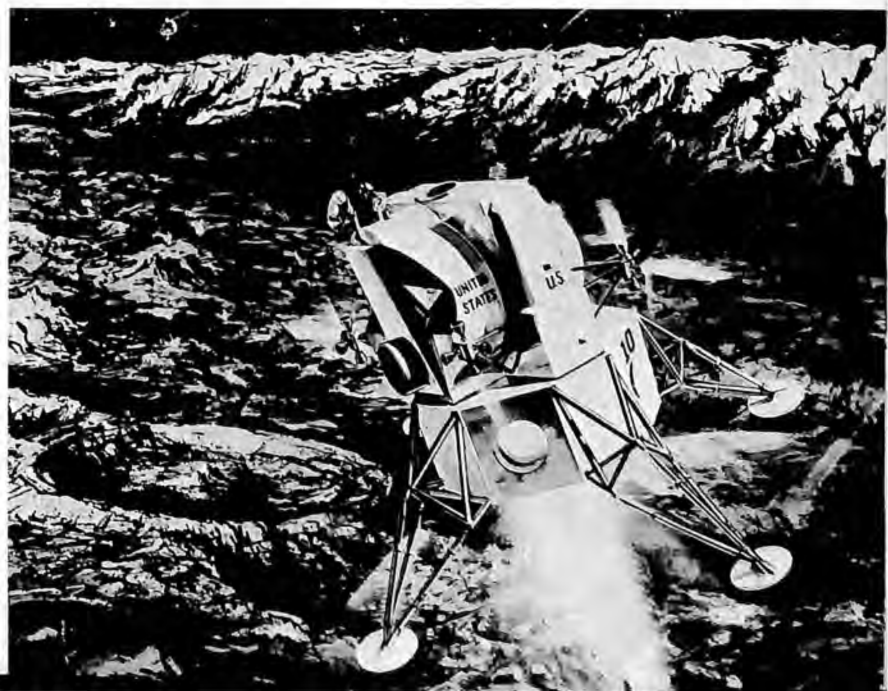
An Electronic Switching System replaces electromechanical switching centers for communication purposes with the use of the electronic computer. This permits "on-line, real-time, full-time," storage and forward type message switching system, utilizing modern electronic components and computer switching 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.

LUNAR MODULE SYSTEMS

Prime Contractor: Radio Corporation of America

Remarks

RCA has multiple systems responsibilities in connection with NASA's Lunar Module, shown descending to the moon after separation from the Apollo spacecraft. RCA provides the DECA (Descent Engine Control Assembly) which regulates the engine thrust over a wide range from a maximum of 10,500 pounds, the amount of thrust, and its direction, determining the rate at which LM slows. Determination of which attitude control thrusters should be fired and for how long is the job of another RCA system, the ATCA (Attitude and Translation Control Assembly.) ATCA also operates in the ascent phase. RCA's Landing Radar for the LM is designed to measure continually the exact altitude and velocity relative to the lunar surface, an invaluable sensory aid to the descending astronauts. RCA provides communications equipment between the LM, the earth monitoring stations and the third astronaut in the Apollo; the company is also supplying a lunar walkie-talkie and a special lunar antenna for relaying television photos to earth. A major RCA assignment is the all-important Rendezvous Radar, which enables the LM crew to rendezvous and dock with the 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/TSC-23 communications van, supplied by Adler Electronics. Units of the system are being transitioned into the operational inventory of the Air Force Communications Service.

AN/TRC-97 TROPOSPHERIC SCATTER RADIO RELAY EQUIPMENT

Prime Contractor: Radio Corporation of America, Defense Electronic Products

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.

CAPRI

Prime Contractor: Radio Corporation of America

Remarks

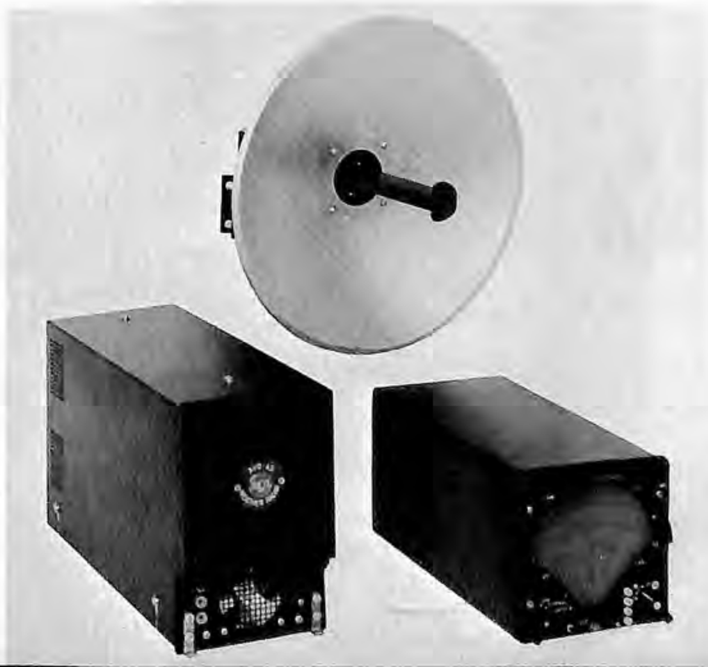
RCA, designer and developer of precision instrumentation radar systems, is producing a new radar concept called CAPRI—Compact, All-Purpose Range Instrument. Developed to meet present and future requirements for versatility, reliability and maintainability, the solid-state CAPRI offers high quality with precision determined by the antenna pedestal selected. The user is able to select only as much capability as he requires to fulfill present missions and can expand the systems for future requirements as well. This flexible and compact radar is designed to locate, track and aid in recovery of space vehicles. It also has capability for range safety use and for tracking space vehicles. Because CAPRI uses solid state and integrated circuit design it is extremely compact and requires far less space and power than conventional systems. It is easily adaptable for installation on board ship, in a trailer, or in a small, one-story building. It can be equipped with a number of pedestal configurations at the option of the user. In photo, CAPRI console.

AVQ-45 WEATHER RADAR SYSTEM FOR LIGHT AIRCRAFT

Prime Contractor: Radio Corporation of America, Aviation Equipment Department

Remarks

The AVQ-45 weather radar is a very-light-weight X-band system designed to bring airline performance over its 50-mile range to the smallest twin-engine aircraft. It is also suitable for medium twin-engine propeller and turboprop aircraft. The radar's X-band feature allows it to penetrate storms to detect cells of heaviest rain—and therefore heaviest turbulence. These cells are vividly displayed as black "holes" in the cloud display when the Contour switch on the radar indicator unit is actuated. The antenna has a sector scan of 90 degrees of the forward area at a rate of 70 looks per minute, and it can be tilted electrically up 12 degrees or down 6 degrees by controls on the instrument panel mounted indicator. Antenna reflectors of 10 or 12-inch diameters are used for maximum installation flexibility. The receiver-transmitter is a short 1/2 ATR unit. All operating controls are on the indicator unit including a self-test feature.



210 DEEP SPACE TRACKING ANTENNA

Prime Contractor: Rohr Corporation, Antenna Division; operational employment by Jet Propulsion Laboratory

Remarks

One of the largest and most precise instruments of its kind in the free world, the 210-foot-diameter antenna is a major instrument at the Goldstone Station of NASA's Deep Space Network. Located in the heart of California's Mojave Desert, it will play a prime role in the nation's space programs, tracking and communicating with spacecraft to the edge of the Solar System. The antenna, now in service, was dedicated April 29, 1966, and turned over to the Jet Propulsion Laboratory, which operates the Goldstone Station for NASA. The 210, which stands as high as a 21-story building, expands the capabilities of the DSN by providing 6.5 times more transmitting and receiving power than the 85-foot-diameter antennas that have been in use. The reflector dish has complete pointing freedom within the geographic horizons. An all-weather instrument, it is designed for 24-hour operation 365 days a year and can withstand 120 mile-per-hour winds. The movable reflector dish, 210-feet in diameter, and its supporting structures, weighing 5,000,000 pounds, are driven by motors with a combined capability of 1,300 horsepower. The dish unit rotates on a pressurized film of oil to form a friction-free bearing and allow rapid, precise movement. The mount of the antenna is a steerable azimuth-elevation configuration supporting the parabolic reflector. The concrete pedestal supporting the antenna houses offices, electronic and data-handling facilities and maintenance shops. One of the earlier assignments of the 210 was serving as a backup during the Surveyor I program.

UPPER STAGE ROCKET NOZZLE

Prime Contractor: Rohr Corporation, Space Products Division

Remarks

This high-expansion ratio submerged nozzle with liquid injection thrust vector control was fabricated for a 156-inch fiberglass reinforced solid-fueled rocket motor developed by Thiokol Chemical Corporation. Over 40 percent of the nozzle was submerged in the motor case, increasing the amount of solid propellant in the case without increasing overall length. The motor was successfully static fired in Utah, May 13, 1966, for the Air Force Space Systems Division, generating more than 300,000 pounds of thrust and temperatures of 5,700 degrees Fahrenheit during its 110-second burn time. The nozzle used in the test was over 12 feet long, weighing 5,600 pounds. Fabrication work included a maraging steel shell of high nickel alloy insulated with tape-wrapped ablative liner of carbon, graphite and silica. The aft portion of the bell-mouthed exit cone, designed with an expansion ratio of 34 to 1, included an external honeycomb sandwich to add structural stiffness to the exit cone. The May 13 test was the third 156-inch motor test fired in the Air Force fiscal 1965 large-solid-motor-feasibility program. The first motor, designed as a potential first-stage on a prototype all-solid launch vehicle, generated 3,000,000 pounds of thrust during nearly 60 seconds of firing time in December, 1965. The nozzle fabricated for this test was composed of a steel outer shell and tape wrapped plastic liner. The thrust was lined with ablative plastics designed to withstand the 5,700 degree temperature and supersonic flow of exhaust gases by gradual vaporization of its surface molecules. The second motor, configured as a potential second stage, was test fired in January, 1966, and delivered more than 1,000,000 pounds of thrust during a 72-second burn time.

PRECISION DROP GLIDER

Prime Contractor: Ryan Aeronautical Company

Remarks

The Precision Drop Glider system is being developed by Ryan Aeronautical Company for the Army as an all-weather aerial delivery system. Designed for delivery of 500 pound payloads of high-priority cargo, the vehicle can be air-launched from rotary or fixed-wing aircraft at altitudes up to 30,000 feet. An electronic system contained in the cargo package guides the vehicle in a 3 to 1 glide ratio to its pre-determined landing site, using a small radio beacon as its homing signal.

Specifications

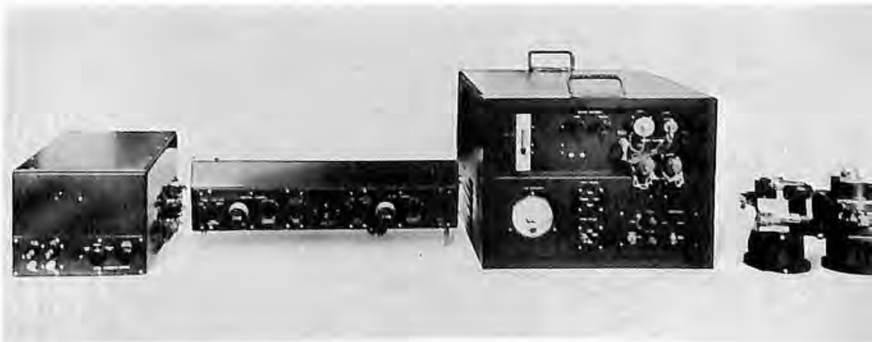
Dimensions (overall packaged) 42 by 32 by 42 3/4 inches; gross weight 628 pounds; payload capability 500 pounds; operational altitude 500 to 30,000 feet; delivery aircraft rotary or fixed wing; glide ratio 3 to 1; automatic landing accuracy, circular error probable of 200 feet; combat readiness 97 percent; flex wing (packed) 30 by 22 by 9 inches, weight 53 pounds; control platform 45 by 32 by 5 1/2 inches, weight 68 pounds; cargo sling weight 7 pounds; total empty weight 128 pounds.

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

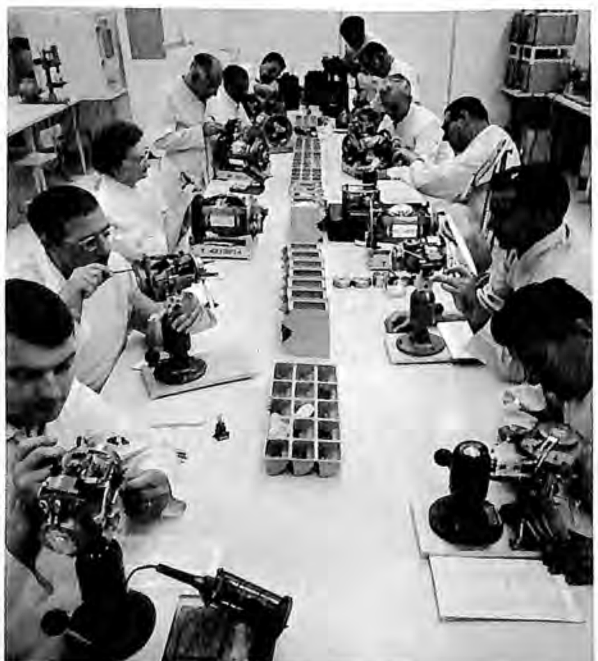
This new line of radar simulators is designed to test pre-flight operational readiness of missile beacon transponders, on the range or in the laboratory. A full portable, battery operated instrument with a tripod mounted 18 inches standard gain directional antenna, the new simulator is light weight and 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 have been delivered to White Sands Missile Range; NASA Flight Research Center (Edwards AFB); the Sandia Corporation; Eglin AFB; Pacific Missile Range; Picatinny Arsenal; Lockheed Missile and Space Company.

SGN-10 INERTIAL NAVIGATION SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Gyroscope Company Division

Remarks

The Sperry SGN-10 is the first inertial system for commercial airlines. It enables jet aircraft to be navigated without reference to celestial or ground-based navigational aids in any part of the world, including polar regions. The inertial navigator supplies a pilot with the steering information required to maintain his flight plan within ATC requirements on a world-wide basis. All navigational computations are performed by a highly reliable digital computer which utilizes the latest in microcircuitry. The computer also is programmed to perform automatic self-test. During 1965, Pan Am selected Sperry's SGN-10 for installation in its entire fleet of Boeing 707s. Since then, the system has been used in normally scheduled service and Sperry has received orders from 3 additional airlines, 3 foreign governments and for a number of Gulfstream II aircraft.



LORAN-C NAVIGATION SYSTEM

Prime Contractor: Sperry Rand Corporation, Sperry Gyroscope Company Division

Remarks

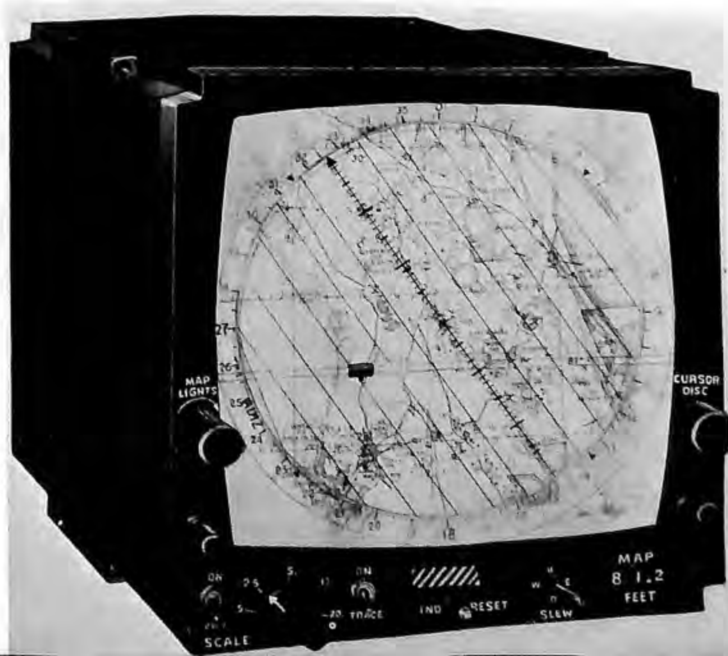
Loran-C, like standard Loran, is a navigation system which determines position by timing signals from master and slave transmitters around the world. It is more accurate than standard Loran, however, and its 100 kc frequency makes the signals usable over land. The microcircuit Loran-C receivers are three 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.

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.

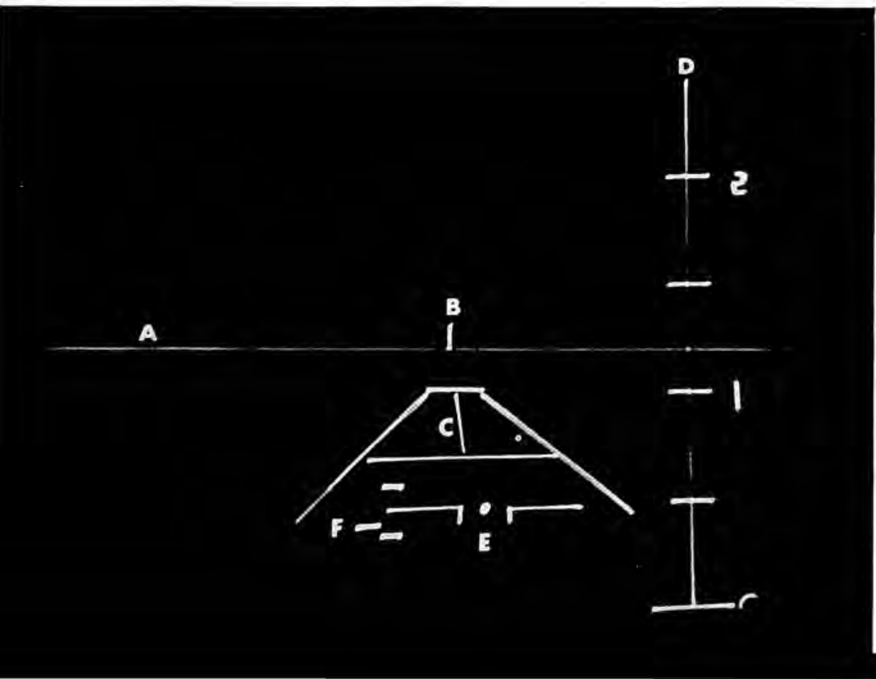


HEAD-UP ELECTRONIC WINDSHIELD DISPLAY

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

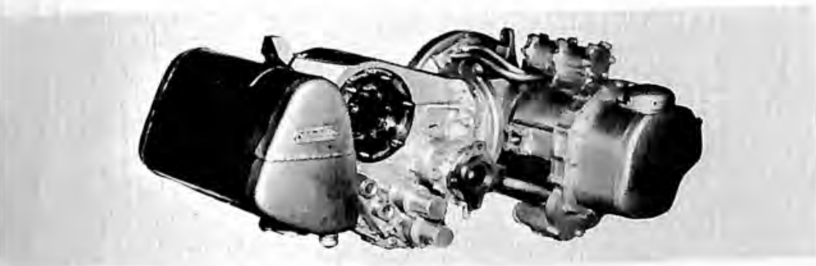
This radar is being developed for the Navy as a general purpose precision tracking radar to acquire and track missiles and aircraft. The design will incorporate solid state circuits throughout, with the exception of the transmitter, to provide high reliability. Approximately 35 per cent of the circuits will be microcircuited, making this radar a first in this field. Now operating at San Nicolas Island on the Navy's Pacific Missile Range, the radar can be operated by 1 person. The Navy has ordered a second AN/FPQ-10 for San Nicolas, 2 for Point Mugu, California, and 2 for its Underwater Tactical Range at Kauai, Hawaii.

ACCESSORY DRIVE SYSTEM

Prime Contractor: Sundstrand Aviation, Division of Sundstrand Corporation

Remarks

The Sundstrand Accessory Drive System (ADS) is used to transmit aircraft engine power to such accessories as the generator/drive package, air compressors, hydraulic pumps and motors. Sundstrand has been funded by The Boeing Company for further work toward producing a gearbox of this type for the Boeing version of the supersonic transport.

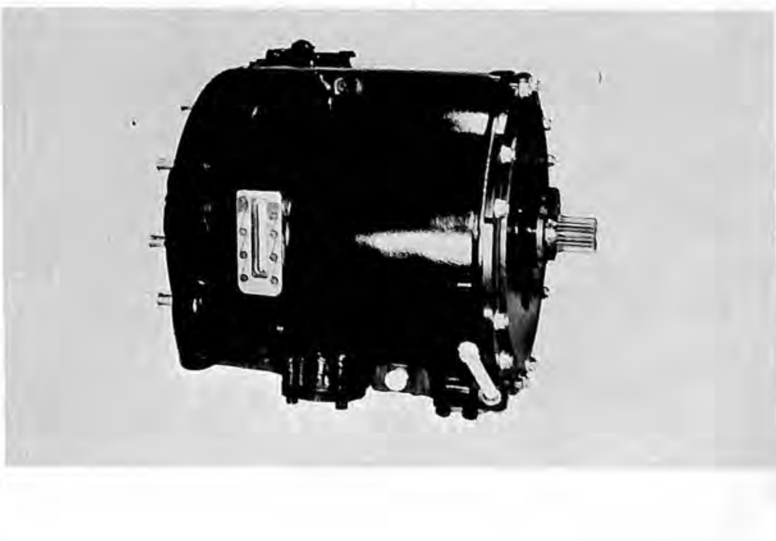


CONSTANT SPEED DRIVE TRANSMISSIONS

Prime Contractor: Sundstrand Aviation, Division of Sundstrand Corporation

Remarks

Sundstrand Aviation, a pioneer in the development of constant frequency AC electrical power for aircraft, manufactures a complete line of constant speed drive transmissions for converting the variable speeds of aircraft engines to the constant speeds necessary to drive electrical generators. Shown here is one of the new Sundstrand AGD constant speed drives of the type used on the F-111, the Douglas DC-9, and the Boeing 737. The AGD drives have demonstrated remarkable reliability with Mean Time Between Failures (MTBF) figures in the neighborhood of 15,000 hours.



TORPEDO PROPULSION SYSTEM

Prime Contractor: Sundstrand Aviation, Division of Sundstrand Corporation

Remarks

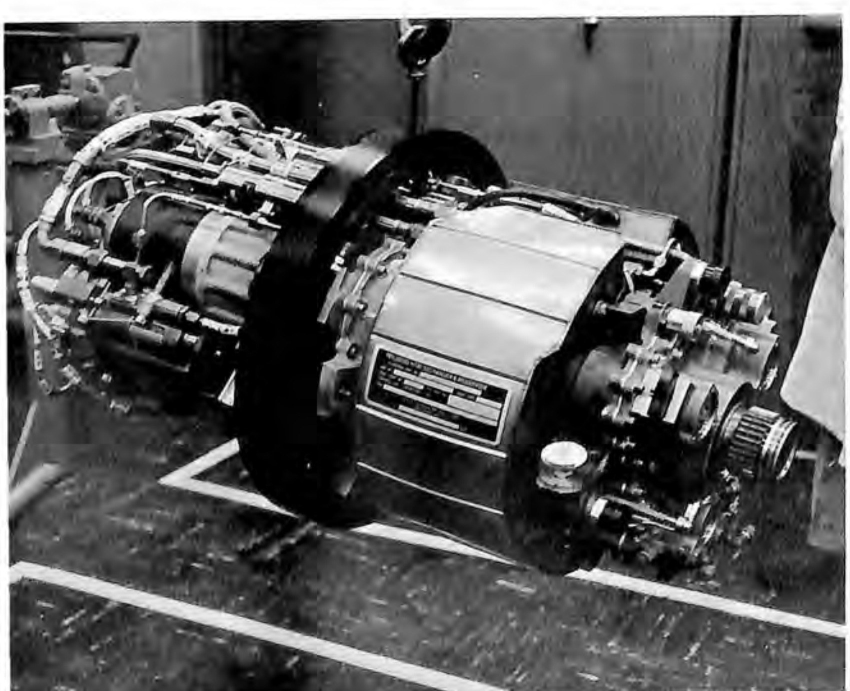
Sundstrand provided a significant advance in torpedo propulsion with the power plant shown here. Manufactured under contract from Westinghouse for the Mark 48 torpedo, the Sundstrand system had been put through in-water testing by late 1966 and production designs were being readied.

TRW 6425 25 MILLIMETER CANNON SYSTEM

Prime Contractor: TRW Inc.

Remarks

The TRW 6425 25 millimeter cannon system comprises 3 major elements: 1) the cannon, featuring a dual feed, selective rate of fire, which can be field stripped in seconds without tools; 2) a family of high velocity ammunition, designed for linkbelt feeding, which includes an armor piercing round that will penetrate 1 inch of steel at 60 degrees obliquity at 1,000 meters, and a high explosive round with self-destruct fuzing; 3) an enclosed cupola designed for 360-degree vision, power controlled and 1-man operated, designed for standard 34–40 inch hull openings. TRW 6425 is lighter (150 pounds) than any existing similar system and has twice the target effectiveness. The gun was designed to fill a need in lightweight armored vehicles for a weapon system that provides a tough, stand-off punch in contests against more heavily armored enemy vehicles. Development started in 1964 and TRW produced the first prototype in just 22 months. During 1966, field and engineering testing of the weapon system continued, conducted for the Army by Pacific Car & Foundry Company. In addition to ground-to-ground employment, the system has potential as a ground-to-air, air-to-air, or air-to-ground weapon. The U. S., British and French governments have bought the weapon for evaluation testing and orders from other NATO countries are pending.



ROLLER DRIVE AND ROLLER GEAR DRIVE

Prime Contractor: TRW Inc., Accessories Division

Remarks

The TRW Roller Drive and Roller Gear Drive are simple, bearingless, 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

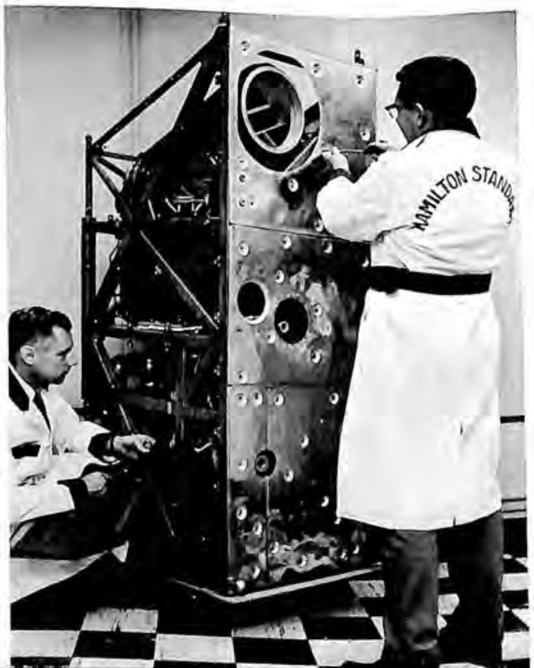
The XC-142A's four 15-1/2 foot main propellers and single eight-foot tail propeller have lightweight blades made out of fiberglass shell bonded to a steel, load-carrying core. This design makes the propellers 25 per cent lighter than metal-bladed propellers of the same size. Additional weight-savings 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.

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.



LEM ENVIRONMENTAL CONTROL SYSTEM

Prime Contractor: Hamilton Standard Division of United Aircraft Corporation

Remarks

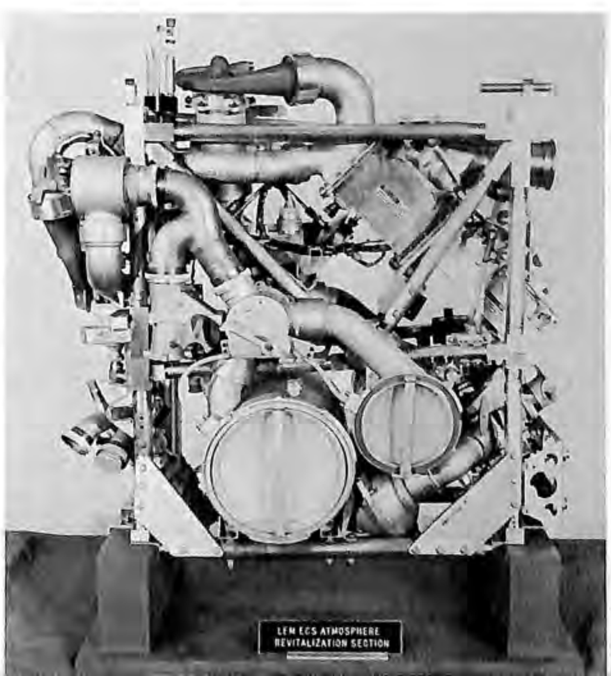
The environmental control system for the lunar excursion module (LEM) supplies oxygen, pressurization and ventilation for the cabin and space suits worn by the two astronauts. It also removes carbon dioxide, odors and other contaminants from the cabin atmosphere. Thermal control includes the temperature 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.

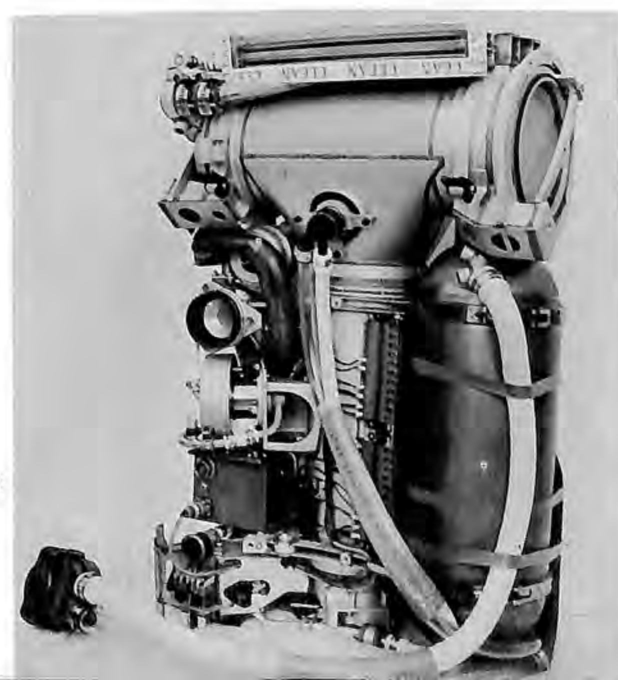
PORTABLE LIFE SUPPORT SYSTEM FOR APOLLO SPACE SUIT

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.





F-111 ELECTRIC POWER GENERATING SYSTEM

Prime Contractor: Westinghouse Electric Corporation, Aerospace Electrical Division

Remarks

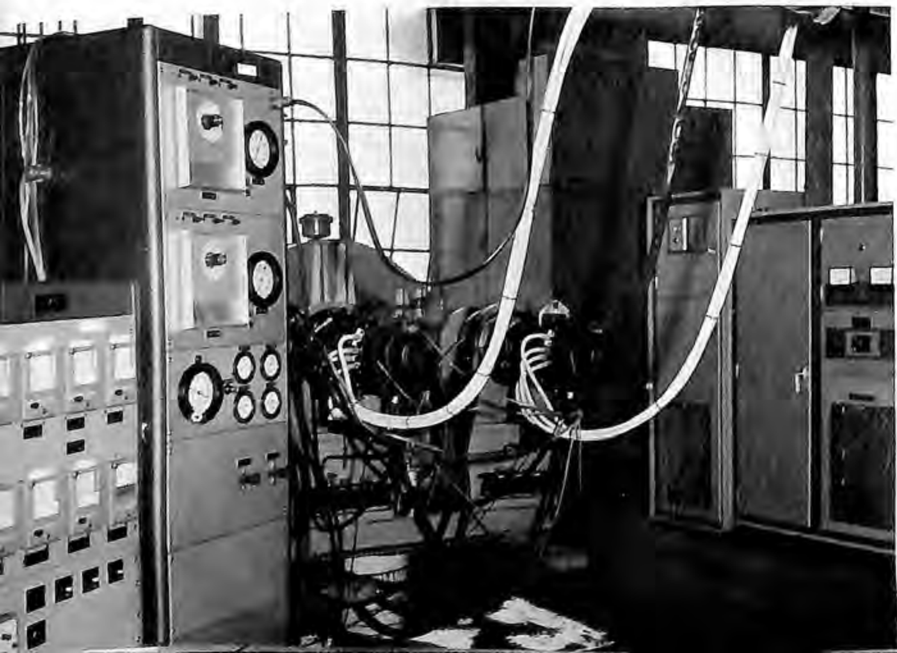
The Aerospace Electrical Division (AED) has designed, developed, and tested the AC electric power system for the multimission F-111. The system provides the primary electric power source for the aircraft. It is a two generator, automatic bus transfer system rated at 62.5 KVA per bus. General Dynamics awarded AED a production contract for 431 aircraft. Each of the 2 aircraft systems consists of an oil-cooled, brushless, 62.5 KVA generator, a generator control and protection unit (GCU), and a GCU mounting rack. As a part of the research, development, test and engineering program, AED demonstrated performance reliability by a 5,000 hour system test. Such test exceeded the specified MTBF by 189% (at 90% confidence level). During the test a complete system was run 40 percent beyond the recommended overhaul point. Inspection teardown following overhaul extension indicated all parts to be in excellent operating condition, and no degradation of operating performance parameters were recorded. The test also demonstrated generator seal capabilities by running at less than 6% of the oil leakage permitted by specification. The test supports excellent field operation results being achieved by this equipment at the airframe manufacturer and on flight tests. In photo, test stand.

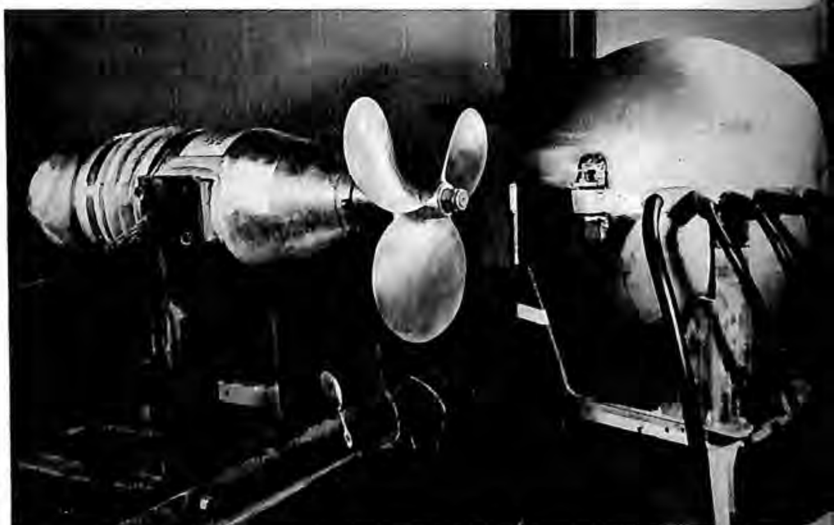
DEEP SUBMERGENCE PROPULSION SYSTEM

Prime Contractor: Westinghouse Electric Corporation, Aerospace Electrical Division

Remarks

The Westinghouse Aerospace Electrical Division, located at Lima, Ohio, has produced a propulsion system for deep diving submersibles in support of the Navy Deep Submergence Program. The system consists of a solid state control which changes the dc power from the vehicles' batteries to controlled 3-phase AC power which drives a pressure compensated induction motor. The solid state control is housed in a spherical pressure resistant enclosure. Pressure compensation of the motor is accomplished by filling the enclosure with oil and transmitting the external pressure to the oil by means of a flexible bellows in the housing. The use of an oil-filled motor eliminates the need for thick seawater resistant electrical insulations in its construction. Instead a thin, durable wire enamel and varnish impregnation are used. This insulation system developed for aerospace electrical equipment provides good heat transfer from the windings to the oil in addition to providing a very compact design. System advantages are wide speed range, high efficiency, proven performance and light weight.





APOLLO INVERTER

Prime Contractor: Westinghouse Electric Corporation, Aerospace Electrical Division

Remarks

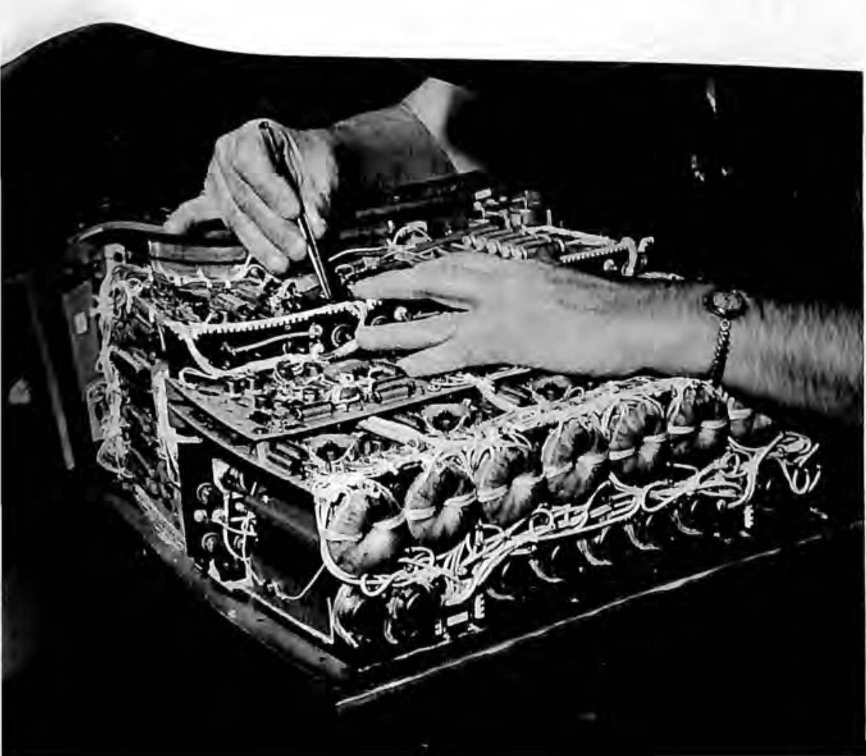
Electrical power inverters that are the result of a new concept in spacecraft electric power conditioning were developed and are now being produced by the Westinghouse Aerospace Electrical Division under contract to the Space and Information Systems Division of North American Aviation. Destined for use on the Apollo spacecraft, the inverters are designed for central power conversion in contrast to the use of a number of small, localized inverters in previous spacecraft systems. The high-power central static inverter concept will assure the high degree of reliability and efficiency required of the Apollo spacecraft's electrical system. The central inverter concept means lighter weight, lower cost, a capacity for load growth, flexibility in load selection and improved maintainability. All of the AC power in the spacecraft is supplied by the new Westinghouse inverters. Some of the electrical and electronic functions in the spacecraft that rely on the high-quality inverter AC output are: instrumentation, environmental control system (astronaut suit compressors, glycol coolant system, cabin recirculation, temperature control), service propulsion gauging, communications and data handling, guidance and navigation, lighting and data viewing, fuel cell control, fuel cell gas and water separation, waste management. The inverter provides AC power of 1,250 volt-amperes at 115/200 volts, 3 phases, and 400 cycles per second frequency. Primary power is supplied to the inverter by the fuel cells which also power other functions that use low voltage DC. Batteries in the command module provide input power for the inverter during reentry into the earth's atmosphere after the service module is jettisoned.

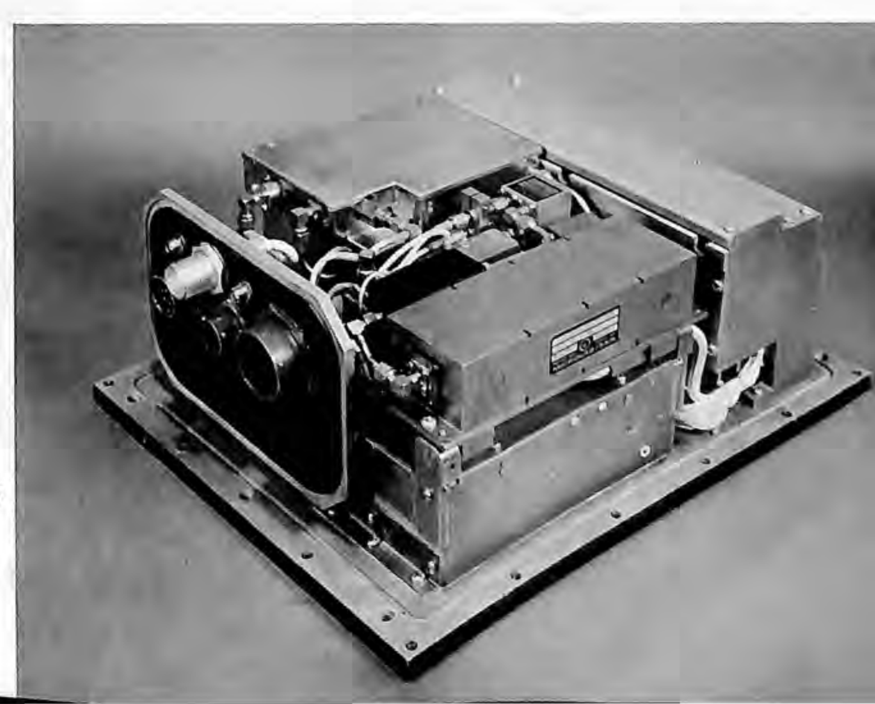
MOLECULAR SATURN RADAR ALTIMETER

Prime Contractor: Westinghouse Electric Corporation, Defense and Space Center

Remarks

Development of a molecular version of the radar altimeter formerly used with the Saturn launch vehicle was performed by Westinghouse under contract to NASA's Marshall Space Flight Center. The prototype unit was delivered in August, 1966. As a result of the development a reliability improvement in excess of 3 to 1 was achieved. The weight was reduced by 10 percent to 23 pounds even though additional capacity was added. The volume was reduced 23 percent to 765 cubic inches and the power reduced 33 percent to 40 watts. Achieving this performance required maximum utilization of molecular circuits together with other reliability enhancements such as selective redundancy. In operation, the altimeter is a pulse radar that operates from 50 km to 400 km with an accuracy of plus or minus 100 feet. A 6 kilowatt peak power, 1-usec pulse at L-band is transmitted. The returned energy is range tracked. The value of altitude is then presented as an 18 bit binary word to the telemetry system. The prototype unit was evaluated over a temperature range of minus 20 to plus 100 degrees Centigrade and over a severe vibrational environment.





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The Sperry Mark XII is no *paper* computer. It's *in production,* and currently in use aboard commercial jet airliners and naval vessels.

The Mark XII is a low-cost, microcircuited digital computer that can be programmed for a wide variety of real-time, digital applications. For example: inertial navigation, automatic tracking, data stabilization and display.

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Others can design a low-cost, microcircuited computer; we're <u>producing</u> it.

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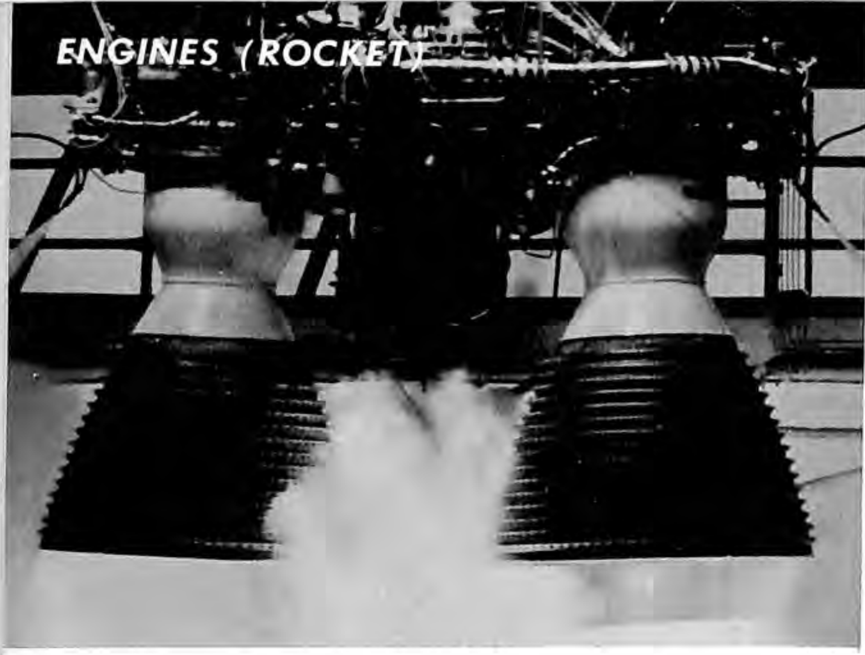


TITAN II FIRST STAGE ENGINE SYSTEM

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

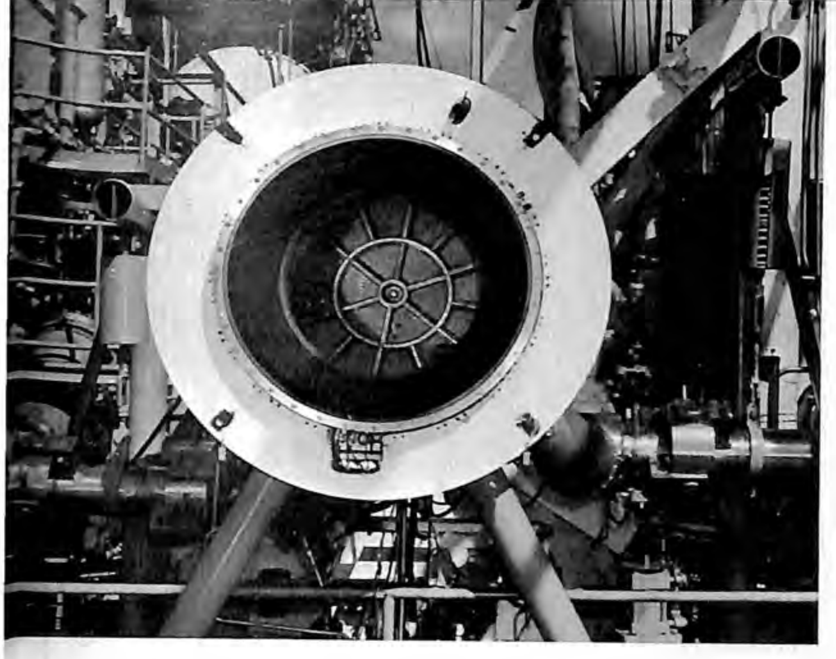
Prime Contractor: Aerojet-General Corporation

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. 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.



ADVANCED HIGH THRUST HYDROGEN ROCKET PROGRAM

Prime Contractor: Aerojet-General Corporation

Remarks

A NASA program to advance the state of the art of high thrust hydrogen/oxygen engine systems is being conducted at Aerojet's Sacramento Plant under the direction of NASA's Lewis Research Center. A fluorine ignition system has been developed along with pumps and a thrust chamber for engine systems of 1,500,000 pounds thrust and above. Test firings are continuing with systems producing the vacuum equivalent of 1,500,000 pounds. Photo shows "breakthrough" injector. This "first-cut" injector has demonstrated excellent performance, mechanical integrity and good stability.

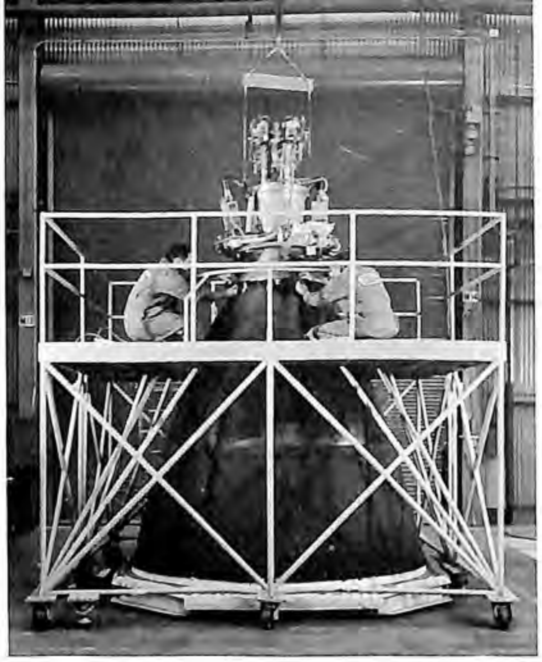
NERVA (NUCLEAR ENGINE FOR ROCKET VEHICLE APPLICATION)

Prime Contractor: Aerojet-General Corporation

Principal Subcontractor: Westinghouse Electric 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

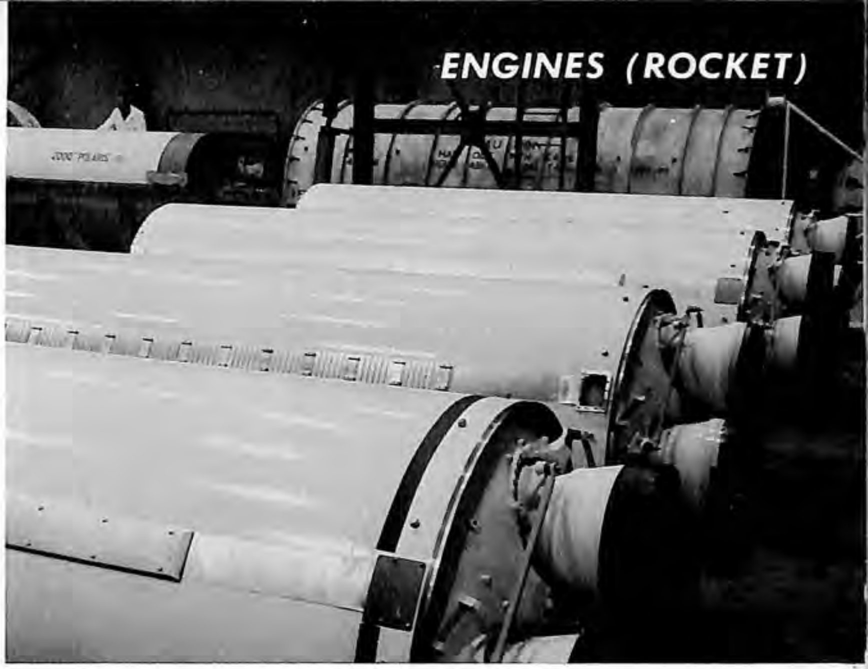
The new second-stage solid-propellant rocket motor for the Air Force Minuteman II ICBM is 50 percent more powerful than its predecessor, increasing the missile range from Minuteman I's 6,300 to 7,000 miles. The advanced motor is equipped with a large single nozzle instead of the 4 smaller nozzles that 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 PROPULSION SYSTEM ENGINE

Prime Contractor: Aerojet-General Corporation

Remarks

The Apollo Service Propulsion system engine is America's largest and most powerful spacecraft rocket engine. Standing 13 feet 4 inches high it is taller than the Command Module of the spacecraft. Producing more than 20,000 pounds of thrust (vacuum) it is more powerful than the most advanced jet fighter aircraft engine. It is designed to produce approximately 3 times the propulsion energy that would be required on a nominal moon mission. It is a simple engine using an ablative thrust chamber with a large extension skirt composed of titanium and columbium. With an expansion ratio of 62.5 to 1 it has the largest expansion ratio of any U. S. rocket engine. The skirt has an average wall thickness of .025 inches. The SPS is fired both automatically and manually by the Apollo command pilot. It is a pressure-fed, multi-restartable engine using the Titan-proved self-igniting storable propellants. SPS missions include maintaining course to and from the moon, placing the spacecraft into and taking it out of lunar orbit, keeping the command/service module in orbit as the lunar module descends to the moon, providing power to help rendezvous with the returning lunar module, going down to within 12 miles of the surface to rescue the LM, if necessary, and providing power for any other large maneuvers required by the spacecraft.



SVM-1 APOGEE KICK ROCKET

Prime Contractor: Aerojet-General Corporation

Remarks

The SVM-1 is a solid propellant 2,900 pound thrust motor for the Commercial Satellite Corporation's Bluebird satellite. Unit provides final velocity increment to place satellites into synchronous equatorial orbit. Motor is contained in the satellite, which is built by Hughes Aircraft.

MINUTEMAN III THIRD STAGE ENGINE

Prime Contractor: Aerojet-General Corporation

Remarks

The new third stage solid rocket engine for the Air Force Minuteman III is to be developed and produced by Aerojet's Solid Rocket Operations. On the Minuteman III, Aerojet will thus be the propulsion contractor for 2 of the 3 solid rocket motor systems. The new unit represents a significant advancement in upper stage solid rocket motors.

ARES

Prime Contractor: Aerojet-General Corporation

Remarks

Aerojet's Liquid Rocket Operations is working under Air Force direction to develop a modular-type high chamber pressure engine applicable to use in any stage of future launch vehicles.

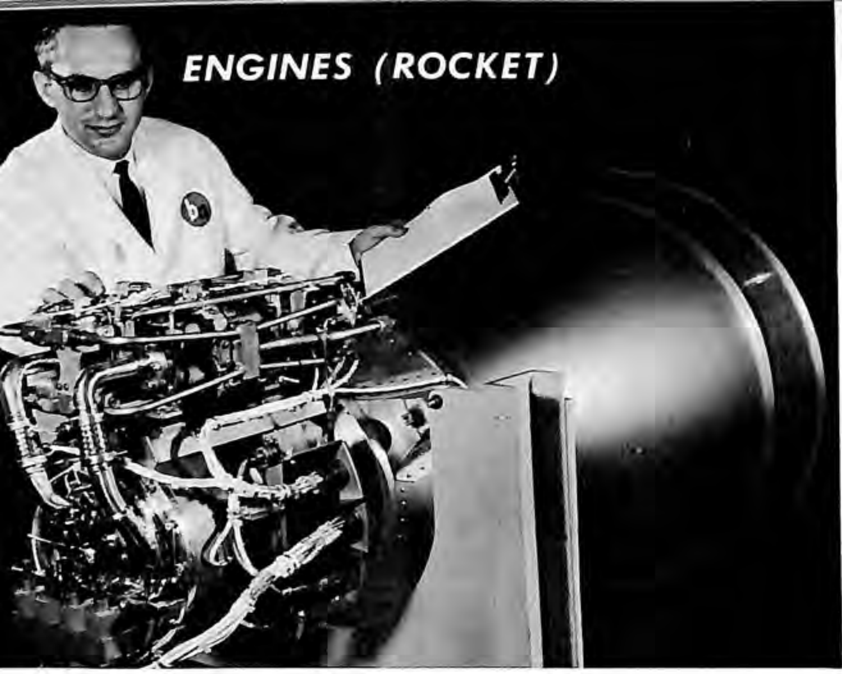
POLARIS MOTORS

Prime Contractor: Aerojet-General Corporation

Remarks

Aerojet-General has produced more than 2,000 solid propellant rocket motors for the Navy's Polaris fleet ballistic missile. While details of the power plant are classified, the engine shown is designed for use in the Polaris A-3, the 2,500 nautical mile range model and the latest to go into service. Aerojet-General started production of Polaris motors in 1959. The company produced all of the first and second stage motors for the 1,200 nautical mile range A-1 version, the first stage units for the 1,500-mile A-2, and is now producing the first stage engine for the A-3.

ENGINES (ROCKET)



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.

Specifications

Propellants: nitrogen tetroxide, 50/50 blend of hydrazine and UDMH; ablative thrust chamber and nozzle; hypergolic ignition; pressure-fed engine with series-parallel redundant valving with a valve-out capability.

Performance

Average thrust 3,500 pounds.

AGENA ENGINE

Prime Contractor: Textron's Bell Aerosystems Company

Remarks

The Agena engine is a liquid bi-propellant system used in a number of Air Force and NASA programs including Lunar Orbiter, Ranger, Mariner, Nimbus, Echo, OGO, POGO 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, 9 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 hundreds of times, the Agena engine has a reliability record exceeding 99 percent.

Specifications

Length 7 feet; width 3 feet; weight 300 pounds; propellants UDMH and inhibited red fuming nitric acid.

Performance

Thrust 16,000 pounds average; specific impulse approximately 300 seconds; chamber pressure approximately 500 psi.

HERCULES SOLID ROCKET SERIES

Prime Contractor: Hercules Incorporated

Remarks

Hercules Incorporated builds solid-propellant rocket motors for the following missile systems: Honest John, Little John, Minuteman, Polaris A2, Polaris A3, Nike Ajax (booster), Poseidon, Sprint, Hibex, Nike Hercules (booster), Talos (booster), Terrier I, Terrier II, and Bullpup. In addition, the company manufactures these motors:

X248 ALTAIR (photo)

Incorporated into Thor, Delta, Scout, Argo and other programs, the Altair was the first rocket to feature a glass fiber filament-wound case structure.

Specifications

Length 58 inches; diameter 18 inches; weight 500 pounds.

Performance

Thrust 3,100 pounds; time 38 seconds.

ANTARES

A scale-up of the X248 Altair built specifically for Scout, Antares is also used in several other space vehicles. It has a mass fraction of 0.93.

Specifications

Length 113 inches; diameter 30 inches; weight 2,285 pounds.

Performance

Thrust 14,000 pounds; time 36 seconds.

RANGER RETRO

Remarks

This motor (in photo) 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.

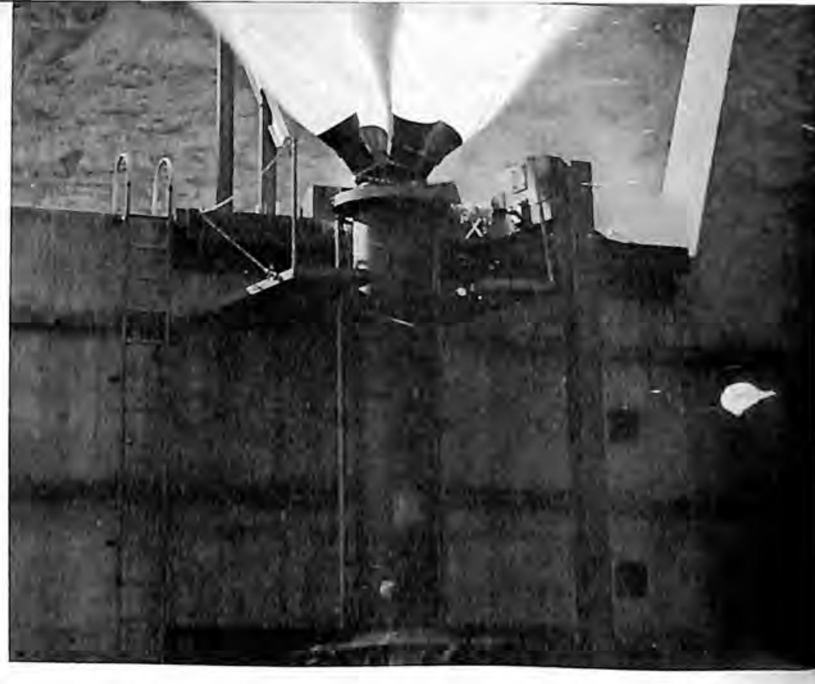
X259 ADVANCED ANTARES

Specifications

Length 113 inches; diameter 30 inches; weight 2,785 pounds.

Performance

Thrust 23,500 pounds; time 33 seconds.



HYDAC—JAVELIN II—JAVELIN III—SIROCCO FAMILY OF SOUNDING AND SLED ROCKET MOTORS

Prime Contractor: Lockheed Propulsion Company

Remarks

The Hydac and Javelin III solid propellant rocket motors are in operation as single-stage motors and in various second, third, and fourth-stage configurations of the Terrier, Honest John and Nike systems. The Sirocco unit is used primarily as a single-stage vehicle, while the Javelin II is a successful sled and sounding rocket. Photo shows Hydac single-stage vehicle.

Specifications

Hydac: length 146 inches, diameter 9 inches, weight 557 pounds. Javelin II: length 101 inches, diameter 8.7 inches weight 341 pounds. Javelin III: length 103 inches, diameter 9 inches, weight 363 pounds. Sirocco: length 112 inches, diameter 5.5 inches, weight 144 pounds.

Performance

Hydac: 10,200 pounds thrust for 9.4 seconds duration. Javelin II: 31,560 pounds for 1.76 seconds; Javelin III: 10,710 pounds for 4.8 seconds; Sirocco 3,340 pounds for 5.5 seconds.

APOLLO LAUNCH ESCAPE MOTOR

Contractor: Lockheed Propulsion Company

Remarks

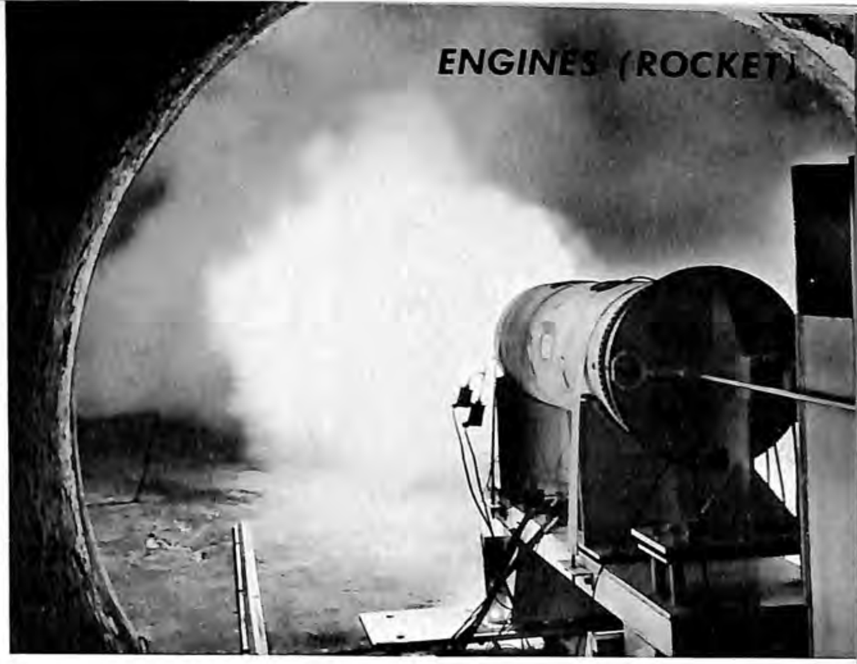
The Apollo Launch Escape motor Subsystem consists of 2 solid-propellant rocket motors designed to pull the Apollo Command module away from the Saturn booster in the event of malfunction during launch. A solid-fuel motor (1) supplies the main impulse. The escaping spacecraft is put into an arching trajectory 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's 156-inch diameter solid-rocket motors under an Air Force feasibility demonstration program have developed thrusts up to 3,000,000 pounds for durations up to approximately 120 seconds. Segmented and monolithic maraged steel cases have been employed in the tests, which have also demonstrated liquid injection, jet tab, and hot gas valve thrust vector control systems.

AIR FORCE PULSE MOTOR

Prime Contractor: Lockheed Propulsion Company

Remarks

Lockheed is conducting a demonstration program for the Air Force of dual-thrust, multi-pulse solid rocket motors. Units have been subjected to severe temperature and vibration conditioning to simulate the most rigorous "air launch" environment ever imposed in the firm's long history of pulse motor work.

R-4D

Prime Contractor: The Marquardt Corporation

Remarks

The Model R-4D is a liquid hypergolic bipropellant rocket engine being used for space applications, including attitude control, propellant ullage control and small velocity corrections on the NASA Project Apollo Service Module and Lunar Module (16 engines on each module, mounted in clusters of 4 engines). This engine also serves as the velocity control rocket for NASA's Lunar Orbiter spacecraft. The Model R-4D provides high pulsing and steady state performance in combination with reliable long-life operation. Fully qualified and in production, the engine has successfully demonstrated flight reliability on Apollo-Saturn flights as well as on the Lunar Orbiter 1 spacecraft.

Specifications

Length 13.4 inches; diameter 5.6 inches; weight 4.9 pounds; propellants: (oxidizer) nitrogen tetroxide and (fuel) 50–50 blend of hydrazine and unsymmetrical dimethyl hydrazine or monomethyl hydrazine; radiation-cooled chamber.

Performance

Thrust 100 pounds nominal vacuum.

R-5B

Prime Contractor: The Marquardt Corporation

Remarks

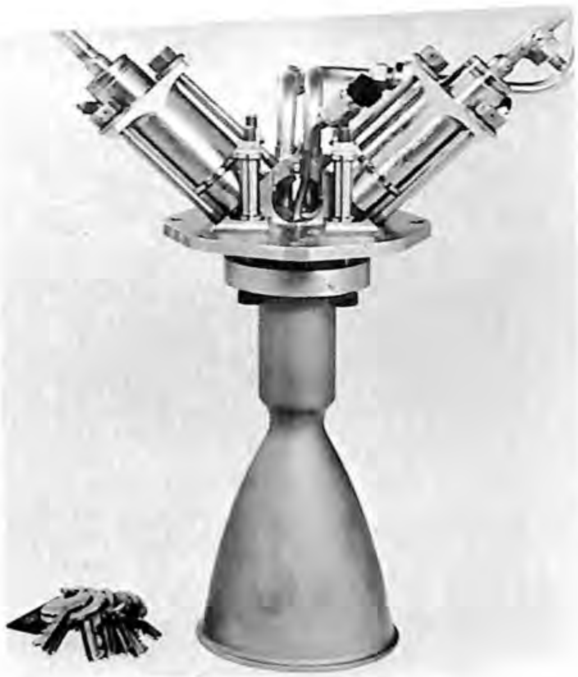
The Model R-5B liquid hypergolic bipropellant rocket engine was developed for NASA as an ullage and Delta-V rocket, originally for application on the Saturn IVB vehicle.

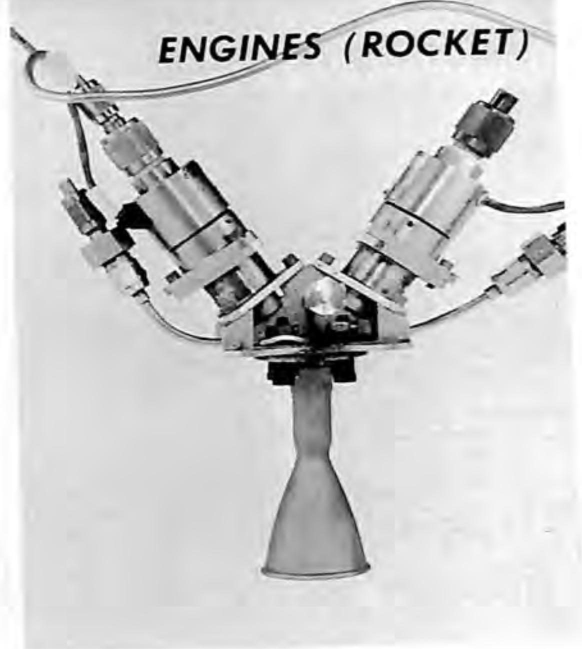
Specifications

Length 38.7 inches; diameter 17 inches maximum; weight 70 pounds; propellants: (oxidizer) nitrogen tetroxide and (fuel) 50–50 blend of nitrogen tetroxide and unsymmetrical dimethyl hydrazine; ablative chamber.

Performance

Thrust 1, 750 pounds nominal vacuum.





R-6C

Prime Contractor: The Marquardt Corporation

Remarks

The Model R-6C is a liquid hypergolic bipropellant rocket engine, originally developed as a velocity control, spin rate control and station keeping rocket engine for NASA's advanced Syncom communications satellite. Since completion of advanced Syncom activity, engine has been further developed to provide excellent pulsing and steady state performance in combination with long life, low weight, high reliability operational characteristics.

Specifications

Length 5.2 inches; diameter, 3.95 inches; weight 1.21 pounds; propellants: (oxidizer) nitrogen tetroxide and (fuel) 50–50 blend of hydrazine and unsymmetrical dimethyl hydrazine, or monomethyl hydrazine; radiation-cooled chamber.

Performance

Thrust 5 pounds nominal vacuum.

R-1E

Prime Contractor: The Marquardt Corporation

Remarks

The Model R-1E, a liquid hypergolic bipropellant rocket engine, is an advanced version of the rocket originally designed and developed for the Advent Communication Satellite Orbit Adjust Propulsion System. Engine is designed to provide high pulsing and steady state performance in combination with reliable, long life operational characteristics.

Specifications

Length 10.1 inches; diameter 6.0 inches; weight 2.8 pounds; propellants: (oxidizer) nitrogen tetroxide and (fuel) monomethyl hydrazine or blend of hydrazine and unsymmetrical dimethyl hydrazine; radiation-cooled chamber.

Performance

Thrust 22 pounds nominal vacuum.

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 Uprated Saturn 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

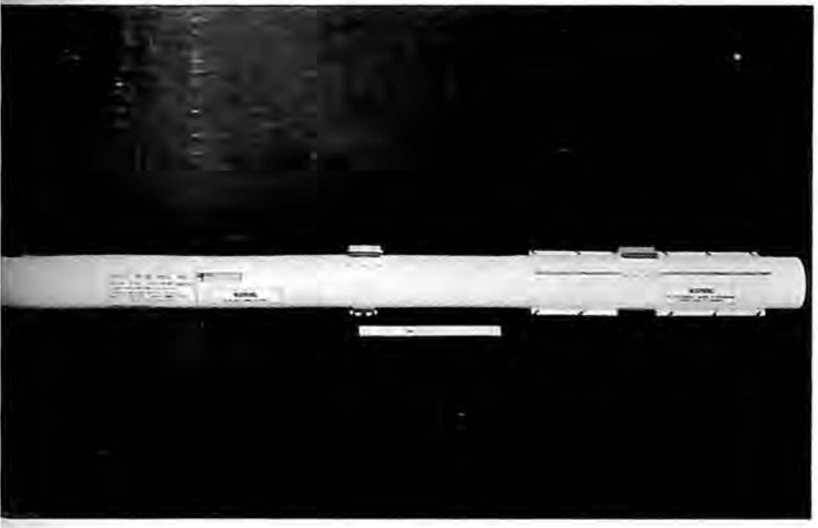
Thrust 15,000 pounds, throttling capability from 100 to 10 percent of rated thrust; specific impulse 10A-3-1 433 seconds; 10A-3-3 44 seconds.

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 on both missiles to rated speed within 1 second.



MARK 36, MOD 2 SIDEWINDER ROCKET MOTOR

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

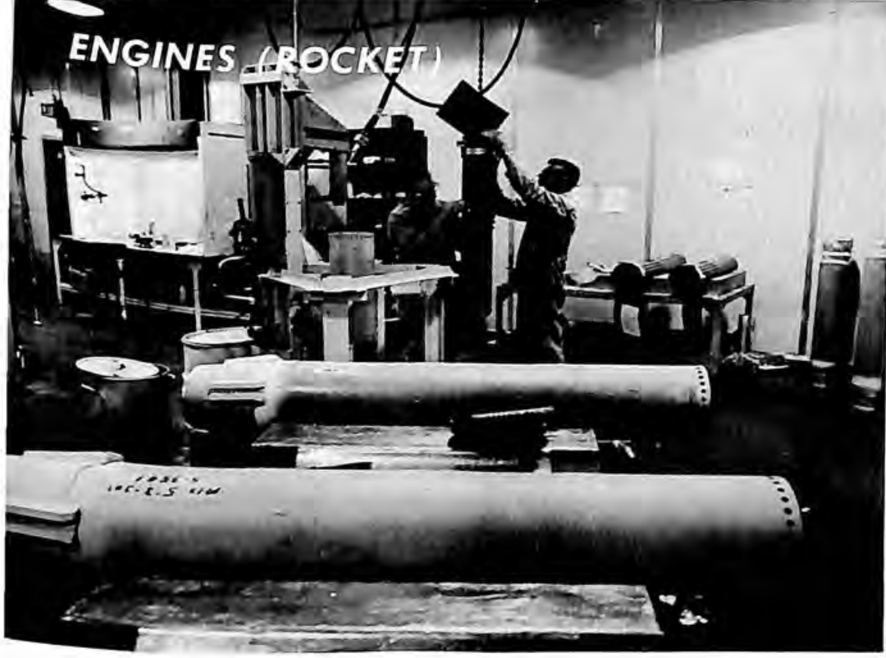
Greater speed and range, plus improved operational characteristics have marked the second generation of Sidewinder with its advanced solid propulsion system being manufactured at Rocketdyne since 1963. This Navy air-to-air missile mounted on F-8's and F-4B's was designed to destroy high-performance fighter 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 in production at Rocketdyne since early 1961. Development and qualification of the advanced propulsion system were completed in 22 months; successful flight tests were held 12 months after 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

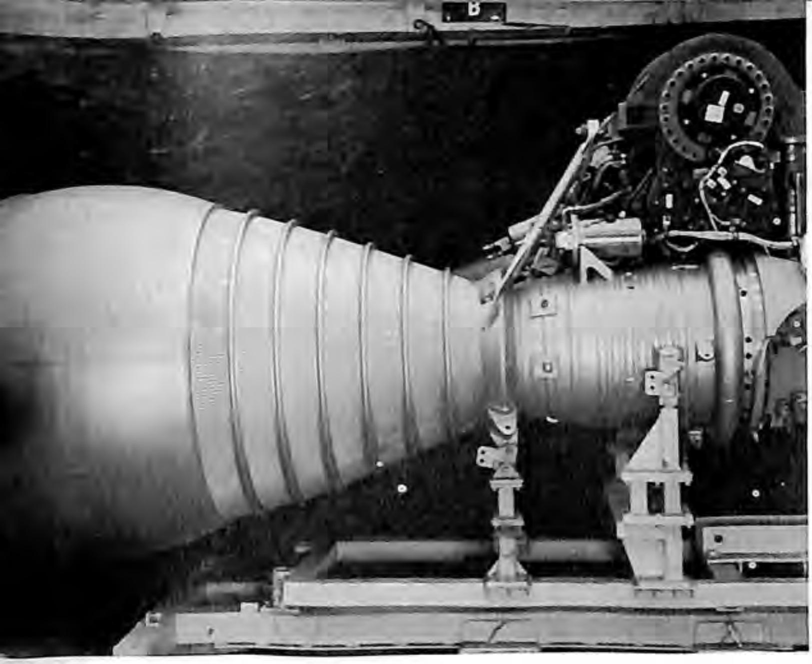
First in a new generation of tactical weapons, the Navy's Shrike air-to-ground missile is powered by a solid-propellant rocket motor similar in design and performance to the propulsion system of Sparrow III. Both motors combine a unique free-standing propellant charge (grain) with Flexadyne, an improved 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.

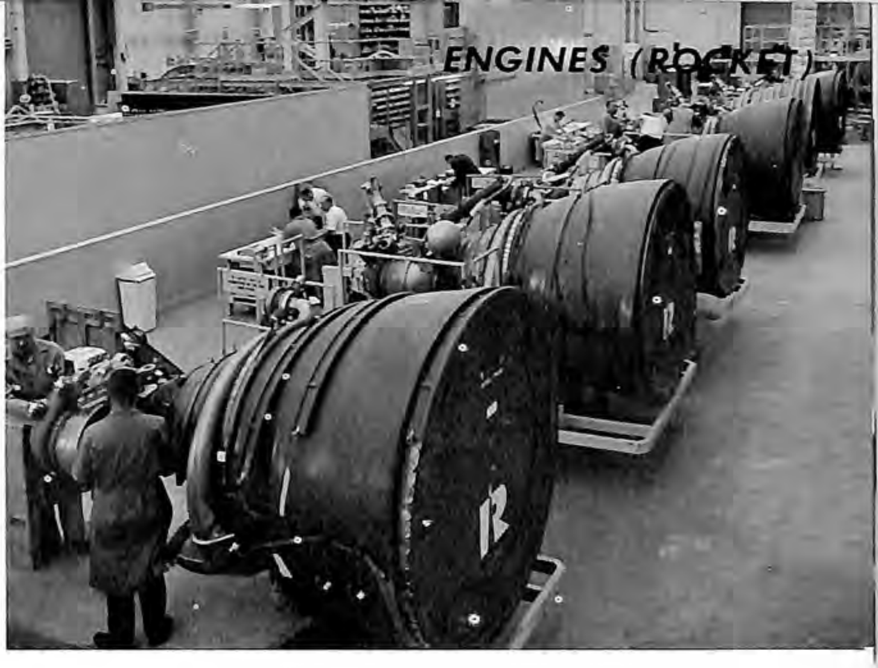
ROCKETDYNE SOLID MOTORS

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-202 zero launch booster for the F-104G, and turbine starters for 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 has been uprated to first stage thrust of 1,640,000 pounds for later flights of the Uprated Saturn I vehicles. Regeneratively cooled, it burns a combination of RP-1 fuel and liquid oxygen oxidizer. Engines are tested singly at Rocketdyne's 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 102 inches; maximum diameter 66 inches.

Performance

Thrust 205,000 pounds.

J-2 ENGINE

Prime Contractor: Rocketdyne, A Division of North American Aviation, Inc.

Remarks

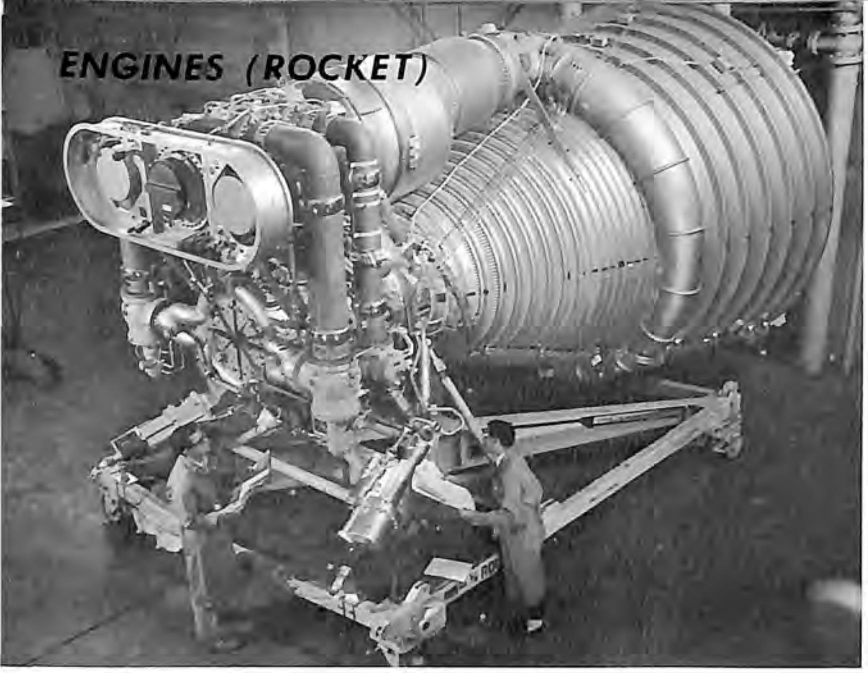
One of the major engines in NASA's manned space flight program is the J-2, which burns liquid hydrogen fuel with a liquid oxygen oxidizer and is the largest hydrogen-burning engine to reach test status (in photo, J-2 production line at Rocketdyne's Canoga Park, California, plant). The regeneratively-cooled engine plays an important role in the nation's 2 largest launch vehicles: in the Uprated Saturn I it is used singly as the propulsion unit for the S-IVB stage, second stage of the vehicle; in Saturn V, it is employed in a 1,000,000-pound thrust cluster of 5 as the second stage and in the S-IVB as the third stage, which will send Apollo astronauts into a lunar trajectory. J-2 is being developed under the technical direction of NASA's Marshall Space Flight Center.

Specifications

Maximum envelope length 133 inches; maximum envelope diameter 80 1/2 inches.

Performance

Maximum thrust 203,000 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 19 feet; maximum envelope diameter 12.4 feet.

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 388,200 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 388,200 pounds total, including: boosters 330,000, sustainer 57,000, 2 verniers 600 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 141.5 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

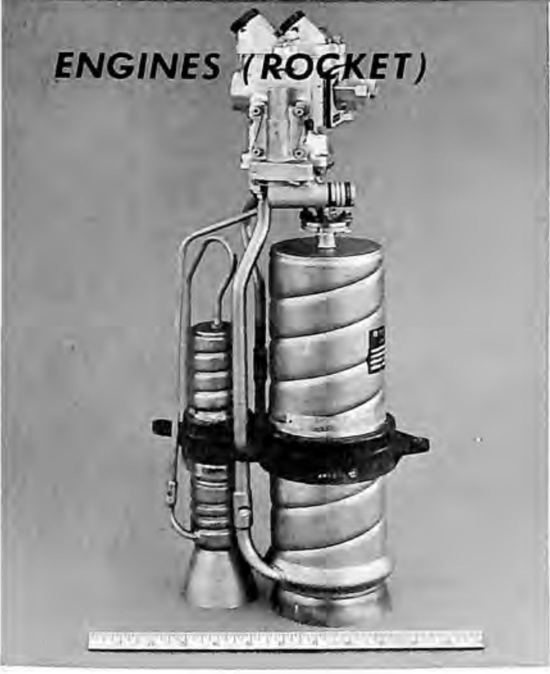
A supplemental propulsion unit for manned aircraft, the AR2-3 provides extra thrust for the Lockheed NF-104A Starfighter to augment its turbojet engines and enable it to attain altitudes up to 130,000 feet for aerospace training missions. The liquid-propellant rocket engines boost thrust by more than 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

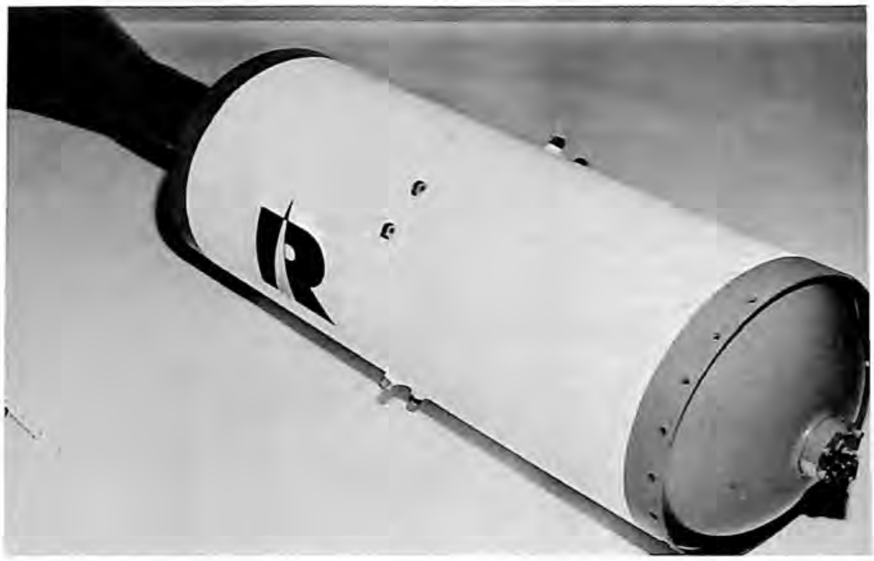
The SE-6, employed in multiple units, provides on-board propulsion for the Gemini spacecraft. It is part of the RCS (Re-entry Control System) for Gemini, used for maneuvering during re-entry phase. RCS has two eight-engine systems, one of which is redundant. It is positioned in the small end of the Gemini 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

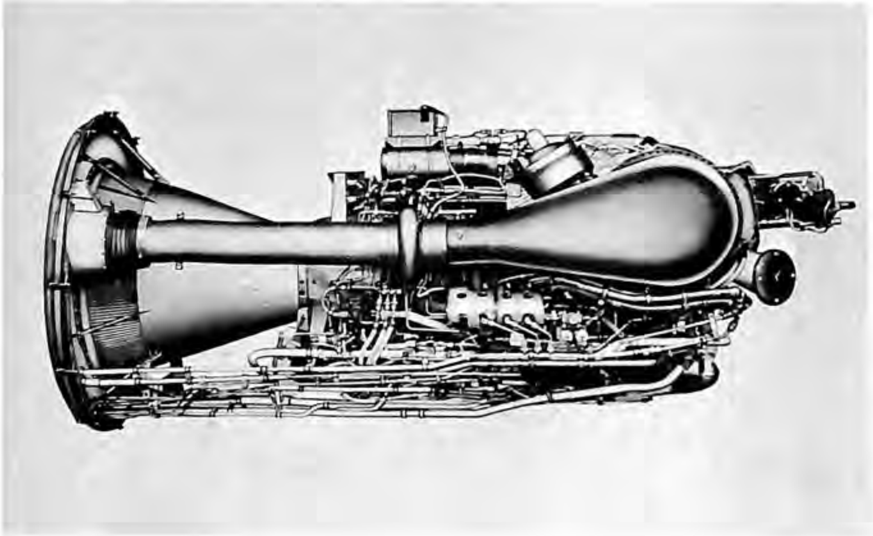
SE-7,-8,-9 are small liquid propellant thrusters burning a combination of monomethylhdrazine fuel and nitrogen tetroxide oxidizer. SE-7 is used for corrections of orbital attitude and maneuvering in the Gemini spacecraft; SE-8 for the attitude re-entry control system in the Apollo command module; SE-9 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.

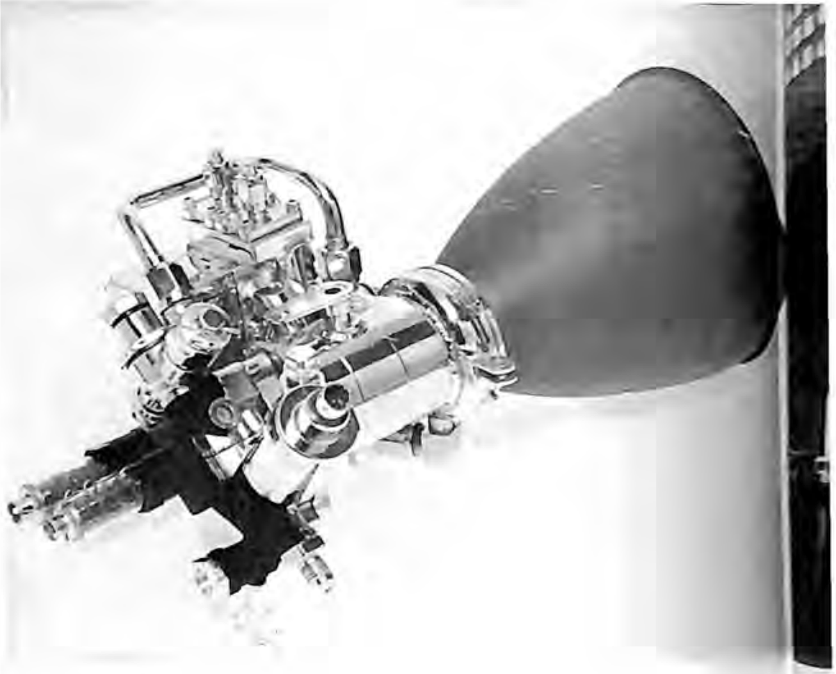
PHOENIX ROCKET MOTOR

Prime Contractor: Rocketdyne, a Division of North American Aviation, Inc.

Remarks

The solid propulsion system for the Navy's advanced Phoenix missile has been under development by Rocketdyne since 1963. The new rocket motor sucsessfully completed its preliminary flight rating tests and in 1966 pre-qualification and qualification phases of development. All work on the propulsion system is being done at Rocketdyne's Solid Rocket Division, McGregor, Texas. First powered flight test of the Phoenix missile, designated XAIM-54A, came in April 1966, just 2 months after completion of the propulsion system development program. The Phoenix motor utilizes an improved version of Flexadyne, a solid propellant developed by Rocketdyne to provide tactical missiles with performance increases throughout an extended environmental operating range. Flexadyne propellant is particularly adaptable to Phoenix missile requirements of high volumetric loading, high total impluse, and long burning time, thus providing the long-range operational capability required by the Navy.





YLR99-RM-1 TURBOROCKET

Prime Contractor: Thiokol Chemical Corporation

Remarks

The YLR99-RM-1 throttleable turborocket engine was developed by Thiokol's Reaction Motors Division to provide propulsion for the X-15 hypersonic manned research aircraft. The engine fulfills the manned safety requirements of MIL-E-5149 and incorporates extensive malfunction self-monitoring and safety features. The engine operates on liquid oxygen and anhydrous ammonia which is fed into the thrust chamber by a hydrogen peroxide-driven turbopump. Major engine components are a thrust chamber, injector gas generator, 2-stage igniter, turbopump and variable governor control, propellant control components, and electrical system. The engine has powered the X-15 to record speeds and altitudes for winged, piloted vehicles.

Specifications

Length 82.03 inches; diameter 39.31 inches; weight 910 pounds (dry) and 1,025 pounds (wet); operational life between overhauls, 1 hour.

Performance

Thrust continuously throttleable from 15,000 to 58,700 pounds (at infinite altitude); rated duration 180 seconds at full thrust depending on aircraft tankage; total propellant flowrate 212.5 pounds per second.

TD-339 SURVEYOR VERNIER ENGINE

Prime Contractor: Thiokol Chemical Corporation

Remarks

TD-339 vernier engines provided power for mid-course trajectory correction, final soft landing velocity and stability control during the lunar landing of America's Surveyor spacecraft on June 1, 1966. Three of these throttling liquid engines, produced by Thiokol's Reaction Motors Division, were installed on the Surveyor vehicle. The TD-339 is a small, regeneratively-cooled liquid system operating on pressure-fed mixed oxides of nitrogen and monomethylhydrazine hydrate fuel. Basic elements of the engine are the thrust chamber and injector assembly, dual propellant valve and propellant shutoff valve. A radiation-cooled molybdenum nozzle extension provides an 86:1 area ratio. Attitude and stability control are achieved by differential throttling of the 3 engines.

Specifications

Weight 5.9 pounds; length 11 inches.

Performance

Thrust continuously throttleable for 27 to 104 pounds; unlimited restart capability; specific impulse 287 seconds at maximum thrust.

THIOKOL SOLID ROCKETS

Prime Contractor: Thiokol Chemical Corporation

Remarks

Thiokol manufactures a varied line of solid rocket motors over a wide thrust range. It largest motors are 2 varieties of 156-inch diameter, the 156-1C-1 and the 156-2C-1. Thrust valves are 1,400,000 pounds for the 1C and 3,000,000 pounds for the 2C. Other Thiokol motors include the TU-465 120-inch booster; with Hercules Incorporated, the first stage Poseidon C-3 motor; the TE-364 Surveyor main retro; TE-385 Gemini retros; TE-260-G Subroc booster; the Falcon TE-287, TX-143-25 and TX-58-4; TU-289 Genie booster; XM100 booster for the Sergeant missile (length 195.3 inches, diameter 32 inches, weight 6,910 pounds); M16E1 Matador booster; the 34,000 pound thrust Recruit rocket (length 102.22 inches, diameter 9 inches, weight 352 pounds); M30 Nike-Hercules sustainer (length 174 inches, diameter 28.44 inches, weight 2,660 pounds); the 64,000 pound 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 Bomarc booster; the TX-135 Nike Zeus booster (length 203 inches, diameter 43.12 inches); the XM-105 Pershing first stage motor (length 78.55 inches, diameter 40 inches); XM-106 Pershing second stage motor (length 63.28 inches, diameter 40 inches); and motors for various other missiles.

C-1 RADIAMIC ENGINE

Prime Contractor: Thiokol Chemical Corporation

Remarks

Under contract to NASA's Marshall Space Flight Center, Thiokol's Reaction Motors Division is currently conducting the Phase II development of the C-1 Radiamic engine. Designated as the C-1 "Common Engine," this unit is intended for a variety of space vehicle missions. By employing 9 different, interchangeable nozzle configurations, the basic engine becomes adaptable for spacecraft attitude control and maneuvering systems and for launch vehicle ullage control. The engine uses storable liquid propellants consisting of nitrogen tetroxide with either a blend of unsymmetrical dimethylhydrazine and hydrazine, or monomethylhydrazine. The C-1 consists of a basic engine (thrust chamber and valve assembly) assembled to an ablative or radiation-cooled nozzle extension.

Specifications

Weight 6.26 pounds (with radiation-cooled nozzle), 7.98 to 14.90 pounds (with ablative cooled nozzle).

LR62-RM-2/4 ROCKET ENGINE

Prime Contractor: Thiokol Chemical Corporation

Remarks

The LR62 packaged liquid propellant rocket engines provide power for Navy and Air Force Bullpup B (ACM-12C) air-to-surface guided missile. The engine, a larger version of Thiokol's LR58 engine which was developed for Bullpup, utilizes factory-loaded propellants of inhibited red fuming nitric acid (IRFNA) and a mixed amine fuel (MAF-1). Arrangement of internal components and operation is the same as the smaller LR58 engine. The engine is handled like a round of ammunition, requiring only insertion of an igniter to arm it for firing. Being a packaged liquid, LR62 can withstand severe handling and thermal environments associated with high speed carrier aircraft operations.

Specifications

Length 61.20 inches; diameter 17.32 inches; weight 536 pounds (loaded).

Performance

Storage life 5 years; reliability 99.84 percent.

LR58-RM-4 ROCKET ENGINE

Prime Contractor: Thiokol Chemical Corporation

Remarks

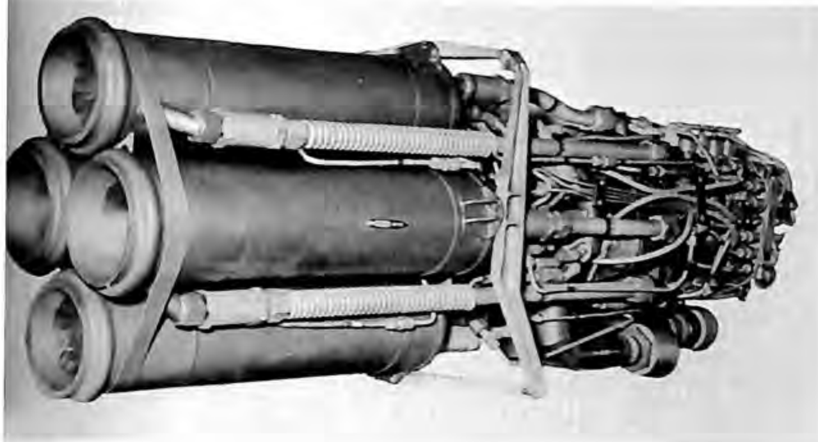
The LR58-RM-4 packaged liquid propellant rocket engine powers the Bullpup A (AGM-12B) air-to-surface guided missile. The LR58-RM-4 is produced by Thiokol's Reaction Motors Division and is the first factory-fueled liquid rocket to reach operational status. It is used by the U. S. Navy, Air Force and Marine Corps. Its hypergolic liquid propellants are inhibited red fuming nitric acid (IRFNA) and a mixed amine fuel (MAF-1). The propellants are loaded and hermetically sealed in high strength tankage at the production plant. A pressurized propellant feed system forces the propellants from the tanks to the combustion chamber by means of a shear slide injector, the only moving engine part. Engine operation is initiated by electrical impulse to an igniter which starts the solid propellant gas generator and begins the propellant pressurization and injection sequence to produce thrust.

Specifications

Length 40.47 inches; diameter 12.10 inches; weight 203 pounds (loaded).

Performance

Reliability 99.83 percent.



LR11-RM-5 ROCKET ENGINE

Prime Contractor: Thiokol Chemical Corporation

Remarks

The LR11-RM-5 engine was developed for use in early rocket-powered piloted aircraft. This engine powered the Bell X series aircraft which in 1946 was the first winged vehicle to break the sound barrier in level flight. Incorporating extensive malfunction safety provisions, the engine has been the 20 year workhorse of manned experimental flight, including the X-15 where a twin XLR11 system was utilized as interim propulsion early in the flight program. The LR11-RM-5 was produced by the Reaction Motors Division of Thiokol. It is a turborocket engine consisting of 4 clustered chambers with the turbopump and control system closely coupled to the forward end of the chambers. Each chamber contains an igniter to provide repeated restarts. LR11-RM-5 is throttleable in step-thrust increments by on-off operation of the chambers in any desired routine. The engine is currently being considered for use in various lifting body vehicles.

Specifications

Length 58 inches; diameter 18 inches; weight 345 pounds (dry).

Performance

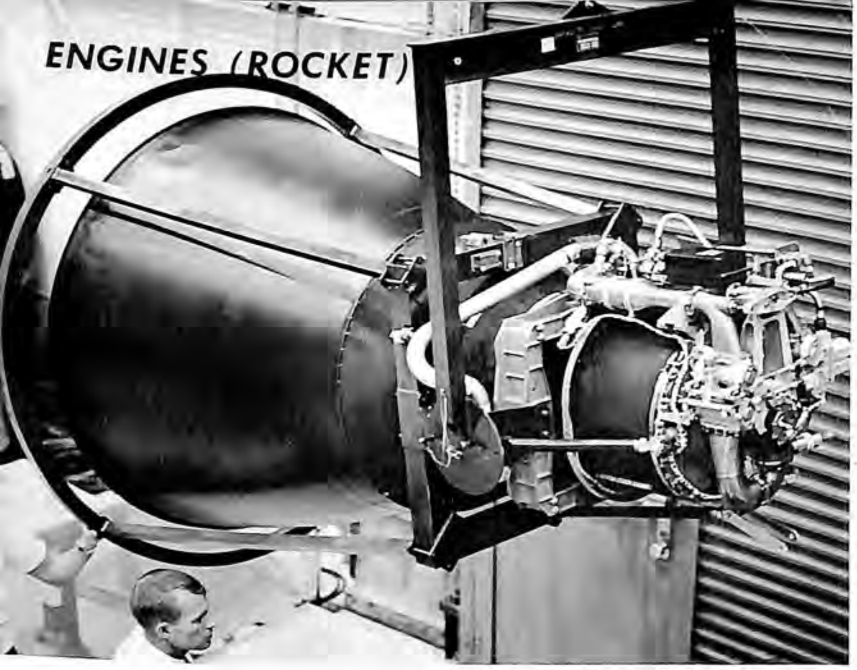
Thrust 8,000 pounds (2,000 pounds per chamber); service life 1-1/2 hours.

MIRA 180 SURVEYOR ENGINE

Prime Contractor: TRW Systems Group of TRW Inc.

Remarks

The MIRA 180 engine, originally designed as the alternate landing and midcourse guidance engine for the unmanned NASA Surveyor spacecraft, features a vastly increased throttle range continuously variable between 20 and 180 pounds of thrust, a 9:1 ratio. 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. Another application for the basic design is related to the thruster requirements of the Air Force's Manned Orbiting Laboratory.



LUNAR MODULE DESCENT ENGINE

Prime Contractor: TRW Systems Group of TRW Inc.

Remarks

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 LM descent engine is designed to land the module and its two astronauts on the surface of the moon in the Apollo program). Top thrust is about 10,000 pounds. Flight-weight models have been delivered to Grumman Aircraft Engineering Corporation, prime NASA contractor for the LM.

SNAPOODLE RADIOISOTOPE THRUSTER

Prime Contractor: TRW Systems Group of TRW Inc.

Remarks

A radioisotope-fueled space engine capable of generating simultaneously thrust and usable electrical power, the Snapoodle is a development of TRW Systems in cooperation with the Air Force. It is a self-contained unit using heat from a radioisotope source for acceleration of gaseous hydrogen to create thrust and to generate electricity through a 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 Group of TRW Inc.

Remarks

One major effort of TRW Systems in its extensive research and development in the field of electric propulsion is a working ion engine, a cesium contact thrust device. The engine operates by feeding cesium to a hot tungsten plate where it ionizes; the positive ions leave the hot plate and pass through a charged electric grid. Accelerating the ions, the grid causes them to exit through the nozzle at velocities of about 30 miles per second.

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. It has also flown as the upper stage of Thor/Delta and Burner launch vehicles, in slightly modified form. The FW-4S is believed to have the highest mass fraction—92 per cent—of any operational solid rocket. Motor can accept spin rates up to 200 revolutions per minute during firing. Case of the 5-foot long, 20-inch diameter motor is of lightweight fiberglass-epoxy.

Performance

Thrust about 6,000 pounds.

UA 1205 SEGMENTED SOLID PROPELLANT ROCKET

Prime Contractor: United Technology Center

Remarks

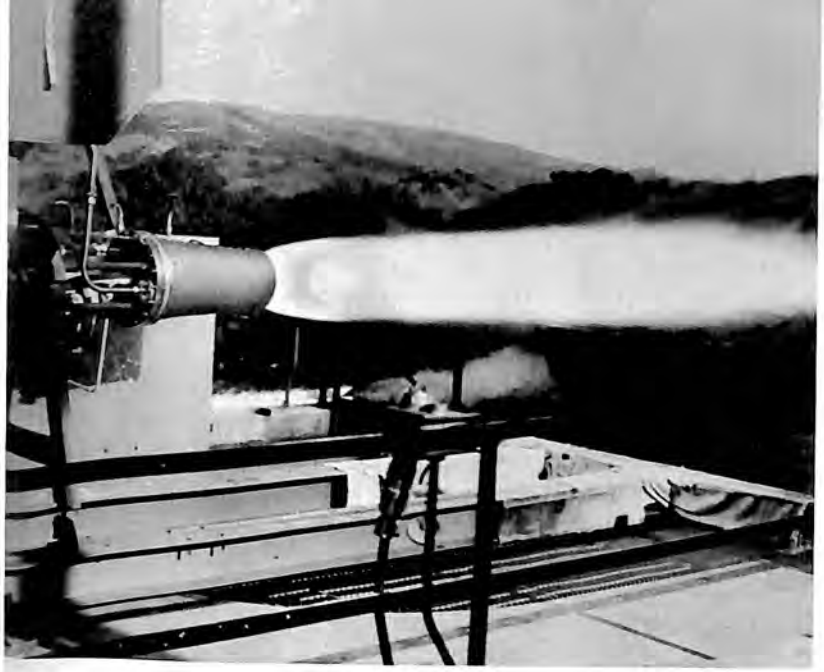
Two 1205's make up the booster stage of the Air Force's Titan III-C. The first large segmented solid-propellant motors to repeatedly demonstrate successful flight performance, they are attached on opposite sides of the vehicle's liquid-fuel core. Each motor consists of 5 center segments, 2 end closures, nose fairing, nozzle,liquid injection TVC and thrust termination and destruct system. A seven-segment version is planned as the booster for the Manned Orbiting Laboratory.

Specifications

Height 86 feet; diameter 120 inches; weight 250 tons; burn time about 115 seconds.

Performance

Peak thrust about 1.2 million pounds.



F600L8.0K FLUORINE-OXIDIZER LIQUID ENGINE

Prime Contractor: United Technology Center

Remarks

UTC has successfully test-fired an ablation-cooled upper-stage liquid rocket engine which burns fluorine as its oxidizer and a fuel mixture of monomethylhydrazine, hydrazine and water. Operated at a nominal sea level thrust of 5,000 pounds, the engine has demonstrated a specific impulse nearly 23 percent higher than contemporary flight-proven upper-stage liquid engines. Lightweight combustion chamber withstands 7,600-degree temperatures for more than 600 seconds.

UTC-HPS-10 HYBRID TARGET MISSILE PROPULSION SYSTEM

Prime Contractor: United Technology Center

Remarks

The first hybrid rocket designed for a specific flight application is being developed by UTC for the Air Force as the propulsion system for an air-launched, multi-purpose target vehicle. The HPS-10 combines maximum safety with high performance and controllable thrust, which can be dial-selected from 60 to 500 pounds. Engine utilizes common plastic material as the solid fuel and nitric oxides for the liquid oxidizer. Cost of 18-month development is about one-tenth that of a conventional program.

IO-720 SERIES FUEL INJECTED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

This 400 horsepower direct drive engine powers the single engine Piper Comanche 400. The same basic model engine is used to power the Riley Dove, Imco Model B1 agricultural sprayer and the Swearingen conversion of the Beech Queen Air 65. Like many of her sister engines in this family, the IO-720 incorporates piston cooling oil jets and a continuous flow fuel injection system.

Specifications

Length 46.08 inches; width 34.25 inches; height 22.53 inches; weight 610 pounds; 5.125 inches bore; 4.375 inches stroke; displacement 722 cubic inches; 8.7:1 compression ratio.

Performance

400 horsepower continuous.

IO-540-K FUEL INJECTED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

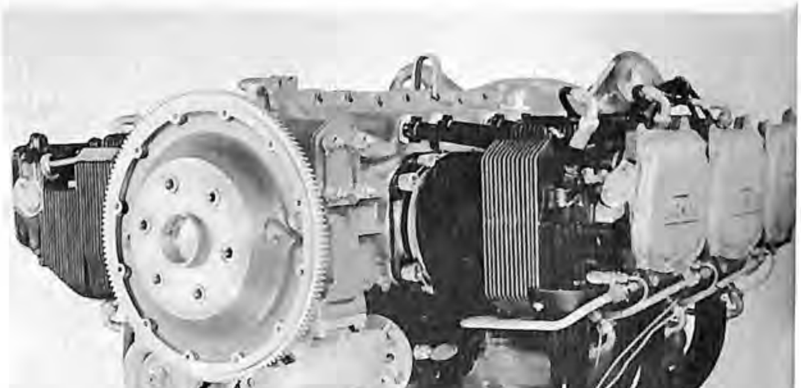
This fuel injected, flat opposed, direct drive piston engine powers the Piper Cherokee 300, a 6-place single engine utility aircraft. This engine incorporates piston cooling oil jets, a tuned induction system, a continuous flow fuel injection system, and like all Avco Lycoming direct drive engines, is supplied with an automotive type starter and generator or alternator. This engine has a continuous rating of 2,700 revolutions per minute and uses 100/130 octane fuel.

Specifications

Length 39.34 inches; width 34.25 inches; height 19.60 inches; weight 470 pounds; 5.125 inches bore; 4.375 inches stroke; displacement 541.5 cubic inches; 8.7:1 compression ratio.

Performance

300 horsepower continuous.



IO-360-A1A FUEL INJECTED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

First installed in the Mooney Super 21, this 200 horsepower, 4-cylinder, flat opposed, direct drive engine also powers the new Mooney Executive model aircraft. Producing 50 horsepower per cylinder, the IO-360-A1A has an excellent horsepower to weight ratio while maintaining the simplicity of design associated with the direct drive type piston engine. A tuned induction system and a continuous flow fuel injection system are incorporated in this series.

Specifications

Length 29.81 inches; width 34.25 inches; height 19.35 inches; 5.125 inches bore; 4.375 inches stroke; weight 323 pounds; displacement 361 cubic inches; 8.7:1 compression ratio.

Performance

200 horsepower continuous.

TIO-540-A1A TURBOCHARGED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

This turbocharged fuel injected engine powers the new Piper Navajo Twin on top of weather not possible with normally aspirated engines. The TIO-540-A1A, like all other Avco Lycoming engines supplied with a turbocharger, incorporates automatic controls to minimize overboost by the pilot. Also, all turbocharged engines built by Avco Lycoming feature shell moulded cylinder heads, ½ inch inconel steel exhaust valves, ni-resist exhaust valve guides and piston cooling oil squirts.

Specifications

Length 51.34 inches; width 34.25 inches; height 22.71 inches; weight 535 pounds; 5.125 inches bore; 4.375 inches stroke; displacement 541.5 cubic inches; 7.3:1 compression ratio.

Performance

310 horsepower continuous to 15,000 feet and 230 horsepower to 25,000 feet.

TIO-541 TURBOCHARGED PISTON ENGINE

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

The first in Avco Lycoming's new series of engines is the TIO-541 which powers the Mooney M22 and will be used by other airframe manufacturers. This new design concept for Avco Lycoming in the piston engine field incorporates all of the engineering improvements learned in 25 years of manufacturing air cooled aircraft engines. Equipped with side mounted accessories for ease of maintenance, the TIO-541 also incorporates an integral oil cooler and a dual scroll turbocharger for cabin pressurization as an option.

Specifications

Length 49.09 inches; width 34.25 inches; height 21.38 inches; weight 579 pounds; 5.125 inches bore; 4.375 inches stroke; displacement 541 cubic inches; 7.3:1 compression ratio.

Performance

310 brake horsepower continuous.

TIGO-541 SERIES TURBOCHARGED PISTON ENGINE

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

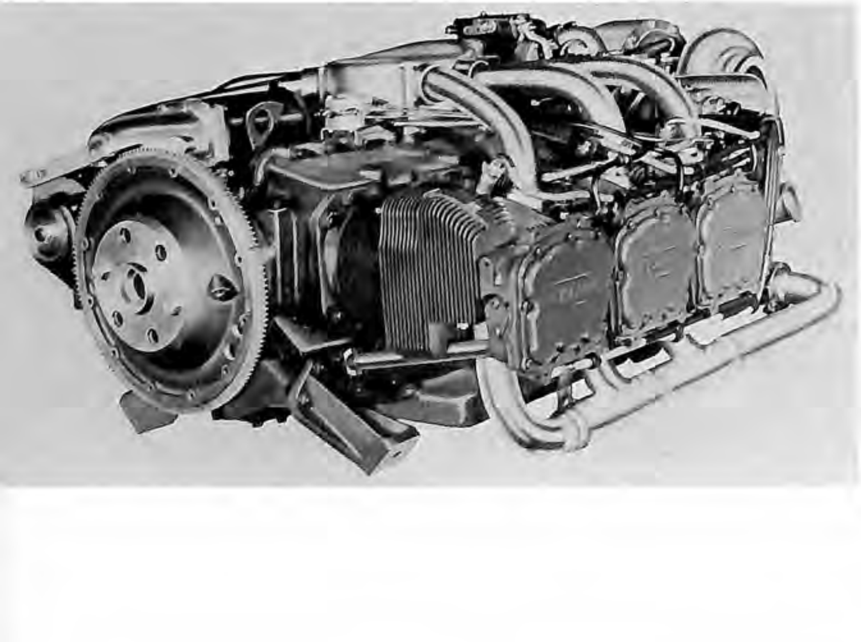
The second in the newest family of piston engines to come from Avco Lycoming will be the TIGO-541 model. Turbocharged for high altitude operation, this engine is basically a TIO-541 with an offset reduction gear having a ratio of 2 to 3. A 1-piece crankcase casting provides a housing for the reduction gear and power section as well as providing pads for side mounted accessories. This model engine is equipped with a dual scroll turbo for cabin pressurization, a drive for a Freon compressor for air conditioning and a torquemeter.

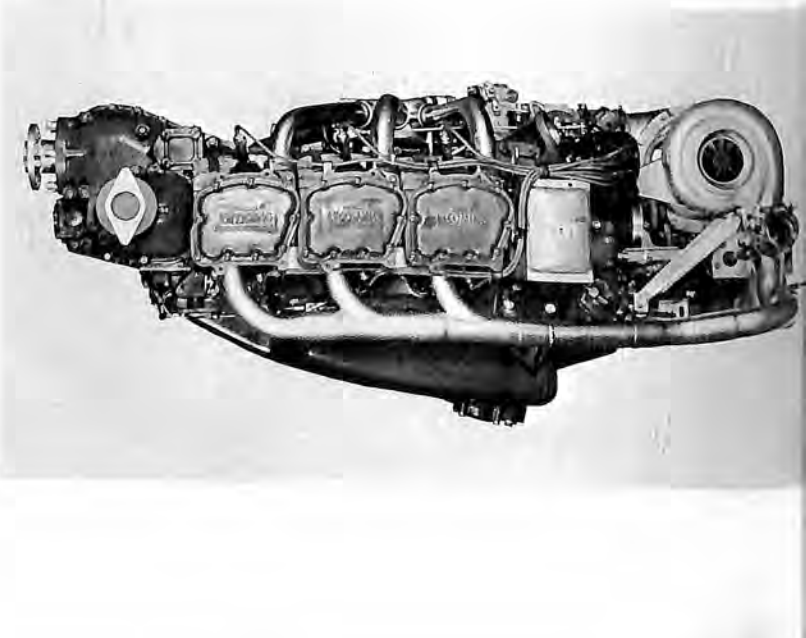
Specifications

Length 58.94 inches; width 35.66 inches; height 27.14 inches; weight 663 pounds; 5.125 inches bore; 4.375 inches stroke; displacement 541 cubic inches; 7.3:1 compression ratio.

Performance

400 brake horsepower continuous.





IGSO-540 SERIES SUPERCHARGED RECIPROCATING ENGINE

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

This series of engines powers the 680 series of aircraft manufactured by Aero Commander and the Queen Air 80 model aircraft manufactured by Beech. A mechanically supercharged fuel injected engine, this model has accumulated many hours of flight time and compiled an envious record of safety and low maintenance costs. Side mounted accessories provide for ease of maintenance and the engine is built with either updraft or downdraft exhaust cylinders. Basically used by Aero and Beech, many smaller companies are using the IGSO-540 as a conversion powerplant to increase the performance of other aircraft.

Specifications

Length 48.15 inches; width 34.25 inches; height 28.44 inches; weight 530 pounds; 5.125 inches bore; 4.375 inches stroke; displacement 541.5 cubic inches; 7.3:1 compression ratio.

Performance

380 brake horsepower take-off, 360 brake horsepower continuous.

MODEL O-200-A

Prime Contractor: Continental Motors Corporation

Remarks

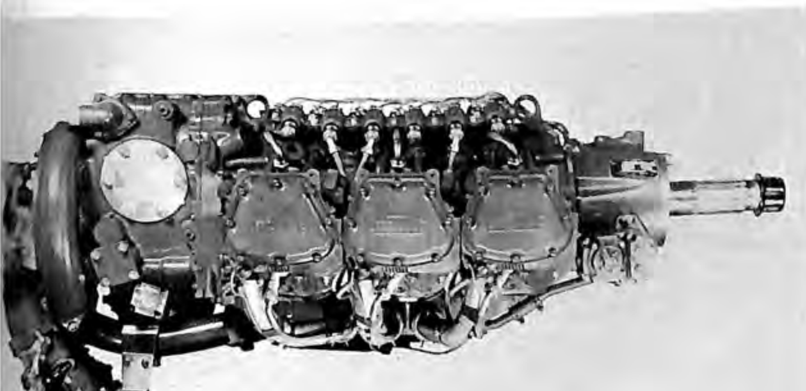
The O-200-A is the power plant for the Cessna Model 150.

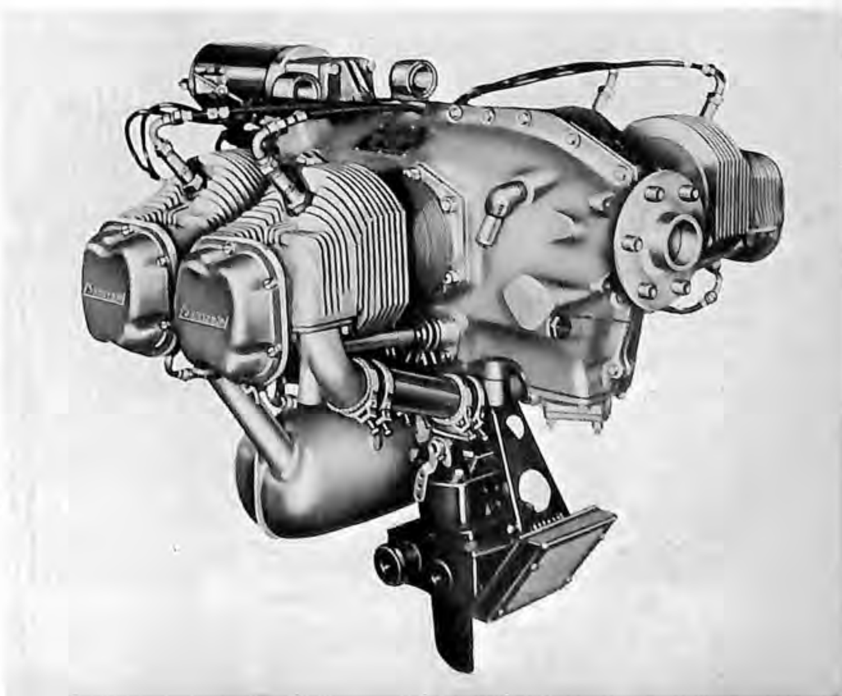
Specifications

Dimensions, with standard equipment installed: length 28.53 inches; height 28.72 inches; width 31.56 inches. Dry weight, with accessories, 217.87 pounds; cylinders 4; bore 4.06 inches; stroke 3.88 inches; displacement 201 cubic inches; compression ratio 7.0:1.

Performance

Rated power, sea level, 100 horsepower; take-off power, sea level, 100 horsepower; recommended cruise rating, sea level, 75 horsepower; revolutions per minute at rated power 2,750; revolutions per minute at take-off 2,750; cruising revolutions per minute 2,500.





MODEL O-470-R

Prime Contractor: Continental Motors Corporation

Remarks

The O-470-R engine powers the Cessna 182.

Specifications

Demensions, with standard equipment installed: length 36.03 inches; height 28.42 inches; width 33.56 inches. Dry weight, with accessories, 438.35 pounds; cylinders 6; bore 5 inches; stroke 4 inches; displacement 471 cubic inches; compression ratio 7.0:1.

Performance

Sea level rating 230 horsepower; sea level take-off rating 230 horsepower; sea level cruise rating 172 horsepower; rated power revolutions per minute 2,600; take-off power revolutions per minute 2,600; cruising revolutions per minute 2,450.

MODELS O-300-A,B,C,D

Prime Contractor: Continental Motors Corporation

Remarks

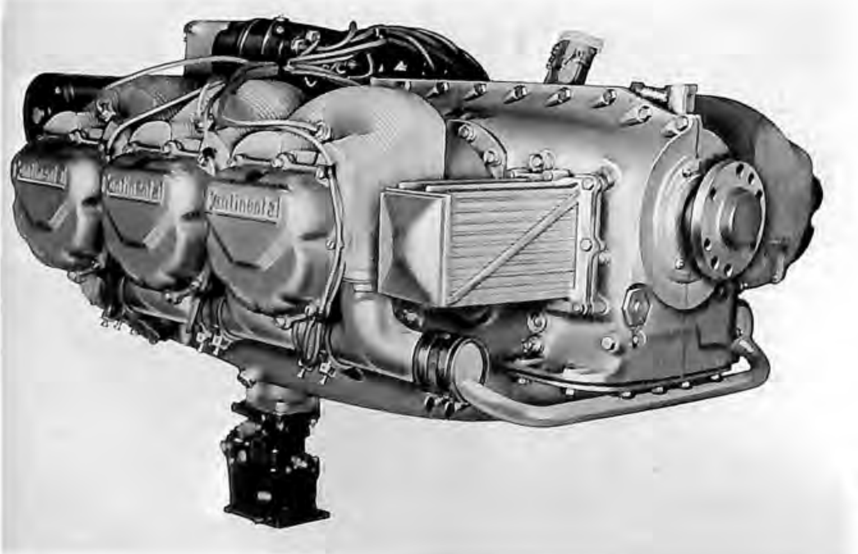
The O-300 engines make up the power plant in the Cessna 172.

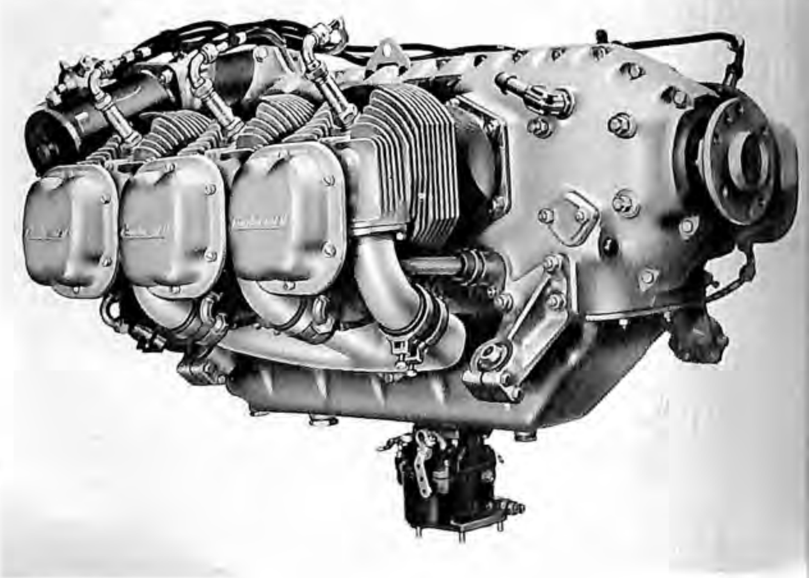
Specifications

Dimensions, with standard equipment installed: length 39 3/4 inches (D 36 inches); height 23 1/4 inches (D 27 inches); width 31 1/2 inches. Dry weight, with carburetor, 268 pounds; cylinders 6; bore 4 1/16 inches; stroke 3 7/8 inches; displacement 301 cubic inches; compression ratio 7.0:1.

Performance

Sea level rating 145 horsepower; sea level take-off power 145 horsepower; cruise 108 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off power 2,700; cruising revolutions per minute 2,450.





MODEL IO-360

Prime Contractor: Continental Motors Corporation

Remarks

The IO-360 engine is the power plant for the Cessna 337.

Specifications

Dimensions, with standard equipment installed: length 35.34 inches; height 23.74 inches; width 3.40 inches. Dry weight, with accessories, 298.25 pounds; cylinders 6; bore 4.438 inches; stroke 3.875 inches; displacement 360 cubic inches; compression ratio 8.5:1.

Performance

Sea level rating 210 horsepower; take-off rating, sea level, 210 horsepower; cruise rating 157 horsepower; revolutions per minute at rated power 2,800; revolutions per minute at take-off power 2,800; cruising revolutions per minute 2,600.

MODEL IO-520-A, D

Prime Contractor: Continental Motors Corporation

Remarks

The IO-520-A engine is the power plant in the Cessna 210.

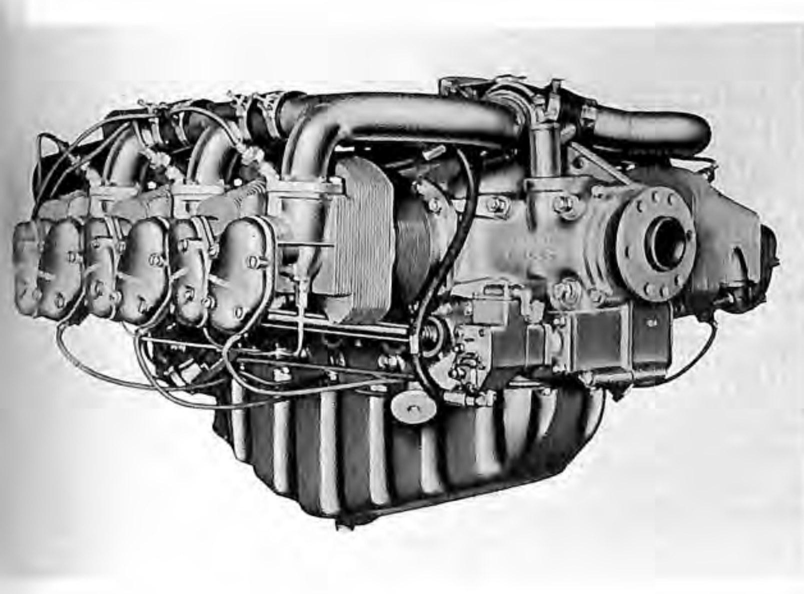
Specifications

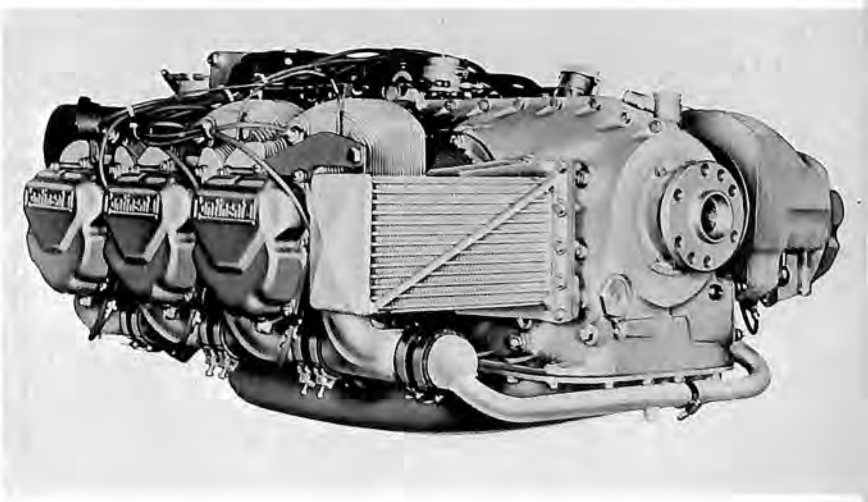
Dimensions, with standard equipment installed: length 41.41 inches; height 19.75 inches; width 33.56 inches. Dry weight, with accessories, 471.28 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 8.5:1.

Performance

Sea level rating 285 horsepower; take-off rating 285 horsepower; cruise rating 215 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off power 2,700; cruising revolutions per minute 2,500.

Note: Model IO-520-D, used in the Cessna 206 and Agwagon, has same specifications with these exceptions: Length 38.86 inches, height 23.79 inches, dry weight 455.56 pounds. Take-off rating of the D is 300 horsepower, take-off revolutions per minute 2,850, cruising revolutions per minute 2,550.





MODEL TSIO-520-B

Prime Contractor: Continental Motors Corporation

Remarks

The TSIO-520-B is the power plant in the Cessna 320.

Specifications

Dimensions, with standard equipment installed: length 39.75 inches; height 20.47 inches; width 33.56; length with turbo 57.73 inches. Dry weight, with accessories, 475 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 7.5:1.

Performance

Sea level rating 285 horsepower; take-off rating, sea level, 285 horsepower; cruise rating 215 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off power 2,700; cruising revolutions per minute 2,350.

MODEL TSIO-520-C

Prime Contractor: Continental Motors Corporation

Remarks

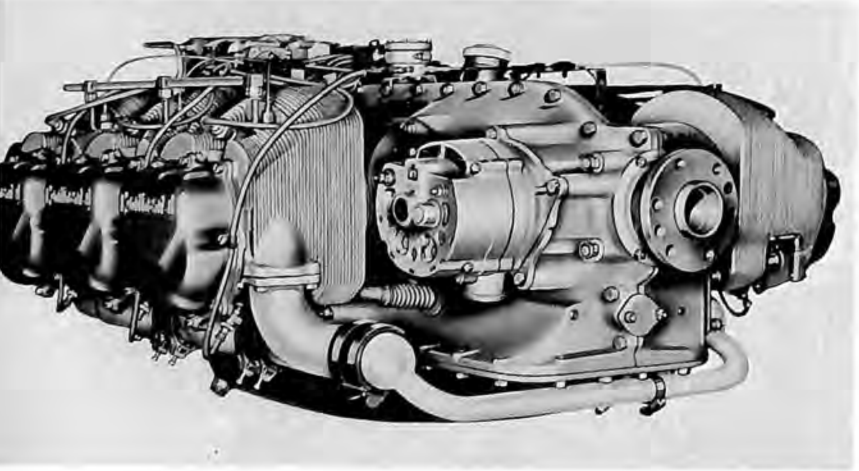
The TSIO-520-C engine is the power plant in the Cessna 210.

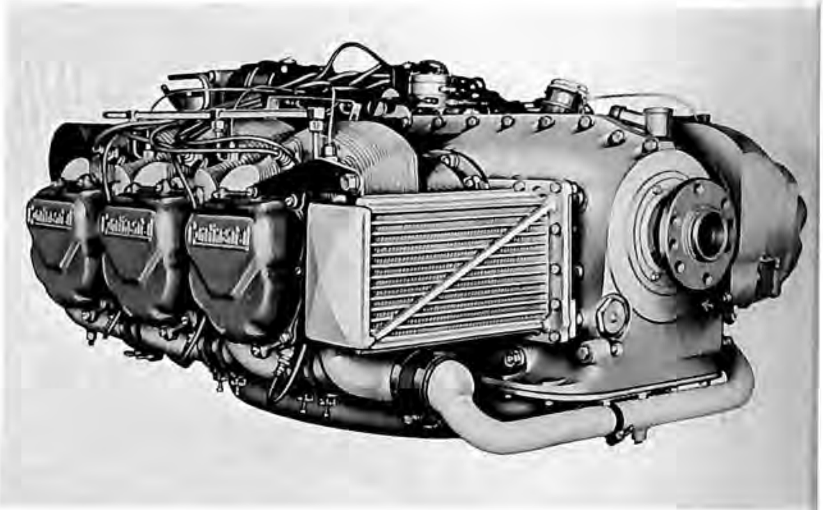
Specifications

Dimensions, with standard equipment installed; length 40.91 inches; height 20.04 inches; width 33.56 inches. Dry weight, with accessories, 458.01 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 7.5:1.

Performance

Sea level rating 285 horsepower; take-off rating, sea level, 285 horsepower; cruise rating 215 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off power 2,700; cruising revolutions per minute 2,500.





MODEL GTSIO-520-C

Prime Contractor: Continental Motors Corporation

Remarks

The GTSIO-520-C engine is the power plant in the Cessna 411.

Specifications

Dimensions, with standard equipment installed: length 43.06 inches; height 23.25 inches; width 34.04 inches. Dry weight, with accessories, 552.52 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 7.5:1.

Performance

Sea level rating 340 horsepower; take-off rating, sea level, 340 horsepower; cruise rating 255 horsepower; revolutions per minute at rated power 3,200; revolutions per minute at take-off power 3,200; cruising revolutions per minute 2,800.

MODEL IO-346

Prime Contractor: Continental Motors Corporation

Remarks

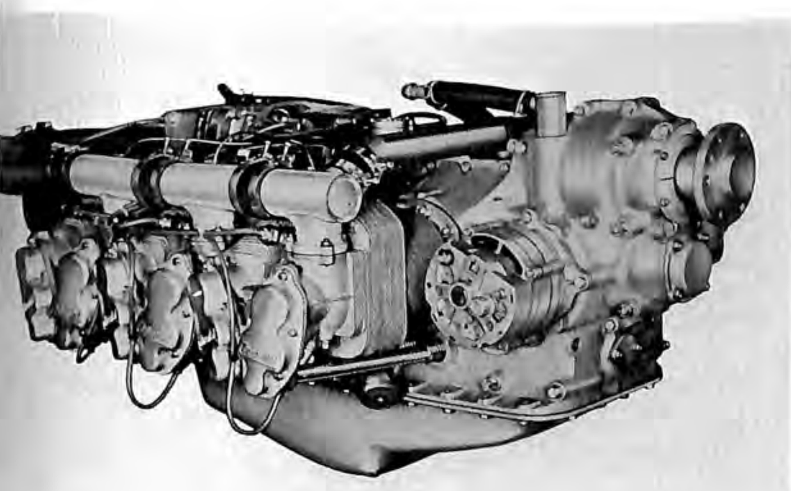
The IO-346 engine is the power plant in the Beechcraft Musketeer.

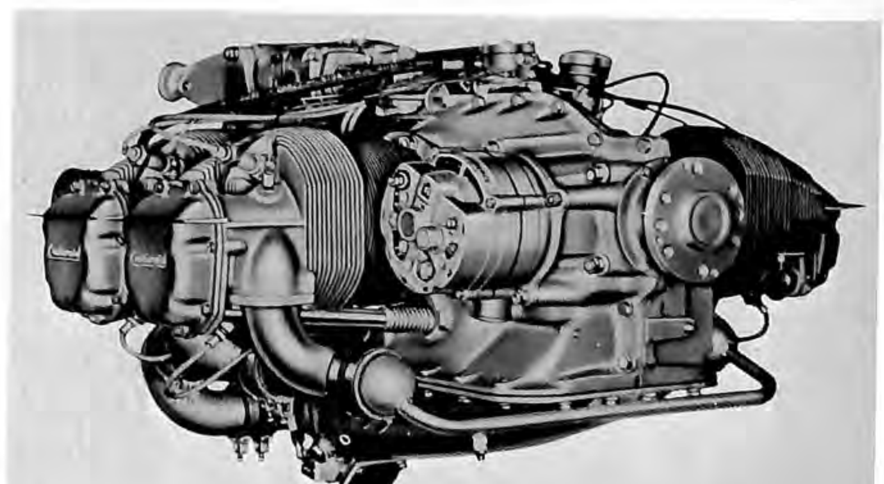
Specifications

Dimensions, with standard equipment installed: length 30 inches; height 22.48 inches; width 33.38 inches. Dry weight, with accessories, 296.50 pounds; cylinders 4; bore 5.25 inches; stroke 4 inches; displacement 346 cubic inches; compression ratio 7.5:1.

Performance

Sea level rating 165 horsepower; take-off rating, sea level, 165 horsepower; cruise rating 125 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off power 2,700; cruising revolutions per minute 2,450.





MODEL IO-520-B

Prime Contractor: Continental Motors Corporation

Remarks

The IO-520-B engine is the power plant in the Beechcraft Bonanza.

Specifications

Dimensions, with standard equipment installed: length 38.47 inches; height 26.71 inches; width 33.58 inches. Dry weight, with accessories, 457.65 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 8.5:1.

Performance

Sea level rating 285 horsepower; take-off rating, sea level, 285 horsepower; cruise rating 213 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off power 2,700; cruising revolutions per minute 2,500.

MODEL IO-520-C

Prime Contractor: Continental Motors Corporation

Remarks

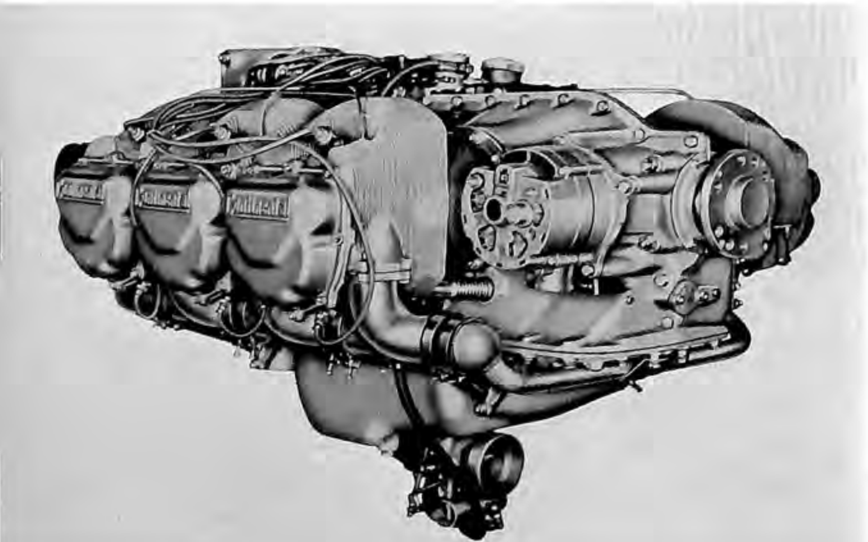
The IO-520-C engine is the power plant in the Beechcraft Baron.

Specifications

Dimensions, with standard equipment installed: length 42.81 inches; height 19.78 inches; width 33.56 inches. Dry weight, with accessories, 450.38 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 8.5:1.

Performance

Sea level rating 285 horsepower; take-off rating, sea level, 285 horsepower; cruise rating 213 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off power 2,700; cruising revolutions per minute 2,500.



MODEL TSIO-520-D

Prime Contractor: Continental Motors Corporation

Remarks

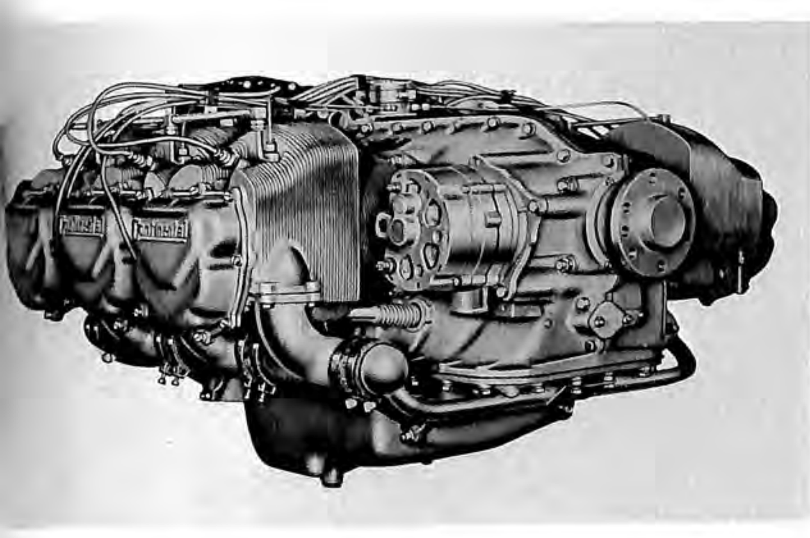
The TSIO-520-D engine is the power plant in the Beechcraft Turbo Bonanza.

Specifications

Dimensions, with standard equipment installed; length, turbo not included, 42.58 inches; height 29.40 inches; width 33.56 inches. Dry weight, with accessories, 484.5 pounds; cylinders 6; bore 5.25 inches; stroke 4 inches; displacement 520 cubic inches; compression ratio 7.5:1.

Performance

Sea level rating 285 horsepower; take-off rating, sea level, 285 horsepower; cruise rating 214 horsepower; revolutions per minute at rated power 2,700; revolutions per minute at take-off power 2,700; cruising revolutions per minute 2,500.



R1820-82A ENGINE (C9)

Prime Contractor: Curtiss-Wright Corporation

Remarks

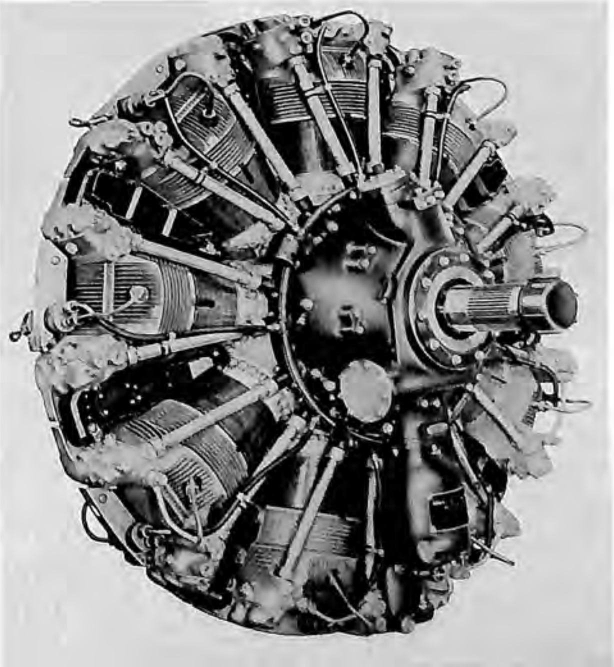
A 9-cylinder single row radial reciprocating engine, the C9 is manufactured for the Grumman S-2D, S-2E and E-1B series aircraft.

Specifications

Dry weight 1,479 pounds; length 50.1 inches; diameter 55.74 inches; fuel grade 115/145.

Performance

Take-off power at sea level 1,525 brake horsepower.



R3350-32W ENGINE (TC18)

Prime Contractor: Curtiss-Wright Corporation

Remarks

The TC18 is an 18-cylinder double row radial turbo compound reciprocating engine used by the military services in P-2 and P-5 series aircraft.

Specifications

Dry weight 3,560 pounds; length 91.8 inches; diameter 56.59 inches; fuel grade 115/145.

Performance

Take off power at sea level 3,700 brake horsepower.

R3350-26WD ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

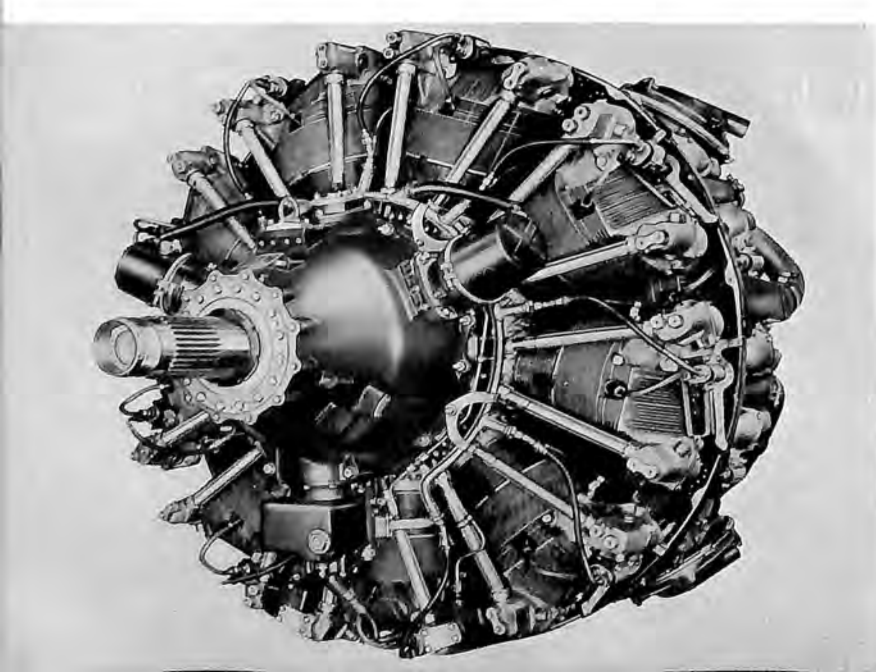
An 18 cylinder double row radical reciprocating engine, the R-3350-26WD is manufactured for the Douglas AD series and Lockheed P2 series aircraft.

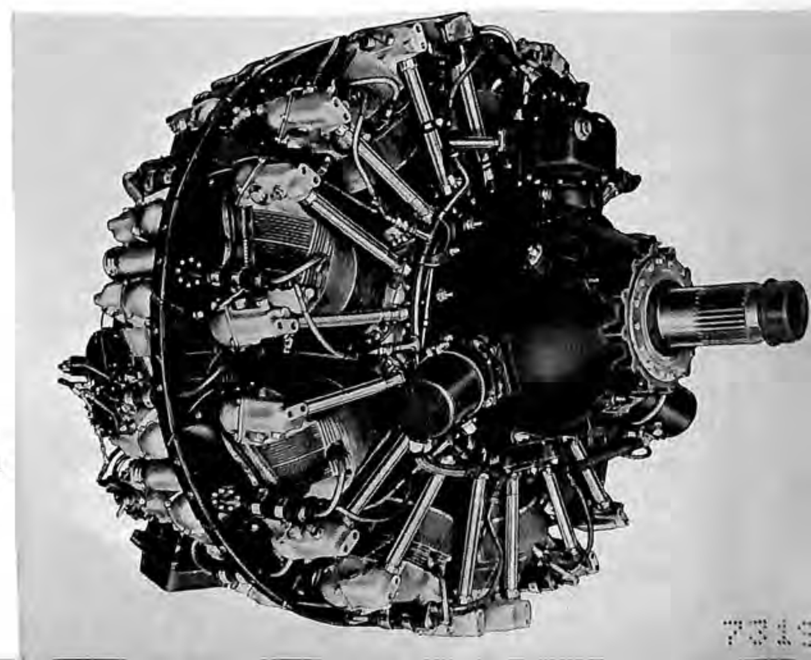
Specifications

Dry weight 2,925 pounds; length 81.23 inches; diameter 55.62 inches; fuel grade 115/145.

Performance

Take-off power at sea-level 2,700 horsepower.





RC2-90 ROTATING COMBUSTION ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

The Rotating Combustion Engine is a new internal combustion engine which operates on the familiar Otto cycle but incorporates a unique and simplified geometry which provides a very high ratio of power to displacement. The RC2-90 is the initial Rotating Combustion Aircraft Engine being developed by Curtiss-Wright. It is an air-cooled, twin rotor engine incorporating JP fuel injection with coordinated spark ignition. The engine is naturally aspirated and has its own cooling air blower. Torque, air and fuel consumption characteristics are comparable to conventional reciprocating engines; size, weight and smoothness of operation approach that of turbine engines.

Specifications

Length 32.4 inches; height 18.0 inches; width 20.7 inches; weight 317 pounds.

Performance

Take-off rating 310 brake horsepower at 6,000 revolutions per minute.

R985 MILITARY-COMMERCIAL RECIPROCATING ENGINE

Prime Contractor: Pratt & Whitney Aircraft

Remarks

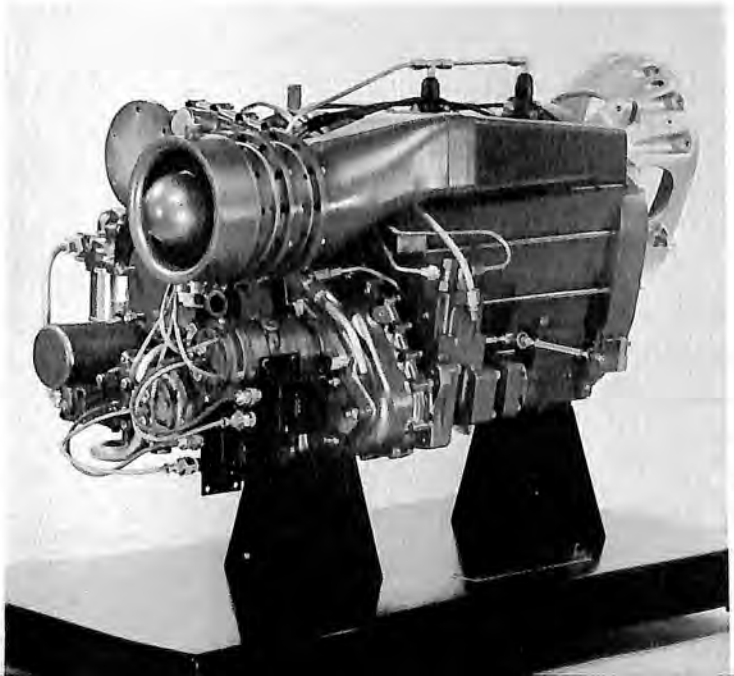
Like its famous predecessor, the Wasp, R985 Wasp Junior is a 9-cylinder radial air-cooled piston engine no longer in production but still in wide use. It powers the Beech 18, the deHavilland Beaver, the Sikorsky S-51 helicopter and other aircraft. A total of 39,037 R985's were built.

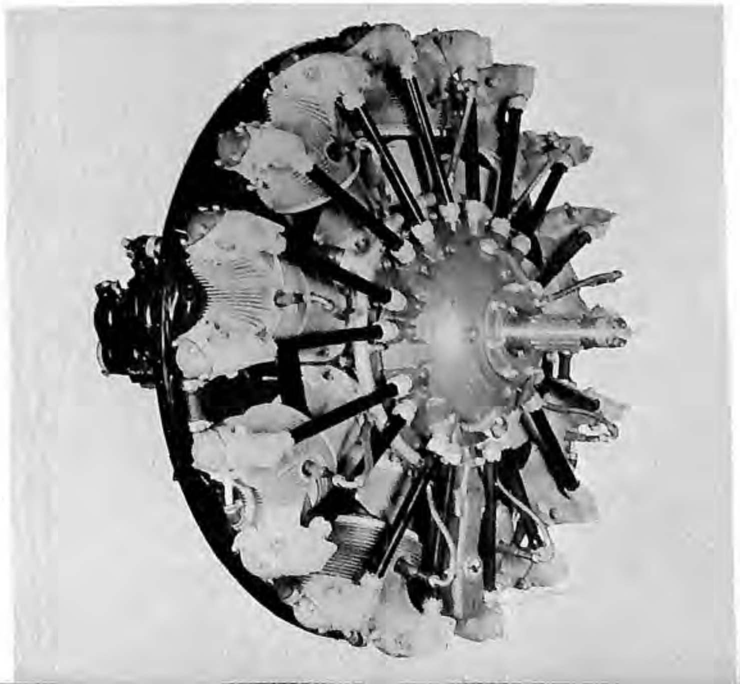
Specifications

(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

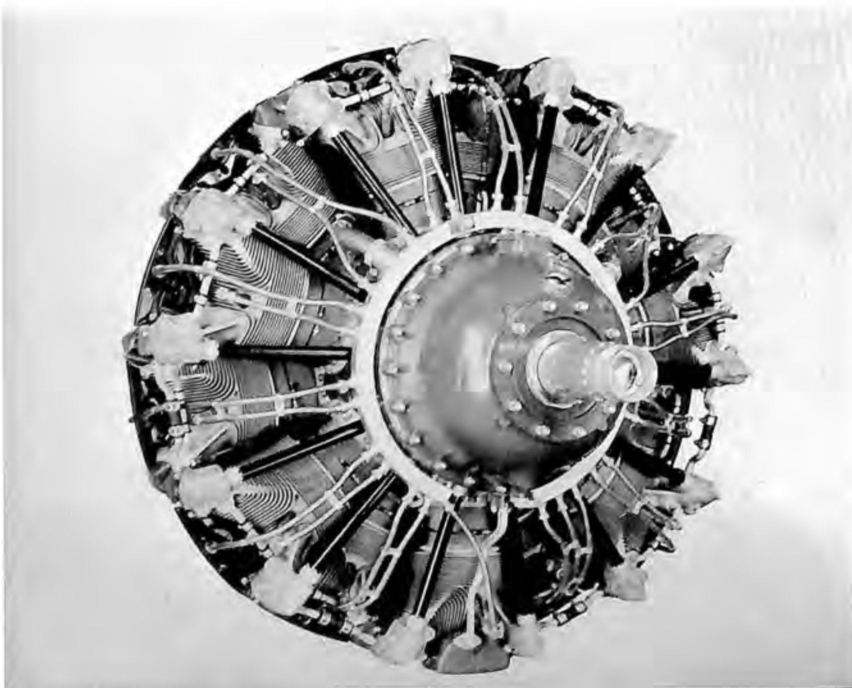
Still in use, the R1340 Wasp was produced in numerous configurations for 35 years—longer than any other Pratt & Whitney engine. It powered many military and commercial airplanes in aviation's pioneering days. Among the planes still flying with R1340 engines are the deHavilland Otter, the Grumman Mallard and various helicopters.

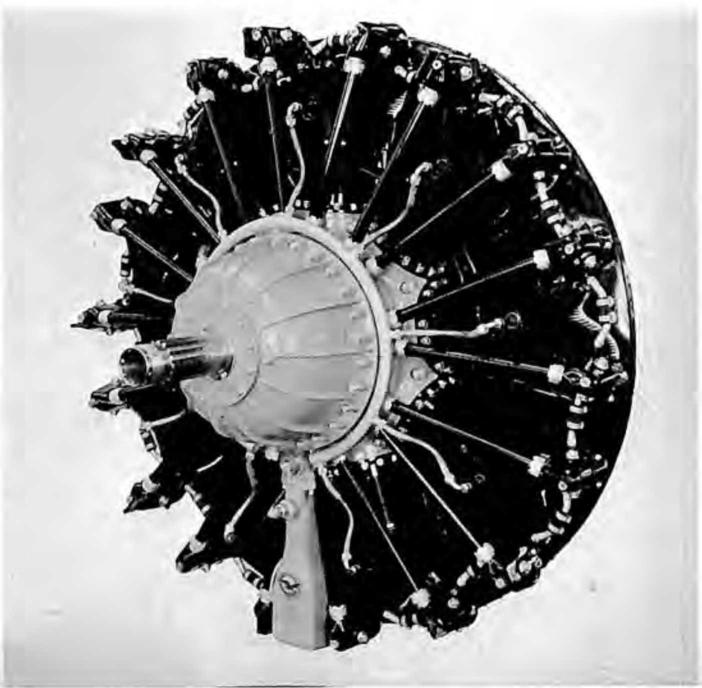
Specifications (Model A)

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

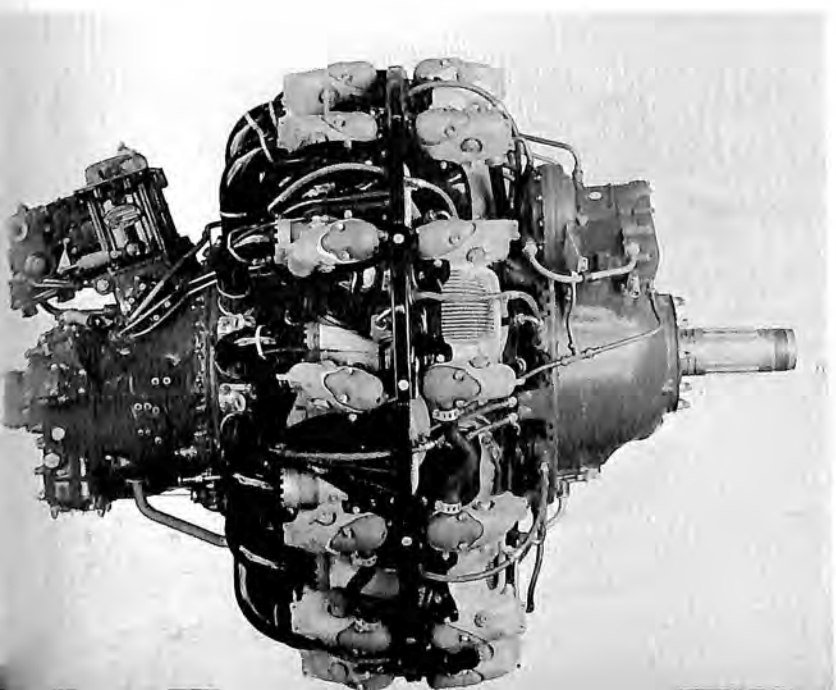
The R2180 Twin Wasp, 14-cylinder radial air-cooled piston engine was developed after World War II but had a short production life. It is used in the SAAB Scandia transport.

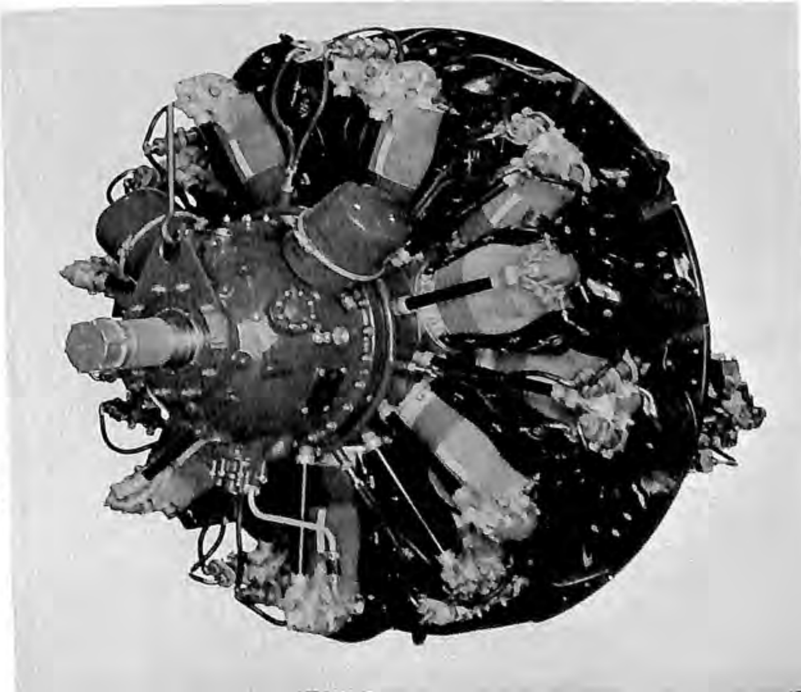
Specifications

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

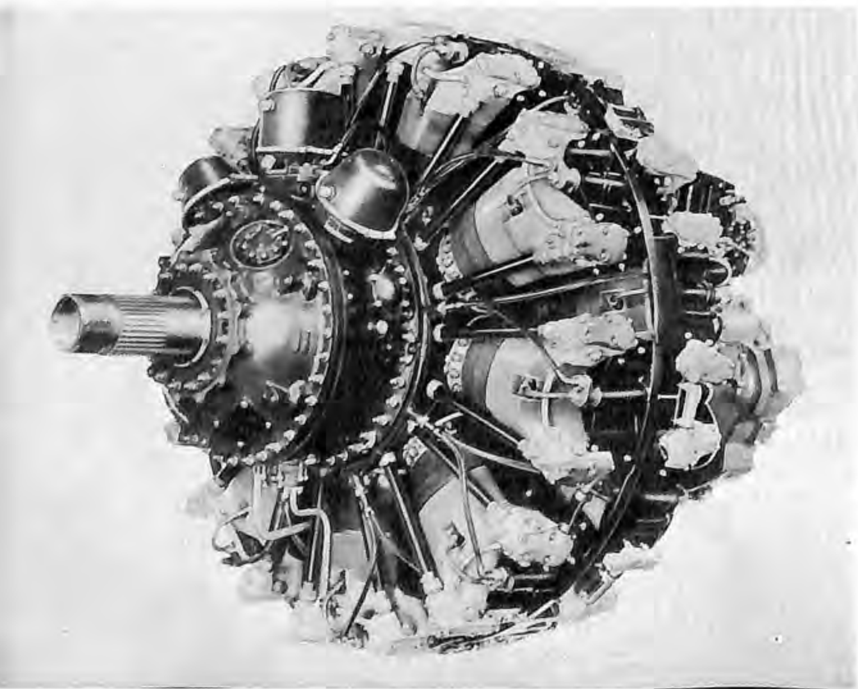
A 28-cylinder radial air-cooled piston engine, the R4360 was the most powerful engine of its type produced. It was developed during World War II and still powers the Boeing C-97, Fairchild C-119, Douglas C-124 Globemaster transports and the Boeing 377 Stratoliner.

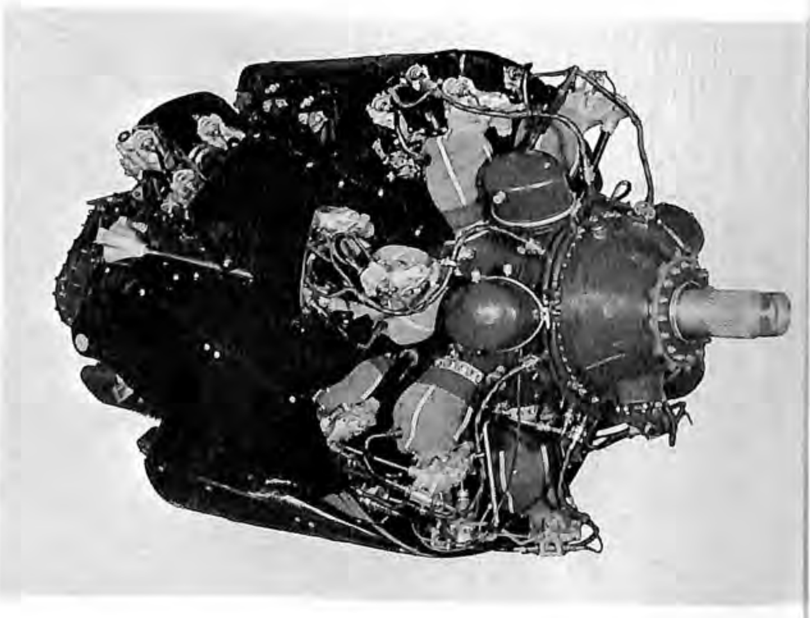
Specifications (Model TSB3-6)

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

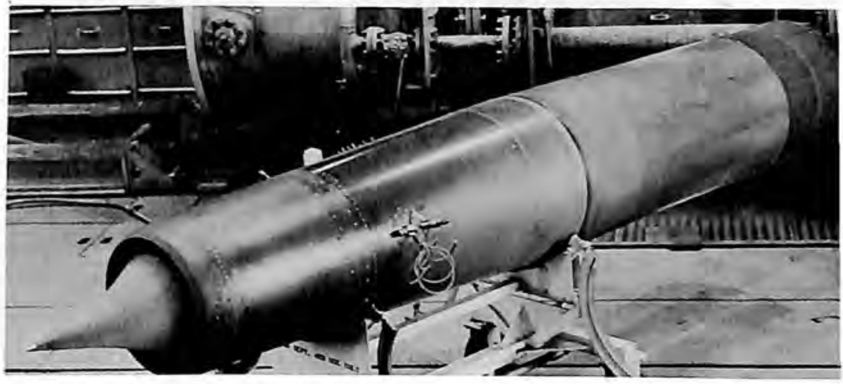
Developed for the Air Force, the RJ-43-MA-3 engine is a complete nacelle-type supersonic ramjet engine with a conical shock inlet. Cruise propulsion for the currently operational Boeing Bomarc A interceptor missile is provided by 2 of these ramjet engines.

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

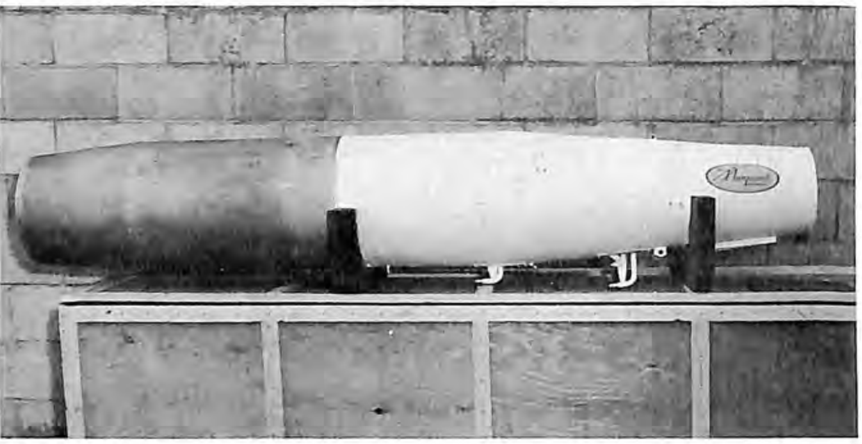
The RJ-43-MA-11, produced for the Air Force, is a complete nacelle-type supersonic ramjet engine with a high compression inlet spike. This engine (2 units) provides the cruise propulsion source for the Boeing Bomarc B interceptor missile.

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

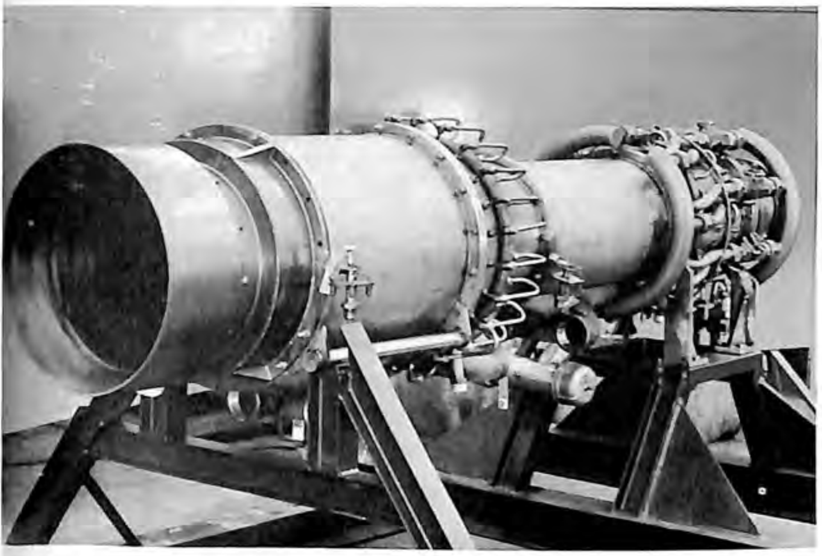
The MA150-XAA is a nacelle-type subsonic and supersonic ramjet engine with normal shock inlet. It provides the cruise propulsion for the Army's North American Advanced Redhead/Roadrunner target missile system for high and low altitude application.

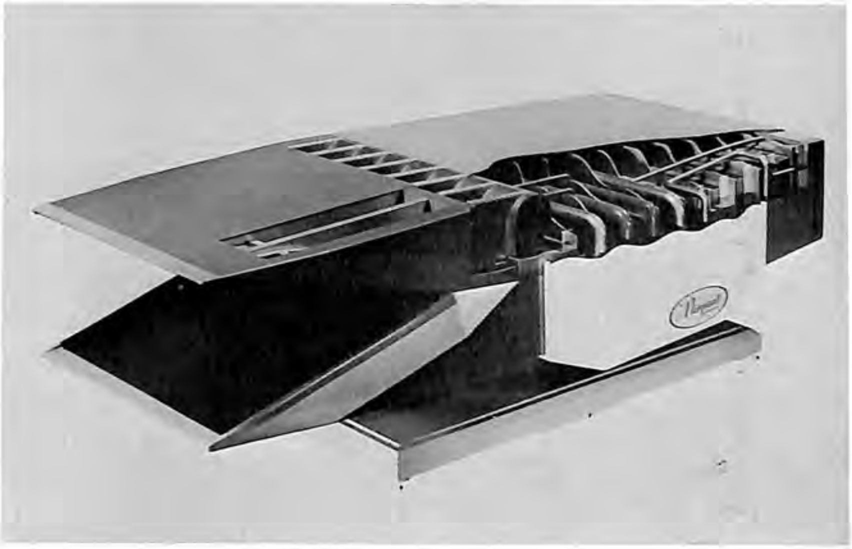
Specifications

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.





EJECTOR RAMJET

Prime Contractor: The Marquardt Corporation

Remarks

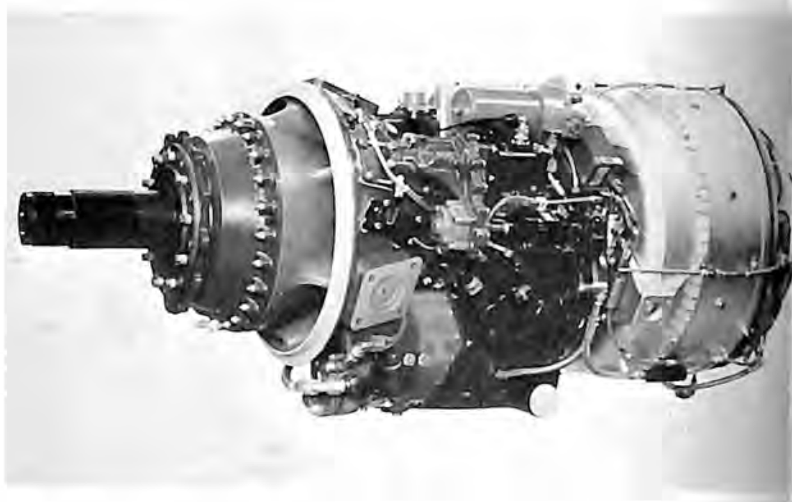
The Ejector Ramjet is a composite (rocket-ramjet) engine concept developed by Marquardt under Air Force sponsorship. It has potential application to missile propulsion, advanced high-payload ratio orbital launch vehicles and advanced "next generation" aircraft. Engine concept combines rockets and ramjets into simple and light weight acceleration-and-cruise propulsion system which provides vehicle performance (1) superior to separate rockets and ramjets due to commonality of structure plus rocket thrust augmentation and (2) competitive with complex turbomachinery at hypersonic flight speeds.

SCRAMJET

Prime Contractor: The Marquardt Corporation

Remarks

Development of supersonic combustion ramjet for hypersonic acceleration and cruise performance; applications include hypersonic cruise vehicles, recoverable launch vehicles and defense and tactical missile systems.



AVCO LYCOMING TURBOFAN GAS TURBINE ENGINES

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

Avco Lycoming's gas turbine design philosophy centers about a "Universal" concept which permits a basic power producer to be used for a variety of output configurations. A significant result of this approach has been the development of a turbofan engine wherein a 6:1 high by-pass ratio fan has been mated to a T55 power producer. This same configuration is feasible for the T53. This design is ideally suited to both standard and steep gradient aircraft requiring substantial operating economies and which operate in the medium altitude, Mach .8 and below range. Medium-sized business jets and long range patrol aircraft are potential applications for the Avco Lycoming turbofan.

Specifications (Approximate) (Mated to T55 Engine)

Length 66 inches; fan diameter 40 inches; by-pass ratio 6:1; other specifications same as basic engine to which fan is mated.

Performance

Rating in the 5,000 pound thrust range; specific fuel consumption about .40 pounds per pound of thrust per hour.

T53 TURBOPROP GAS TURBINE ENGINE

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

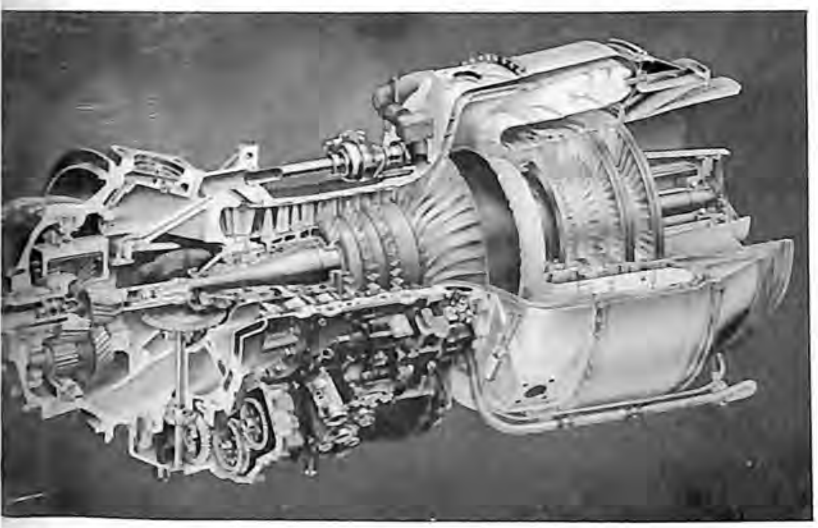
The turboprop version of the T53, designated L-7, powers the Army's Grumman OV-1 "Mohawk" STOL surveillance aircraft. This engine is basically the same as the shaft version except for the front-end gearing which mates the engine to a conventional propeller. The 1,160 shaft horsepower T53-L-15 is the latest production configuration.

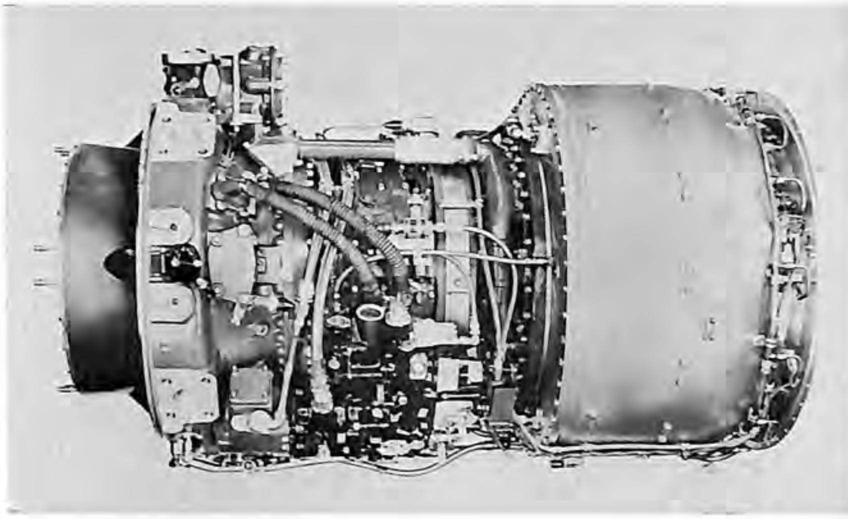
Specifications

Length 59 inches; diameter 23 inches; weight 555 pounds; compressor stages 5 axial, 1 centrifugal; compressor turbines 2 (1 in L-7 version); power turbines 2 (1 in L-7 version.)

Performance

T53-L-15: 1,160 shaft horsepower (1,400 thermodynamic); specific fuel consumption .61 pounds per horsepower per hour. T53-L-7 (photo): 1,100 shaft horsepower; specific fuel consumption .67 pounds per horsepower per hour.





T53 TURBOSHAFT GAS TURBINE ENGINE

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

With multi-million hour flight experience accumulated under diverse environmental conditions, the T53 turboshaft engine is the most experienced of its class in the world. It has powered helicopters to more world-recognized records than any other turbine engine, and has been installed in many pioneering VTOL, STOL and V/STOL vehicles. Current versions power the Army's Bell HU-1 "Huey" and AH-1G "HueyCobra" tactical helicopters as well as the Air Force's Kaman HH-43 "Huskie" rescue helicopter. The engine also powers the commercial Bell model 204. A pair of T53's capable of full vertical operation are installed on the Canadair CL-84 tilt-wing V/STOL. All T53's are of modular design to facilitate field maintenance.

Specifications

Length 48 inches; diameter 23 inches; weight 496 pounds; compressor stages 5 axial, 1 centrifugal; pressure ratio 6:1; compressor turbines 2 (one in L-11 version); power turbines 2 (1 in L-11 version.)

Performance

T53-L-13 (photo): 1,400 shaft horsepower; specific fuel consumption .58 pounds per horsepower per hour. T53-L-11: 1,100 shaft horsepower; specific fuel consumption .68 pounds per horsepower per hour.

T55 TURBOSHAFT GAS TURBINE ENGINE

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

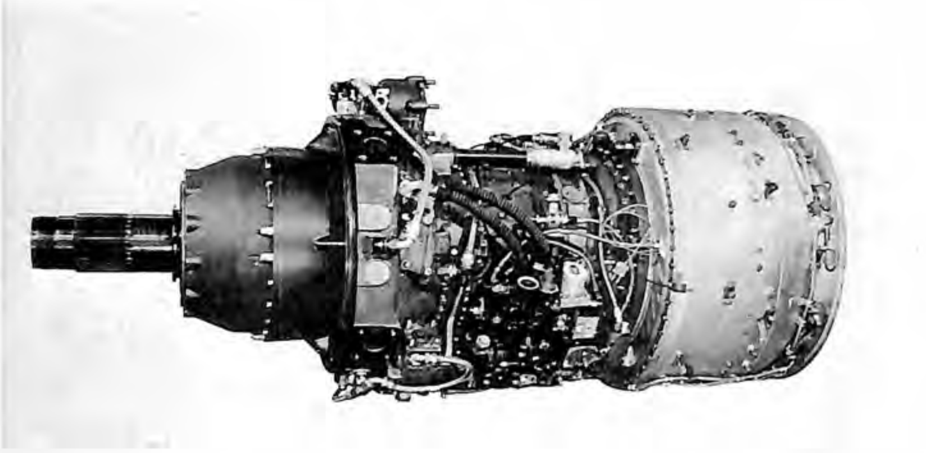
Maintaining the proven T53 design philosophy, the T55 is the more powerful of Avco Lycoming's two families of gas turbine engines. Twin 2,650 shaft horsepower T55's power the Army's battle-tested Boeing-Vertol CH-47A "Chinook" medium transport helicopter. Uprated 2,850 shaft horsepower T55's power the advanced CH-47B "Chinook" and provide it with a 40 percent increase in payload as well as increasing its cruise speed to 155 knots. Current development programs will elevate the basic T55's output to approximately 3,400 shaft horsepower. The engine now has the highest power-to-weight ratio in its class.

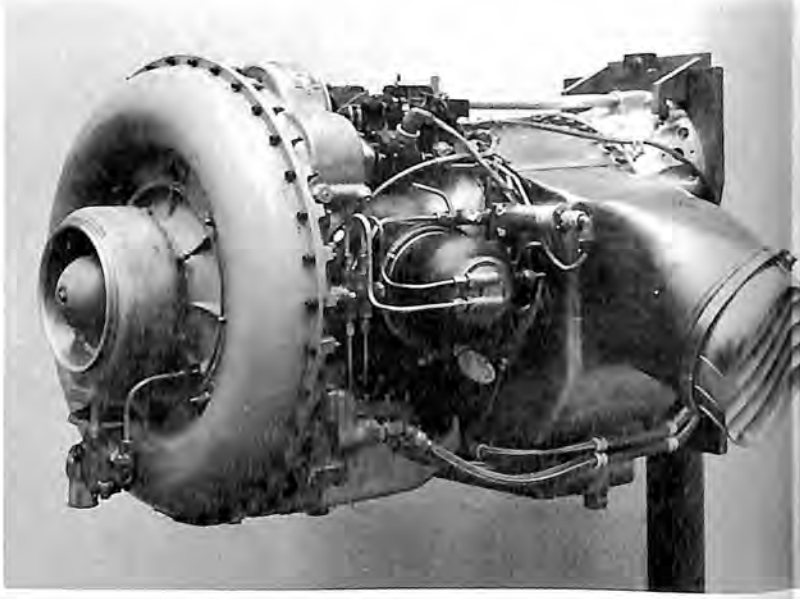
Specifications

Length 44 inches; diameter 24¼ inches; weight 580 pounds; compressor stages 7 axial, 1 centrifugal; pressure ratio 6:1; compressor turbines 1; power turbines 2.

Performance

T55-L-7: 2,650 shaft horsepower; specific fuel consumption .61 pounds per horsepower per hour. T55-L-7C: 2,850 shaft horsepower; specific fuel consumption .60 pounds per horsepower per hour.





T55 TURBOPROP GAS TURBINE ENGINE

Prime Contractor: Avco Corporation, Lycoming Division

Remarks

The turboprop T55 is the powerplant for North American's YAT-28E, which has been under evaluation by both the Navy and Air Force. As a Naval aircraft the YAT-28E would fill a training role. The engine is slated for development up to 3,400 shaft horsepower.

Specifications

Length 62 inches; diameter 24¼ inches; weight 795 pounds; compressor stages 7 axial, 1 centrifugal; pressure ratio 6:1; compressor turbines 1; power turbines 2.

Performance

2,445 shaft horsepower; specific fuel consumption .62 pounds per horsepower per hour.

T50 MILITARY TURBOSHAFT

Prime Contractor: The Boeing Company

Remarks

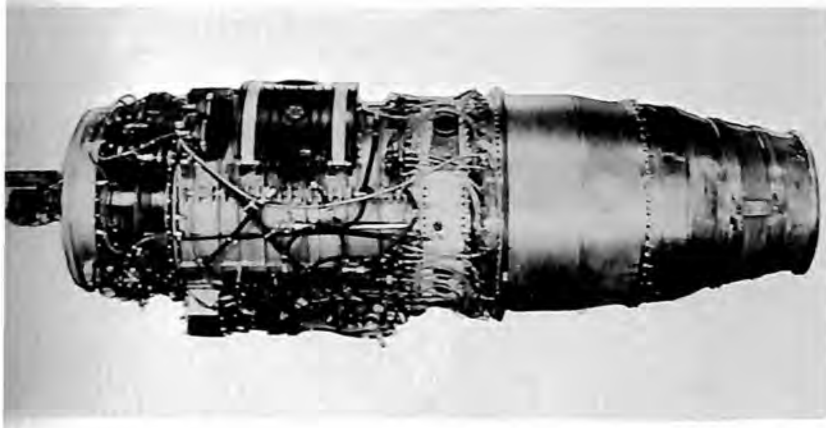
Configurations of the T50 military turboshaft engine power the Navy/Gyrodyne QH-50 series drone anti-submarine helicopters.

Specifications (T50-BO-12)

Length 37.5 inches; diameter 24.0 inches; weight 250 pounds; compression ratio 6.1:1; axial flow 2-shaft engine; compressor 1 axial, 1 centrifugal; turbine stages 2, 1 gas producer, 1 power output.

Performance

Rating 365 shaft horsepower at 60 degrees Fahrenheit seal level (– 12 model); 300 shaft horsepower at 60 degrees Fahrenheit sea level (– 8A model).



J65-W-7 ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

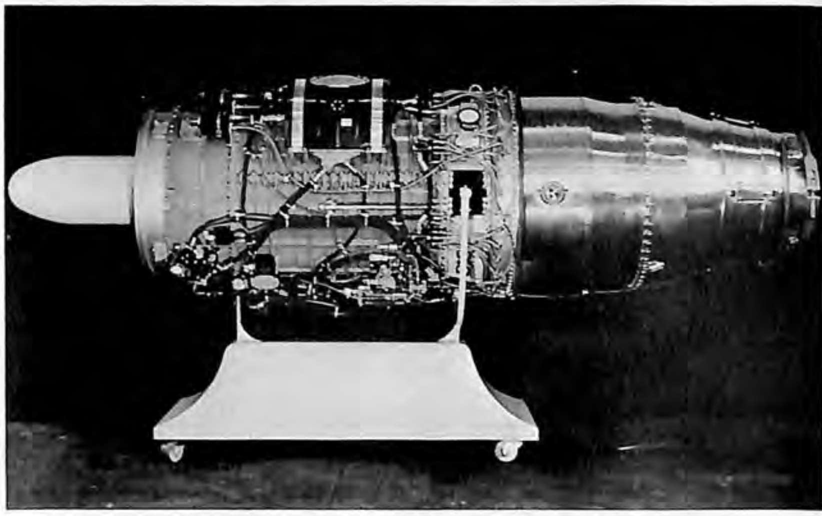
The J65-W-7, used by the military in the F/RF84F aircraft, is a single spool axial flow compressor type jet power plant.

Specifications

Dry weight 2,795 pounds; length 115.0 inches; diameter 37.5 inches; type fuel JP-4.

Performance

Take-off power at sea level 7,800 pounds thrust.



J65-W-16A ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

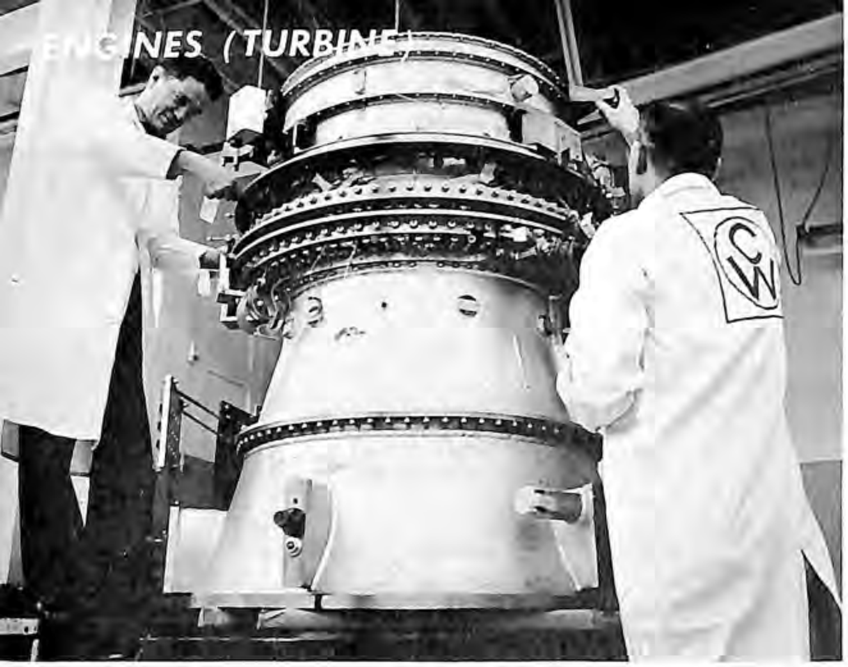
The J65-W-16, used by the military in the A-4A, A-4B, A-4C series aircraft, is a single spool axial flow compressor type jet power plant.

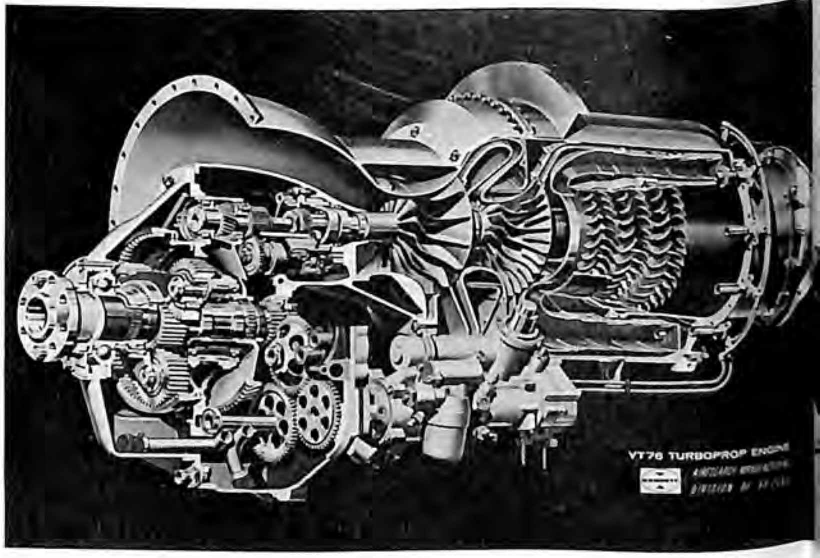
Specifications

Length 108.0 inches; diameter 37.5 inches; weight 2,757 pounds; fuel JP-4.

Performance

Take-off rating at sea level 7,700 pounds thrust.





WTF60 TURBOFAN ENGINE

Prime Contractor: Curtiss-Wright Corporation

Remarks

Called the "building block" for a new generation of gas turbine engines to boost both range and payload of subsonic and supersonic aircraft, the WTF60 is a new experimental gas turbine engine under development for the USAF's Aero Propulsion Laboratory. The basic gas generator can be adapted and used as a turbojet or turbofan engine for cruise and lift/cruise applications. Features of the new WTF60 concept to increase efficiency and performance are transpiration air-cooled turbine blades, a new advanced compressor and vaporizing combustor.

T76 MILITARY TURBOPROP

Prime Contractor: The Garrett Corporation, AiResearch Manufacturing Company of Arizona

Remarks

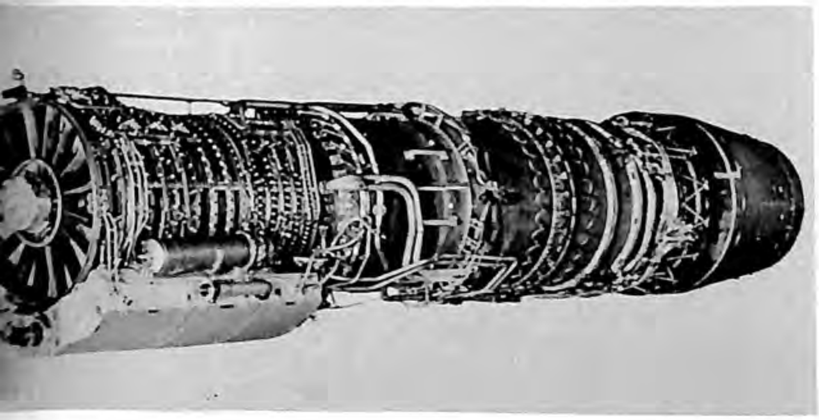
The AiResearch T76 military turboprop engine powers the North American OV-10A (COIN) aircraft. A commercial version designated TPE 331 is in production for Aero Commander's Turbo Commander, the Mitsubishi Mooney MU-2, Volpar Beech 18 modification and the Fairchild and Pilatus Heli-Porter. Among the features of this engine are rapid reverse thrust; 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 27 inches; weight 310 pounds; compressor 2-stage centrifugal; turbine 3-stage axial.

Performance

Rating 715 shaft horsepower (T76); 605 equivalent shaft horsepower (TPE 331). An uprated 700 equivalent shaft horsepower version of the TPE 331 is also being offered.



YJ93 MILITARY TURBOJET

Prime Contractor: General Electric Company

Remarks

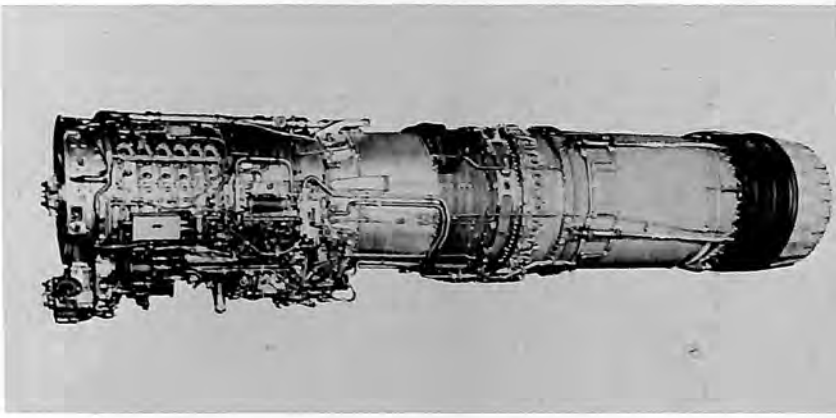
The YJ93 is a Mach 3 engine designed to power the Air Force XB-70 (North American Aviation) at a speed of 2,000 miles per hour above 70,000 feet.

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

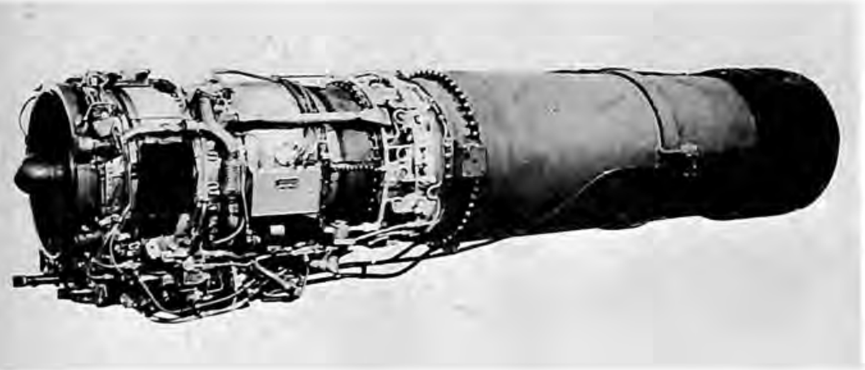
A military turbojet engine, the J79 is widely used on Air Force, Navy and NATO aircraft, including the Lockheed F-104, Convair B-58, North American RA-5C and the McDonnell Phantom. Current production models are the J79-10 and J-79-17.

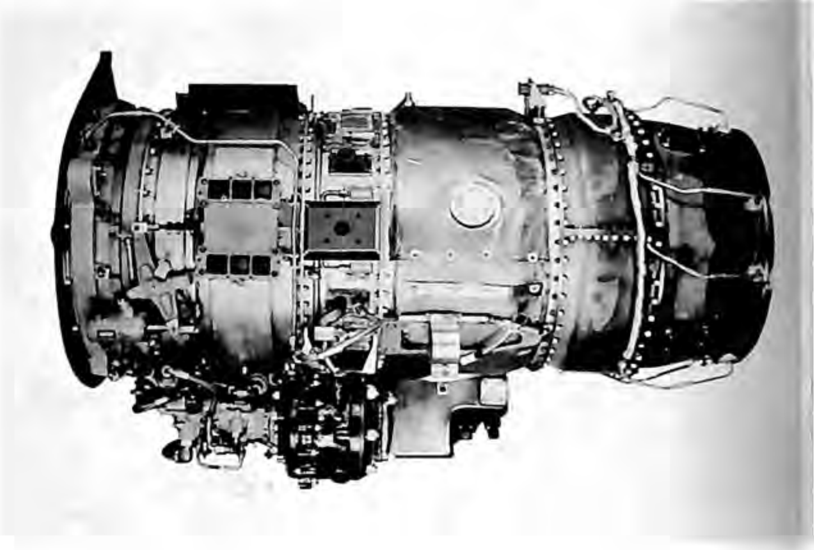
Specifications

Length 208.69 inches; diameter 39.6 inches; weight 3,800 pounds; compressor stages 17; turbine stages 3.

Performance

Thrust with afterburner 17,900 pounds.





J85 MILITARY AFTERBURNING TURBOJET

Prime Contractor: General Electric Company

Remarks

Power plant for high performance aircraft and air breathing missiles, the J85 turbojet is available in both afterburning and non-afterburning configurations. It has the highest power-to-weight ratio of any production engine in its class in the free world. This engine provides power for Northrop's F-5 and T-38A and Fiat's G91Y. An advanced version, with 5,000 pounds of thrust, is designated J85/J1A.

Specifications (J85-5, -13, -15)

Length 108.9 inches; flange diameter 21 inches; compressor stages 8; turbine stress 2; weight -5 584 pounds, -13 597 pounds, -15 615 pounds; thrust/weight ratio, -5 6.59:1, -13 6.67:1, -15 7:1.

Performance

Maximum thrust -5 3,850 pounds; -13 4,080 pounds; -15 4,300 pounds.

J85 NON-AFTERBURNING TURBOJET

Prime Contractor: General Electric Company

Remarks

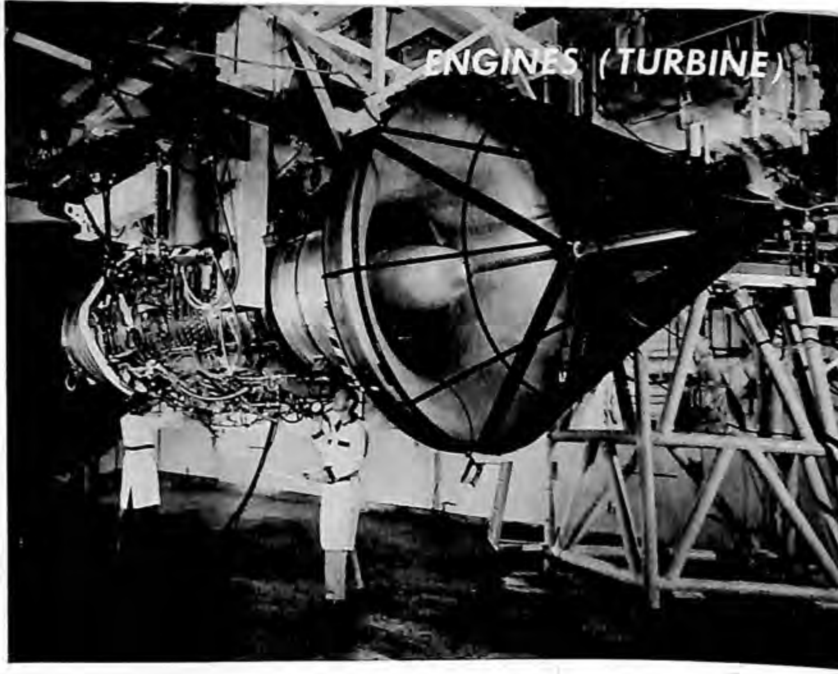
The dry J85 turbojet is a derivative of the J85 afterburning engine. The compact, lightweight design makes it an ideal powerplant for transports, trainers, fighters, VTOL aircraft, missiles and take-off boost applications. This engine provides power for Lockheed's XV-4B, Canadair CT-114, Cessna AT-37D, McDonnell GAM-72, GE/Ryan XV-5A, Bell X-14A, Fairchild-Hiller's C-123K and C119, and the Martin SP-5B. A VTOL version (YJ-19) rated at 3,015 pounds thrust with a 7.8:1 thrust/weight ratio is being qualified.

Specifications (J85-17)

Weight 398 pounds; thrust-to-weight ratio 7.16:1; length 45.5 inches; diameter 17.7 inches; compressor stages 8; turbine stages 2.

Performance

Maximum thrust 2,850 pounds.



TF39 MILITARY TURBOFAN

Prime Contractor: General Electric Company

Remarks

The TF39 is a high bypass ratio turbofan designed to power the Air Force C-5A (Lockheed) heavy logistics transport over exceptionally long distances. Engine parts are designed for unusually long life.

Specifications

Length 189.5 inches; maximum diameter 100 inches; thrust to weight ratio is 5.5 plus; by-pass ratio is in the 8:1 class; pressure ratio at cruise altitude is in the 25:1 class.

Performance

Maximum thrust is 41,100 pounds.

GE4/J5 COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

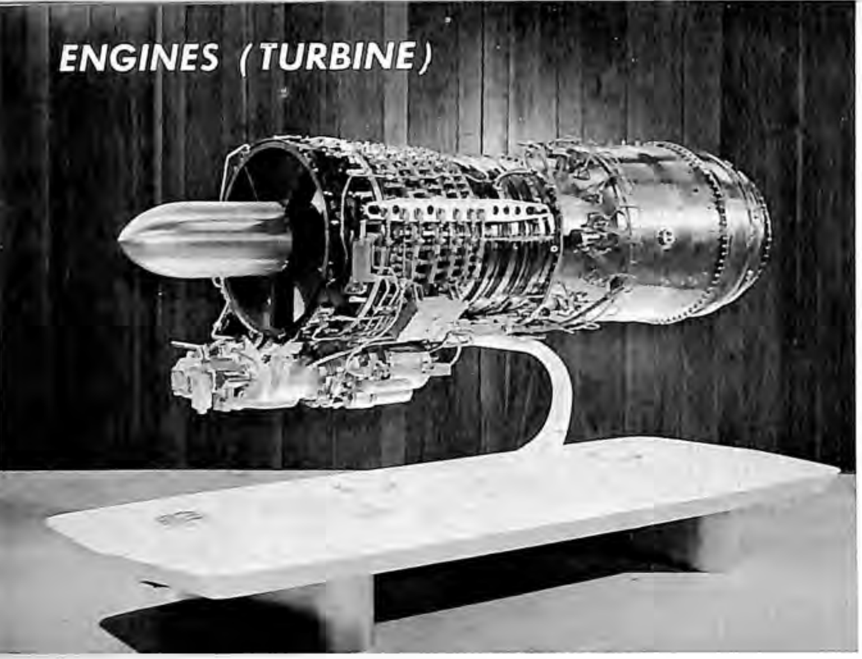
The GE4/J5 is a supersonic transport engine incorporating design features of the J79 and YJ93 engines and advanced technology. Full-scale engine testing began in mid-1966.

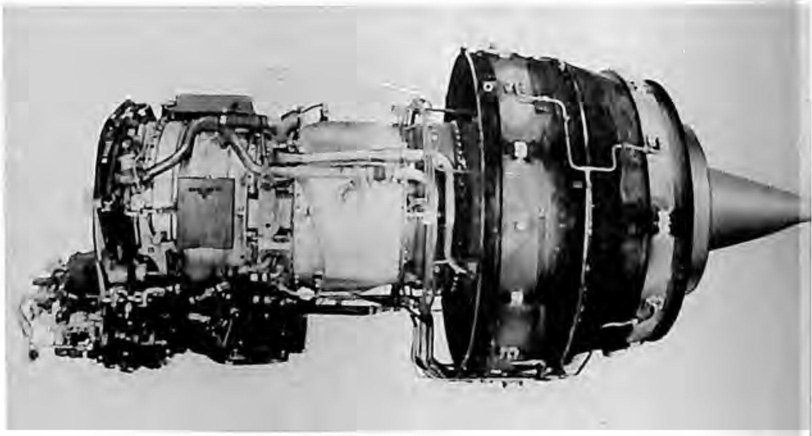
Specifications (Preliminary)

Length 25 feet; maximum diameter 6 feet; weight (for Mach 2.7) 10,300 pounds.

Performance

Thrust class 60,000 pounds.





GE1 MILITARY/COMMERCIAL TURBOJET

Prime Contractor: General Electric Company

Remarks

The GE1 Building Block approach provides for one gas generator as the basis of a family of advanced propulsion systems. Buidling Block components—turbofans, afterburners, thrust vectoring devices—are added to the GE1 gas generator to provide performance and configurations tailored to specific aircraft missions and designs. The GE1 features application versatility, time and cost savings and hardware standardization.

Specifications

The GE1 compared with the earlier J47 engine represents a 51 percent reduction in length, 79 per cent reduction in volume plus reduced weight and fuel consumption.

Performance

The GE1 is in the same thrust class as the J47 and has a versatility of thrust size spanning a range of almost 6 times the basic gas generator thrust.

CF700 COMMERCIAL TURBOFAN

Prime Contractor: General Electric Company

Remarks

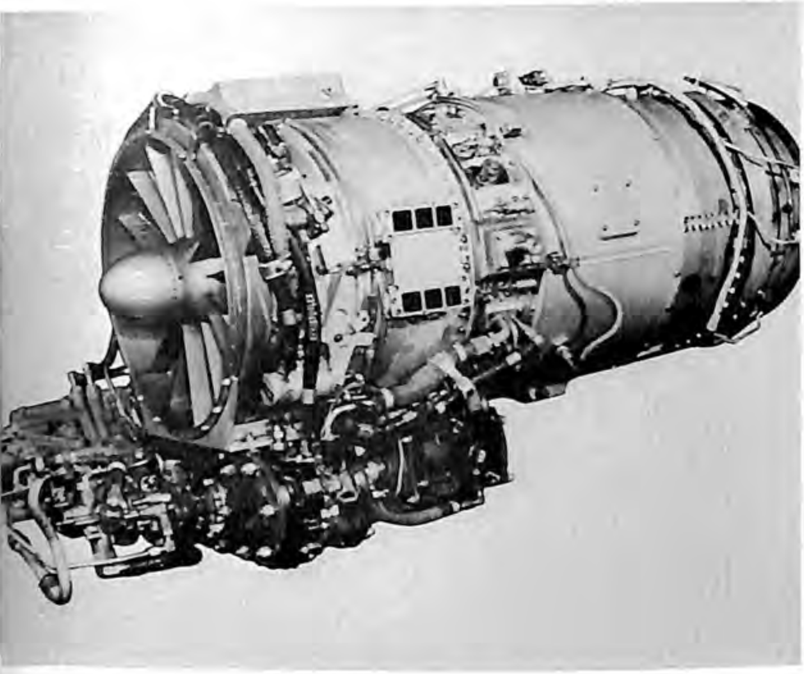
An aft fan version of the J85/CJ610 turbojet family, the CF700 is now being produced in volume for commercial aircraft. Applications include the Dassault Mystere 20/Fan Jet 10 passenger business jet aircraft. It is also used in the Bell lunar landing research vehicle to equalize the forces of gravity and rockets for pilot control movements.

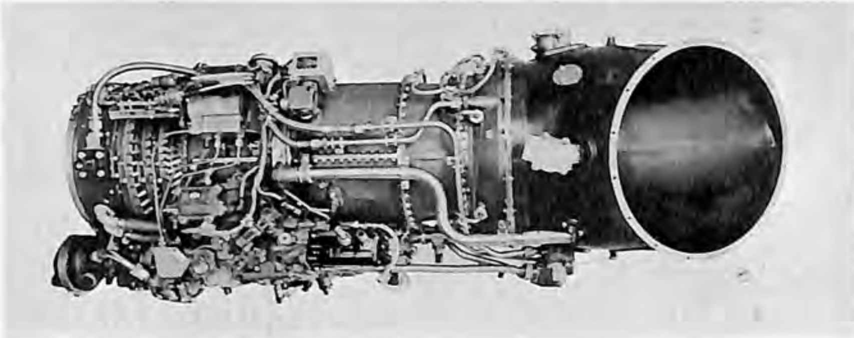
Specifications

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 4,125 pounds; maximum continuous thrust 4,000 pounds.





CJ610 COMMERCIAL TURBOJET

Prime Contractor: General Electric Comapny

Remarks

The CJ610 is a derivative of the J85 turbojet and is available in 4 configurations. Twin CJ610 engines power the Aero Commander Jet 1121, HFB 320 Hansa and the Lear Jet business aircraft.

Specifications (CJ610-6)

Length 51.1 inches; flange diameter 17.7 inches; weight 339 pounds; thrust to weight ratio 7.14:1; compressor stages 8; turbine stages 2.

Performance

Take-off thrust 2,950 pounds.

T58 MILITARY TURBOSHAFT

Prime Contractor: General Electric Company

Remarks

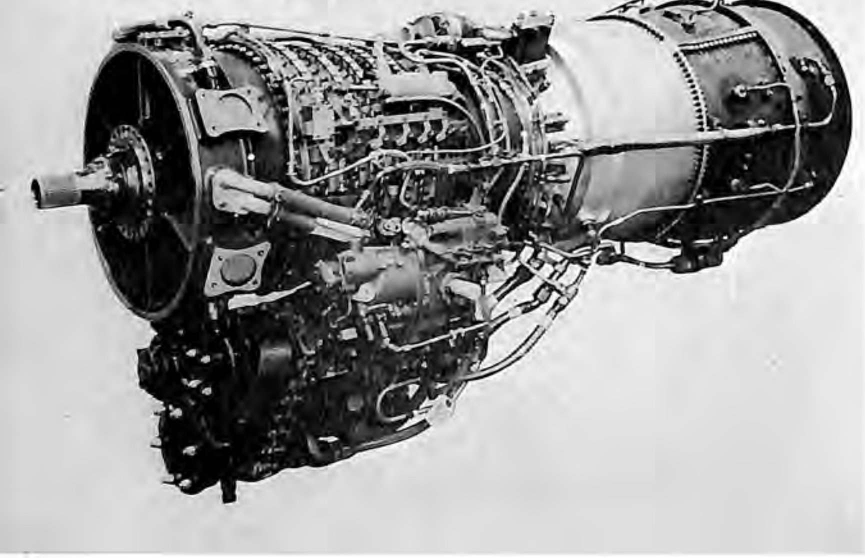
There are in production several configurations of the T58 turboshaft engine, powerplant for a wide variety of helicopters and VTOL aircraft. Applications include Sikorsky SH-3A/D, Kaman UH-2A/B, Boeing-Vertol CH-46A/D, Sikorsky HH-52A, Sikorsky CH-3C/E, Sikorsky HH-3E, Bell UH-1F, Piasecki 16-H-1A, Kaman UH-2C, Agusta Bell 204-B and Bell X-22A. A higher rated version of engine is under development.

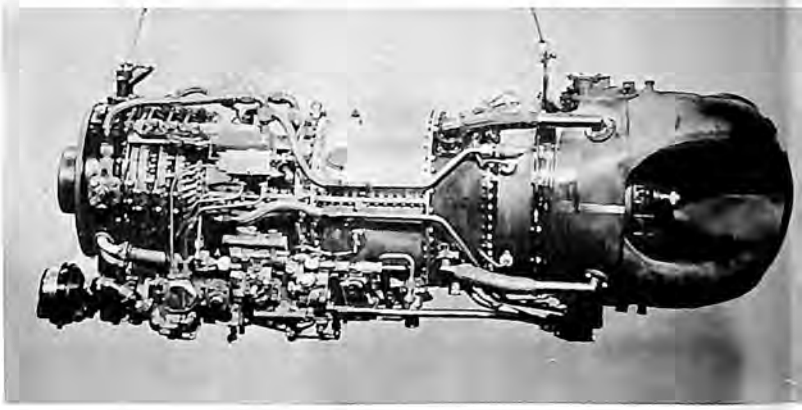
Specifications

Length 59 inches; maximum width 21 inches; weight 335 pounds; compressor stages 10; turbine stages 3.

Performance

Maximum shaft horsepower 1,500.





T64 MILITARY TURBOSHAFT/TURBOPROP

Prime Contractor: General Electric Company

Remarks

The T64 is a free turbine power plant for helicopter and V/STOL aircraft. The basic engine is designated T64-6. With a single reduction gearbox added it is the T64-2. Addition of a planetary reduction gear creates the turboprop configuration with the T64-4 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 CH53A, Vought/Hiller/Ryan XC-142A, Hughes XV-9A, Fiat G-222, Kawasaki GK-210 and Shin Meiwa PX-S. A flat rated 3,400 horsepower growth version is under development for use on the Lockheed AH56A (AAFSS) Escort Helicopter

Specifications (T64-6)

Length 62 inches; maximum height 30 inches; horsepower/weight ratio 4:1; compressor stages 14; turbine stages 4, weight 723 pounds.

Performance

Maximum shaft horsepower 2,850.

CT58 COMMERCIAL TURBOSHAFT

Prime Contractor: General Electric Company

Remarks

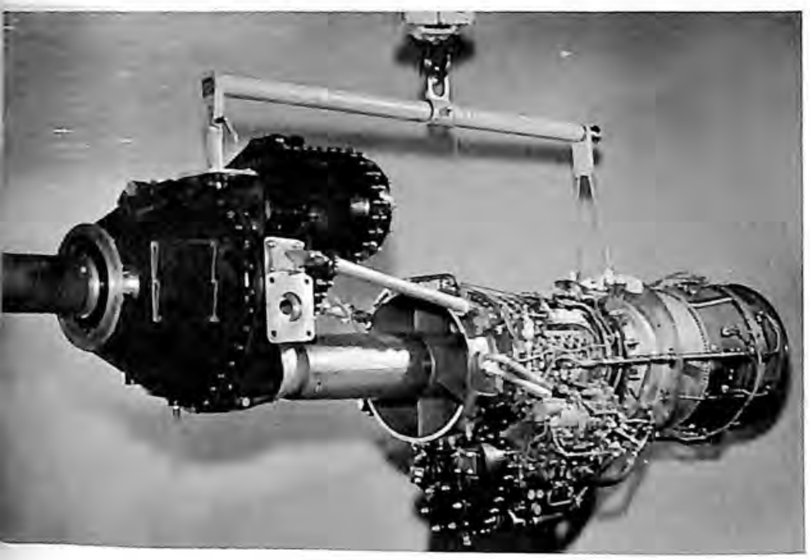
The CT58-110 configuration, serving a variety of helicopter applications, has been succeeded by the higher rated CT58-140, which began production in 1965. Modification of the -110 engines to the higher power rating is accomplished through kit conversion. Applications include the Boeing-Vertol 107 and the Sikorsky S-61 and S-62.

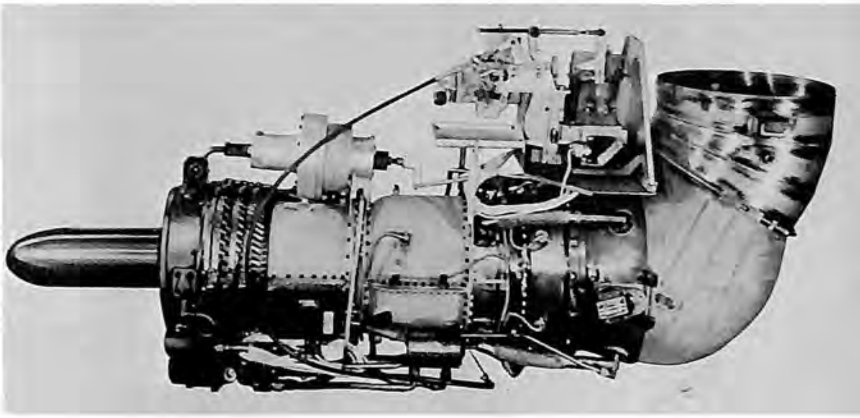
Specifications

Length 59 inches; maximum width 21 inches; weight 340 pounds (CT58-140)

Performance

Take-off rating 1,400 horsepower (CT58-140); 1,250 horsepower (CT58-110)





CT64 COMMERCIAL TURBOSHAFT/TURBOPROP

Prime Contractor: General Electric Company

Remarks

Configurations of the T64 commercial turboshaft/turboprop are in production and certified for civil use. The CT64-410-1, and CT64-810-1 are turboprop engines and the CT64-610-1 is a direct drive powerplant.

Specifications (CT64-810-1 Turboprop)

Length 112.9 inches; maximum height 46 inches; weight 1,167 pounds; compressor stages 14; turbine stages 4.

Performance

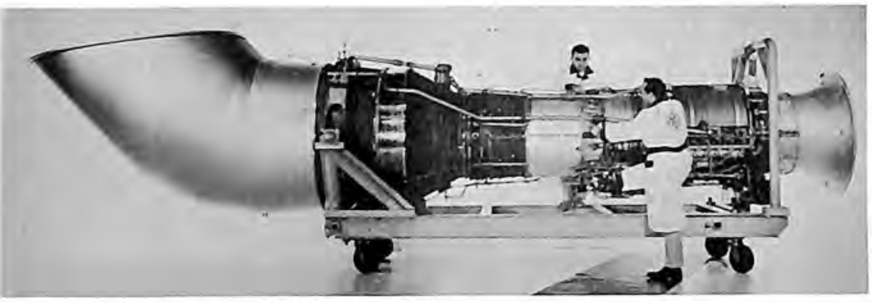
Maximum equivalent shaft horsepower 2,850.

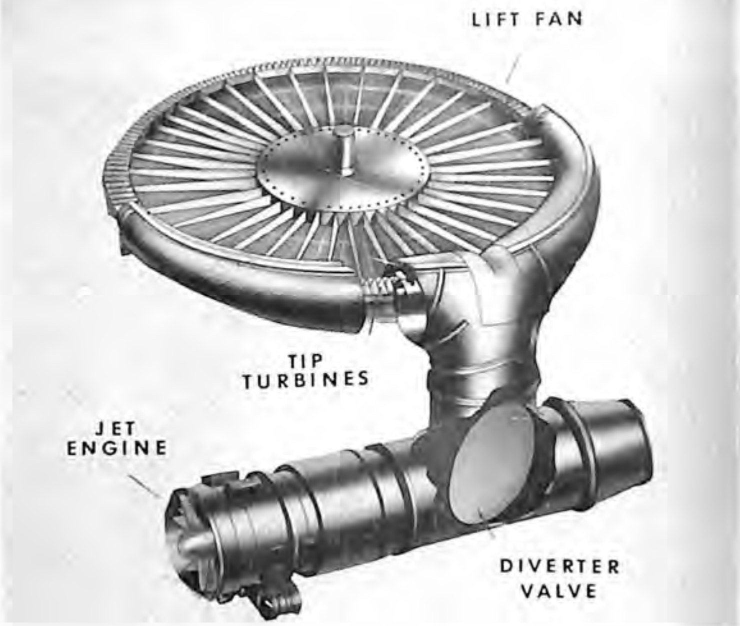
LM100 GAS TURBINE

Prime Contractor: General Electric Company

Remarks

Derived from the T58 aircraft engine, the turboshaft LM100 is a jet engine for marine and industrial uses, developing up to 3 horsepower per pounds 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. Main propulsion system for the Victoria also powers 100-ton capacity ore hauling truck and most important, the SK-5 air cushion vehicle. 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.





LM1500 GAS TURBINE

Prime Contractor: General Electric Company

Remarks

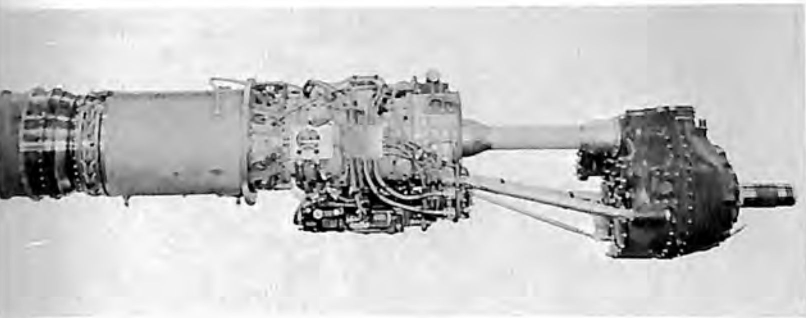
Available as a shaft power engine or a gas generator, the LM1500 is derived from the J79 aircraft engine. It supplies main propulsion for the Maritime Administration's 60-knot H. S. Denison hydrofoil, powers the Navy's 320-ton hydrofoil ship U.S.S. Plainview.

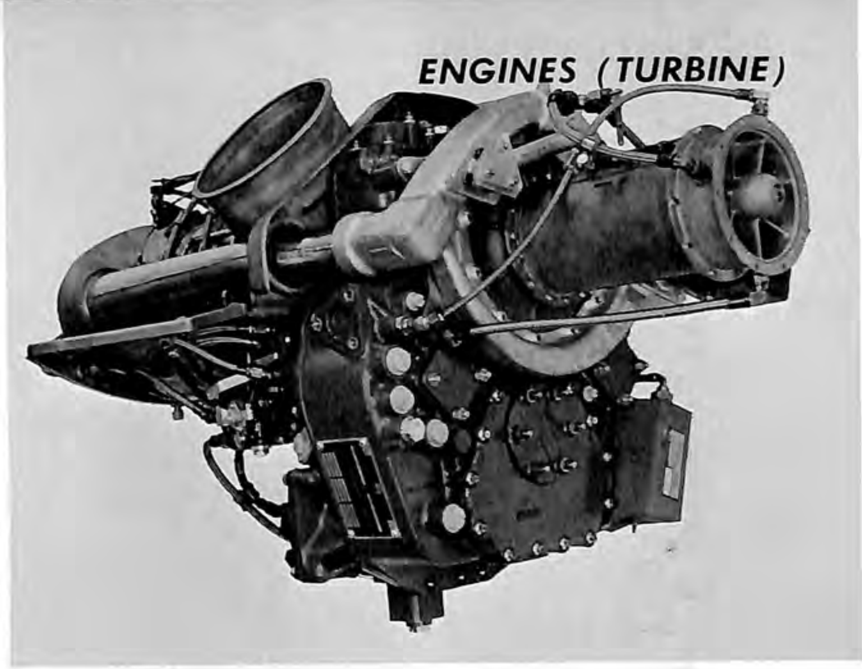
LF1 "TURBOTIP" LIFT FAN SYSTEM

Prime Contractor: General Electric Company

Remarks

A convertible "Turbotip" propulsion system, the LF1 is designed to power highspeed vertical take-off and landing aircraft. The "Turbotip" fan system consists of 2 wing-mounted lift fans and a nose fan to control pitch of the aircraft. The lift fans installed in the XV-5A Army VTOL research aircraft nearly triple the gas generator thrust of the twin J85 power plants.





501-D13D COMMERCIAL TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

The 501-D13D is the powerplant for the Convair 580 operating with 5 airlines, 14 corporations, the Federal Aviation Agency, U. S. Air Force and Royal Canadian Air Force. A similar engine powers the Lockheed Electra.

Specifications

Length 145 inches; width 30 inches; height 43 inches; weight 1,756 pounds; compression ratio 9.25:1; compressor stages 14; turbine stages 4.

Performance

Rating 3,750 shaft horsepower.

250-C18 COMMERCIAL TURBOSHAFT

Prime Contractor: Allison Division of General Motors

Remarks

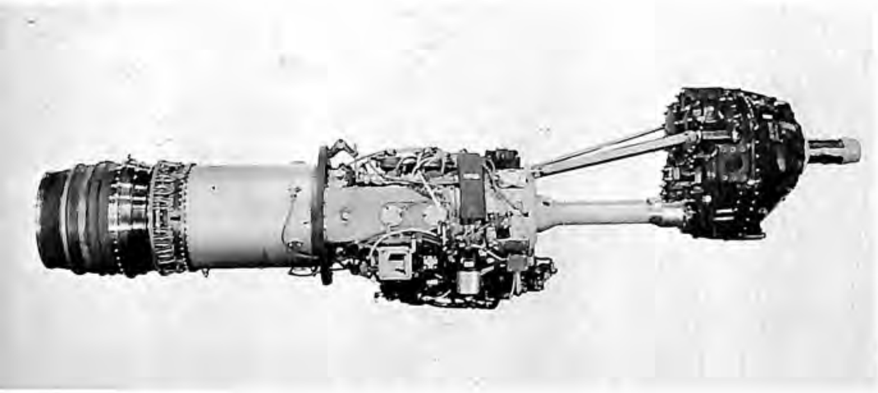
Model 250 powers the Hiller FH-1100 and Hughes 500 light helicopters.

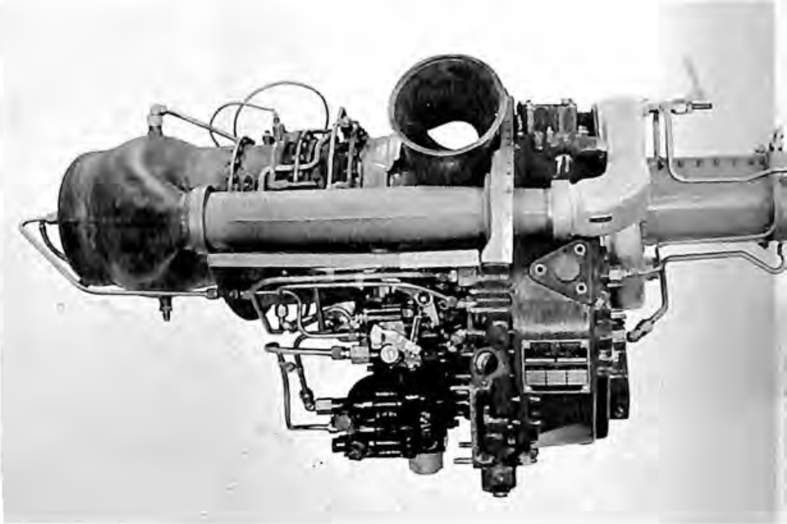
Specifications

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 100, 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

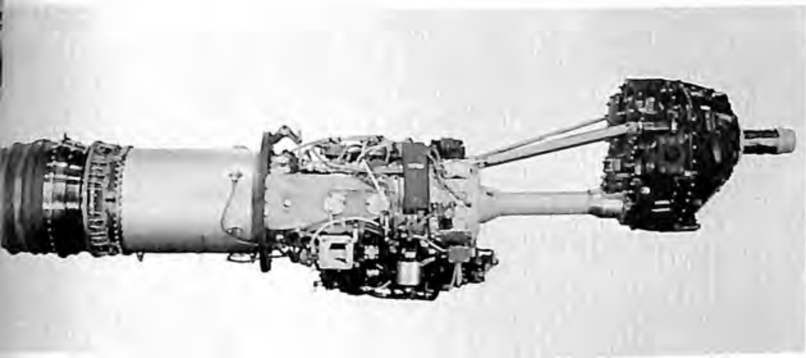
The T63-A-5A powers the Army OH-6A light observation helicopter.

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

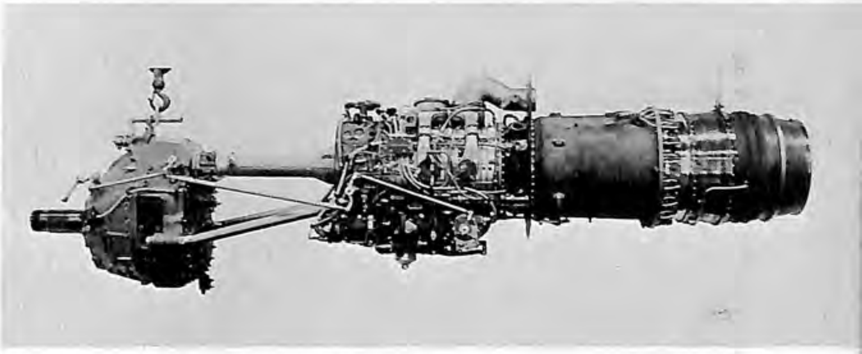
The T56-A-7 is a military engine operational in various versions of the Lockheed C-130 Hercules serving the Air Force, Coast Guard, Marine Corps, Military Air Transport Service and the Navy, as well as governments of 11 foreign nations. T56-A-8 is used in the Grumman E2A and C2A aircraft.

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-14 MILITARY TURBOPROP

Prime Contractor: Allison Division of General Motors

Remarks

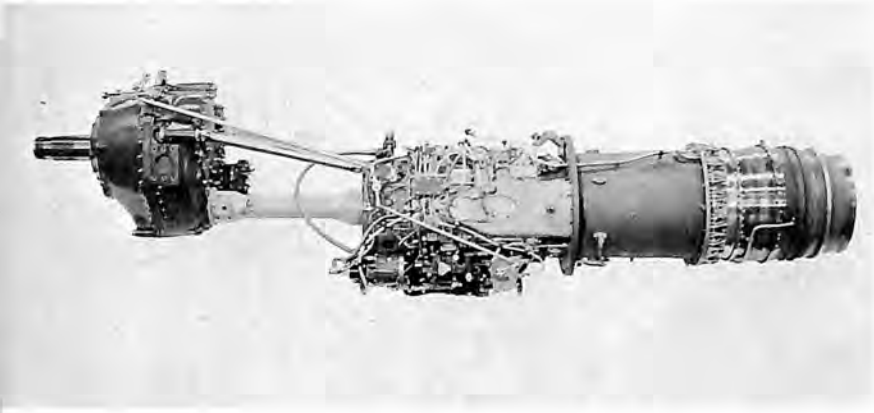
The T56-A-14 is a follow-on military engine for the Lockheed P3 antisubmarine warfare plane.

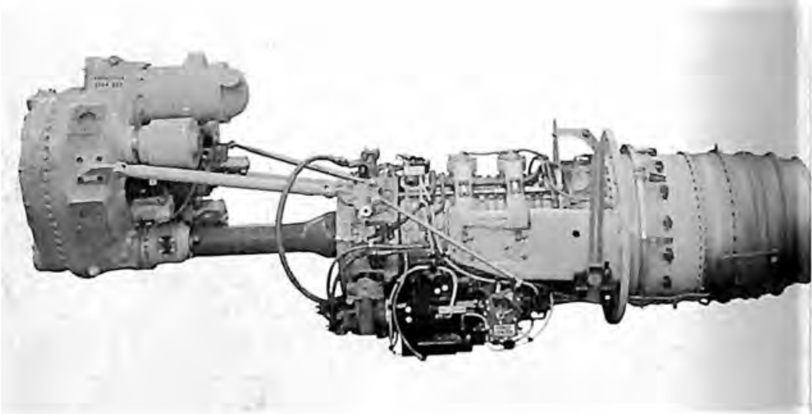
Specifications

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

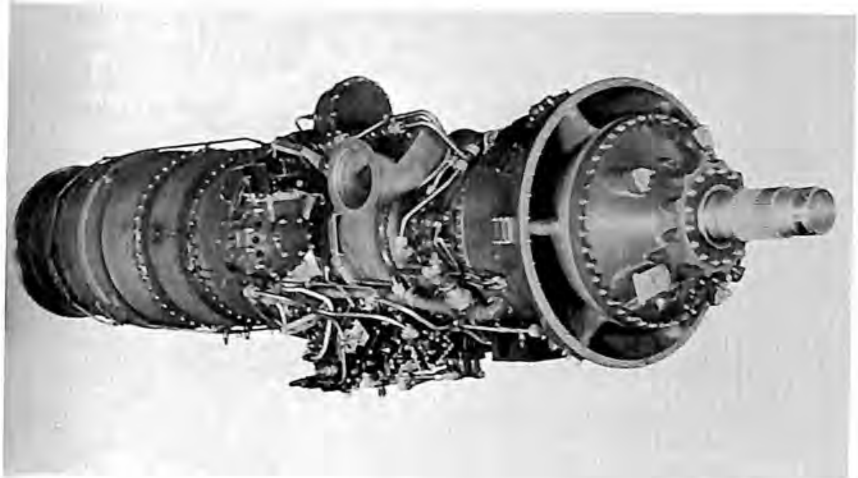
A growth version of the T56 engine, T56-A-18 is being developed for Navy use.

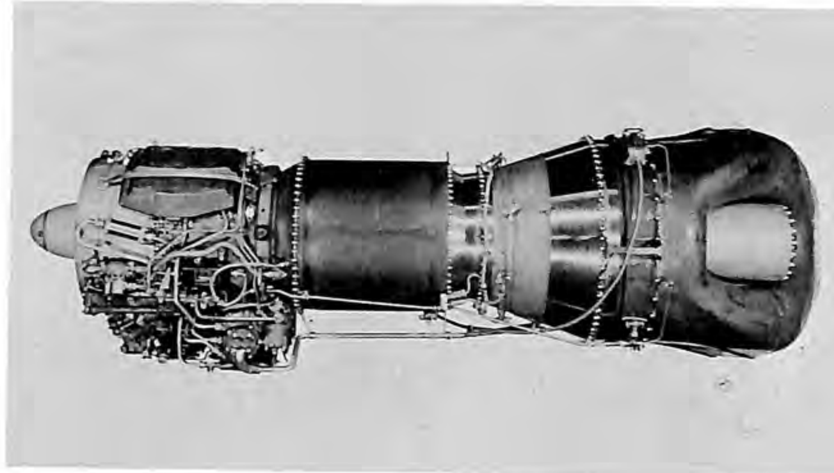
Specifications

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.





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

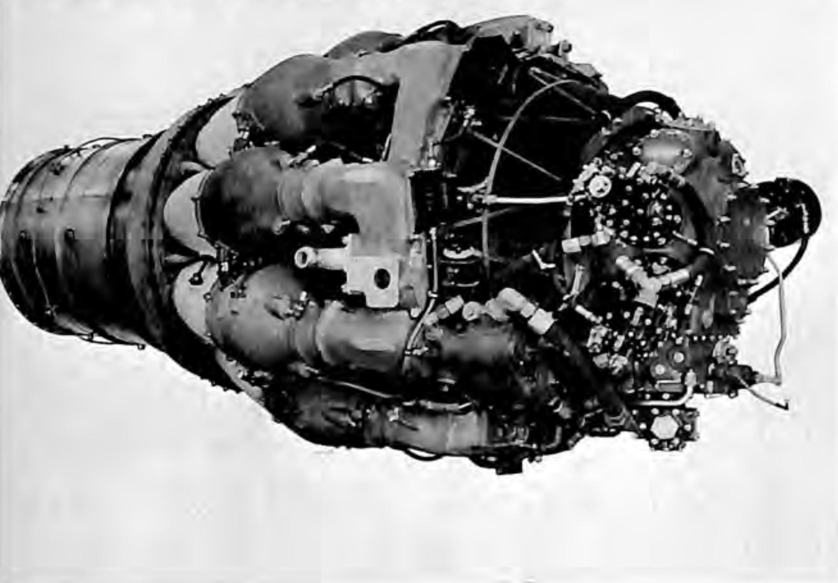
A turboshaft adaptation of the JT12 engine, the JFTD12 has a 2-stage free turbine added in the rear. Two of these engines power the Sikorsky S-64 Skycrane, an all-purpose heavy-lift transport helicopter.

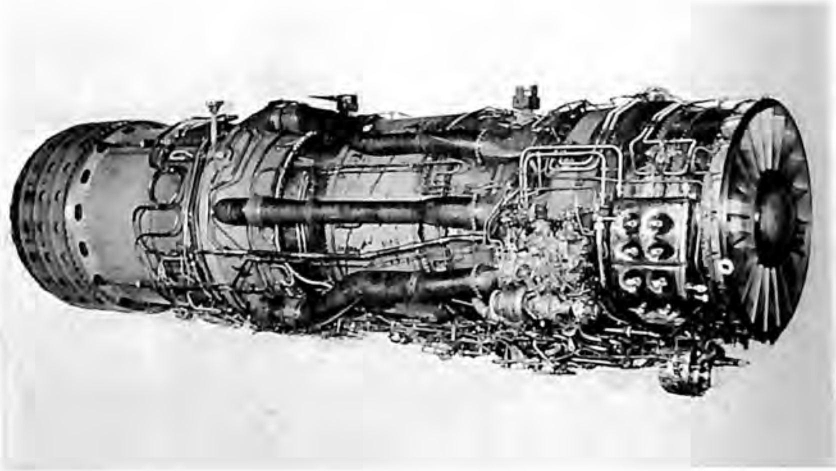
Specifications

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

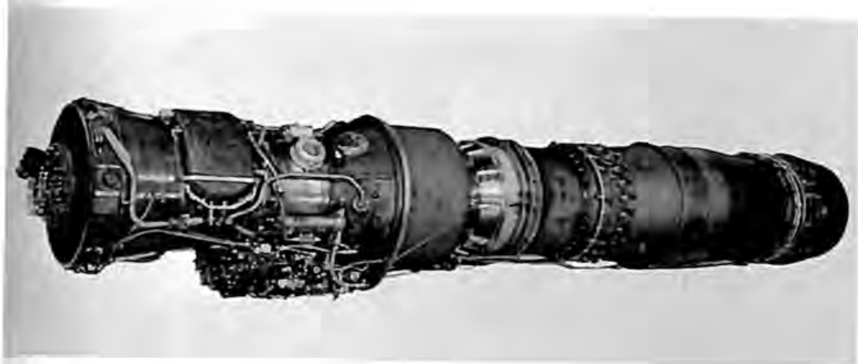
The J58 powers the twin-engine Mach 3 Lockheed YF-12A interceptor and the SR-71 strategic reconnaissance aircraft.

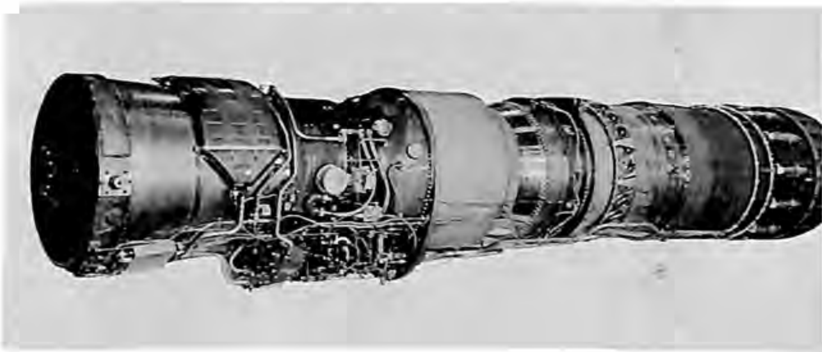
Specifications

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 38,000,000 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

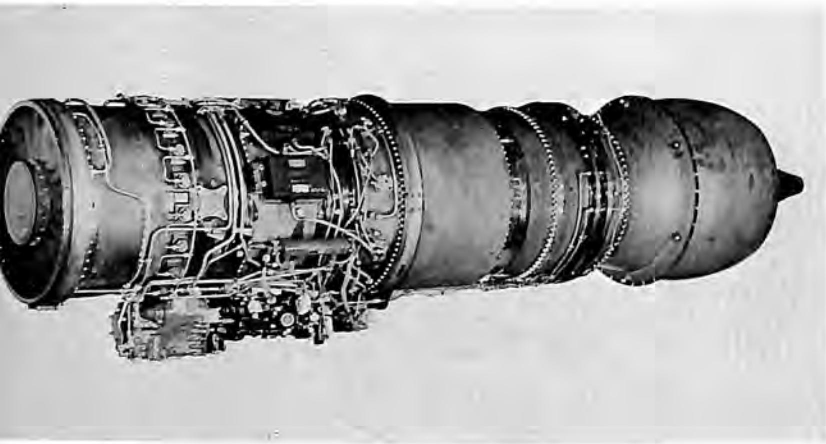
Design work on the J75 (JT4 commercial) began in 1952. To design an engine with 50 per cent more output but only slightly larger than the similar J57 (JT3) at the time, engineers took the advanced step of increasing the hub to tip ratio. This essentially reduced the diameter of the hub which reduced 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.

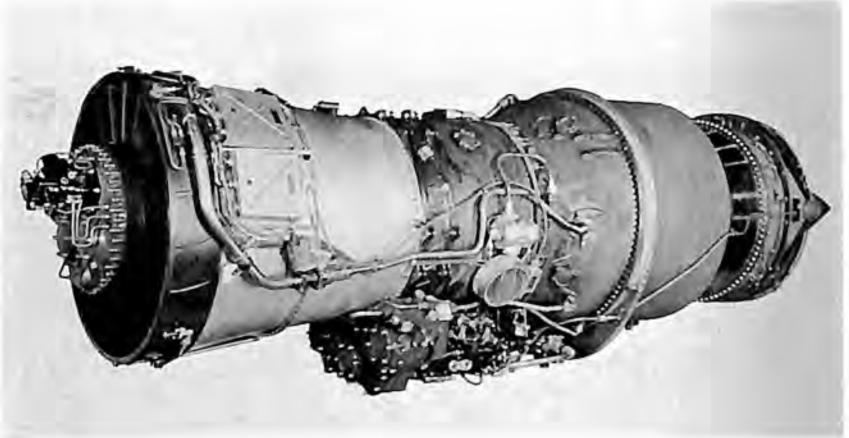
Specifications

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-4F Skyhawk and TA-4E, the Grumman A-6A and the North American Hound Dog missile.

Specifications

Length 116.9 inches; diameter 30.15 inches; compression ratio 12; weight (P-8A) 2,118 pounds; axial flow, dual rotor; compressor stages 12; turbine stages 2.

Performance

Thrust (P-8A) 9,300 pounds.

JT3 COMMERCIAL TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

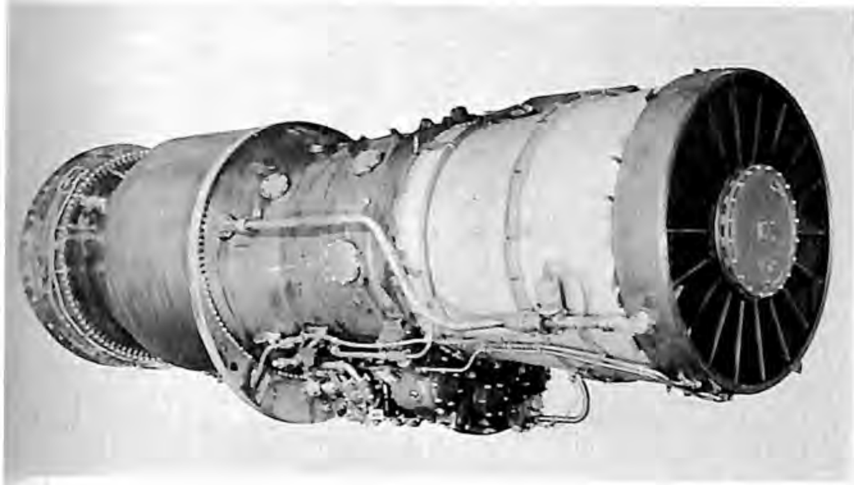
On October 26, 1958, the JT3 Turbo Wasp ushered in the American commercial jet age. A commercial version of the J57, this engine was produced from 1958 to 1961. Configurations are in wide service on the Boeing 707-120 and 720, and the Douglas DC-8-10.

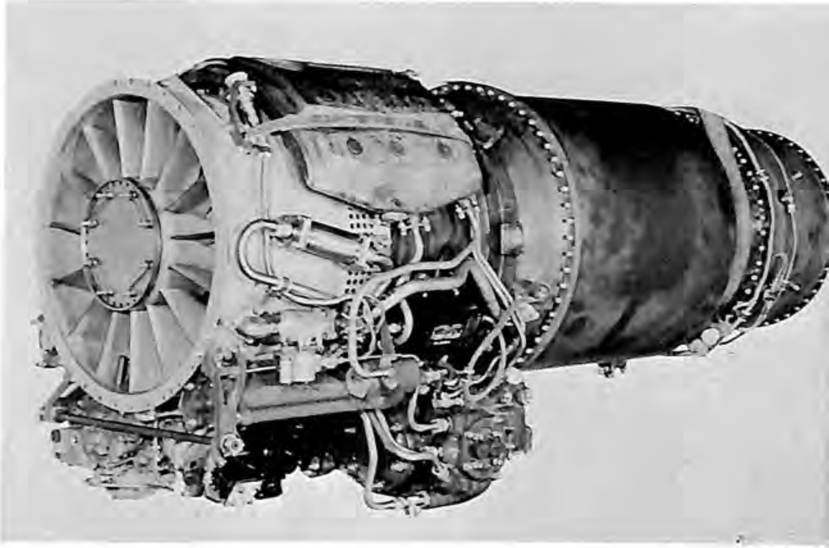
Specifications (JT3C-6)

Length 138 inches; diameter 38.8 inches; weight 4,234 pounds; compression ratio 13; axial flow, dual rotor; compressor stages 16; turbine stages 3.

Performance

Thrust 13,500 pounds with water injection.





JT4 COMMERCIAL TURBOJET

Prime Contractor: Pratt & Whitney Aircraft

Remarks

A larger, advanced configuration of the JT3, the JT4 (military version J75) is used in the long-distance Boeing 707-320 and Douglas DC-8-20, -30 airliners. Built between 1959 and 1961, it 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

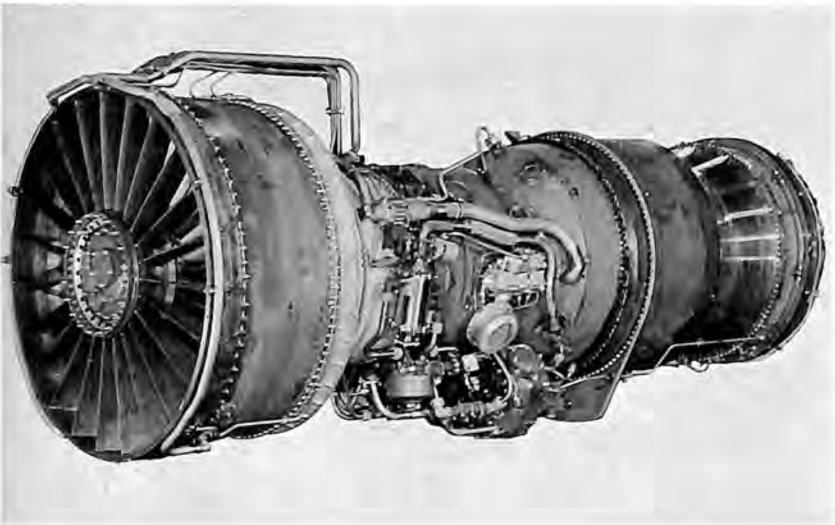
The JT12A-6A (military designation J60), smallest in the company's jet engine family, powers the 4-engine Lockheed JetStar and twin-engine North American Sabreliner business aircraft.

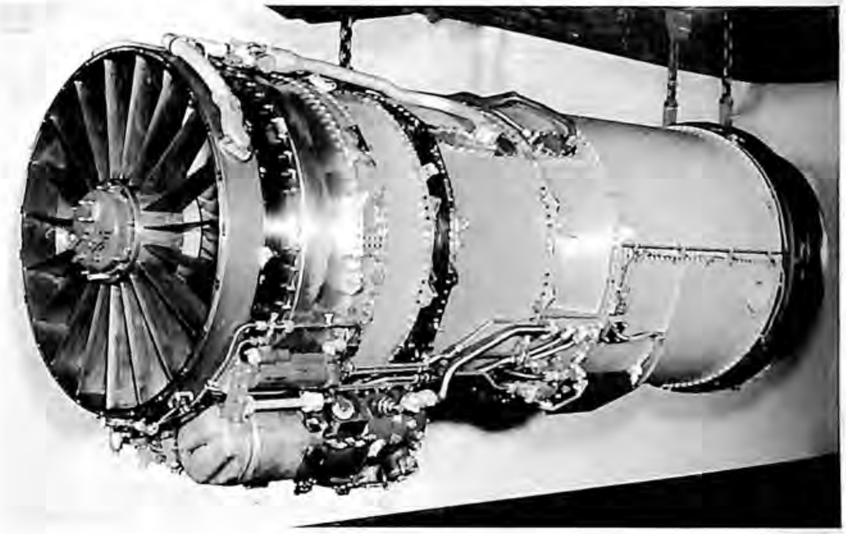
Specifications (JT-12)

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, DC-8F, and the Super Sixty series. The most advanced model is scheduled as powerplant for Lockheed's projected L300B, 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 Aircraft

Remarks

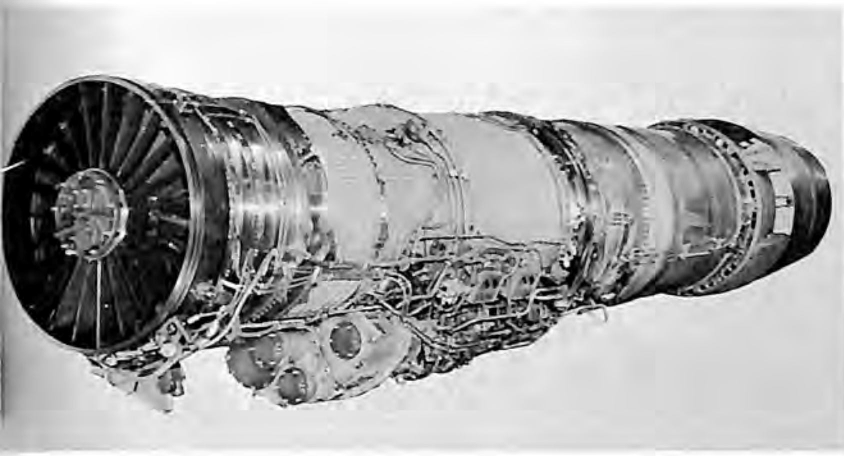
The company-financed JT8D was designed and developed from the outset for application to short and medium range aircraft. Approximately a year and a half after entering commercial service, it reached a time between overhaul (TBO) of 3,200 hours. The JT8D turbofan engine powers the Boeing 727 and 737, the twin-engine Douglas DC-9 and the Sud Aviation Super Caravelle 10B, 10R, and 11R.

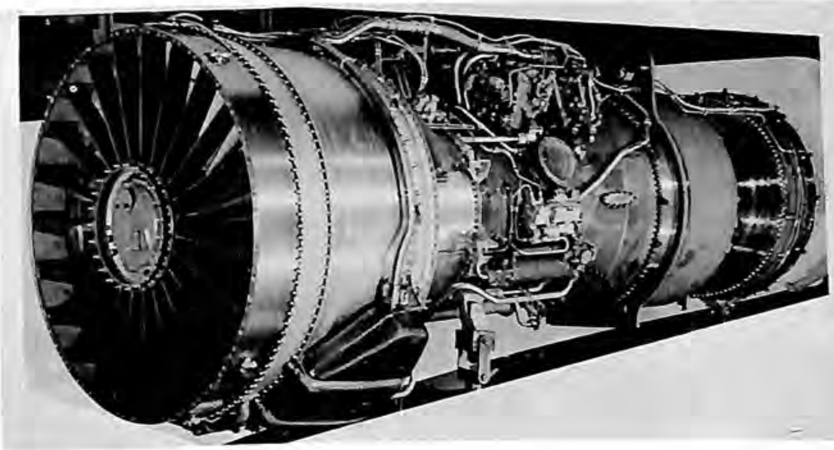
Specifications

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

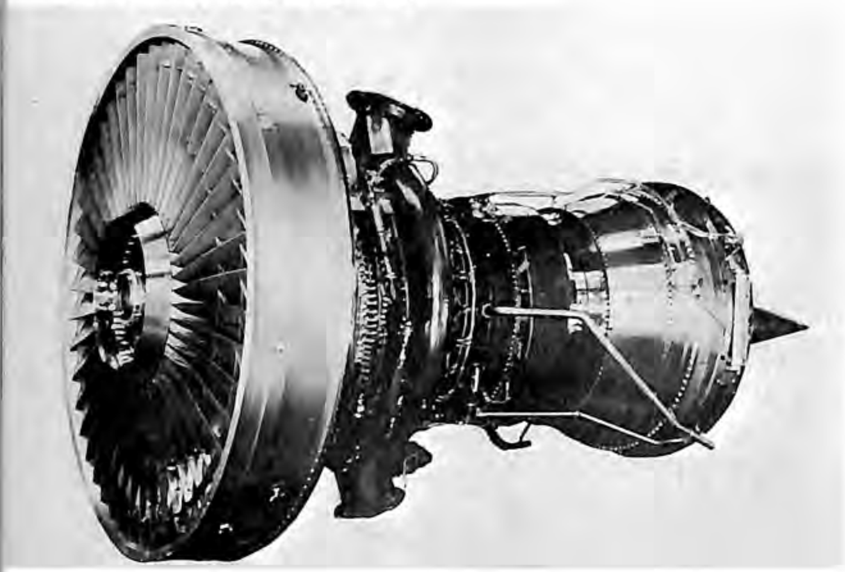
Configurations of the TF33-P-3 (JT3D-1 in the commercial version) power the Boeing B-52H missile platform bomber, the C-135B and KC-135B, as well as the Lockheed C-141A.

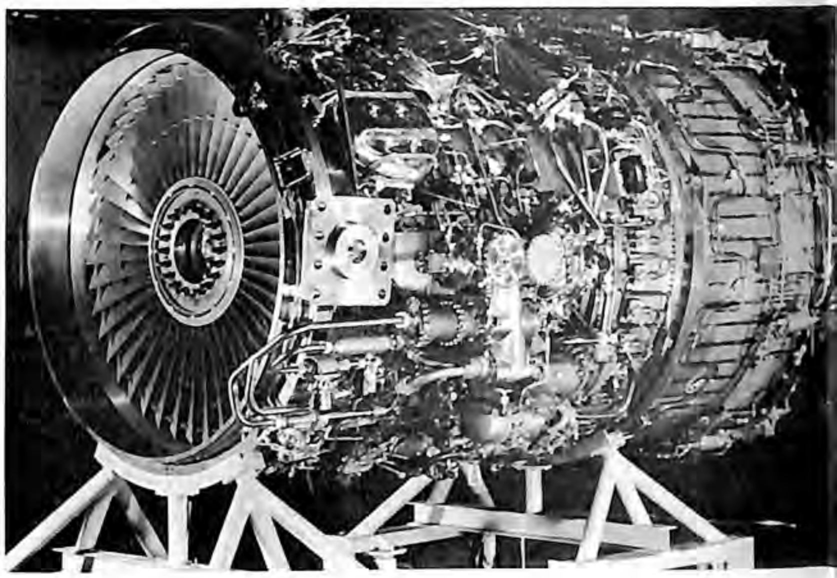
Specifications (TF33-P-3)

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.





JT9D COMMERCIAL TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

The JT9D, powerplant for the Boeing 747, utilizes advanced cycle and design concepts which have been under development for 6 years. Despite its size, with an 8-foot inlet, the JT9D is quieter than current jet engines and is only 125 inches long—9 inches shorter than the JT3D. Each of the twin rotors is supported on only 2 bearings. The JT9D uses a rotary spinner to improve air flow conditions and has a plug nozzle in the exhaust section. The turbine section is air-cooled and has a take-off inlet temperature of 2,045 degrees Fahrenheit.

Specifications

Length 125 inches; diameter 95.7 inches; compression ratio 20.9; weight 8, 580 pounds; axial flow dual rotor; compressor stages 15, including fan; turbine stages 6.

Performance

Thrust 41,000 pounds.

JTF17 COMMERCIAL TURBOFAN

Prime Contractor: Pratt & Whitney Aircraft

Remarks

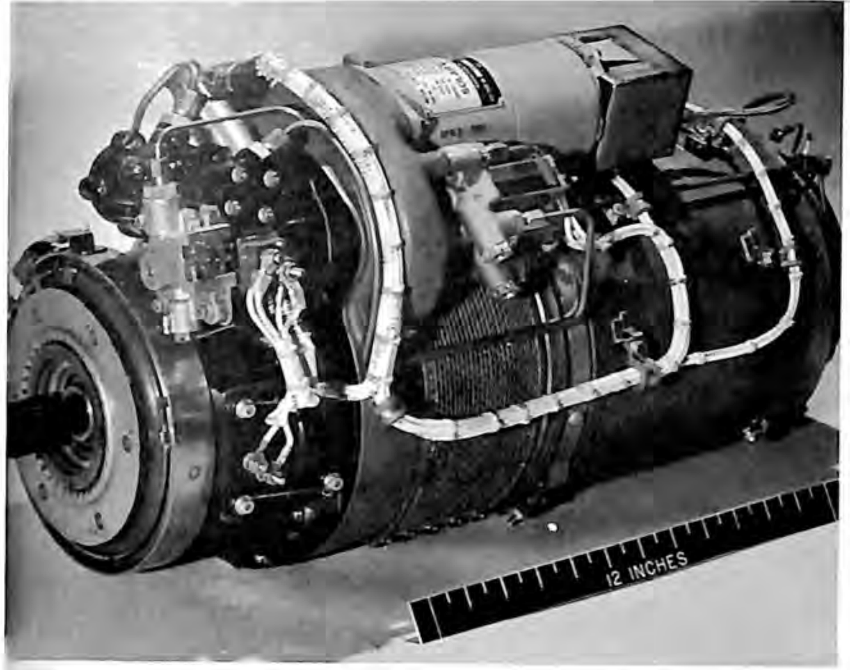
This turbofan, designed for the Mach 2.7 supersonic transport under the FAA program, was developed at the company's Florida Research and Development Center. It has a duct heater with a ram induction burner system. This concept provides improved payload and range characteristics, operational versatility, and less engine noise. Accompanying photograph of uncased engine does not include the rear-end blow-in door suppressor-reverser section.

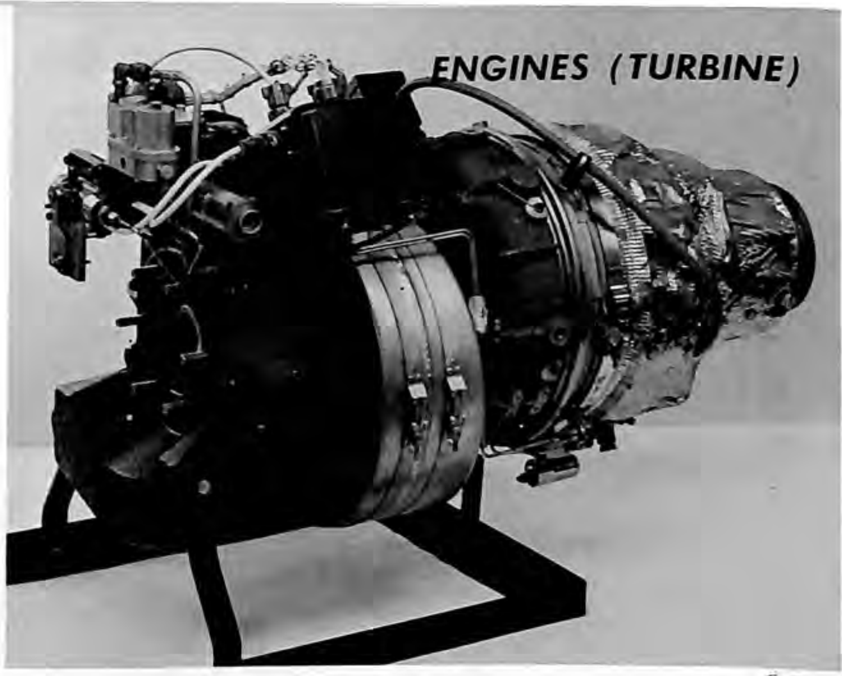
Specifications

Length 213 inches; diameter 69 inches; compression ratio 13; weight 10,500 pounds; axial flow dual rotor; compressor stages, 8, including fan; turbine stages 3.

Performance

Thrust, more than 60,000 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

The T-62T (Titan) is an extremely rugged and compact gas turbine engine which has been service-proven in both military and commercial applications. It is being used as the auxiliary power unit (APU) in every major U. S. military cargo helicopter program. In these applications, the APU provides power necessary to start main engines and operate all hydraulic and electrical systems, allowing aircraft operation completely independent of ground support equipment. Titan commercial applications include installations in F-27 and FH-227 aircraft of several airlines and in Falcon and Jetstar business jet aircraft. Functions in these installations include driving the aircraft air-conditioning system and providing both a.c. and d.c. electric power for main engine starting and emergency service.

Specifications

Length 26 inches; diameter 12.5 inches; weight 70 pounds; radial flow; electric or hydraulic starting.

Performance

Rating 80 to 105 horsepower.

Argo D-4 (Javelin)

SOUNDING ROCKETS

Listed under system contractor: manufacturer's nomenclature, type, stages and thrust, launch weight and overall length, performance, remarks and using organizations.

AEROLAB DEVELOPMENT COMPANY

ARGO A-2 (PERCHERON)

Boosted single-stage solid research rocket, Thiokol Castor TX-33 with 2 Thiokol Recruit TE-29's (122,000 pounds total thrust); weight 10,000 pounds; length 21 feet; 500 pound payload to altitude of 200 nautical miles; first stage Shotput; NASA

ARGO A-3

Single-stage solid research rocket, Hercules M-6 Honest John (86,000 pounds thrust); weight 5,910 pounds; length 21 feet; 2,000 pound payload to altitude of 10 nautical miles; used in Goodyear/USAF-ASD ballute tests; AF

ARGO B-1

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700 pounds thrust), 2nd—Thiokol Cajun TE-82 (9,600 pounds thrust); weight 1,540 pounds; length 23 feet; 50 pound payload to altitude of 100 natuical miles; NASA, AF

ARGO B-2

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700 pounds thrust), 2nd—Thiokol Apache TE-307 (5,000 pounds thrust); weight 1,600 pounds; length 27 feet; 60 pound payload to altitude of 135 nautical miles; operational; NASA

ARGO B-7

Two-stage solid research rocket, 1st—Hercules M-6 Honest John (86,000 pounds thrust); 2nd—Hercules M-5 Nike (48,700 pounds thrust); weight 5,900 pounds; length 31 feet; 400 pound payload to altitude of 40 nautical miles; 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 pounds thrust each); weight 28,000 pounds; length 27 feet; 400 pound payload to altitude of 30 nautical miles; used in Goodyear/USAF-ASD ballute tests; AF

ARGO B-21

Boosted 2-stage solid research rocket, 1st—Thiokol Castor TX-33 with 2 Thiokol Recruit TE-29's (122,000 pounds total thrust), 2nd—Thiokol TX-261 (57,000 pounds thrust); weight 13,000 pounds; length 42 feet; 1,300 pound payload to altitude of 250 nautical miles; under development (in-house)

ARGO C-23

Three-stage solid sounding or research rocket, 1st—Thiokol TX-33 with 2 Thiokol TX 77's (147,000 pounds total thrust), 2nd—Thiokol TX-261 (57,000 pounds thrust), 3rd—Thiokol TX-306 (11KS-13430); weight 14,300 pounds; length 41.3 feet; 150 pound payload to altitude of 2,000 nautical miles, Mach 21; in development for AF

ARGO D-4 (JAVELIN)

Four-stage solid research rocket, 1st—Hercules M-6 Honest John (86,000 pounds thrust), 2nd & 3rd—Hercules M-5 Nike (48,700 pounds thrust each), 4th—Hercules X-248 (3,000 pounds thrust); weight 7,400 pounds; length 48.7 feet; 100 pound payload to altitude of 550 nautical miles; NASA, AF


Arcas Family

ARGO D-8 (JOURNEYMAN A)

Four-stage solid research rocket; 1st—Thiokol XM-20 with 2 Thiokol 1.5KS-3500 Recruits (121,000 pounds total thrust), 2nd & 3rd—Lockheed Lance (47,000 pounds thrust each), 4th—Hercules X-248 (3,000 pounds thrust); weight 14,000 pounds; length 62.0 feet; 135 pound payload to altitude of 1,260 nautical miles; Mach 24; holds record for highest altitude (1,269 nautical miles) for recovered payload; NASA

TRAILBLAZER I

Six-stage (including 3 downward-thrust packaged in reverse in 3rd stage) solid research rocket, 1st—Hercules M-6 Honest John (86,000 pounds thrust), 2nd—Hercules M-5 Nike (48,700 pounds thrust), 3rd—either Lockheed Lance (47,000 pounds thrust) or Thiokol TX-77 (46,000 pounds thrust), 4th—Thiokol T-40, 5th—Thiokol T-55 (4,650 pounds thrust), 6th—NASA/Langley 5-inch spherical motor; weight 7,500 pounds; length 56 feet; 3 stages up to altitude of 200 nautical miles; 3 stages down attain 24,000 feet per second (a "gun-fired" pellet fired downward has reached 35,000 feet per second); NASA

AMERICAN MACHINE & FOUNDRY COMPANY YORK DIVISION

LR 64

Two-stage rocket engine, to propel drone targets for military aircraft, 1st stage booster—(837 pounds thrust), 2nd stage sustainer—(136 pounds thrust) at altitude of 70,000 feet.

ATLANTIC RESEARCH CORP. (ARC)

ARCAS

Single-stage solid sounding rocket, ARC 29KS-336; weight 65 pounds; length 6.6-9.1 feet; 12 pound payload to altitude of 40 miles; all services and NASA

ARCAS, BOOSTED

Two-stage solid sounding rocket, 1st—ARC IKS-2200, 2nd—ARC Arcas 29KS-336; weight 100 pounds; length 10.5 feet; 12 pound payload to altitude of 50 miles; all services, NASA, Canada, Sweden

ARCHER

Single-stage solid sounding rocket, ARC 35KS-1375; weight 330 pounds length 12.8 feet; 40 pound payload to altitude of 90 miles; all services and NASA

BOOSTED-ARCAS I

Two-stage solid sounding rocket, 1st—ARC MARC 14 A1 (1.0-KS-2200), 2nd—ARC ARCAS (29-KS-324); weight 120 pounds plus payload; length 10 feet 6 inches; 8 pound payload to 61 miles; NASA

BOOSTED-ARCAS II

Two-stage solid sounding rocket, 1st—ARC MARC 42 A1 (3-KS-2740), 2nd—ARC HV ARCAS (29-KS-324); weight 134.3 pounds plus payload; length 13 feet 3 inches; 12 pound payload to 96 miles; tube or rail launch; Army, NASA

HONEST JOHN-NIKE

Two-stage solid sounding rocket, 1st—Hercules M-6 Honest John (86,000-pound thrust), 2nd—Hercules M-5 Nike (48,700-pound thrust); weight 5,464 pounds; length 40 feet; 250 pound payload to altitude of 57 miles; Army, Air Force, NASA.

HONEST JOHN-NIKE-NIKE

Three-stage solid sounding rocket, 1st—Hercules M-6 Honest John (86,000 pounds thrust), 2nd and 3rd—Hercules M-5 Nike (48,700 pounds thrust); weight 6,784 pounds; length 47 feet; 250 pound payload to altitude of 118 miles; Army, AF, NASA

HYDRA-IRIS

Two-stage solid sounding rocket, 1st—3 clustered Aerojet Sparrow 1.8-KS-7800's (22,400 pounds total thrust), 2nd—ARC 52KS-4375; weight 1,350 pounds; length 24 feet; 100 pound payload to altitude of 200 miles; Navy

IRIS

Single-stage solid sounding rocket, ARC 52KS-4375; weight 1,350 pounds; length 24 feet; 100 pound payload to altitude of 200 miles; all services and NASA

METROC

Single-stage solid sounding rocket, ARC 16KS-140; weight 15 pounds; length 4.6 feet; 2 pound payload to altitude of 20 miles; all services and NASA

METROC, BOOSTED

Two-stage solid sounding rocket, 1st—ARC Metroc 16KS-140, 2nd—2.75 FFAR (Navy rocket, 720 pounds thrust); weight 26 pounds; length 8.8 feet; 2 pound payload to altitude of 52 miles; all services and NASA

NIKE-APACHE

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700 pounds thrust), 2nd—Thiokol Apache TE-307 (5,900 pounds thrust); weight 1,550 pounds; length 23 feet; 50 pound payload to altitude of 163 miles; all services and NASA

NIKE-ARCHER

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700 pounds thrust), 2nd—ARC Archer 35KS-1375; weight 1,650 pounds; length 25 feet; 40 pound payload to altitude of 230 miles; all services and NASA

NIKE-CAJUN

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700 pounds thrust), 2nd—Thiokol Cajun TE-82 (9,600 pounds thrust); weight 1,550 pounds; length 23 feet; 50 pound payload to altitude of 94 miles; all services and NASA

SIDEWINDER-ARCAS

Two-stage sounding rocket, 1st—NPP Sidewinder Mk 17 Mod 1A, 2nd—ARC HV ARCAS (29-KS-324); weight 168.4 pounds plus payload; length 14 feet 2 inches; 12 pound payload to 72 miles; all services, NASA and Norway

SPARROW-ARCAS

Two-stage sounding rocket, 1st—Aerojet Sparrow Mk 6 Mod 3, 2nd—HV ARCAS (29-KS-324); weight 206 pounds plus payload; length 12 feet 6 inches; 12 pound payload to 109 miles, all services and ESRO.

SWIK

Two-stage solid research rocket, 1st—Thiokol Castor TX-33 (55,000 pounds thrust) 2nd—Hercules X254 (14,100 pounds thrust); weight 13,200 pounds; length 35 feet; 300 pound payload to altitude of 750 miles; Army, AF

TRAILBLAZER II

Four-stage solid research rocket, 1st—Thiokol Castor TX-33 with 2 Thiokol Recruit TE-29's (122,000 pounds total thrust), 2nd—Lockheed Lance (47,000 pounds thrust), 3rd—Hercules Altair X-248 (3,000 pounds thrust), 4th—ARC/NASA 15-inch spherical (5,000 pounds thrust); weight 13,344 pounds; length 50 feet; 2 stages up, 2 stages downward to achieve reentry velocity of 22,000 feet per second; NASA, Army, AF.

HERCULES INCORPORATED

DEACON (POGO-HI)

Single-stage Hercules X-220 solid motor (6,400-pound thrust); weight 200 pounds; length 9.7 feet; payload weight versus altitude varies with each program; Army, Navy, NASA, ARPA

LANGLEY RESEARCH CENTER, NASA

METEOR SIMULATION VEHICLE (1)

(Modified Trailblazer II); 6-stage solid research rocket; 1st—Thiokol Castor TX-33 with 2 Thiokol Recruit TE-29's (122,000 pounds total thrust), 2nd—Lockheed Lance 47,000 pounds thrust), 3rd—Hercules Altair X-248 (3,000 pounds thrust), 4th—NASA Cygnus-15 (3,200 pounds thrust, 15-inch diameter spherical), 5th—NASA Cygnus-5 (550 pounds thrust, 5-inch diameter spherical), 6th—Army Ballistics Research Laboratory shaped-charge accelerator and re-entry pellet; ARC spin-stabilized velocity package contains last 4 stages; 13,500 pounds, 51.5 feet; 2 stages up to 300-kilometer altitude, remaining stages packaged in reverse to achieve 20-kilometer-per-second re-entry velocity, 15 degrees off vertical at 75-kilometer altitude; NASA

METEOR SIMULATION VEHICLE (2)

(Modified Nike-Cajun); 4-stage solid research rocket; 1st—Hercules Nike (53,000 pounds thrust), 2nd—Thiokol Cajun TE-82 (8,600 pounds thrust), 3rd—NASA Cygnus-5 (550 pounds thrust, 5-inch diameter spherical), 4th—Army Ballistics Research Laboratory shaped-charge accelerator and re-entry pellet; Zimmey Corporation spin-stabilized velocity package which contains 2 sets of the 3rd and 4th stages mounted in reverse; 1,575 pounds, 27.5 feet; 2 stages up to 120-kilometer altitude, 2 separate re-entries of different pellet materials each with 11-kilometer-per-second re-entry velocity, 15 degrees off vertical at 75-kilometer altitude; NASA

NAVAL MISSILE CENTER, POINT MUGU, CALIFORNIA

SPAROAIR

Air-launched 2-stage research rocket for use on F3B or F6B jet aircraft; Mach 0.8 at 32,000 feet; 1st and 2nd—Aerojet Sparrow III's; 35 pound payload to altitude of 65 nautical miles; used in Projects Tee Pee, Jane, and Night Owl for plasma generation, infrared and ultraviolet research, respectively; Navy, Army, General Motors Corporation

NAVAL ORDNANCE TEST STATION CHINA LAKE, CALIFORNIA

HOVERING ROCKET SYSTEM

Two-stage research rocket; 1st—Thiokol Pershing TX-175 2nd stage, 2nd—NOTS to develop 19 by 3-foot-diameter liquid engine (8,000 pounds thrust); weight 700 pounds; length 27 feet; recoverable payload to altitude of 65,000 to 50,000 feet; 2nd stage carries command guidance capable of stabilized 120 to 130 seconds hovering; 2 vehicles in development for upper-atmosphere research measurements and possibly surveillance use; Defense Atomic Support Agency

ROCKET POWER, INC.

HOPI CHAFF DART

Single-stage RPI 2.4-5600 HOPI-II solid motor; weight 95 pounds; length 11 feet; 11.5 pound payload to altitude of 380,000 feet; NASA

JUDI BALLOON DART

Single-stage RPI 1.9KS-2150 JUDI-I solid motor; weight 33.7 pounds; length 9 feet; 10 pound payload (standard AF Mylar Robin Sphere) to 200,000 feet; all services and foreign governments.

JUDI CHAFF (OR PARACHUTE) DART

Single-stage RPI 1.9KS-2150 JUDI-I solid motor; weight 33.7 pounds; length 8.6 feet; 10 pound payload to altitude of 240,000 feet; all services, NASA and foreign governments.

JUDI INSTRUMENTED DART

Single-stage RPI 1.9KS-2150 JUDI-I solid motor; weight 33.7 pounds; length 9 feet; 10 pound payload to altitude of 220,000 feet; all services and foreign governments.

PHOENIX-I

Two-stage solid sounding rocket; 1st—RPI 5.5KS-6100 KIVA-I, 2nd—RPI 3.OKS-4000 HOPI-II; weight 320 pounds; length 18 feet; 10 pound payload to altitude of 225 miles; all services.

RAVEN

Single-stage RPI 7.8KS-1945 HOPI IV solid motor; weight 107 pounds; length 10.8 feet; 10 pound payload to altitude of 225,000 feet; under development for meteorological use by all services and NASA.

SIDEWINDER-RAVEN

Two-stage solid sounding rocket; 1st—Naval Propellant Plant, SIDEWINDER 1A, 2nd—RPI 7.8KS-1945 HOPI IV; weight 208 pounds; length 17 feet; 20 pound payload to altitude of 400,000 feet; all services.

Nike-Tomahawk

SANDIA CORPORATION

NITEHAWK 9

Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,000 pounds thrust); 9-inch diameter payload section; 40-60 pound payload to 200 miles altitude; Mach 8.5; Atomic Energy Commission

SPACE-GENERAL CORPORATION

AEROBEE 150 & 150A

Boosted single-stage sounding rocket; sustainer—liquid IRFNA and aniline-furfuryl-alcohol mixture engine (4,100 pounds thrust for 51.8 seconds), booster—Aerojet 2.5KS-18,000 solid motor; weight (150), 1,943 pounds; length (150), 29.67 feet; weight (150A), 1,941 pounds; length, (150A), 30 feet; 150 pound payload to altitude of 152 miles; maximum acceleration 10.3 g; tower-launched; 150 version has 3 fins, 150A has 4 fins; attitude control and recovery systems available in both vehicles; NASA, AF, Navy, Kitt Peak Observatory

AEROBEE 300 & 300A

Two-stage sounding rocket; 1st—Aerobee 150 or 150A, 2nd—solid Aerojet Sparrow 1.8KS-7800; weight 2,103 pounds; length (300), 33.00 feet, (300A), 33.30 feet; 35 pound payload to altitude of 300 miles; maximum acceleration 63.8 g; 300A has 4 fins; NASA, AF

AEROBEE 350

Boosted single-stage stage sounding rocket; sustainer—4 Aerobee 150 thrust chambers, booster—Hercules M-5 Nike; 150 pound payload to altitude of 290 miles; tower-launched; 4 fins; NASA

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 pounds; length 34.17 feet; 130 pound payload to altitude of 1,300 miles; maximum acceleration 37 g; boom-launched; under development for NASA, AF, (replacement for NASA Journeymen A)

THIOKOL CHEMICAL CORPORATION ASTRO-MET DIVISION

NIKE-TOMAHAWK

Two-stage solid propulsion sounding rocket; 1st—NIKE M5 or M5E1 (48,700 pounds thrust), 2nd—Thiokol TE-416 Tomahawk (10,500 pounds thrust); weight 1,850 pounds without payload; length 286 inches without payload; 9-inch diameter, 125 pound gross payload to altitude of 200 miles; 12-inch diameter, 200 pound gross payload to altitude of 110 miles; Sandia Corporation, NASA/GSFC, University of Michigan, NASA/MSFC, AFCRL, and Douglas Aircraft Company.

TOMAHAWK

Single-stage solid propulsion sounding rocket; Thiokol TE-416 Tomahawk (10,500 pounds thrust); weight 531 pounds without payload; length 141 inches without payload; nominal configuration 125 pounds gross payload to altitude of 60 miles; low-drag configuration 60 pounds gross payload to altitude of 130 miles; high-drag configuration 80 pounds gross payload to altitude of 74 miles; Tomahawk-Dart 140 pounds gross payload (Dart) to altitude of 57 miles; NASA, Sandia Corporation.

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